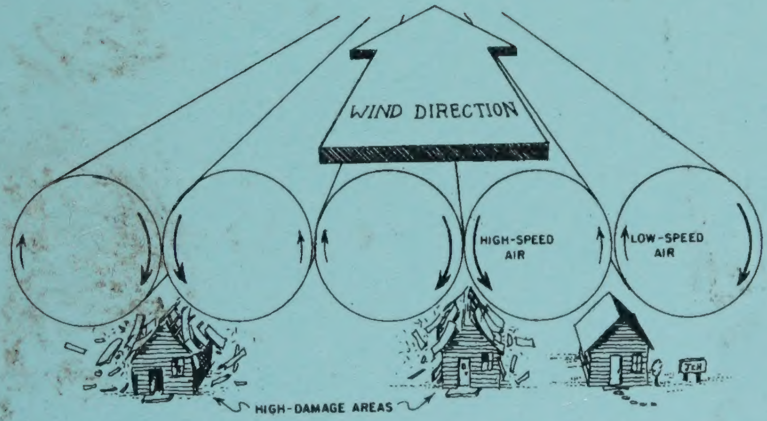
DARK DAYS, ICE FALLS, FIRESTORMS,
AND RELATED WEATHER ANOMALIES

Compiled by

William R. Corliss



A CATALOG OF GEOPHYSICAL ANOMALIES

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AND RELATED WEATHER ANOMALIES

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"ROUND ABOUT THE ACCREDITED AND ORDERLY FACTS OF EVERY SCIENCE THERE EVER FLOATS A SORT OF DUST-CLOUD OF EXCEPTIONAL OBSERVATIONS, OF OCCURRENCES MINUTE AND IRREGULAR AND SELDOM MET WITH, WHICH IT ALWAYS PROVES MORE EASY TO IGNORE THAN TO ATTEND TO .... ANYONE WILL RENOVATE HIS SCIENCE WHO WILL STEADILY LOOK AFTER THE IRREGULAR PHENOMENA. AND WHEN THE SCIENCE IS RENEWED, ITS NEW FORMULAS OFTEN HAVE MORE OF THE VOICE OF THE EXCEPTIONS IN THEM THAN OF WHAT WERE SUPPOSED TO BE THE RULES."

William James

Illustrations initialed JCH are the work of John C. Holden

PREFACE

After more than twenty nine years of scouring the scientific and semiscientific literature for anomalies, my major observation is that the search has been most fruitful. In fact, I have wondered why the scientific community itself has not been systematically compiling such information. It is surprising that a Catalog of Anomalies does not already exist to guide scientific thinking and research. It is at least as important to recognize what is anomalous as it is to realize what is well-explained in terms of prevailing paradigms. With this outlook and philosophy, here is the eighteenth volume of such a Catalog. It is largely the product of one person's library research. The work has been carried forward entirely through the sale of these Catalog volumes and associated publications.

Under the aegis of the Sourcebook Project, I have already published 34 volumes, totalling roughly 14,000 pages of source material on scientific anomalies. (See page iv for a list of titles.) As of this date, these 34 volumes represent only about 40% of my data base. New material is being added at the rate of about 1,200 new items per year, about 700 of which come from the current scientific literature. This acquisition rate could easily be multiplied several-fold just by spending more time in libraries. Even after twenty-nine years, only a handful of English-language journals have received my serious attention. The journals in other languages, government reports, conference papers, publications of research facilities, proceedings of state academies of science, and an immense reservoir of pertinent books remain almost untapped. Every library foray uncovers new anomalies; the world's libraries are bulging with them.

Given this rough assessment of the extent of the anomaly literature, one can understand why the Catalog of Anomalies will require at least 30 volumes, many of them larger than the one you now hold. I visualize a shelf of these 30 volumes, or an equivalent CD, accompanied by master indexes, to be the logical initial step in providing scientists with access to what, in my opinion, is not well-explained. The underlining of "my" is significant because anomalousness is often in the eye of the beholder. It depends upon how well one is satisfied with those explanations based on currently accepted paradigms. In the Catalog of Anomalies, the data rule; all theories and hypotheses are considered tentative. The history of science, from the luminiferous ether to the static continents, demonstrates that this is a wise policy.

Will the Catalog of Anomalies impact science significantly? Probably not---at least not right away. Quite often the initial reaction to the volumes already published has been disbelief and even disdain. The data must be in error; the data are too often anecdotal; the data are too old; the purported anomaly was really explained long ago. Germs of truth reside in such complaints. Some science and some observations reported in the Catalog are certainly bad; but this is minimized by a heavy reliance upon respected journals. In addition, the baseline of well-established theories---against which anomalousness in measured---is always shifting. And for every anomaly that can be explained away, a trip to a library will quickly replace it with ten more from impeccable sources. Nature is very anomalous or, equivalently, Nature is not yet well-understood. Much remains to be done in both anomaly research and in the resulting scientific research that will ultimately dispose of these anomalies.

William R. Corliss

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October 30, 2006

HOW THE CATALOG IS ORGANIZED

Purpose of the Catalog

The Catalog of Anomalies is designed to collect and categorize all phenomena that cannot be explained readily by prevailing scientific theories. Following its definition, each recognized anomaly is rated in terms of: (1) its substantiating data; and (2) the challenge the anomaly poses to science. Next, all examples of the anomaly discovered so far are noted, some in detail. Finally, all examined references are listed. Thus, the Catalog is a descriptive guide as well as a compendium of examples and references. Scientific researchers therefore have a ready-made foundation for beginning further investigations into these intriguing phenomena. This is the basic purpose of the Catalog: the collection and consolidation of the unknown and poorly explained to facilitate future research and explanation.

General Plan of the Catalog

It was tempting to organize this Catalog alphabetically, making it an "encyclopedia of anomalies." But many of the phenomena have obscure names or, even worse, no names at all. Under these circumstances, access to the data base would be difficult. Therefore, a system of classification was designed based upon readily recognized classes of phenomena and the means by which the observer detects them. Subject matter is first divided into nine general classes of scientific endeavor, as illustrated in the diagram. Few persons would have difficulty classifying a phenomenon as biological, astronomical, etc. The second, third, and fourth levels of classification are also based upon generally recognized attributes, such as luminosity, sound, etc. The similarity of this method of categorization to those employed in natural history field guides is purely intentional. Like bird identification, phenomenon classification soon becomes second nature. In fact, almost all of the phenomena described in the Catalog are accessible to everyone with five normal senses and perhaps binoculars and telescope.

Most catalogs boast numbering systems and this one is no exception. Rather than employ a purely numerical system, the first three levels of classification are designated with letters. The triplets of letters chosen have some mnemonic value. Thus, a GWP anomaly is easily recognized as being in the geophysics class (G), weather-related (W), and involving some type of precipitation (P). The number added to the triplet of letters marks the fourth level of classification, so that GWP1 signifies cloudless rain. Every anomaly type has a unique alphanumeric code, like GWP1. All cross references and indexes are based upon this system. Catalog additions and revisions are made much easier with this scheme.

The Catalog codes may seem cumbersome at first but their mnemonic value to the compiler has been significant. Hopefully, they will help other users, too. The codes are simple, yet flexible enough to encompass the several thousand types of anomalies identified so far.

A glance through this volume of the Catalog will reveal that each example of a specific anomaly type bears an X-number, and each reference an R-number. GWP1-X12 therefore specifies the twelfth example of cloudless rain, and GWP1-R17 the seventeenth reference to cloudless rain. Indexes and cross references can consequently be made more precise then conventional page references.

How Data and Anomalies Are Evaluated

Each anomaly type is rated twice on four-level scales for data "validity" and "anomalousness," as defined below. These evaluations represent only the opinion of the compiler and are really only rough guides.

Data Evaluation Scale

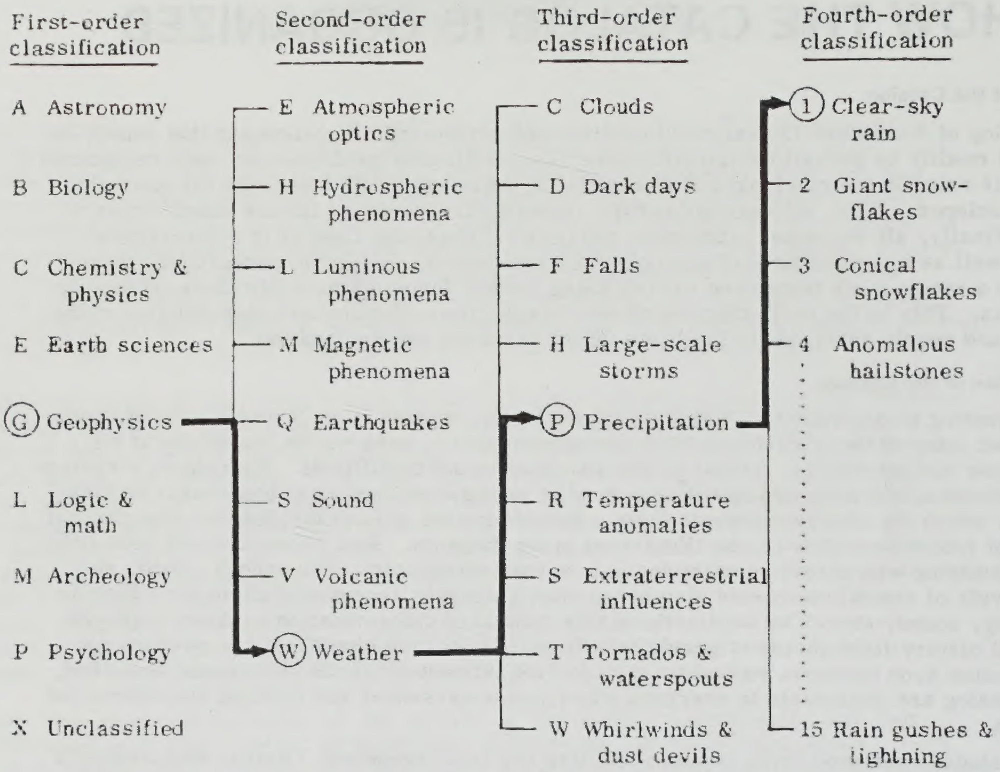
1 Many high-quality observations. Almost certainly a real phenomenon.

2 Several good observations or one or two high quality observations. Probably real.

3 Only a few observations, some of doubtful quality. Pheonomena validity questionable.

4 Unacceptable, poor-quality data. Such phenomena are included only for purposes of comparison or amplification. Only two such items are registered in this volume.

HOW THE CATALOG IS ORGANIZED



Catalog Coding Scheme

Anomaly Evaluation Scale

1 Anomaly cannot be explained by modifications of present laws. Revolutionary.

2 Can probably be explained through relatively minor modifications of present laws.

3 Can probably be explained using current theories. Primarily of curiosity value.

4 Well-explained. Included only for purposes of comparison and amplification. Only one such item is registered in this volume.

Anomalies that rate "1" on both scales are very rare. Such anomalies, however. are the most important because of their potential for forcing scientific revolutions.

Anomaly Examples

Examples of anomaly types are designated by the letter X in the body of the Catalog. All examples discovered so far are listed. If the example is of the event type, time and place are specified if available. Some of the more significant geophysical events, such as the remarkable "Dark Day" of 1780, may appear in several references, all of which are provided in full and keyed to the X-number of the example. Dark days are represented by scores of examples (hundreds exist but have not yet been collected); but only a single example of dust spouts or "land spouts" is listed. When library research has made many examples of an anomaly type available, several of the most interesting and instructive are reported in some detail. Direct quotations from the eye-witness accounts are frequently employed to convey accurately the characteristics of the phenomenon to the reader. These selected examples are printed full-width in the Catalog columns. Examples of less import are indented to separate them visually.

The References and Sources

Each anomaly type and the examples of it are buttressed by all references that have been collected and examined. Since some references describe several examples, each reference includes the X-numbers of the examples mentioned. When a reference covers more than one type of anomaly, it is repeated in the bibliography following each anomaly type. Actually, there is little repetition of this sort in the Catalog.

Perusal of the Source Index will demonstrate that the great majority of references come from the scientific literature. Heavily represented in this volume of the Catalog are: Nature, Science, Monthly Weather Review, Meteorological Magazine, and the Quarterly Journal of the Royal Meteorological Society. Several less technical publications are also frequently mentioned: Marine Observer, Scientific American, and English Mechanic. The Marine Observer is a publication of the U.K. Meteorological Office. The English Mechanic was for many years an important English technical magazine, much like Scientific American. All of the serials mentioned so far are considered generally reliable, although one must always be wary. In addition to these often-referenced journals, there is a very wide selection of other publications. Some of these are more popular in character. In this context, it should be remembered that unusual phenomena do not seek out scientists, and the laymen who observe many anomalies have no knowledge of or access to scientific journals.

The time span covered by the sources ranges over 150 years. Many excellent reports of anomalies come from the latter half of the Nineteenth Century. Although many scientists frown on such old reports, the quality is often good, and they should not be discarded arbitrarily. Not only were the observers of a century ago competent, they were unbiased by knowledge of modern theories and lived in an environment unpolluted by modern vehicles, effluxes, and other contaminants. It should also be mentioned here that the modern meteorological literature tends heavily toward mathematical modelling and theory as opposed to eye-witness accounts of strange phenomena. Two journals that are exceptions to this rule are the Marine Observer and the U. K. Journal of Meteorology.

The Indexes

This volume concludes with four separate indexes. At first glance this may seem to be too much of a good thing. But in the context of a science-wide catalog of anomalous events and phenomena, these multiple indexes have important roles to play.

The Subject Index is essential to any work of this type. It is placed last for easy access. The Time-of-Event Index can be an important tool for anomaly researchers. It helps identify phenomena that are listed more than once because of their divergent features, but which are really different aspects of the same event. This integrating feature will become more useful as Catalog volumes accumulate. To illustrate, the 1908 Tunguska Event produced catalogable luminous and barometric phenomena as well as atmospheric optical effects---all entered separately in different parts of the Catalog---often in different volumes. It is possible that the Time-of-Event Indexes collectively will reveal cause-and-effect relationships that have not been recognized before.

HOW THE CATALOG IS ORGANIZED

The Source Index shows the dependence of the Catalog on scientific literature rather than newspapers and other popular publications. Its real purpose, though, is the rapid checking to determine if a specific reference has or has not been caught already in the fishing nets of this Catalog project. The source index is doubly valuable because many footnotes and bibliographies in the scientific literature display sources only; that is, titles and authors are omitted entirely. The researcher also comes across many vague references to such-and-such an article by so-and-so back in 1950 in Nature. The exhaustive and rather ponderous source and first-author indexes can help pin down many references lacking specifics.

All four indexes use the catalog codes described above rather than page numbers. The codes are permanent whereas the page numbers will change as addenda and revised volumes are produced. The mnenonic value of the catalog codes is useful here, too, because the approximate nature of each index entry is readily apparent, while page numbers give only location.

Each anomaly type and the examples of it are buttressed by all references that have been collected and examined. Since some references deal with several examples, each reference includes the X-numbers of the examples mentioned. When a reference covers more than one type of anomaly, it is repeated in each anomaly bibliography. Actually, there is little repetition of this sort in the Catalog.

Catalog Addenda and Revisions

Over 1200 new reports of anomalies are collected each year from current and older scientific journals. New anomaly types and additional examples of types already cataloged are accumulating rapidly. When sufficient new material has been assembled, Catalog volumes will be revised and expanded.

The Sourcebook Project welcomes reports of scientific anomalies not already registered in extant Catalog volumes. Reports from scientific journals are preferred, but everything is grist for the anomaly mill! Credit will be given to submitters in new and revised Catalog volumes. If the reports are from current literature, they may be mentioned in Science Frontiers, the Project's newsletter. Send data to: Sourcebook Project, P.O. Box 107, Glen Arm, MD 21057, USA.

INTRODUCTION TO WEATHER PHENOMENA

"Weather" is a composite experience of sight, sound, temperature, and other sensations of the elements. The phenomena of this Catalog volume are not primarily luminous or acoustic or confined to the sensory channels that form the bases for the other volumes in the field of geophysics. Here, we deal with rain, fog, wind, clouds, precipitation, and sunshine---but only when they are anomalous or at least curious enough to attract our attention.

Our weather experiences are so widely variable that a phenomenon has to be very strange indeed to gain access to this volume. The entrance criteria are not so much related to intensity or rarity as they are to unexpectedness and their deviations from meteorological theory. Thus, very heavy general rains, even with catastrophic flooding, are excluded, while rain from a cloudless sky and "point" rainfall are welcome additions.

Several themes that thread their ways through the geophysical volumes of the Catalog recur in this book:

1. The importance of electricity in geophysical phenomena
2. The possible influences of the sun, moon, planets, and inbound meteoric material on terrestrial weather
3. The occasional prankish, frivolous behavior of some weather phenomena. This judgment is, of course, highly subjective.

One interesting feature of weather phenomena taken as a whole is their rather low level of anomalousness; at least when compared to other geophysical phenomena in the Catalog of Anomalies. Weather, it seems, is not as strange as, say, luminous geophysical phenomena. There are more plausible theories available to explain weather phenomena than for ball lightning or long-delayed radio echoes. Of course, this does not mean that science understands all facets of the weather---this volume would not exist if it did.

GWC UNUSUAL CLOUDS

Key to Phenomena

GWC0 Introduction

Clouds can be classified as unusual if they possess anomalous shape, motion, color, orientation, or emit unaccountable light or noise. Meteorologists recognize a variety of clouds as "usual" even though they are not fully understood. Lenticular clouds, for example, are lens-shaped and produce not a few UFO reports. Nevertheless, lenticular clouds are a recognized species and at least partially comprehended. They are, therefore, omitted here. Rotating, ring-shaped clouds and some spectacular roll clouds (i.e., the Morning Glory) do find places in this Catalog. Although these types of clouds are doubtless created by atmospheric vortices and solitary waves, they are neither common nor easy-to-explain. Cloud arches connecting two seemingly unrelated clouds pose some intriguing questions: Are the arches umbilical in character? Is a flow of electricity involved? Some clouds seem to interact in mysterious ways with the earth's magnetic field, as in the case of the so-called polar bands, which are evidently cirrus clouds aligned with the magnetic meridian. How can the earth's magnetic field twist lines of nonmagnetic ice crystals into neat bands oriented like compass needles? All in all, there are many imponderables in the character and behavior of the prosaic cloud.

GWC1 The "White Sky" Phenomenon and Low-Altitude Haze

Description. Persistent veiling of the sky over wide areas by a high layer of haze of uncertain origin. During periods of white sky, the dimmed sun appears white and can be viewed with the naked eye. Stars are seen only dimly at night.

Background. The most notable examples of "white sky" occured in Europe during the summers of 1912 and 1916. The superficially similar Arctic hazes are recent, being due mainly to industrial pollution.

Data Evaluation. The European 1912/1916 episodes and the recurring Arctic low-altitude haze are well-established in the science literature. Rating: 1.

Anomaly Evaluation. Several reasonable explanations are noted below, resulting in a low anomaly rating. Rating: 3.

Possible Explanations. Dust raised by violent winds in desert areas; volcanic eruptions, industrial air pollution. A comet's tail was suggested for the 1912 episode.

Similar and Related Phenomena. Stratospheric haze layers (GWC17); high-level "auroral" hazes (GLA12 in Remarkable Luminous Phenomena); noctilucent clouds (GWC7); dry fogs and dust fogs (GWD4).

Examples of White Sky

X1. Summer 1912. Much of the Northern Hemisphere, especially Europe. "For weeks, when not clouded, it (the sky) has been white, and one could look at the white sun with the naked eye near the zenith in the unclouded sky---not a patch of blue to be seen, and frequently no clouds. (R1) Also seen in France and Germany.(R2) "It having been my good fortune to spend a few weeks in Ireland lately, I have been able to observe the strange condition of the upper atmosphere, which has been noted by several of our correspondents. At Ealing the sky has been of unusual whiteness, certainly, since the middle of June. This haze became more marked in August, and when I went to Western Ireland, on the 15th of that month, I found it much denser. During the daytime the sun never shone brilliantly, and towards sunset the upper atmosphere was filled with layers of fleecy mist. (R3). Extraordinary twilight colors seen in Europe. (R4) White sky also observed by a Greenland expedition, even when above 8,000 feet altitude. Dust from the eruption of Katmai in Alaska a possible cause. (R5)

Additional details on the 1912 "white sky" appeared in the following letter from W.N. Shaw then working at the British Meteorological Office.

"During the past months several correspondents have written to the Meterological Office drawing attention to the peculiar persistent whitish haze which has covered the sky even on apparently cloudless days during the past summer. On August 11, Sir John Moore wrote from Dublin remarking---'the sky is constantly covered with a thin film of apparently uniform cloud in which no holes develop, and through which the sun, moon, and stars shine with a subdued, sickly brightness.' Very similar descriptions have come to hand from Mr. Henry Johnstone, writing on August 13 from Downpatrick, and from Rev. F. Hamilton Claypole Rectory, Newark.

"The phenomenon seems to have prevailed over a very wide area, for in the July, August, and September numbers of the Meteorologische Zeitshrift similar observations are reported from such places so far apart as Heidelberg (Professor Max Wolf), Switzerland (Professor Maurer), and Sweden (Professor Hildelbrandsson).

"A long account has also reached the Office from a correspondent in Riga. Mr. W.D. Addison writes---'We have had a magnificent, warm, dry summer, with long spells of cloudless weather, but since the latter part of May, never once have we beheld a sky which it would be reasonable to call blue. A 'veil'---I can call it by no other name---seems to have been imposed between us and the sky. The sun presents a most unusual appearance, very difficult to describe; it has a dead appearance, and frequently I have been able, two hours or more before its setting-time, to look at it with unprotected eyes without blinking. It then presents a sickly, almost green, and pallid appearance; it also entirely fails to light up the cloud formations." (R7)

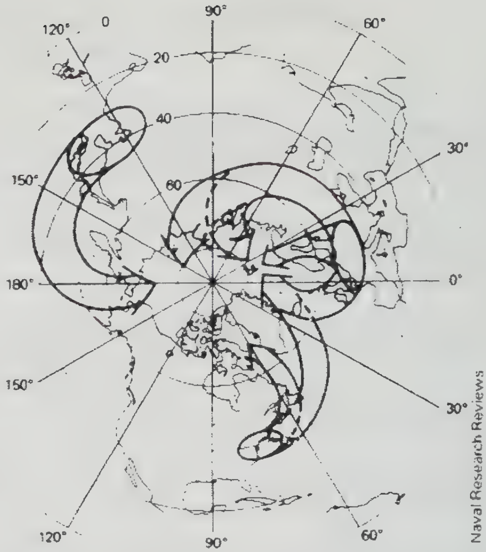
X2. Frequent occurrence in March and April. Alaska and part of Arctic Ocean. "It's quite a high haze, around 10,000 feet. You can still see the mountains off in the distance. Yet the sky has a whitish, diffuse look to it... (from the air) the horizon almost becomes invisible... One of its puzzling features is its height;... haze usually hugs the ground... It no doubt also goes over at least part of the Arctic Ocean." Possibly due to dust from the Gobi and other Asia deserts. A layer of haze at lower levels seem to be air pollution from Japan. (R6)

The expanding and thickening Arctic haze has been sampled by NOAA aircraft flights through it in 1983. " R.A. Rasmussen of the Oregon Graduate Center, Beaverton, Ore., said the haze was exceedingly thick just over the ice cap, reaching as high as 5450 m, but thinning at higher altitudes. Air samples taken by Rasmussen on the flight have indicated so far, that the haze was composed largely of perchloroethylene (PCE). Among other things, the chemical PCE is found in dry cleaning solution and hydrocarbons from burning fossil fuel.

"Evidence such as this supports the belief that the haze is caused by human activities. According to James T. Peterson, Director of NOAA's Geophysical Monitoring for Climatic Change in Boulder, Colo., much of the haze is thought to originate from Europe and Northern Asia." (R12)

X3. Summer 1916. Europe. The "white sky" of 1912 was repeated over the European continent, perhaps elsewhere, too, although no other reports are on file. In 1916, however, the phenomenon was ascribed to "deterioration of the atmosphere," which again tells us nothing about its cause.

Dr. Maurer, director of the Swiss Meteorological Institute wrote the following about the 1916 occurrence.



Possible sources and transport routes for airborne pollutants at Arctic mid-altitudes. (R14)

"Remarkable optical deterioration of the atmosphere became apparent in the Swiss Alps during the last ten days of July by the persistently abnormal magnitude and unusual intensity of the bright patch round the sun, to which the name aureole is sometimes assigned. Observations in previous years have established a well-defined minimum during the summer months, both in the diameter and the intensity of the solar aureole, but during the present year, from July 23 to the middle of August, the diameter generally obtained 120° to 130°, and on August 25 even 140°, with relative great intensity." (R9)

X4. 1883-4 and 1902-3. "White sky" phenomena similar to those of X1 (1912) and X3 (1916) are also on record. (R9)

X5. June 1950, Pacific Ocean. "A strange haze covering a million square miles hung over the Pacific today for the third straight day. Official observers said it contained no atomic radiation.

"The haze extended westward beyond Wake Island, 2,000 miles away, and 400 miles eastward. Its north-south range was about 600 miles, with Johnson Island on the southern edge.

"While the source of the grey foglike mist had not been determined, the best surmise of the Weather Bureau here [Honolulu] was that it resulted from foreign matter, including a heavy concentration of salt particles, trapped beneath a layer of immobile air at 6,000 feet.

"It is expected to remain until surface winds return to blow it away.

"Whatever the source of the mid-Pacific phenomenon, it has no parallel in Hawaiian weather records.

.....

"R.H. Simpson, in charge of the Honolulu Weather Bureau, described the fog as composed mostly of salt particles swept up in spray from the ocean." (R10)

Note that this mid-Pacific haze seems to have a different source and different characteristics from the recurring low-altitude Arctic haze. (X2)

References

R1. Moorhead, T.H.; "White Skies and a White Sun," English Mechanic, 96:133, 1912. (X1)

R2. "White Sky," English Mechanic, 96: 199, 1912. (X1)

R3. Offord, J. Milton; "The White Sky," English Mechanic, 96:222, 1912. (X1)

R4. Hollis, H.P.; "A Sky Phenomenon in 1912," English Mechanic, 97:220, 1913. (X1)

R5. Scientific American, 108:171, 1913. (X1)

R6. "Alaska's Imported Haze," Mosaic, 9:41, September/October 1978. (X2)

R7. Shaw, W.N.; "Peculiar Appearance of the Sky during the Summer," Meteorological Society, Quarterly Journal, 38:312, 1912. (X3)

R8. MacDermott, Joseph et al; "Astronomical---The White Sky," English Mechanic, 96:155, 1912. (X3)

R9. Shaw, Napier; "Optical Deterioration of the Atmosphere in July and August, 1912," Nature, 98:90, 1916. (X3, X4)

R10. Anonymous; "Strange Million-Mile Haze Hangs over Pacific Third Straight Day," New York Times, June 15, 1950. Cr. M. Piechota. (X5)

R11. Anonymous; "Arctic Haze," Eos, 51:1193, 1982. (X2)

R12. Anonymous; "Heavy Arctic Haze Confirmed by NOAA Research Team," American Meteorological Society, Bulletin, 64:659, 1983. (X2)

R13. Anonymous; "Arctic Haze Observed," Science News, 123:229, 1983. (X2)

R14. Simon, C.; "Chilling Hints of a Warmer Arctic," Science News, 123: 69, 1983. (X2)

R15. Anonymous; "Haze Layer Heats Arctic at Faster Rate," Science News, 125:47, 1984. (X2)

R16. Anonymous; "Alpine Haze Due to the War?" Scientific American, 115: 405, 1916. (X3)

R17. Anonymous; "Strange High-Level Haze in the Arctic," Mosaic, 9:14, September-October 1978. (X2)

GWC2 Cloud Arches

Description. Narrow bands of clouds crossing the sky in an arc that usually joins two widely separated cumulus clouds. While most arches seem formed from cloud, the arch sometimes seems to be simply a band of light. Most observations of cloud arches have been made from ships at sea.

Data Evaluation. A well-attested phenomenon. Rating: 1.

Anomaly Evaluation. The nature of the cloud arch is in question. Is it simply a cloud formed from a long, narrow vortex, or possibly of electrical origin similar to that suggested by some for tornados, or purely an optical phenomenon? No matter which, the formation and maintenance of these arches are very puzzling. Rating: 2.

Possible Explanations. Cloud arches may be long, narrow roll clouds that flare out into cumulus clouds at both ends---something like an intercloud tornado funnel.

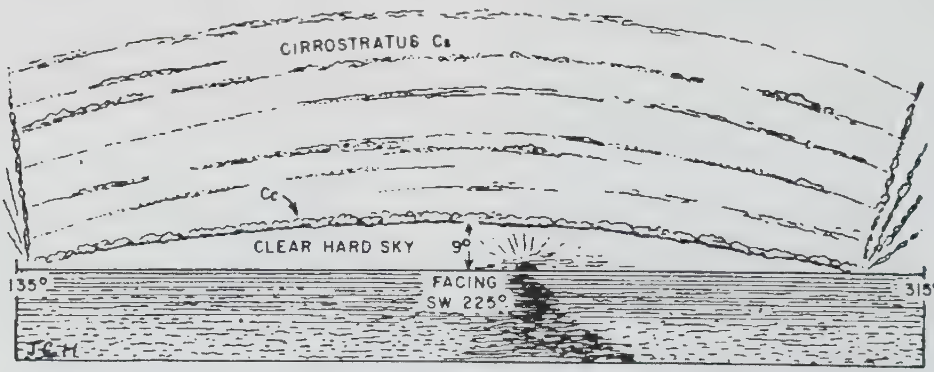
Similar and Related Phenomena. Roll clouds (GWC12); anomalous cloud lines (GWC10); magnetically aligned cirrus clouds (GWC3); mirror-type cloud mirages (GEM); and, in geometry if not reality, cloud-like auroral arches (GLA2) and the banded sky phenomenon (GLA23); waterspouts between clouds (GWT10).

Examples of Cloud Arches

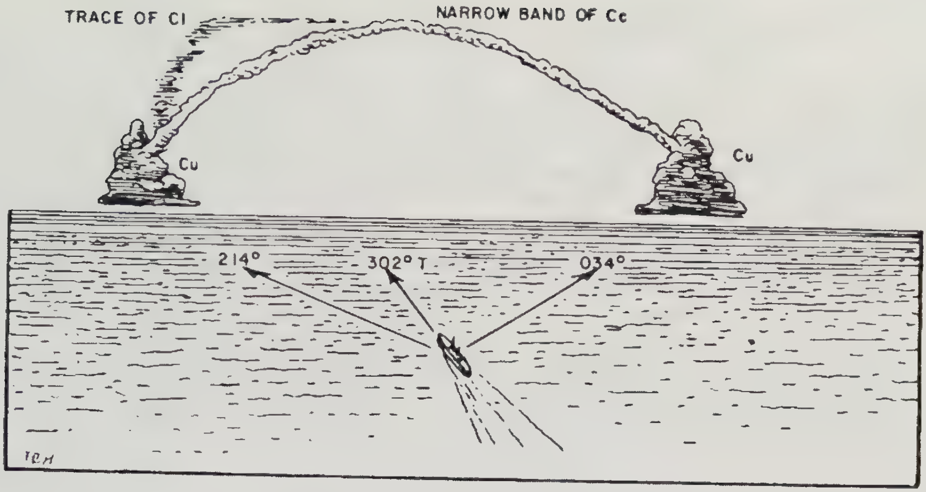
X1. February 8, 1933. South Atlantic Ocean. A well-defined arch of cirro-stratus joins two rain squalls about 8 miles apart. (R1)

X2. November 24, 1933. South Atlantic Ocean. "From two points on the horizon bearing 138° and 304° respectively, an area of hard clear sky arched itself to an altitude of 9°. This maximum angular height was approximately above the sun, which set bearing 237 1/2°. Maintaining an almost equal distance with the rim of this arch was another smaller arch with an angular height of 2°. The space between these two arches was packed with Cirro-Cumulus globules which appeared to be closely stowed between well-defined layers of Cirro-Stratus clouds. Another patch of Cirro-Stratus cloud, low in the sky, temporarily dimmed the setting sun. From the two points on the horizon, bands of cloud radiated and passed obliquely into the sky, the Northerly band in both cases being composed of Cirro-Cumulus clouds. These bands became fainter with altitude and finally diffused into the upper sky." (R2) This example resembles in some ways the displays of aligned cirrus clouds (GWC3).

X3. May 31, 1952. Indian Ocean. "Two very dark towering Cu clouds bearing 034°, appeared to be joined to a single dark towering Cu cloud, bearing 214°, by a narrow band of



System of cloud arches in the South Atlantic (X2)



Cloud arch connecting two cumulus clouds (X3)

Cc which stretched across the sky over the ship. This formation lasted about 2 hours before disintegrating. The moon was not visible at the time and the sky was cloudless except for the above formation." (R3)

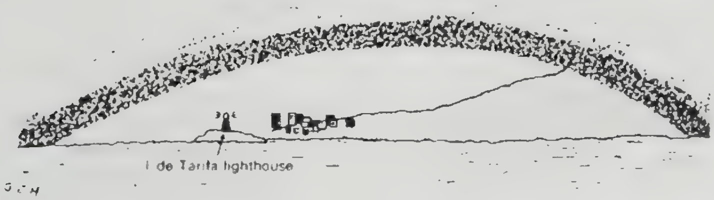
X4. June 3, 1952. Indian Ocean. A cloud formation similar to that of X3. (R3)

X5. April 25, 1956. Arabian Sea. "A thin white band, not appeared to be cloud, joined two tufts of towering Cu. The band remained as such until the clouds dispersed." (R4)

X6. July 12, 1980. Strait of Gibraltar. "At 1825 GMT whilst the vessel was transiting the Strait of Gibraltar, a line of low cloud was observed in an otherwise cloudless sky, see sketch. The cloud was in the form of an arch in an east-west line, reaching the surface approximately 2 n. mile ahead and astern of the vessel. Visibility under the cloud was about 10 n. mile in the north-south direction and 2 n. mile to the east and west. Once the vessel reached the point where the cloud touched the surface, the visibility was reduced to approximately 1.5 n. mile. Whilst the vessel was passing the cloud, the barograph trace fell almost vertically and both the air and sea temperatures dropped several degrees." (R5) Although there are no cumulus clouds at the terminations of the arch, this phenomenon is very similar to others in this category.

References

R1. Harvey, H. B.; "Cloud Arch," Marine Observer, 11:6, 1934. (X1)
R2. Nelson, A. L.; "Cloud Formation," Marine Observer, 11:138, 1934. (X2)
R3. Townshend, C. R.; "Unusual Cloud Formations," Marine Observer, 23:76, 1953. (X3, X4)
R4. Mould, F. W.; "Unidentified Phenomenon," Marine Observer, 27:82, 1957. (X5)
R5. Shepherd, F.; "Cloud," Marine Observer, 51:107, 1981. (X6)



Curious cloud arch in the Strait of Gibraltar. The ends terminated in the ocean at points 4 miles apart. (X6)

GWC3 Polar Bands

Description. Long, parallel, sharply defined streaks of cirrus cloud aligned along the magnetic meridian. Taking perspective into account, a ground observer sees these parallel clouds as fans radiating from points on the northern and southern horizons. They spread out when overhead into evenly spaced bands, tenuous in nature, more like strips of haze in some cases, and sometimes faintly luminous at night.

Background. Von Humboldt applied the term "polar bands" to these geometrically aligned cirrus bands. English folklore dubs them "wind reels." Early observers believed that this phenomenon was surely associated with auroral activity. Indeed, many of the examples presented here possess auroral overtones. See GLA12 in this regard. The polar bands also bear a striking resemblance to the banded sky (GLA23), and in fact may be the same phenomenon, occurring in the daytime instead of at night.

Data Evaluation. Many observations of polar bands reside in the older literature, but they are recorded infrequently in recent times. Rating: 1.

Anomaly Evaluation. Two characteristics of the polar bands make them anomalous: (1) Their frequent alignment with the magnetic meridian; and (2) A less frequent association with auroral displays. Cirrus clouds would not seem to have intrinsic magnetic properties, nor do they occur anywhere close to the altitudes of normal auroras. Rating: 2.

Possible Explanations. The magnetic alignment may be just a coincidence, perhaps due to the creation of cirrus bands by high altitude winds with preferred directions of propagation. Less likely is the possibility that the auroras, which are usually magnetically oriented, and polar bands have a common cause, say, particles that cause high-altitude luminous phenomena and low-altitude nucleation of ice crystals.

Similar and Related Phenomena. Banded skies (GLA23), and the apparent close relationship between some auroras and some clouds (GLA12), cloud arches (GWC2).

Examples of Polar Bands

X1. October 30, 1870. England. "On that day the finest films of cirrus stratus cloud radiated in a most beautiful and symmetrical manner from a point below the northwest horizon, and their resemblance to the streamers of aurora was most perfect. Later, at about 1 o'clock on the same day, long ridges of cumuli were arranged in the same manner." (R1)

X2. April 8 and 9, 1871. England. Long streaks of cirrus stratus were polarized NW-SE. Auroral streamers on April 9 were parallel to the cloud display. (R2)

X3. April 10, 1872. Champion Hill, England. Cirrus clouds radiated from magnetic north. An aurora followed. (R3)

X4. June 18, 1872. England. Masses of cirrus cumulus clouds were polarized nearly along the magnetic meridian. (R4)

X5. October 23, 1872. England. Polarized streaks of haze and cirrus clouds. (R5)

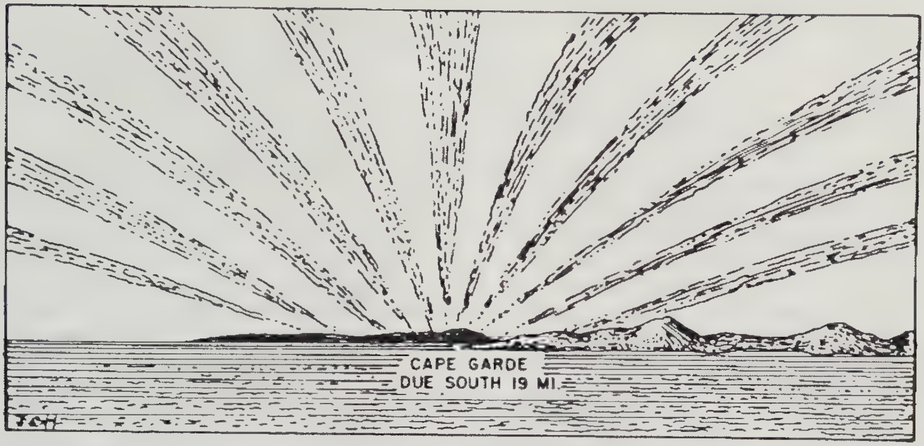
X6. September 11 and 12, 1873. England. Polarized streaks of haze and cirrus clouds. (R5)

X7. March 12, 1900. Harefield, England. "A number of gauze-like white clouds, in perfectly straight lines, radiated like a huge fan from a point due north, slightly below the visible horizon, where a clump of elm trees, about half a mile away, grew. The clouds were straight white streaks, of which the edges shaded off into the blue of the sky visible between them. The streaks were at regular distances apart, and about 24 in number above the horizon, those near it being but a few degrees from the horizontal, and stretching from the centre to about 40^{o} of declination; but those near the horizon, apparently about 60^{o}, and what struck me as most singular, they all ended almost abruptly." Later, the clouds extended and converged in the southwest. (R6)

X8. June 30, 1925. East London, South Africa. Cloud streamers radiated from the south. (R7)

X9. January 25, 1926. Indian Ocean. Cirrus streaks radiated from a point bearing 45^{o}. (R8) A rare instance where the streaks do not radiate from magnetic north. (WRC)

X10. October 22, 1927. Mediterranean Sea.



Polar bands over the Mediterranean (X10)

"On 22nd October, 1927, off Cape Garde at about 5.30 a.m., observed remarkable cloud formation consisting of radiating streaks of Cirrus cloud forming complete evenly spaced arcs terminating in approximately the true north and south points of the horizon. It gave the sky a wonderful domed appearance and lasted until after sunrise (about 6.45 a.m.), the formation gradually broke up merging into Alto Stratus." (R9)

X11. General observation. A study of cirrus bands observed 1840-1847 indicated that their alignment was most frequently along the magnetic meridian. (R10) Contrast this with X12. (WRC)

X12. General observation. Polar bands are no longer believed to be preferentially aligned along the magnetic meridian. (R11)

X13. March 20, 1932. Oxford, England. Just before sunrise, a single band of cirrus 5° wide spanned the heavens north to south. It was a brilliant pink. (X12) If the observer had not identified this arch as composed of cirrus cloud, it might well be classified as auroral in category GLA2, auroral arches. (WRC)

X14. July 24, 1933. Westcliff-on-Sea, England. "During the evening of July 24th, 1933, an unusual cloud formation of cirrus was seen at Westcliff-on-Sea, Essex. At 21 h. 20 m. G.M.T. a belt of cirrus cloud was observed stretching across the western sky at an elevation of 35°, from north to south, forming a bow, and moving in an easterly direction. This was rapidly followed by a second belt, and between 21 h. 20 m. to 21 h. 50 m. eight belts of cloud travelled across the sky from due west to east, the eighth belt disappearing at 21 h. 50 m. at an elevation of 105°. None of the belts appeared from the west until at an elevation of 35°, probably because the western sky was too bright at the time to allow any contrast at lower elevations, nor were any visible after reaching the elevation at 105°. At 21 h. 30 m. four belts were visible simultaneously at elevations of 35°, 55°, 70° and 105° from west. All the belts were approximately 1 1/2° in width, the width being even throughout their length. The belts of cloud were whitish in appearance, the three lower being very clear, whilst that which had passed overhead was considerably less clear. The brilliancy of the belts was similar to that of the Milky Way on a clear moonless night. As the belts of cloud travelled across the sky they presented a striking appearance. As each attained the 70° elevation and beyond, stars in the path of travel were plainly seen through the cloud, which clearly denotes that the cloud belts were very tenuous." (R13) Once again there is little to separate this observation and the banded sky phenomenon (GLA23). (WRC)

X15. General observation. Cirrus clouds often align in bands parallel to the magnetic meridian. This orientation may be due to ice crystals forming around meteoric dust particles which are frequently magnetic. (R14) See also X16.

X16. General observation. In reference to X15, meteoric dust has not been proven to be a nucleating agent for ice crystals. Furthermore, the alignment of individual ice crystals would not explain the macroscopic structure of the polar bands; i.e., parallel streaks aligned with magnetic north. (R15)

X17. November 24, 1883. Corinth, Mississippi. T.E. Whitfield, the Chief Signal Officer at this location, reported polar-aligned cloud bands. "The phenomenon was observed at 7 p.m., when twelve well-defined bands of dark clouds were seen diverging from a point beneath the 'north' star. Four of these bands were east of the star named, and the remaining eight were west of it, those near the western limit of the display being shorter and less inclined toward the horizon. The lower ends of the seven largest clouds terminated abruptly at an equal distance from a common point near the northern horizon, leaving an almost perfect semicircle of clear sky beneath, from which the bands radiated like the spokes of a wheel."

References

R1. Ingall, Herbert; "Aurora of 9th April and Polarisation of Clouds," English Mechanic, 13:155, 1871. (X1)

R2. Birt, W.R.; "Polarisation of Clouds and Magnetic Phenomena," English Mechanic, 13:131, 1871. (X2)

R3. Ingall, Herbert; "Aurora," English Mechanic, 15:147, 1872. (X3)

R4. Birt, W.R.; "Thunderstorm of June 18, 1872;" English Mechanic, 15:381, 1872. (X4)

R5. Ingall, Herbert; "Polarisation of Haze," English Mechanic, 18:262, 1873. (X5, X6)

R6. Sigma, Jemina; "Beautiful Atmospheric Display," English Mechanic, 71:127, 1900. (X7)

R7. Holcroft, A. V.; "Cloud Streamers," English Mechanic, 122:52, 1925. (X8)

R8. McCornish, A. B.; "Radiating Streaks of Cirrus," Marine Observer, 4:5, 1927. (X9)

R9. Bedwell, L. A.; "Radiating Cirrus Cloud," Marine Observer, 5:203, 1928. (X10)

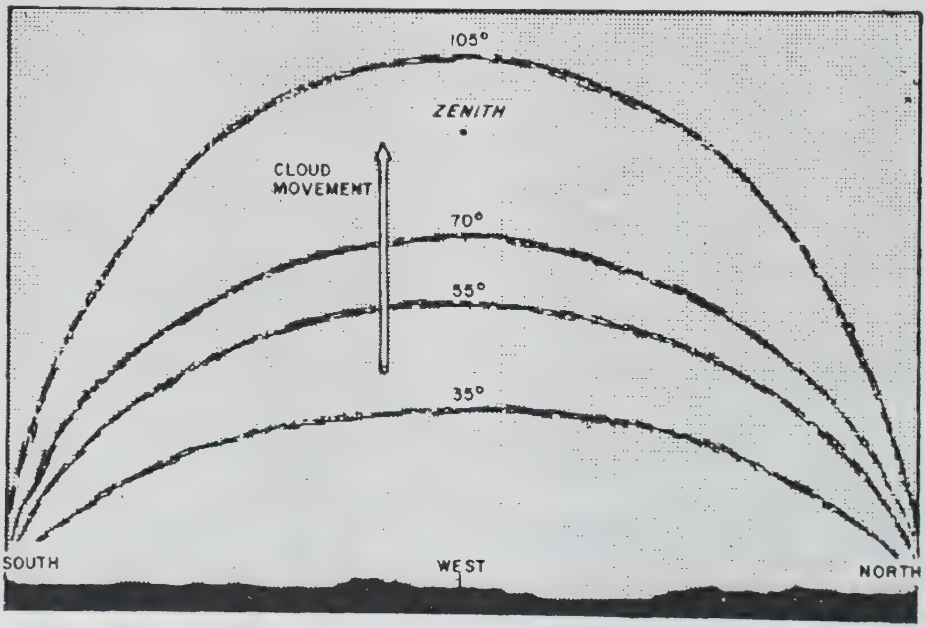
R10. Stevenson, William; "Abstract of Observations on the Aurora....," Philosophical Magazine, 4:6:20, 1853. (X11)

R11. Talman, C. Fitzhugh; "Polar Bands," American Meteorological Society, Bulletin, 9:84, 1928. (X12)

R12. Jupp, C. A.; "A Remarkable Cirrus Band," Meteorological Magazine, 67:93, 1932. (X13)

R13. Horrex, E.J.; "Luminous Night Cloud," Meteorological Magazine, 68: 186, 1933. (X14)

R14. Kellner, L.; "Alignment of Cirrus Clouds along the Magnetic Meridian,"



North-south cirrus streaks over England, 1933 (X14)

Nature, 199:900, 1963. (X15)
R15. McDonald, J. E., and Kellner, L.; "Meridional Alignment of Tropical Cirrus Clouds," Nature, 201:1316, 1964. (X16)
R16. Anonymous; Monthly Weather Review, 11:264, 1883. (X17)

GWC4 Miniature Thunderclouds

Description. Electrically active thunderclouds with dimensions measured in feet rather than miles.

Data Evaluation. Only a single good observation, and this under special meteorological conditions. Rating: 3.

Anomaly Evaluation. Normal thunderstorm convection cells are measured in thousands of feet. It seems improbable that a cell a few feet across could form under natural conditions. Rating: 2.

Possible Explanations. The local conditions (X1 below) may result in the separation of enough electrical charge to cause local discharges resembling normal lightning, as sometimes seen in dust and snow storms. Ball lightning is also a possibility.

Examples of Miniature Thunderclouds

X1. Circa 1919. Stockton Heath, England. "I was staying at Stockton Heath, in July, about 400 yards from the Manchester Ship Canal. The evening was somewhat oppressive, and the air had become strangely still. Gazing down the road, I saw a small black thundercloud gathering along the length of the canal, and about 30 or 40 feet above it. It was approximately 400 yards long and perhaps 6 feet thick. As I gazed at this strange formation, a dazzling lightning flash raced through the entire cloud, i.e. parallel to the water, and a bang like the discharge of field artillery followed immediately. About 40 seconds later, another flash and report occurred; then the cloud thinned and dispersed in about four minutes. I might add, that at least in those days an air current of varying intensity moved up that canal almost incessantly, i.e. inland towards Manchester, at the Stockton Heath section, one felt it on the neighboring bridge." (R1)

X2. No date or place given. Reference to a statement by Acamedician Marcolle that lightning from a cloudlet 1 1/2 feet in diameter killed a woman. (R2) Obviously this datum is too vague to be of much use, although the cloudlet might have been a form of ball lightning (GLB).

References

R1. Bailey, C. S.; "A Miniature Thunderstorm," Weather, 4:267, 1949. (X1)
R2. "Curiosities of Thunderstorms," Eclectic Magazine, 38:458, 1856. (X2)

GWC5 Noisy Clouds

Description. Rumbling, grating, hissing, crackling low-level clouds showing no evidence of lightning or other electrical discharge.

Data Evaluation. Data are sparse here. The situation is worsened by the great difficulty in eliminating obvious noise producers, such as internal electrical discharges. Rating: 3.

Anomaly Evaluation. Noisy clouds, although curious, almost certainly have prosaic explanations. Rating: 3.

Possible Explanations. Unseen electrical discharges are good noise-making candidates. The rattling of suspended hail is another possibility.

Similar and Related Phenomena. The hissing and crackling sounds associated with brush discharge and low-level electrified luminous patches (GLD4).

Examples of Noisy Clouds

X1. 1881. Haute-Garonne, France. "During a recent thunderstorm in Haute-Garonne, M. Larroque heard a dull continuous sound (like that of heavy carriages on pavement), which could not, apparently, be thunder, and which he accounts for thus: The storm was caused by meeting of two currents, one warm and charged with rain, the other cold and charged with hail. They met pretty high up, producing a gyratory storm centre, a cylindical vortex, in which the hail was liquified. The sound is attributed to the hail whirling in this cylinder." (R1)

X2. July 1932. Cache Lake, Ontario. "It was a chilly morning and the sky was completely overcast with clouds. My attention was attracted by a rumbling sound coming from the west, such as heralds the approach of a heavy thunderstorm. As I watched, a very long, low, narrow, tenuous cloud, resembling a squall cloud, appeared above the trees on the opposite shore, moving at right angles to its length. The continuous, rumbling noise, now grown remarkably loud, seemed to come unmistakably from this cloud, whose cross-sectional diameter was only about 200 feet. The cloud passed overhead eastward and was not followed by the expected rain storm. The cloud apparently marked the meeting place of two oppositely directed currents of air that differed in temperature. It seems almost incredible, however, that so much sound could have arisen from the agitated air alone, and yet this seems to be the only plausible explanation of its origin. I steadfastly looked for small lightning flashes in the cloud and saw none, although they would have had to come in rapid succession to produce the persistent sound which was heard. The noise could not have come from the rattle of hail because the cross-section of the cloud was too small to give time for hail formation; and in any case no hail fell." (R2)

X3. February 1969. Jacksonville Beach, Florida. Two clouds emitting sounds like "rattling cellophane" and "someone walking on pebbles." The clouds disappeared when they reached the Atlantic. (R3)

References

R1. English Mechanic, 34:11, 1881. (X1)
R2. Zeleny, John; "Rumbling Clouds and Luminous Clouds," Science, 75:80, 1932. (X2)
R3. Associated Press dispatch, reprinted in Pursuit, 2:32, April 1969. (X3)

GWC6 Noctilucent Clouds

Description. Very high, glowing clouds seen at high latitudes (45° to 70°) during the summer months. Noctilucent clouds, which often have band or wave structures occur at altitudes of about 50 miles and are illuminated by the sun, which may be well below the observer's horizon. These clouds are always white with perhaps a tinge of blue. The anomalous aspects of the phenomenon are intrinsic in the following questions: (1) Where do the nucleating particles and water vapor come from at such extreme altitudes; (2) Why the band and wave structures; (3) Why do the clouds form only at high latitudes during the summer; and (4) Why are they formed at such a narrow range of altitudes?

Background. Rockets probing the region of noctilucent cloud formation in the 1960s at first indicated that noctilucent clouds were composed of ice crystals formed around meteoric dust particles. (R1) Later experiments cast doubt on these results. (R2) Many unknowns still remain in this field; so many that noctilucent clouds are included in this catalog. The literature on the subject is extensive, and no attempt has been made to gather it all.(R3)

Data Evaluation. A common phenomenon in high latitudes. Rating: 1.

Anomaly Evaluation. The questions raised above about the origin and distribution of noctilucent clouds probably have simple answers. Rating: 3. However, if the time-space distribution of noctilucent clouds is due to the nonuniform distribution of meteoric dust, this rating would have to be revised.

Possible Explanations. The banded structure may be the result of high-altitude gravity waves, but no one yet understands their origin either. The concentration of these clouds at high latitudes during the summer could be the result of moisture being carried to high altitudes by turbulence during the warm months. Meteoric dust or ions and molecules released by meteors may be nucleating agents. Rocket launches may also contribute. (R4)

Similar and Related Phenomena. The same sort of banded structure is found in the banded sky (GLA23), magnetically aligned cirrus clouds (GWC3), and some air-glow events (GLA3).

References

R1. Soberman, Robert K.; "Noctilucent Clouds," Scientific American, 208:51, June 1963.

R2. Soberman, Robert K.; "Noctilucent Clouds," McGraw-Hill Encyclopedia of Science and Technology, 9:135, 1977.

R3. Ivengar, R.S.; "Origin of Noctilucent Clouds," Science, 145:767, 1964.

R4. Meinel, Aden B., and Meinel, Carolyn P.; "Low-Latitude Noctilucent Cloud of 2 November 1963," Science, 143:38, 1964.

R5. Weisburd, S.; "Mysterious Clouds Caused by Cosmoids?" Science News, 129:344, 1986.

GWC7 Ring Clouds

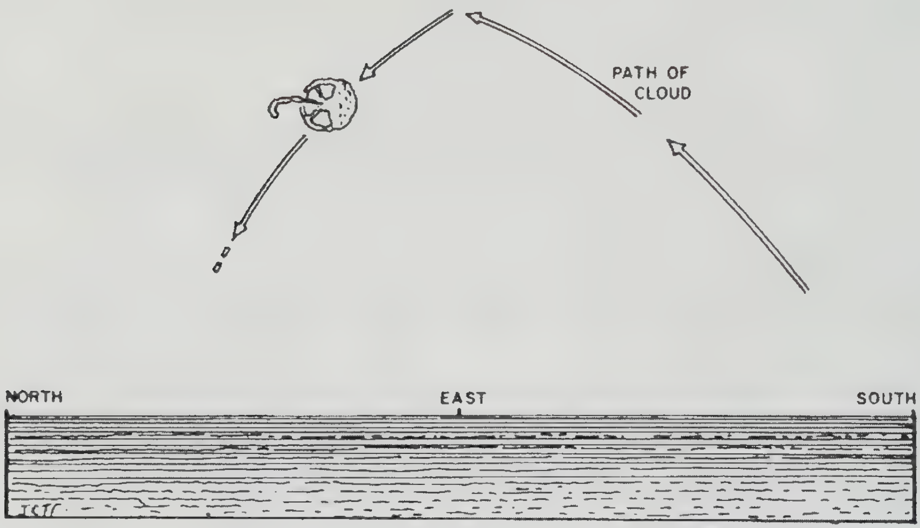
Description. Circular clouds with clear centers---like 'smoke rings'---which in many cases seem to rotate about the axis of the circle. Most ring clouds move at normal cloud levels, but examples at 30-miles-altitude have been reported.

Data Evaluation. Several good observations plus photographs. Rating: 1.

Anomaly Evaluation. Ring clouds are probably just the consequence of freak local meteorological conditions that generate small vortexes. No significant anomaly here. Rating: 3.

Possible Explanations. Pressure, temperature, and wind measurements made during the passage of a ring cloud confirm the presence of a small, local vortex. The precise origin of these small vortexes is not known. High-altitude ring clouds, which seem rare, may just be aberrant nacreous clouds; that is, accidentally distorted into rough circles.

Similar and Related Phenomena. Circular holes in cloud decks (GWC9).



Ring cloud with spokes and tail (X1)

Examples of Ring Clouds

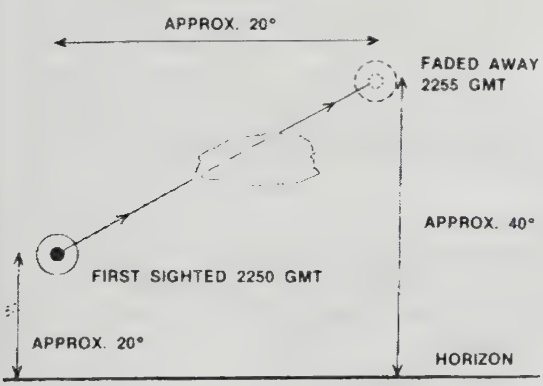
X1. March 22, 1870. North Atlantic Ocean. "At from 6.30 to 7 P. M. a curious-shaped cloud appeared in the S. S. E. quarter, first appearing distinct at about 25° from the horizon, from where it moved steadily forward, to about 80°, where it settled down bodily to the N. E. Its form was circular, with a semicircle to the northern face near the centre, and with four rays or arms extending from centre to edge of circle. From the centre to about 6° beyond the circle was a fifth ray broader and more distinct than the others, with a curved end:---diameter of circle 11°, and of semicircle 2 1/2°. The weather was fine, and the atmosphere remarkably clear, with the usual Trade sky. It was of a light grey colour, and, though distinctly defined in shape, the patches of cirro-cumulus at the back could be clearly seen through. It was very much lower than the other clouds; the shape was plainest seen when about 55° to 60° high. The wind at the time was N. N. E., so that it came up obliquely against the wind, and finally settled down right in the wind's eye; finally lost sight of it through darkness, about 30° from the horizon at about 7.20 P. M. Its tail was very similar to that of a comet." (R1) This observation is frequently referenced in the Fortean literature. (WRC)

X2. December 5, 1922. Biggin Hill Aerodrome, England. A cloud ring, 60° in diameter, moved across the sky, with stars occasionally visible in the center. "The phenomenon was like a great smoke ring." The ring broke up after passing through zenith. (R2)

X3. February 1, 1958. Gulf of Aden. "At 2300 S. M. T. a cloud, in the form of a circle about 1 mile in diameter, was observed lying above and ahead of the path of the ship. When the vessel came nearer, the cloud was clearly seen in the moonlight to be revolving in a clockwise direction. The centre of the circle was completely cloudless. While passing under the cloud there was a fall in barometric pressure of 3.5 mb and a 3° drop in temperature. The sea also was noticeably calmer under the clear sky. As the vessel left the area, both pressure and temperature reverted to their former values. The wind which had been NE., force 4, for a long time, veered completely round while the vessel was passing under the cloud, and finally settled again in the NE. quadrant, at force 3. When last seen, the cloud formation was thought to be breaking up. The phenomenon observed lasted for a little over 15 min." (R3)

X4. November 1, 1962. Red Sea. Cloud resembling a huge smoke ring moves northeast while rotating anticlockwise. (R4)

X5. November 27, 1980. North Atlantic Ocean. "At 2250 GMT a glowing 'smoke ring' phenomenon was observed on the starboard quarter at approximately 20° altitude and bearing approximately west. It moved towards the stern and climbed in the sky, disappearing behind a cloud and reappearing on the other side before finally fading away at approximately 40° altitude, bearing WNW, at 2255 GMT. The diameter was about 3-4° and the centre seemed to be darker than the surrounding sky when viewed through binoculars." (R5)



Smoke ring phenomenon in the North Atlantic (X5)

X6. February 28, 1963. Arizona. "Abstract. An unusual ring-shaped cloud was widely observed over northern Arizona near sunset on 28 February 1963. From a large number of observer's reports it is known to have appeared overhead near Flagstaff, Arizona. From initial computations based on four photos taken in Tucson, 190 miles south of the cloud, its altitude was approximately 35 kilometers. The most distant observation reported was made 280 miles from the cloud. The cloud remained sunlit for 28 minutes after local sunset. Iridescence was noted by many observers. Tentatively, the cloud may be regarded as similar to a nacreous cloud; but its unusually great height and unusually low altitude, plus its remarkable shape, suggest that it was a cloud of previously unrecorded type." (R6, R7) In the last sentence of the quotation, "altitude" evidently means "angular elevation, otherwise the sentence makes little sense.

X7. June 15, 1963. North Pacific. Aboard the S.S. Elizabethport enroute from the Panama Canal to Long Beach, California "....an unusual cloud was observed. It was composed of four concentric rings and pure white. It bore 280°, altitude 35°. It appeared above large cumulus clouds which were tinged with gray and pale yellowish tints. Two other clouds similar but of less regular formation were observed at the same time."

There is no recognized meteorological mechanism that produces concentric ring clouds. However, rocket launches may create weird cloud formations. This ship's position (7°10' N, 81°26' W) and the cloud's azimuth make the missile explanation unlikely, even for launches from California. (R8)

X8. 2002. Germany."Flying over the German Bight at about 13,000 metres I saw a completely annular cloud. It appeared unrelated to the other scattered clouds that were present and, for the two minutes I was able to watch it, it didn't change its appearance. It must have been 3 to 4 kilometres across and 300 or 400 metres thick, though this varied around its circumference."(R9)

References

R1. Banner, Frederick W.; "Extract from the Log of Barque 'Lady of the Lake'," Royal Meteorological Society, Quarterly Journal, 1:157, 1873. (X1)
R2. "An Unusual Sky Effect," Meteorological Magazine, 58:13, 1923. (X2)

R3. Jones, Digby; "Revolving Ring of Cloud," Marine Observer, 29:19, 1959. (X3)
R4. Dennis, T. S.; "Unidentified Phenomenon," Marine Observer, 33:190, 1963. (X4)
R5. McIntosh, H. H.; "Unidentified Phenomenon," Marine Observer, 51:185, 1981. (X5)
R6. McDonald, James E.; "Stratospheric Cloud over Northern Arizona," Science, 140:292, 1963. (X6)
R7. "The Mystery of the Flagstaff Cloud," New Scientist, 18:303, 1963. (X6)
R8. Anonymous; "Cloud Formation," Notices to Mariners, July 20, 1963. Cr. B. Green. (X7)
R9. Miller, Chris; "Flying Doughnuts," New Scientist, p. 114, June 19, 2002. (X8)

GWC8 Thunderclouds Affecting the Ionosphere

Descriptions. Sharp increases in the level of sporadic E ionization in the ionosphere correlated with the passage of thunderstorms.

Data Evaluation. A single series of experiments in a single locality. Rating: 3.

Anomaly Evaluation. Thunderstorms occur in the lower atmosphere, whereas the E layer of the ionosphere exists between 50 and 85 miles altitude. How are the two phenomena connected physically? Rating: 2.

Possible Explanations. A channel of lower electrical conductivity may be established between the ionosphere and lower atmosphere by penetrating radiation.

Similar and Related Phenomena. Low-level auroras (GLA4); luminous phenomena above thunderstorms (GLL1); correlation of thunderstorms and cosmic rays (GLL16); correlations of auroras and thunderstorms (GLA9). Chapters GLA and GLL are in Remarkable Luminous Phenomena.

Examples of Thunderclouds Affecting the Ionosphere

X1. 1953 and 1954. Calcutta, India. The level of ionoization in the sporadic E layer of the ionosphere was found to increase sharply with the passage of thunderclouds over Calcutta. The authors ventured that thunderstorms might be one of the causes of sporadic E ionization. (R1)

References

R1. Mitra, S.K., and Kundu, M.R.; "Thunderstorms and Sporadic E Ionization of the Ionosphere," Nature, 174:798, 1954. (X1)

GWC9 Circular Holes in Cloud Decks

Description. Circular holes several miles in diameter that form in otherwise dense, uniform cloud decks. Horn-shaped tails under the holes may infer precipitation.

Data Evaluation. Several modern observations complete with series of photographs. Rating: 1.

Anomaly Evaluation. Holes in cloud decks are symptomatic of natural or artificial seeding. In the observations recorded here, no artificial seeding was known to have occurred in the affected areas. The problem relates to what natural phenomenon seeded the cloud deck. Several candidate phenomena are available, so that circular holes in cloud decks are very likely only minor anomalies. Rating: 3.

Possible Explanations. Besides intentional cloud seeding for purposes of weather modification, rockets, aircraft, and even ground-based industries may contribute nucleating materials. Natural seeding may initiate from higher-level clouds.

Similar and Related Phenomena. Black spots on satellite images of the earth's airglow (GWC20).

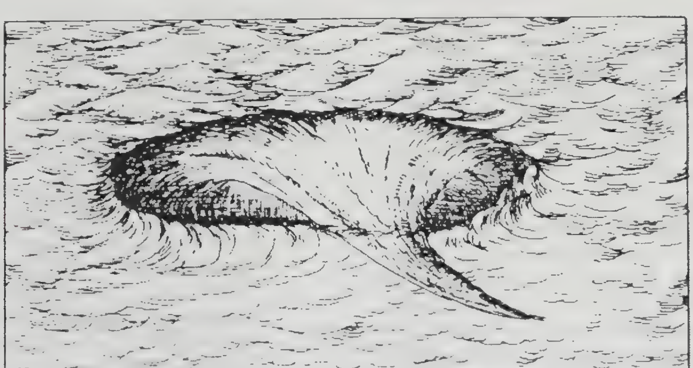
Examples of Circular Holes in Clouds

X1. December 1, 1967. Miami, Florida. 0830 EST. "At about this time one of us independently noted a distinct downward protrusion of what appeared to be middle cloud below the base of the otherwise uniform altocumulus layer. By 0900 EST the holes were conspicuous almost perfect circles. The sketch of the southern hole....depicts conditions observed at about 845 EST. A well-developed cirrus tail extended down from this hole, and trailed off approximately west-northwestward, thus indicating a downward decrease in wind speed." Some spectacular photographs attest to the nice circularity of the two holes, each of which measured about 4 miles in diameter. Some sort of natural cloud-seeding process was suspected. (R1)

X2. February 23, 1968. Vandenberg Air Force Base, California. A circular hole, about 6 miles in diameter, was observed in a cirro-cumulus cloud deck at 26,000 feet. (R2)

X3. General observations. In 1985, P.V. Hobbs reviewed the "hole-in-cloud" phenomenon in Weatherwise.

First, he reminded meteorologists that unusual, roughly circular holes in cloud decks have been reported for at least 60 years and the first photographs taken in 1926. He included a long list of profferred explanations ranging from downbursts of cold air to UFOs. The two

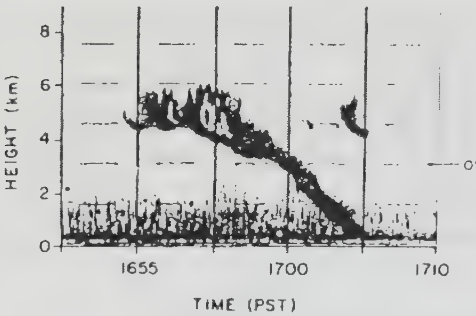


Circular hole in cloud deck with a cirrus tail (X1) favored theories involve: (1) fallstreaks of ice crystals from clouds above that in effect puncture a hole in the affected cloud deck; and (2) aircraft ascending or descending through the cloud deck.

Actually, fallstreaks of ice crystals are rather common. Most of them do not reach the ground. They have roughly the same effects as the artificial seeding of clouds with such crystals as sodium iodide. Often though, holes appear in cloud decks in the absence of higher clouds that might release fallstreaks of ice crystals.

It is known, too, that the propellers and wings of aircraft flying through clouds may stimulate the formation of ice crystals. These crystals are called APIPs (Aircraft-Produced Ice Particles). If conditions are favorable, holes-in-clouds may appear about half an hour after a plane has passed through a cloud deck.

In some well-publicized cases (X1), however, neither fallstreaks nor aircraft are involved, leaving the mystery partly unsolved. (R3)



A radar-detected fallstreak from an altocumulus cloud, probably resulting in a visible hole in the cloud. (R3)

X4. November 9, 2000. Melbourne, Florida. We quote from Florida Today. (R4)

> An unusual cloud formation appeared in the skies over the Space Coast on Thursday caused by ice crystals and enhanced by the jet stream...The National Weather Service calls the formation "hole-punch" clouds because of the oval-shaped opening
>
> .....
>
> The atmosphere on Thursday was very dry from about 5,000 to 28,000 feet. There was a rather extensive deck of cirrocumulus (mixture of "supercooled" water droplets and ice crystals) invading the sky associated with strong westerly jet-stream winds.
>
> However, the 'hole-punch' features were aligned north/south. This suggests that there was some sort of 'wave' in the atmosphere that was causing rising/sinking air couplets.
>
> This would cause ice crystals in the descending portion of the wave to fall into the supercooled (liquid) cloud layer. When this occurs, the ice crystals grow (at the expense of the liquid droplets). Therefore, a hole opened in the deck of the cirrocumulus.
>
> This process is similar to the principle used in cloud seeding to make cloud particles larger and produce precipitation. In this case, the precipitation aloft (meteorological term is 'virga') descended into the dry air below 28,000 feet and evaporated. (R4)

References

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GWC10 Anomalous Cloud Lines and "Streets"

Description. Lines of clouds, often hundreds of miles long and tens of miles wide, many without obvious causes. Anomalous cloud lines appear predominantly over the oceans.

Background. When high-resolution satellite photographs of the earth's surface became available in the 1960s, many showed anomalous cloud lines over ocean areas. At first, they were believed to be the contrails of ships. Later studies concluded that several other factors were also operating (see below) and that some had no obvious explanation.

Data Evaluation. Abundant, high quality satellite photographs. Rating: 1.

Anomaly Evaluation. Due to the multiplicity of reasonable explanations, anomalous cloud lines must be considered mainly as curiosities, although the precise method of formation of some remains unknown. Rating: 3.

Possible Explanations. Ship and aircraft contrails, meteor trails (rare), orographic clouds formed in the lees of oceanic islands, and clouds formed over linear perturbations in sea temperature arising from currents and internal waves.

Similar and Related Phenomena. Multiple, long, parallel roll clouds (GWC12); polar bands (GWC3); luminous nocturnal streaks (GWC32); banded skies (GLA23 in Remarkable Luminous Phenomena).

Examples of Anomalous Cloud Lines

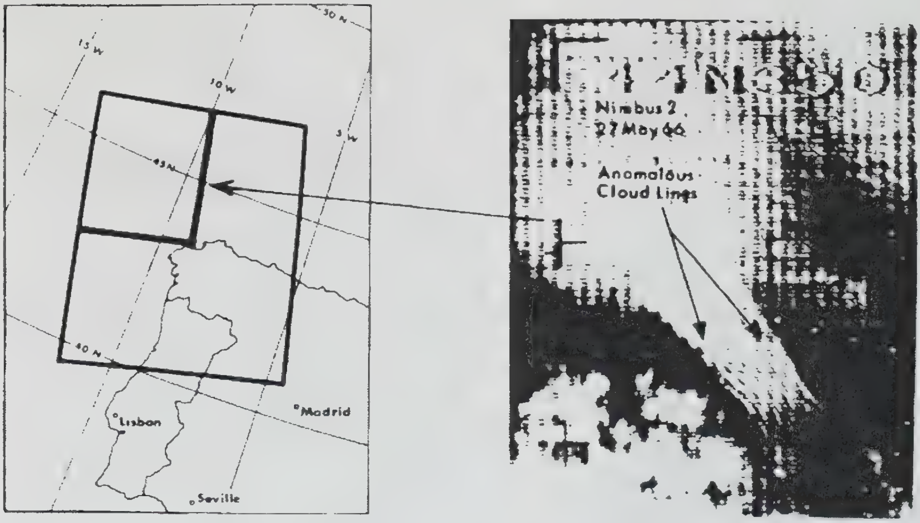
X1. General observation. "Satellite cloud photography occasionally reveals anomalous cloud lines in the form of plumes often 500 km long and up to 25 km wide. These lines, found over the ocean, are composed of liquid particles. Hollow polygonal, convective or thin stratiform, cloud patterns in varying amounts are associated with these lines. Numerous lines within a 10-deg square have been observed which cover up to 4 per cent of the total area." In the author's opinion the cloud lines are exhaust plumes from ships. (R1)

X2. June 27, 1967. North Pacific Ocean. "On June 27, 1967, the ESSA 2, automatic picture transmission (APT) photograph, taken at 1720 GMT, showed anomalous cloud lines. B.J. Haley, pilot of United Airlines flight 185-27, flew over this area at 1945 GMT. He reported no clouds or vapor trails at his flight level of 31,000 ft. Below him, he observed a layer of low, thin stratus through which sunlight, reflected from the ocean, could be seen. He estimated the height of the stratus layer to be 1,000 ft above the surface. Haley also reported that a ship located near 35°N, 131°W and traveling due east was clearly visible through the stratus layer. The smoke from the ship's stack was forming a 'definite line of thicker clouds' in the layer of scattered and broken stratus. This condensation trail was estimated to be 2-4-mi wide at a point 10 mi behind the ship, and to extend 125-150 mi before fading out." (R2)

X3. General observation. After reviewing the problem, the authors concur with the ship exhaust theory. (R3)

X4. General observations on various satellite photos. "Anomalous cloud lines are depicted in Fig. 1, which was taken off the west coast of the United States (the date and time of the imagery are unknown). This is a DMSP product, daytime visual imagery with a 1/3 n mi resolution. An extended band of stratocumulus clouds, tops at 1200 m is shown. The upper left diagonal half of the picture contains a minimum of five anomalous cloud lines. Close examination revealed the majority of these lines to be connected to layers of clouds. Studies were performed by the First Weather Wing, Air Weather Service, using DMSP visual and infrared data in the early '70s. Hundreds of anomalous cloud lines similar to Fig. 1 were studied in an attempt to relate the lines to ship smoke trails. The following conclusions were derived: (1) All the lines consisted of stratocumulus type clouds with tops ranging from 1000 to 1400 m. (2) A U.S. Navy investigation at Pearl Harbor revealed that no ships were at the ends of any of the lines. In fact, most of the lines occurred above the ocean surface away from the major shipping lines. (3) It was concluded that the lines were random cloud activity oriented with ocean gradients." Several of the photographs examined showed cloud lines that could not be attributed to any artificial, meteorological, or oceanographic conditions. (R4)

Satellite photo of anomalous cloud lines (Fig. 1 from R4) (X4) (Courtesy H. W. Brandli)

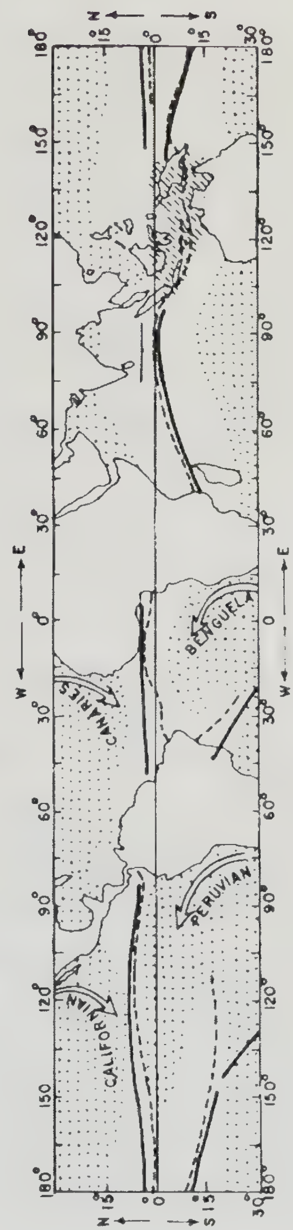


System of anomalous cloud lines taken from the satellite Nimbus 2 off the coast of Spain (X4) (Courtesy H. W. Brandli)

X5. Frequent occurrence. Tropical oceans.
"Summary. Available observational evidence regarding occurrence of double cloud bands, one in each hemisphere, over tropical oceans is reviewed. An examination of their locations appears to suggest that these may be related to maxima in ocean surface temperature. Significant asymmetry and discontinuity are noticed over areas which are affected by cold ocean currents and monsoons.

"1. Observational Evidence. During the last quarter century or so, there have been occasional references in literature to the occurrence of double cloud bands in the tropical zone, although definitive information regarding their origin, nature and locations relative to the Equator in different regions has been rather scanty. The earliest reference appears to be that of Fletcher (1945) who cites aircraft reports of frequent occurrence of double cloud lines, one on each side of the Equator, in equatorial eastern Indian Ocean during autumn through spring. Recently, after the introduction of Meteorological satellites, double cloud bands have been observed in other parts of the Tropics as well."

The salient features of the double bands are:
"(i) Double cloud bands are characteristic features of all tropical oceans; (ii) The cloud bands do not cross the Equator in any region; (iii) The intensity of the cloud bands generally varies with the seasons, the summer hemispheric band being the more intense. (iv) In some regions such as the equatorial western Pacific, the cloud bands in both the hemispheres lie close to and are more or less parallel with the Equator. In equatorial eastern Indian ocean, the cloud bands during February also lie close to and more or less parallel with the Equator. In the Atlantic and eastern Pacific, while the northern hemispheric cloud band lies close to and more or less parallel with the Equator, the southern hemispheric cloud band is displaced from the near-equatorial position and lies oblique to the Equator. (v) The continuity of the cloud bands in both the hemispheres is broken over some oceanic regions. Prominent among these regions are south-eastern Pacific, south-eastern Atlantic and western Indian ocean especially the western Arabian sea. (vi) In the monsoon regions, while the cloud band in the summer hemisphere is attracted to the continental landmass, that in the winter hemisphere shifts little from its near-equatorial position. The cloud bands are thus widely separated from each other. These effects are most prominently seen in the regions of the summer monsoon of Asia and Australia." (R5)



February double-cloud bands (solid lines) and lines of maximum ocean temperatures (dashed lines) (X5)

X6. February 25, 2000. Western Europe. A photograph taken from satellite NOAA-14 shows lee waves over Scotland oriented at right angles to "cloud streets" over southern Britain---even though both are in the same air stream. The situation is described further in Weather.

"Over lowland England the clouds are arranged in lines, called cloud streets, approximately parallel to the low-level wind in an inversion-topped boundary layer. These cloud streets are very striking in the north-westerly flow over the Low Countries in continental Europe. Here, surface warming on a sunny day allows the convection layer to grow in depth further inland, as do the clouds. Eventually, the convection is vigorous enough to overcome the stability aloft which keeps them in streets." (R6)

No attempt is made in the article to explain the origin of cloud streets or their right-angle relation to the lee clouds.

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GWC11 Dispersal of Clouds by the Moon

Description. The tendency of clouds to disperse under the influence of the moon, particularly the full moon.

Background. Folklore has long stated that "the moon eats clouds." Scientific analyses have been both positive and negative in this matter---more negative than positive in the long run. Modern science looks with disfavor on the folklore assertion but nevertheless has found some evidence that supports the reality of a lunar influence on rainfall (GWS1), which in essence links the moon to cloudiness or the lack of it.

Data Evaluation. Several conflicting studies and many disagreeing opinions by observers of the night sky. Rating: 3.

Anomaly Evaluation. Moonlight should have no direct effect on clouds, but if it seems to there are at least two reasonable explanations (see below), a situation rendering this phenomenon "not very anomalous." Rating: 3.

Possible Explanations. Scientists agree that there is a tendency for clouds to disperse in the early evening (a solar effect?), which is precisely the time most people would notice a full moon if it were in the sky. Consequently, what is really coincidental might be labelled cause-and-effect. Some studies suggest that the moon's phase can be correlated with rainfall (GWS1) and suggest this effect may be due to the moon's gravitational field affecting the influx of meteoric nucleating debris, providing a cause-and-effect relationship between the moon and cloudiness.

Similar and Related Phenomena. The moon and the weather (GWS1).

Examples of the Dispersal of Clouds by the Moon

X1. General observation. Greenwich, England. Noting that Sir John Herschel had proclaimed that the full moon tended to disperse clouds, the author analyzed 7 years of cloud data recorded at Greenwich Observatory. Conclusion: the moon has no effect on general cloudiness. (R1)

X2. General observation. Greenwich, England. A study similar to X1, also using Greenwich cloud data. Same conclusion. Author noted, however, the tendency of the sky to clear in the early evening regardless of the moon's position. Since the full moon is always conspicuous at this time, the two unrelated phenomena might be assumed to have a cause-and-effect relationship. (R2, R6, R7)

X3. General observation. Batavia, Java. "In the appendices to the volumes of observations at Batavia, Dr. van der Stok publishes studies of the influence of the moon on the meteorological elements. He finds an appreciable effect on the cloudiness. The cloudiness there increases with the increase of the distance of the moon above the horizon, reaching its maximum at the superior meridian transit and its minimum at the inferior one. Thus the influence of the moon appears to be felt when she is below the horizon, which excludes the hypothesis of its being the result of direct radiation. There is also greater cloudiness at full than at new moon. In each case the extreme difference averages about 5 per cent." (R3)

X4. General observation. Several observers in mountainous regions have concluded that the full moon does indeed tend to disperse clouds. (R4) No further details given. (WRC)

X5. General observation. England. Analysis of 15 years of data showed no effect of the full moon on cloudiness. (R5)

X6. January 4, 1912. Dublin, Ireland. "This somewhat rare phenomenon could be observed here, Jan. 4d. 20h. 30m. to 21h. Two air-currents, the upper from S. S. W., and lower from W., carried their strata of clouds across the moon's disc. The lower clouds traveled at a very fast rate, while the lunar disc seemed to rise up to meet them as it advanced from E. The swiftly advancing clouds, on coming in contact with the moon's North Polar Region, instead of passing across the disc, coasted round it and drifted on their way. At times the scattering was directed in all directions, just as a piece of ice thrown on a frozen pond breaks and scatters broadcast." (R8) This may only have been a contrast effect, with bright moonlight seeming to make the thin clouds invisible. (WRC)

X7. 1908-1911. England. Of the 50 full moons during this period, 31 appeared to disperse clouds. (R9)

X8. General observation. Observations, such as those of X6, are merely matters of perspective; i.e., clouds seem to thin out when viewed directly overhead. (R10)

X9. General observation. England. An amateur astronomer avers that the full moon, in his experience, indeed does disperse clouds. (R11)

X10. General observation. The brightness of the full moon makes thin clouds seem to disappear; i.e., apparent dispersal is a matter of contrast. (R12)

X11. General observation. "The moon's changing faces, already linked to heavy rainfall, are also related to sunshine. There is more sunshine than usual when the moon is between first quarter and full moon, and between last quarter and new moon. Below average sunshine occurs between new moon and first quarter, and between full moon and last quarter. This relationship was reported to the American Meteorological Society meeting in Vancouver, Canada, by Iver A. Lund of the U. S. Air Force Cambridge Research Laboratories, Bedford, Mass. He studied weather records covering 58 years, from 1905 through 1962, for ten cities, a total of more than 211,000 observations." (R13)

X12. Frequent observation. Oxford, England. Re: the cloud-dispersing capability of the moon. "From repeated observations it appears that at Oxford the influence begins after the moon is four or five days old, and lasts till she approaches the sun again the same distance on the other side. So frequently has this been noticed by Mr. Johnson, that during a course of observations on which he was engaged a few years ago, he felt that his attendance at the observatory could not be dispensed with, however unpromising might be the appearance of the night, until the moon had fairly risen; and over and over again when this has occurred, the sky, before completely obscured, has become clear."(R14)

X13. Frequent occurrence. R. Baum is a well-respected British amateur astronomer and writer on celestial matters. His opinions are the result of long experience with telescopic observations. In his classic book The Planets, he made the following statement in connection with preparations for a search for natural lunar satellites at Flagstaff, Arizona, in 1956. "It is well known that there is a tendency for cloud to disperse about midnight when the Moon is full and close to the zenith." (R19)

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GWC12 The Morning Glory Phenomenon

Description. Long, spectacular roll clouds that usually advance rapidly in an otherwise nearly cloudless sky, bringing sudden wind squalls but little or no precipitation. Most occur in the morning, but evening glories are known. Rarely, two morning glories advancing from different directions will intersect one another.

Background. This phenomenon is most frequent in northern Australia's Gulf of Carpentaria. However, reports of analogous phenomena from Africa and North America exist.

Data Evaluation. Many scientific and popular articles make the morning glory a well-known phenomenon. Rating: 1.

Anomaly Evaluation. The morning glory has been termed a solitary wave, an undular bore, and/or a hydraulic jump. Details of the conditions that initiate the phenomenon are not well-understood, particularly the southerly Australian morning glories. Rating: 3.

Possible Explanations. Morning glories are propagating cloud lines analogous to tidal bores and solitary waves.

Similar and Related Phenomena. Anomalous cloud lines (GWC10) are similar but do not propagate. Better analogies are tidal bores and solitary waves in bodies of water (GHS3 in Earthquakes, Tides ...).

Examples of the Morning Glory Phenomenon

X1. Frequent occurrence. Gulf of Carpentaria, Australia. "The Morning Glory cloud assumes the form of an arch or bow stretching across the sky but its lateral dimensions are generally uniform along its entire length---the arched appearance to the ground observer being produced by perspective. The cloud is only 100-200 m thick and is very low (the highest base reported is 500 m but some as low as 50 m have been observed). Both the bases and the tops are quite regular and well defined but often the tops are inclined ahead of the bases. This gives a rolling effect but the cloud is not always observed to be actually rotating. One of the most remarkable features of the Morning Glory is its great length. Ground observers frequently report it as extending from one horizon to the other, and an aircraft pilot once flew along one for 120 km without coming to the end.....double Morning Glories are commonly reported and as many as seven successive rolls have been observed. They are usually oriented north-north-west to south-south-east and move from east to west at speeds which range from 10 to 25 m s^{-1}. In cases of multiple rolls the whole entourage may take more than an hour to pass. The clouds do not usually produce precipitation but a fine mist sometimes occurs with multiple rolls." (R1-R3)

X2. October 5, 1979. Camooweal, Australia. Two closely spaced, propagating, cumulus cloud lines, extending from horizon to horizon. (R3)

X3. July 25, 1979. Julia Creek, Australia. Horizon-to-horizon cumulus line propagating over a featureless plain at 12 m s^{-1}. (R3)

X4. October 1980. Gulf of Carpentaria, Australia. Southerly morning glories. The Gulf morning glories rarely approach from the south. Their origin is debatable. We quate from a summary of an observational expedition by R.K. Smith et al. "Observations made during an expedition in October 1980 to study 'morning glory' wind squalls in the Gulf of Carpentaria region of Northern Australia are described. During a ten day period in Burketown, north Queensland, six squalls were documented on consecutive

The Morning Glory, a spectacular roll cloud (X1) mornings (8-13 October) including two moving from the south, an apparently unusual direction. The unique data gathered from the latter confirm that these have the same character as their north-easterly counterparts; that is, they are undular bores. The origin of southerly glories remains uncertain, but, at least, in some cases, seems to be linked with the advance of a frontal trough across central Australia." (R6) (See also R10)

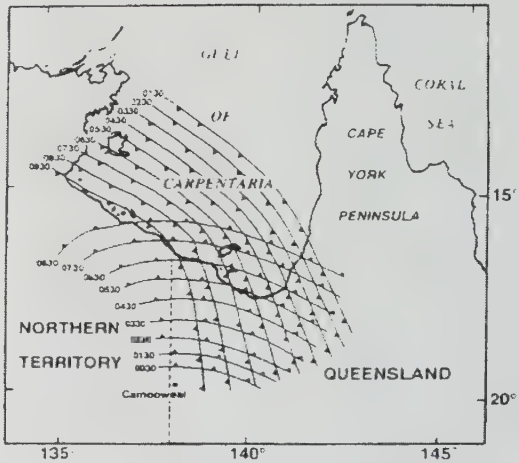
X5. Occasional occurrence. Invisible morning glories. These can be dangerous to aircraft, as now discussed. "And while the coastal weather conditions in Burketown [Australia] create a clearly visible cloud, elsewhere in the world these atmospheric waves form in dry air, creating an invisible menace that can cripple aircraft in midair or suddenly fling a plane off its runway approach. If your pilot can't see the wave coming, you could be in big trouble." (R15)

In the United States, tornado observation networks can detect invisible morning glories as they pass by. (R15) (See X9)

X6. January 18, 1979. The Gambia, Africa, C.P.A. White observed an evening glory. "I was birdwatching in a coastal mangrove swamp when I noticed a peculiar band of low-level cloud over the sea to the north, extending from horizon to horizon. As it approached it became apparent that it would be an unusual and violent phenomenon, so we headed back to our cars to take cover. The cloud was smooth and regular, and the leading edge apparently rolling strongly.

"The appearance of the cloud was very similar to that on the cover of Weather for May 1981, although in our case the medium cloud was much more extensive and less ordered. As the roll cloud passed overhead the wind increased from calm to force seven or eight almost instantaneously, but dropped to light after about 90 seconds, as it roared inland leaving light rain behind it." (R8)

X7. October 3, 1991. Gulf of Carpentaria, Australia. Interactive morning glories. On this day, a northeasterly morning glory (the usual variety) met a southerly morning glory. The two clashed over the Gulf waters creating turbulence as they mixed. They passed through each other and resumed their initial courses. (R13)



Isochrones of intersecting northeasterly and southerly morning glories in the Gulf of Carpentaria, Australia. (R13)

X8. November 12, 1995. Washington, D.C., about 8 P.M., M.T. Shoemaker observed a massive evening roll cloud. "What I saw was a dense, yellow-white, sharply defined, linear cloud roll that stretched from horizon-to-horizon on a southwest to northeast course. It had an almost self-illuminated brightness, which may have been due to reflection of the abundant light of Washington's night sky. The cloud's oddest characteristic was that it remained absolutely stationary. The temperature was brisk, and the sky was unusually clear. No other clouds were visible except for the roll and one other seemingly unconsolidated roll." Later examination of satellite photos revealed that this roll cloud stretched 400 miles from Delaware to Kentucky. (R14)

X9. June 9, 1982. Near Oklahoma City, Oklahoma. Eight cloud lines, each about 250 kilometers long. Speed: 15 meters/ second. "Early in the morning on 9 June 1982 a system of traveling wave cloud lines passed over Oklahoma, and in particular, over the relatively dense mesonetwork of surface stations, including the instrumented 444-m KTVY television tower, operated by the U.S. National Severe Storms Laboratory. An analysis of the network and other data presented herein shows that, in structure, the associated disturbance was an internal undular bore propagating on a low-level stable layer, similar to 'morning glory'-type disturbances, which are common at certain times of the year in parts of northern Australia." (R9)

X10. September 2, 1984. English Channel. A "sausage" roll cloud was seen from an aircraft. "Some four nautical miles north of 50°N, a cloud bank was seen ahead, at right-angles to the flight path. As they came level to it, the pilot and his two passengers were amazed to find that it was, in fact, an enormous long sausage shape, perfectly circular in cross-section, extending from a few hundred feet above the sea to a level top at 2000 ft (610 m). There was little wind and the roll of cloud appeared to rotate around its axis." (R12)

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R15. Torok, Simon; "Morning Glory," New Scientist, p. 34, January 20, 2001. (X5)

GWC13 Long, Hollow, Cylindrical Clouds

Description. Long, white clouds in the shape of hollow cylinders, 300 or so feet in diameter and on the order of 100 miles long.

Data Evaluation. Only a single observation. Rating: 3.

Anomaly Evaluation. Since several reasonable explanations exist, this phenomenon is included primarily for its curiosity value. Rating: 3.

Possible Explanations. A smoke and/or dust trail left by a large, low-altitude meteor; a roll cloud like the Morning Glory (GWC12) at unusual heights; an aircraft contrail (not especially likely in X1 due to date and location).

Similar and Related Phenomena. Anomalous cloud lines (GWC10), the Morning Glory Phenomenon (GWC12).

Examples of Long, Hollow, Cylindrical Clouds

X1. February 7, 1948. North Atlantic Ocean. Altitude: 10,000 feet; time: 1145 GMT. "At this time, an apparent condensation trail was seen overhead against a blue sky. (The pilot) added that he would hesitate to estimate the height to which the east end of the trail was visible, but that it was certainly higher than indicated on the sketch (40,000 feet). As the trail lay almost along the route, the aircraft, by a slight alteration in course, was flown underneath it for 25 minutes and then thru the lower end of the trail. The crew, by looking backwards and upwards from the top of the aircraft, could see into and along the trail. It appeared to be cylindrical, and about 300 to 400 feet in diameter at the level of flight. The diameter of the upper section must have been considerably larger, judging by the clarity with which it could be observed. The upper end of the trail was clearly defined, while the lower end was diffuse and disappeared at about 8,000 feet. The trail was white at all levels, altho the lower end was somewhat darker than the rest....it appeared in a straight line, disappearing into the eastern sky at great altitude, and in places appeared to be composed of spiral-shaped wisps." (R1) The trail length was estimated at 60 miles. Its downward trajectory made a meteoric explanation reasonable. (WRC)

Reference

R1. LaPaz, Lincoln; "A Possibly Meteoric Dust Cloud," Popular Astronomy, 58: 355, 1950. (X1)

GWC14 Cloud Spokes Radiating from Thunderclouds

Description. Cloud bands or ridges extending spoke-like from thunderclouds.

Data Evaluation. Very few observations, and these are rendered doubtful due to the problem of perspective. Rating: 3.

Anomaly Evaluation. Radial cloud structures are rare in meteorology and current theory offers no hints on why cloud spokes should radiate from thunderclouds. Rating: 2.

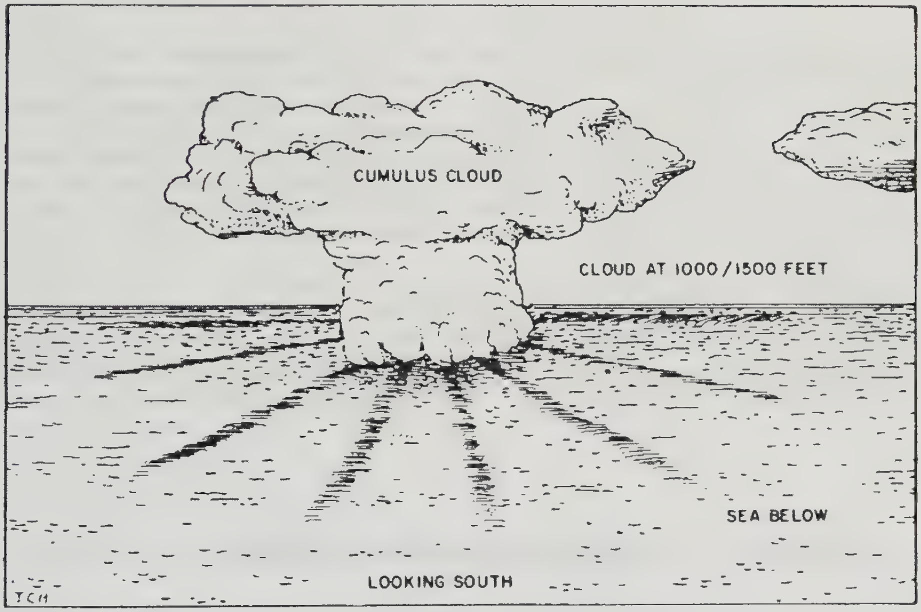
Possible Explanations. Conceivably, a strong central convection cell could set up a swirling pattern with spokes. More speculatively, electromagnetic forces might be involved.

Similar and Related Phenomena. Marine light wheels (GLW4); the banded sky (GLA23); magnetically aligned cirrus clouds (GWC3).

Examples of Cloud Spokes

X1. August 18, 1870. England. "A curious and I think important phenomenon to be investigated is the apparent radiation of luminous streamers or lines of haze from distant thunderstorms. My attention was first drawn to this on August 18th, 1870, when after a very hot day, (88° in shade), an exceedingly violent thunderstorm traversed the western and midland counties of England. The sky was very clear here, but from the distant storm, lines of faintly luminous haze of extreme tenuity appeared to radiate, and retained their position for a very considerable time." (R1)

X2. November 1, 1937. English Channel. A pilot observes a large cumulus near the center of a shallow weather depression. "The main body of the cloud with its anvil-like development is typical of a large cumulus cloud, but the radiating bands extending horizontally from the cloud base are remarkable. A continuous layer of low cloud was observed farther east and it is reasonable to suppose that the air at this level was almost saturated, and so required little upward motion to produce condensation. One is tempted to visualize a wave motion circulating round the cloud base although it is doubtful whether such an explanation would be dynamically acceptable. Judging from the diagram the bands might, however, be regarded as radiating from a point on the horizon rather than from the cloud base, in which case they would be parallel. The formation might therefore have to be explained as merely an illusion of perspective." (R2)



Bands radiating from a cumulus cloud over the English Channel (X2)

References

R1. Ingall, Herbert; "Polarization of Haze," English Mechanic, 18:262, 1873. (X1)
R2. "Curious Cloud Formation," Meteorological Magazine, 73:45, 1938. (X2)

GWC15 Great Excess of Ice Crystals in Cumulus Clouds

Description. Concentrations of ice crystals in the summits of slightly cooled cumulus clouds that are two to four magnitudes higher than the surrounding clear air.

Data Evaluation. Evidently a well-verified phenomenon. (R1) Rating: 1.

Anomaly Evaluation. The discrepancy in ice-crystal concentrations infers that some unknown cloud process can multiply crystal concentration. This process is not understood but is probably well within the capacity of today's cloud physics to explain. At least one promising process is at hand. See below. Rating: 3.

Possible Explanation. The author of R1 believes that rimed ice pellets may shed ice splinters as the first step in a rather complex process of crystal generation. See R1.

Similar and Related Phenomena. None.

Examples of Ice Crystal Excess in Cumulus Clouds

X1. General observation. "Perhaps the most puzzling observation in cloud physics reveals that some slightly supercooled cumulous clouds, with summit temperatures only a few degrees below 0° C, contain high concentrations of ice crystals two to four orders of magnitude greater than the concentrations of ice nuclei measured in clear air at the same level. According to a series of careful and detailed aircraft observations and measurements by Mossop and his colleagues, such high concentrations of crystals occur only in aged cumulus that has been in existence for some time and acquired widths of several kilometres but are absent from newly rising cloud towers..... This large discrepancy between the concentrations of ice crystals and of ice nuclei suggests that some process of ice crystal multiplication must be active in the cloud." (R1)

References

R1. Mason, B. J.; "Production of Ice Crystals in Slightly Supercooled Cumulus," Nature, 245:451, 1973. (X1)

GWC16 Cloud Brightness Changes

Description. Certain clouds in aggregations of clouds exhibit marked changes in brightness.

Data Evaluation. A few observations of fair quality. Rating: 3.

Anomaly Evaluation. The nature of the anomaly is not clear because the source of the brightness changes is unknown---optical, electrical, or something else? However, since several possibilities exist (see below) this phenomenon is probably not especially mysterious. Rating: 3.

Possible Explanations. The most likely sources of brightness changes are altered reflecting and/or refracting characteristics of ice crystals within the clouds in question. For example, aerodynamic and electrical forces may change crystal orientation and, of course, the movement of the cloud itself changes the sun-cloud-observer angles. Then, too, the brightness changes may be due to internal electrical action.

Similar and Related Phenomena. Dazzling lights on clouds (GLD15), luminous patches moving on cloud surfaces (GLD16).

Examples of Cloud Brightness Changes

X1. September 27, 1880. Sweden. "A singular phenomenon of clouds was observed on Sept. 27, last year, by M. Hildebrandsson, of Upsala Observatory. About 6.34 p.m. bands of cirro-stratus extended N.E. to S.W.; they were moving slowly S.W. One of the bands, passing Auriga and Polaris, presented rapid changes of brightness. Sometimes it disappeared almost completely, then it would become very distinct again. The band next to it to the S.E. presented the same fluctuations, but in less degree. It was not a mere subjective phenomenon, for another observer perceived the variations. The luminous intensity sometimes remained constant a few minutes; then suddenly varied in a few seconds. The alternations lasted half an hour. The phenomena, it is suggested, may have been due to variations of the electric charge of the cloud; they cannot, apparently, be attributed to variations of illumination by the sun, for the twilight was already faint, and no other clouds than the cirro-stratus appeared in the sky." (R1) These may have been noctilucent clouds. There is also a strong similarity to those daytime clouds that seem to become luminous auroral streamers at night (GLA12). (WRC)

X2. February 25, 1942. Malmesbury, England. "A curious cloud phenomenon never previously seen by the present writer was observed near Malmesbury in Wiltshire on 1942 February 25 at 14 hours U.T., his attention at that time being directed to a patch of very high thin cloud about four degrees in diameter which appeared to shine with a radiance nearly, if not quite, as bright as that of the sun, at the same time exhibiting various prismatic colours, mainly yellow, pale orange and pale violet. The effect lasted at least four minutes and gradually faded away. The sun was shining brightly in a south-westerly direction at an altitude of approximately 25-30°... The curious thing about the luminous cloud... was that it did not appear in the same line of sight as the sun, but about 30° away in a westerly direction. Although there were other and similar clouds in the sky at the same time, none showed the same striking brilliance as the one here described, which was seen by at least four other persons..." (R2) The colors may have been due to irridescence.

References

R1. English Mechanic, 32:493, 1881. (X1)
R2. Welsh, Henry; "A Cloud Phenomena," British Astronomical Association, Journal, 52:115, 1942. (X2)

GWC17 Anomalous High-Altitude Haze Layers

Description. Strata of haze, usually undetected from the ground, found by instruments at altitudes above 15 miles.

Data Evaluation. Although only two recent articles discussing the detection of high-level hazes by balloon-borne instruments have been found, it is claimed (R1) that 183 stratospheric clouds were recorded between 1870 and 1972, inferring that high-altitude hazes and clouds and rather common. (Obviously these very early reports were ground observations and may have included noctilucent clouds.) Nevertheless, we are probably safe in assuming that high-altitude hazes are well-attested. Rating: 1.

Anomaly Evaluation. The presence of haze above 15 miles is classified as anomalous because the sources are not known with any certainty. Also problems are the evident stability and wide geographic dispersal of the haze layers. Rating: 2.

Possible Explanations. Particulate matter may be injected into high-levels of the stratosphere by volcanic eruptions, meteors, and the solar wind.

Similar and Related Phenomena. Noctilucent clouds (GWC6), low-level hazes, bright night skies (GLA13), the white sky phenomenon (GWC1).

Examples of High-Altitude Hazes

X1. June 20, 1974. New Mexico. Balloon-borne instruments reveal a large haze layer at 25 kilometers. (R1)

X2. February 5, 1982. Wyoming. Balloon experiments detected a 'mystery cloud' at 20 miles (32 kilometers). Author claims this is too high for volcanic ejecta (?). (R2)

References

R1. Gibson, Frank W.; "A Rare Event in the Stratosphere," Nature, 263:487, 1976. (X1)

R2. "2d, Higher 'Mystery Cloud' Found by Wyo. Scientists," Baltimore Sun, March 12, 1982, p. A3. (X2)

GWC18 Anomalously Long and High Arctic Cloud Plumes

Description. The observation of unusually high and long cloud plumes over some Russian Arctic islands (especially Bennett Island). Early on, it was suspected that these cloud plumes might have been the consequence of unannounced Soviet nuclear tests.

Data Evaluation. Large quantities of data came from surveillance aircraft and satellites. Many articles appeared in the unclassified science literature in the late 1980s and early 1990s. Rating: 1.

Anomaly Evaluation. After nuclear tests and seafloor releases of methane (from the decomposition of buried methane hydrate) had been eliminated, scientific opinion decided that the the cloud plumes were orographic; that is, natural lee clouds created by wind flowing across high Arctic ridges.

However, the ridges in the region are only about 2,500 feet high while the cloud plumes are up to 200 miles long and 6 miles high. The proposed cause and results seem dimensionally incompatible. It is also curious that such clouds are not seen elsewhere in the Arctic. Rating: 3.

Possible Explanations. Extreme examples of orographic clouds.

Similar and Related Phenomena. The 1984 "mystery cloud" (GWC22).

Entries

X0. Introduction. During the 1980s, a series of plume-shaped clouds appeared over the Soviet Arctic. These clouds concerned scientists because of their unusual structure and location. They especially perturbed American military planners because the Cold War was in progress, and the clouds looked much like those created by nuclear tests.

The first plume-cloud in this series to receive widespread public scrutiny was the "mystery cloud of April 8, 1984." This cloud looked so much like the consequence of a nuclear detonation that an F-4 Phantom aircraft was sent from Japan to investigate it. No nuclear debris was detected. See GWC22 for a fuller account of this particular cloud. (R12)

X1. The nature of the Arctic plume-clouds. Evidently the mystery cloud of 1984 mentioned above was only one in a long series of puzzling Arctic-cloud events. Some of these are now described:

> Large icy clouds, similar to plumes of gas that rise over volcanoes, have appeared over islands along the coast of the Soviet Union during the past several years, baffling experts, who cannot explain what they are or what

causes them.

The clouds dissipate in a few hours vanishing as mysteriously as they appear.

Among the plumes are a series of massive clouds that during the past four years have periodically swelled over Novaya Zemlya, the Arctic island long used by the Soviets for nuclear weapons tests.

However, there appears to be no correlation between the clouds and known Soviet tests, which are usually detected by Western governments. Further, non-governmental scientists said the 200-mile-long plumes appear to be many times larger than the largest conceivable nuclear explosion could produce.

In one incident, a NOAA satellite detected a large plume coming from the Arctic Ocean near Bennett Island, north of the Soviet Union, in 1983. Three distinct sources were found; one on the island and the other two about 9 miles off-shore on the ice-covered ocean. This plume was 6 miles wide, 155 miles long, and 23,000 feet high. (R1)

An additional "unclassified" plume description appeared in 1988 in Eos, a weekly publication of the American Geophysical Union.

This issue (R2) provided some amazing and at the same time unsettling photographs of these huge plume-clouds taken by satellites passing over Soviet Arctic islands. Eleven such events were tabulated from October 12, 1980, to June 12, 1986. Perhaps the most dramatic event occurred on March 12, 1982, over Novaya Zemlya. The picture shows a sharply etched tongue of cold vapor arcing some 175 kilometers at a maximum altitude of 9.5-10 kilometers. As with most of the plumes, movement of the vapor does not correspond to wind direction. Volcanic activity and natural methane gas releases are considered unlikely explanations. Since the islands involved are used for Soviet weapons tests, the plumes may be due to some incredibly energetic devices, although no radioactive releases or seismic activity seem correlated with the plume appearances. Queries to Soviet scientists went unanswered. (R2)

X2. Searching for a natural explanation. F.C. Parmenter-Holt, a NOAA scientist, reacted to the descriptions and scientific discussions of the Soviet plume events as follows:

> I believe that these clouds are naturally occurring, orographically-induced formations. When winds blow perpendicular to the 2,500-plus foot glacial ridge, along the northern portion of the island, a long gravity-wave pattern is established downwind, on the lee side. The cases collected by Matson show sharp boundaries conforming to the contour of this glacial barrier. (R5)

Parmenter-Holt could well be correct in some cases, for wave-like orographic clouds often form in the lees of mountain ranges, such as the Rockies. Some of the plumes, however, extend for 175 kilometers, as described above. This is pretty long for a low-altitude glacial ridge. Then, too, one should inquire whether such plumes occur near similar ridges in other northern climes and not just over Soviet territory.

F.C. Parmenter-Holt opined above that the long plume-like clouds detected over Soviet territory were merely orographic clouds; that is, a consequence of the terrain below. Some facts presented by W.O Roberts, in The Explorer, hardly square with that interpretation. For example, the March 12, 1982 plume seen over Novaya Zemlya was 109 miles long and at an altitude of about 6 miles. Its position did not conform to the wind direction at that altitude. Other plumes over Novaya Zemlya have been aligned with the wind, but they too have been at great altitudes. Said Roberts:

> Taken together the data suggest irregular emissions from a single point source near the north end of the Island as the cause of the mysterious episodes.

Just what is being vented, if anything, remains unknown. No active volcanos are in this area, neither are there copious sources of natural gas. There have been no seismic nor radioactive indications of nuclear tests. (R6)

By 1992, following the cessation of the Cold War, joint studies of the plume-clouds were being made by U.S. and

Schematic illustration of winds flowing over a mountain range creating long, plume-like lee clouds. The long, high Arctic cloud plumes may be extreme examples of this phenomenon.

Russian scientific teams. Nuclear tests had long been ruled out. The possibility that methane gas was being released from the decomposition of sea-floor deposits of methane hydrate was also disposed of. Were the mysterious plumes just "odd clouds" after all? (R7)

The answer seems to be "yes." Aircraft-based experiments over the Arctic islands seem to have confirmed that the plumes are truly orographic clouds created when airstreams pass over the low mountains of the Arctic islands.

The conundrum that remains is the anomalous heights of the plumes. Sometimes, the plumes reach heights of 3 kilometers above the rather low ridges that are supposed to cause them. (R9)

To our knowledge, this characteristic has not been explained.

References

R1. Anonymous; "'Plumes' over Soviet Isles Continue to Baffle Experts," Las Vegas Sun, July 20, 1986. (Cr. T. Adams via L. Farish) (X1)

R2. Anonymous; "Large Plume Events in the Soviet Arctic," Eos, 67:1372, 1986. (X1)

R3. Parmenter-Holt, Frances C.; "The Large Plumes of Novaya Zemlya," Eos, 68:1129. 1987.

R4. Weisburd, Stefi; "Cloud Conundrums," Science News, 131:204, 1987.

R5. Parmenter-Holt, Frances C,; "Plumes and Peaks," Science News, 131:403, 1987. (X2)

R6. Roberts, Walter Orr; "Mystery at Novaya Zemlya," The Explorer. 4:6, April 1988.

R7. Kerr, Richard A.; "U.S.-Russian Team Solves Arctic Mystery," Science, 257:35, 1992. (X2)

R8. Paull, Charles K., and Buelow, William J.; "Arctic Mystery: Plumes or Clouds," Science, 258:725, 1992.

R9. Monastersky, R.; "Mountains Give Rise to Perplexing Plumes," Science News, 141:422, 1992. (X2)

R10. Fett, Robert W.; "Major Cloud Plumes in the Arctic and Their Relation to Fronts and Ice Movement," Monthly Weather Review, 120:925, 1992.

R11. Paull, Charles K., and Buelow, William J.; "Enigmatic Cloud Plumes," Science, 259:164, 1993.

R12. McKenna, Daniel L., and Walker, Daniel A.; "Mystery Plumes and Clouds over Soviet Territory," Science, 234:412, 1986. (X0)

GWC19 Atmospheric Rivers and Reservoirs

Description. The existence in the earth's atmosphere of vast quantities of water vapor in the form of river-like filaments and so-called "reservoirs." Ordinary, low-altitude clouds are not included here.

Data Evaluation. Published observations are to be found in several science journals. (See references.) The primary data sources have been instruments carried aboard satellites, such as the Space Shuttle. Rating: 1.

Anomaly Evauation. The tropospheric rivers, sometimes called "Amazons in the sky," present two salient anomalies.

- The unknown forces that split the flow of tropical water vapor into rather-well-defined "rivers" when one would expect a homogeneous flow. Rating: 3.
- The origin of the "waves" in the tropospheric rivers. Rating: 3.
- The controverted origin of excess water vapor above 70 kilometers. Rating: 2.

Possible Explanation. The river-structure of water-vapor flow is probably created by atmospheric currents and circulation.

Similar and Related Phenomena. Hypothesized icy comets bombarding the earth's upper atmosphere (GWC20).

Entries

X0. Introduction. Most of our experience with water in the atmosphere occurs at ground level in the forms of precipitation and humidity. At higher altitudes, though, there are at least two important, very different manifestations of water vapor. In the troposphere, immense filaments---virtual atmospheric "rivers"---carry water vapor rising from the humid tropics north and south toward both poles. (X1) At much higher altitudes, 70 kilometers-plus, a region long believed to be very dry, scientists have recently discovered reservoirs of water vapor of unknown origin. (X2) Anomalies accompany both of these hydrological "structures."

X1. Rivers in the atmosphere. It has been long held by meteorologists that the water vapor rising from the warm, wet tropics was carried north and south by more or less continuous, homogeneous flows of moisture-laden air. The study of modern water-vapor maps of the troposphere (roughly 10-20 kilometers altitude), have disproven this simple model. Actually, the huge flows of water vapor are split into several filamentary structures resembling rivers.

These filaments are many times longer than they are wide, and deserve to be called "rivers." Some are 4,800 miles long and 420-480 miles wide. These aerial streams of water vapor develop in regular patterns and persist as they are transported through the troposphere. The huge quantity of water vapor carried by these aerial rivers make them worthy of note here. And they are also anomalous in at least two ways, which adds to their legitimacy in this catalog.

Especially remarkable is the atmospheric river that frequently flows south from Brazil to east of the Andes and thence southeast into the Atlantic.

> A typical flow in this South American tropospheric river is very close to that in the Amazon (about 165 x 10^6 kg sec^{-1}). There are typically five rivers leading into the middle latitudes of the Southern Hemisphere and four or five leading into the Northern Hemisphere. The rivers persist for 10 days or more while being translated generally eastwards at speeds of 6 m sec^{-1}. (R1)

While the sizes of these "Amazons in the sky" are impressive, we do not know why the water-vapor flow splits into about a dozen rather well-defined "rivers." To add to the puzzle, these atmospheric rivers have a curious wave-like structure. (R2)

X2. Water-reservoirs in the upper atmosphere.

> It can't be true because it violates our ideas. (R4)

This was the collective opinion of many atmospheric scientists when a satellite experiment found approximately 50% more water vapor at an altitude of 75 kilometers than well-established theory predicted. That was back in 1991. In 1996, a second satellite experiment of different design has confirmed the existence of this "excess" water vapor. Most geophysicists are perplexed, to say the least.

Not L. Frank, though, because these experiments are in line with his theory that the upper atmosphere is continuously pelted by house-size, fluffy, icy comets---some 20 each minute. Such comets could account for the excess water vapor at these altitudes. (GWC20)

Frank asserts:

> When you get that excess of water vapor up there, it just can't come from the Earth. It must come from space. (R4)

Even so, other geophysicists are reluctant to accept Frank's icy comets---that would be too much "crow" to eat! One point levied against Frank's icy comets is that they would introduce more than three times the amount of water vapor actually measured. M. Summers, a theoretician at the Naval Research Laboratory, summed up mainstream opinion:

> There's definitely something very unusual going on in the mesosphere that we don't understand at all, but I'm not even close to saying this supports the small-comet hypothesis. (R4)

By 2006, few scientists accepted L. Frank's icy-comet hypothesis. Nevertheless the excess water-vapor still exists above 70 kilometers altitude, and we do not have a consensus theory.

References

R1. Newell, Reginald E., et al; "Tropospheric Rivers: A Pilot Study," Geophysical Research Letters, 19: 2401, 1992. (X1)

R2. Anonymous; " Scientists Discover Lengthy Rivers of Vapor in the Atmosphere," Baltimore Sun, January 22, 1993. (X1)

R3. Zhu, Yong, and Newell, Reginald E.; "Atmospheric Rivers and Bombs," Geophysical Research Letters, 21: 1999, 1994. (X1)

R4. Monastersky, R.; "Reservoir of Water Hides High above the Earth," Science News, 152:117, 1997. (X2)

R5. Anonymous; "Space Shower," New Scientist, p. 25, July 3, 1999. (X2)

R6. Kerr, Richard A.; "Rising Damp from Small Comets?" Science, 277: 1033, 1997. (X2)

GWC20 Black Spots on Ultraviolet Images of the Earth's Dayglow

Description. The appearance of black spots upon satellite images of the earth's dayglow in the ultraviolet portion of the spectrum. This phenomenon is intimately associated with the controversial hypothesis that said spots are caused by the impact and vaporization of icy minicomets in the upper atmosphere.

Data Evaluation. The black-spot phenomenon has been observed repeatedly by different satellites. The black spots are generally accepted as real phenomenon, but most likely only instrument artifacts. It is the interpretation that they are the consequence of a rain of incoming icy minicomets that is controversial. We do not evaluate hypotheses. Black-spot rating: 1.

The Icy Minicomet Hypothesis. The black spots seen in ultraviolet images of the earth's dayglow are due to clouds of water vapor in the upper atmosphere released by impacting house-sized, icy comets.

Some Implications of the Icy-Comet Hypothesis. If correct, the icy-comet hypothesis has some rather profound terrestrial and solar-system consequences. In the list of implications below, X-numbers refer to catalog entries that follow this introduction; R-numbers designate the many references at the end of this section.

- Icy minicomets are and have long been an important source of ocean water (X1-X4, X6, X7, X10, R20)

- Water vapor in the upper atmosphere derived from storms of impacting icy minicomets may be responsible for pluvial episodes in the earth's history. (X1, R20)

- Terrestrial cloudiness due to water vapor released from icy minicomets may have triggered the Ice Ages. (X1, R20)

- Impacting minicomets may have carried prebiotic chemicals and, possibly, actual life forms. (X1-X3, R20)

- Icy minicomets may be responsible for water/ice deposits on Mars, Mercury, the moon, and Saturn's rings.

Phenomena Possibly Related to the Icy-Comet Hypothesis.

- Differences between isotope ratios of meteoric and ocean water. (X2, X5, X8, R20, R33)

- Microwave detection of upper-atmosphere water-vapor "events" (trails, bursts). (X5, X7, X8, R20)

- Terrestrial telescopic detection of minicomets. (X5, X8, X11, X12, R20, R42, R44-R47)

- Presence of excess terrestrial carbon. (X13)

- Presence of unexpected quantities of water vapor in the upper atmosphere. (X5, X10, X12, X13, R20, R59)

- Terrestrial radar detection of minicomets. (X7, X8, X12, X13)

- Lack of comet-carried noble gases in terrestrial atmosphere. (X11)

- Lack of lunar seismic events attributable to impacts of icy comets. (X11, R6, R20)
- Satellite instrument noise/artifacts. (X6, X13, X14, R20, R30, R35, R43, R52)
- Satellite detection of bright trails of water debris in upper atmosphere due possibly to icy comets. (X9, X14, R26)

Anomaly Evaluation. The fundamental anomaly is the unexplained presence of black spots in images of the earth's ultraviolet airglow. Rating: 2.

Possible Explanations. Instrument noise/artifacts; vaporization of icy minicomets.

Similar and Related Phenomena. As listed above. Water rivers and reservoirs in the atmosphere (GWC19).

Entries

X0. Introduction. It is reasonable to ask why such an ostensibly astronomical phenomenon as "icy comets" is classified in this catalog under GEOPHYSICS and, in particular, is placed in the chapter on CLOUDS. Our rationale holds that the basic, defining phenomenon consists of the appearance of black spots (the "clouds") on satellite ultraviolet images of the earth's dayglow.

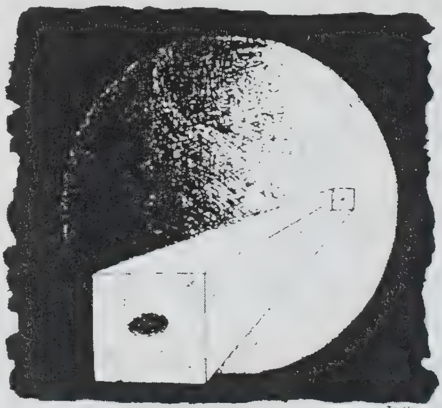
These small, ostensibly simple, black spots were sufficient to stimulate a decades-long controversy concerning their basic nature and, especially, their implications, chief of which are the filling of the earth's oceans and the origin and transportation of prebiotic chemicals and even life itself throughout the cosmos.

The lengthy controversy stems from the interpretation of the dayglow's black spots as clouds of water vapor released by small, icy comets that blot out tiny areas of the ultraviolet images of the dayglow.

It is truly amazing how a serendipitous, totally unexpected, apparently trivial observation could lead to a radical hypothesis with such wide and crucial implications. Like so many other paradigm-challenging observations, the dayglow black spots produced intense contention among scientists in astronomy, geology, geophysics, and biology. In this entry, we tie all these implications of the dayglow black spots and the resulting political milieu together.

The black spot/ice minicomet controversy epitomizes how mainstream science deals with radical, disturbing hypotheses The controversy is replete with acrimony and claims of data suppression---just as science has seen before in the debates over continental drift, cold fusion, etc.

Our newsletter Science Frontiers followed this saga in detail from 1985 to date. Our newsletter coverage of the icy-comets has been voluminous and relatively complete. We, therefore, draw heavily upon it, editing and adding supplementary information where needed. This is a reasonable approach because the saga is best appreciated in a historical context, such as provided by our timely newsletter.



Sketch of the earth's ultraviolet dayglow as recorded by satellite DE-1. One of the anomalous black holes is shown enlarged. (R20)

This said, we now present thirteen newsletter items in chronological order, edited and condensed where required. Access to specific subjects and anomalies is provided by the forgoing sections on Implications and Pertinent Phenomena, which here become indexes of sorts.

(Note that in the following pages, SF#xx refers to Science Frontiers newsletter number xx, and Rxx designates Reference xx at this section's end.)

A few pertinent observations and criticisms never appeared in the newsletter. Those we know about appear at the end of each entry as Supplementary Information and in entry X14. These are indexed and referenced in the same manner as the formal newsletter entries.

Each of the thirteen "X" entries that follows is tagged with tne newsletter number (SF#xx) and date.

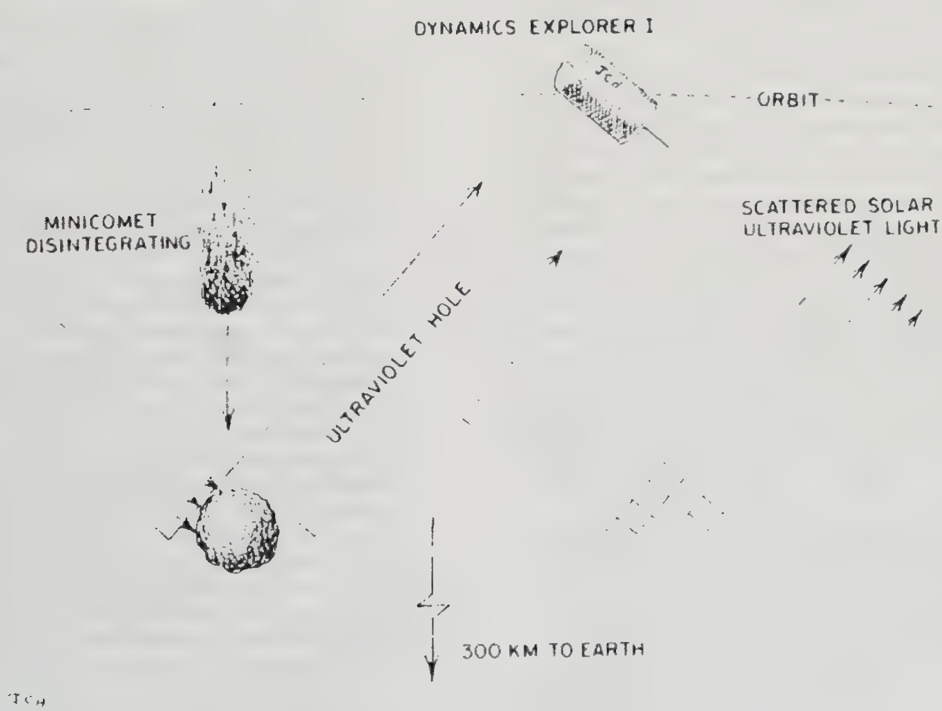
We do not claim completeness in relating this saga of science.

X1. Atmospheric footprints of icy meteors. This newsletter appeared in SF#44, 1985)

Serendipity triumphs again. From a dayglow experiment aboard NASA's satellite DE-1 (Dynamic Explorer-1) comes an unexpected discovery of considerable potential importance. Looking down on the earth, the DE-1 records the light emitted by atmospheric oxygen at altitudes of about 200-300 kilometers---this is the so-called "dayglow." The experimenters, L. Frank, J. Sigwarth, and J. Craven, all at the University of Iowa in Iowa City, have found that their dayglow images are speckled with transitory dark spots.

> According to Sigwarth, each hole expands like a drop of dye spreading out in a glass of water; within about 30 seconds the dayglow intensity drops by about 95 percent over an area of about 3,000 square kilometers. Then, over the next 3.5 minutes, the dayglow intensity increases toward its normal value as the hole grows to an area of about 25,000 km^2. (R1)

The Iowa group thinks that the holes



(Left) Normal back-scattering of the ultraviolet part of sunlight. (Right) Hypothesized icy-comet debris suppresses ultraviolet scattering, leaving a black spot in the satellite's image of the earth's dayglow. (R20)

or spots are created by meteors hitting the upper atmosphere because the spots follow the same time distribution as meteors. For example, they are more frequent during the well-known meteor showers. The theory is that the dark spots are formed when ice associated with the meteors is turned into water vapor, which reacts with the atmospheric oxygen producing the dayglow, in effect removing temporarily part of the light source. So far, everything seems relatively nonanomalous. But when quantities are calculated, though, jaws begin to drop. The sizes of the spots imply that the average meteor involved weighs 10 kilograms, mostly ice and far larger than has been thought. In fact, they may be characterized as small icy comets; that is, compositionally like the dirty snowballs that comets are now thought to be, but much, much smaller. The implication is that from 1,000 to 10,000 times more material is being added to the earth's atmosphere than previously believed---most of it being water. (R1)

From the pictures from this orbital launchpad, one's thoughts can really take off. How much water can this bombardment of icy meteors add to the earth, Mars, and other solar system bodies?

It is known from the Greenland ice cores, that the extraterrestrial dust influx during the Ice Ages might have been as high as 3×10^7 tons per year. If 10,000 times this amount of water is added to the atmosphere from icy comets, we are approaching 10^{12} tons of extraterrestrial water per year---far from an inconsiderable amount. The effects on the earth's climate could be large. If even greater fluxes of icy meteors were intercepted in the past, one might account for "pluvial episodes" on the planets. And, further, comets now seem to transport "primordial organic sludge" around the solar system. The postulated icy comets might then also be carriers of life forms or prebiotic chemicals.

Supplementary information. The DE-1 was launched in August 1981. Later that year, Frank and his colleagues were already puzzling over curious black spots appearing on the ultraviolet dayglow images they were receiving from the satellite. The first formal announcement of the existence of the spots was published in the May 3, 1983, issue of Eos. (R60)

Considerable additional information on the DE-1, the black spots, and Frank's hypothesized icy comets can be found in the book: The Big Splash, by L. Frank with P. Huyghe in 1990. (R20)

But the black-spot saga was far from over in 1990 when Frank's book was published. Of especial concern was Frank's interpretation of the black spots and even the physical reality of the spots. The spots, some proposed, were simply instrument noise.

The Polar satellite was launched 15 years after DE-1 in 1996. It carried an experiment by G. Parks that also showed black holes in the ultraviolet dayglow images of the earth. Here was seeming vindication of Frank's DE-1 controversial discovery and, possibly, his icy minicomet interpretation. (R26, R44, R47)

In 1998, R.A. Kerr wote in Science:

> Dismissed as instrument noise 10 years ago, the spots reappeared last year in images from a new satellite, Polar, persuading a few researchers that something peculiar---although not a rain of comets---is going on in the upper atmosphere. (R45)

Despite the Polar data, in 1998 it was still scientifically politically incorrect to mention the icy minicomet hypothesis favorably in the science journals, even though favorable data were in hand! There were still too many negatives, as we shall see in X2-X14.

X2. Oceans from space? (S#47, 1986)

In X1, we related how L.A. Frank et al, at the University of Iowa, had detected dark spots on satellite images of the earth's dayglow. Frank thought that the spots might be due to clouds of water vapor released as small, icy comets hit the atmosphere.

P. Huyghe has recently written more about Frank's discovery, Frank's hypothesis and its cool reception by the scientific community in the popular magazine Oceans. As Huyghe points out, there are several profound implications regarding the earth's history if Frank's interpretation of the black spots on the dayglow are on the mark.

> These comets are not occasional visitors, he [Frank] says, like the one that comes by every 76 years and---lucky for us---never actually drops

in. No, these are very small, comet-like objects that enter our atmosphere at a rate of 20 per minute, he says. These comets, which he believes must contain about 100 tons of water apiece, vaporize on impact with the atmosphere and fall as rain or snow. Now that may seem like one sizeable cold shower, but on a yearly basis he says it's actually only a tiny fraction of the annual preciptation. Then again, over a span of 4.5 billion years, which is about how old the earth is, that's enough water, he says---trumpets blaring---to create the oceans. (R8)

Naturally, such a theory is very disturbing because it runs counter to the widely accepted idea that the oceans were created by the outgassing of water vapor from the newly accreted earth. As a consequence, Frank's satellite data are readily accepted, but his radical explanation of them is not, as now noted.

> That's as crazy as they come. (A noted astronomer)

> ...a case of Halley's fever. (One geologist)

> ...his interpretation is preposterous. (Fred Whipple, an authority on comets)

Critical as other scientists may be of Frank's theory, they have no other explanation for the dark spots on the earth's dayglow images. Furthermore, scientists are far from united about how the earth's oceans really did form.

Supporting L. Frank's hypothesis that icy minicomets might be the source of the earth's oceans, in 1996 the European spacecraft Giotto obtained "chemical footprints" of Halley's comet that closely matched those of seawater, In this regard, L. Frank elaborated:

> Analysis of the Giotto results carried out by Swiss physicist Peter Eberhardt and his colleagues show that the earth's oceans contain the same ratio of deuterium-to-hydrogen as Halley's Comet. The relative concentrations of oxygen isotopes are also the same. And the same is true for sulfur. Eberhardt believes that these findings are in agreement with models proposing that the earth may have acquired its water and other volatiles from comets. (R20)

The Giotto results, however, have been challenged by measurements made by the James Clerk Maxwell submillimeter radio telescope on Hawaii. A study of comet Hale-Bopp showed a deuterium-to-hydrogen ratio twice that of seawater. Similar results have been announced by others for comets Halley and Hyakutake. (R33)

The radio telescope findings are obviously contradict those of Giotto.

More on this subject in X5 and X10.

As serendipity would have it, Frank's theory also connects in an interesting fashion with origin-of-life speculations Frank remarks, in connection with the organic sludge supposedly present in comets:

> These objects, because they are like a piston of gas, can bring organic material down without burning it up like a meteor does. (R8)

X3, Small, icy comets and cosmic Gaia (SF#52, 1987)

L.A. Frank and his associates at the University of Iowa have speculated that the earth is continuously and copiously bombarded by small, icy comets. Not just a few now and then, but a steady rain so intense that over geological time some major geological consequences must ensue. (See X1.)

Some observers commented that surely these scientists have thrown away their careers by suggesting something so ridiculous. But some suggestive data are there---in the form of dark spots on satellite images of the earth's ultraviolet dayglow---and late results continue to support this far-out interpretation, ridiculous or not, as now reported by L.A. Frank et al.

> The mass of these objects is estimated at about 10^8 gm each, and the total flux is about 10^7 small comets per year. If this flux is representative of the average flux over geologic time, then the water influx is sufficient to fill the Earth's oceans. The fluxes of these objects are also large for all the planets outside the orbit of Earth. Considerations of thermal stability imply that the fluxes of comets that impact Venus are con-

siderably less. The outer giant planets may be significantly heated relative to solar insolation by the small-comet impacts. For example, the total energy input due both to solar insolation and comet impacts may be similar for Uranus and Neptune. Thus it is possible that the temperatures of these two planets are similar, even though Neptune is farther from the Sun. (R9)

Comment. What has all this to do with "cosmic Gaia"? By "cosmic Gaia" we mean the cosmic version of the conventional Gaia concept; i.e., earth-as-an-organism. The answer is that small icy comets can in principle transport throughout all of space:

- Immense quantities of water needed for life-as-we-know-it.
- The carbonaceous material basic to that same kind of life.
- The seeds of life, a la Hoyle and other proponents of panspermia.
- Energy, as discussed above by Frank et al. Observe that Frank et al are saying that the kinetic energy in the flux of small comets is sufficient to raise a planet's temperature as well as supply water.

Comment. In this light, exobiologists need not confine their search for extraterrestrial life to planets surrounding warm suns. Somewhere, even far from stars, there may be places where comets may raise atmospheric temperatures to where life can prosper! Sunlight, of course, is not needed absolutely, as demonstrated by the profusion of life around deep-sea vents. (R9)

In fact, Frank and Huyghe devote an entire chapter in their book to the possible tranport of water to Mars and the outer planets. (R20)

X4. Oceans from Space (SF#56, 1988)

Although science-in-general dismissed L. Frank's proposal that the earth's oceans may have been delivered by icy minicomets, (X2) Some astronomical data do not negate the idea of an exogenous origin of the oceans.

As theorized by L. Frank, comets seem to be the most likely candidates as extraterrestrial water sources.

C.F. Chyba has examined the lunar impact record and derived an estimate of the total mass of objects impacting the moon during the (hypothetical) period of heavy bombardment 3.8 to 4.5 billion years ago. This allowed him to calculate the mass influx for the earth during this period. His conclusion: if only about 10% of the incoming mass consisted of comets (mostly ice), the earth would have acquired all its ocean water. (R10)

Comment. Frank claims that the earth today is continually bombarded by small icy comets, which down the eons may have kept the ocean basins full. In fact, we have two possible extraterrestrial sources of oceans---both of a cometary nature; that is, the massive comets such as Halley's and Frank's house-sized icy minicomets.

It was only yesterday that the idea of ice surviving in the near-vacuum of outer space was ridiculed; few even dreamed that our oceans might be composed of space ice!

X5. One of the most astonishing discoveries of modern science! (SF#58, 1988)

We take this title from P. Huyghe's recent overview of the "oceans-from-space" controversy, printed not surprisingly in Oceans. (R8)) We have been following this debate for over two years. Rather than retrace all the details, it is sufficient to say that the scientific community has been generally negative and dismissive about L.A. Frank's assertion and supporting evidence that each year some 10 million icy comets, each averaging sixty compact cars in weight, strike the earth's atmosphere, convert to water vapor and, in the fullness of time, help fill the ocean basins.

In his article Huyghe reviews the considerable evidence that has accumulated supporting Frank's claim:

(1) The water in Halley's comet had the same abundances of two key isotopes as the earth's oceans;

(2) The rocket detection of unexpected amounts of water vapor in the upper atmosphere;

(3) The microwave detection of unusual water-vapor events in the upper atmosphere;

(4) The Lyman-alpha detection of hydrogen concentrated near the earth; and

(5) The photographic detection of small, incoming objects with the characteristics of the debated icy comets. (R8)

Item 5 above has been reported in other publications:

> Using a telescope with a moving field of view---a difficult technique that required a year of preliminary calculations to plan---physicist Clayne Yeates has found and photographed what seems to be a population of fast-moving objects near earth that range between 8 and 16 feet in size. These previously undetected bodies match Frank's predictions concerning the speed, direction and number of proposed comets flying by earth, says Yeates, a scientist at the Jet Propulsion Laboratory in Pasadena, Calif. (R16, R17)

Comment. Now all this does not mean that Frank's hypothesis is proven in the eyes of all scientists. Far from it, there is too much at stake; namely, our whole view of the small-scale structure of the solar system and, even more important, the heretical notion that the earth's oceans have slowly filled with extraterrestrial water.

It has not been an easy two years for Frank. His reputation has been at risk. Huyghe hinted at this when he recorded Frank's reactions to the new photographic evidence. Frank commented:

> Looking at the data, seeing those streaks, has made a lot of people's hearts stop.

He is thrilled at this result, but he dreads what will follow.

> For the past two years I paid the price for being wrong. Now I'll pay an equal price for being right. After all, you can't just tip the scientific world askew and expect everyone to cheer. (R8)

Supplementary information. Frank was overly optimistic about the positive effect Yeates' images would have. His findings were announced in two science magazines (R16, R17) but were seemingly suppressed by most of the science journal, which really count in deciding such controversial matters.

In The Big Splash, published in 1990, Frank and Huyghe went to the core of the rejection problem, which, to them, was more political than scientific:

> There was a war going on out there. We had to fight to get our papers published. We had to fight to let astronomers know that these objects existed. If Yeates had gotten negative results his papers would have been accepted for publication within forty-eight hours and he would have been proclaimed a hero. That is the way the system works. But these findings were embarrassing. How could astronomers miss these things? So when the comets were seen through the telescope no one believed it. (R20)

Supplementary information. In 2001, L.A. Frank commissioned photos to be taken from a ground-based telescope. He employed a photographic exposure routine designed to demonstrate that the black spots seen in the earth's ultraviolet dayglow are not just instrument noise.

> The telescope at the Iowa Robotic Observatory in Arizona used different exposure times to pick out genuine objects from noise. The telescope's camera took a 20-second exposure, waited 10 seconds and then took a further exposure of 10 seconds. Any object moving across the sky would produce one trail followed by a second trail half as long.
>
> Frank claims to have found nine comet trails in the photographs. He says the objects he detected were 50,000 kilometers from the Earth and travelling at 10 kilometres per second, which agrees with his theoretical predictions. (R52)

X6. Impact delivery of early oceans (SF#68, 1990)

Where did the earth's oceans come from? For decades the stock answer has been: from the condensation of vapors escaping from the planet's cooling crust; that is, "outgassing." The possibility that some terrestrial water might have arrived from extraterrestrial sources after the earth's formation has been discounted. The major reason behind this neglect was the expectation that the erosive effects of large-scale impacts of water-carrying comets and asteroids would preclude any net accumulation of volatiles, and could even reduce any existing inventories of surface water.

C.F. Chyba has recently reexamined this question of cometary water influx vs. impact-caused water losses using the latest estimates of comet/asteroid fluxes during the period between 4.5 and 3.5 billion years ago, when bombardment of the inner solar system was thought to be especially severe. Rather than the expected net loss, Chyba computes that the earth would really have gained more than 0.2 - 0.7 ocean masses in that billion-year period. Venus would have fared equally well, but Mars, more sensitive to impact erosion, would have accreted "only" a layer of water 10-100 meters deep over the whole planet! (This Martian water is now mostly below the surface supposedly.) (R23)

Comment. Not mentioned in this paper is what might have happened after 3.5 billion years ago. The comet/asteroid flux did not drop suddenly to zero. In fact, there may still be some net influx of cometary extraterrestrial water, as suggested by L.A. Frank. Incidently, the work of Frank et al is not mentioned at all in Chyba's article. Too controversial?

X7. Icy minicomets not so dead (SF#72, 1990

An item in the June 1990 issue of Scientific American is entitled "Death Watch." In it, J. Horgan plays dirges for four phenomena that have received considerable attention in Science Frontiers:

- Minicomets;
- Cold fusion;
- Abiogenic oil; and
- The fifth force.

Apparently Benveniste's "infinite dilution" work had already been definitively interred!

But wait, there is a microwave flicker of life remaining in the minicomets. J.J. Olivero and his colleagues at Penn State have been monitoring the sky with a microwave radiometer in their search for emissions from high-altitude gases. During more than 500 days of observations, they detected 111 sudden bursts of water vapor.

Olivero et al suggest that these bursts occur when small, icy comets vaporize at very high altitudes. These minicomets are of the same size (about 100 tons) and frequency (20 per minute over the whole atmosphere) as those predicted by L.A. Frank. Frank's icy comets have been received with about as much warmth as "cold fusion." One reason for the unpopularity of icy comets is that they might have provided sufficient water to fill the ocean basins, thus undermining the accepted view that our oceans derived from outgassed water vapor from deep within the earth.

Besides this mindset, the minicomets do have some counts registered against them:

- The effects of all the purported water vapor on the ionosphere should be easily detected but they are not;
- Seismometers emplaced on the moon have not detected their impacts there; and
- Military surveillance satellites have not seen these house-sized objects. (R21, R22)

See fuller discussion by Frank and Huyghe in The Big Splash. (R20)

X8. Earth's water not imported. (SF#83, 1992)

That the earth is continuously bombarded by icy minicomets is unpopular in the Court of Science. Even less acceptable is the notion that over the eons these house-sized chunks of ice contributed substantially to our planet's inventory of water.

In what will surely be hailed as the death knell of the icy comet theory is the discovery by K. Muehlenbachs, of the University of Alberta, and F. Robert and M Javoy, from the University of Paris, that the water contained in the earth's rocks, both ancient and recent, is isotopically different from the water found in meteorites. Meteoric water is assumed to be isotopically the same as cometary water. Conclusion: comets could not have contributed substantially to our planet's water inventory in the geological past. (R54)

Comment. Of course, the isotopic measurements have to be weighed against all the data supporting the icy comet theory.

Also, no terrestrial laboratory has ever actually analyzed a piece of cometary ice. In the above article, it is simply assumed that it would be similar to meteoric water.

There have, however, been remote chemical assays of comets. See the Supplementary information following X2, where two such remote assays contradict one another.

X9. Icy minicomets caught by a satellite camera? (SF#112, 1997)

A geophysicist really risks his or her reputation if he or she suggests that the earth is bombarded each minute by 20 house-size, icy minicomets. Well, L.A. Frank, University of Iowa, did just that in 1985. He was duly pilloried for his trouble.

But, at the 1997 spring meeting of the American Geophysical Union, Frank presented new data to back up his previous assertions. The most startling of his new evidence came from a camera aboard a NASA satellite. Time-lapse photos imaged two objects streaking into the atmosphere over Poland and Germany. Frank identified these as clouds of water molecules from disrupted icy minicomets. The clouds had expanded from the house-size minicomets to clouds 35-50 miles wide, weighing 20-40 tons each.

Frank thinks the minicomets come from a cloud of such objects orbiting the sun from earth out to Jupiter and beyond. Why don't they evaporate in the sunlight and near-vacuum of outer space? Perhaps, thought Frank, they are protected by a thin coating of carbon. (R31, R32)

Supplementary information. Refer back to X5, where C. Yeates reported telescopic observations of small, fast-moving objects close to earth.

Yeates' data seem to have been suppressed in the mainstream science media. However, Frank and Huyghe assign two full chapters to it in their book The Big Splash. (R20)

X10. It can't be true because it violates our ideas! (SF#114, 1997)

Such was the collective opinion of many atmospheric scientists when a satellite experiment found approximately 50% more water vapor at an altitude of 75 kilometers than well-established theory predicted. That was back in 1991. Now, in 1997, a second satellite experiment of different design has confirmed the existence of this "excess" water vapor. Most geophysicists are perplexed, to say the least.

Not physicist L. Frank, though, because these water-vapor experiments are in line with his theory that the upper atmosphere is continuously pelted by house-size, fluffy, icy comets---some 20 each minute.

Frank asserts:

> When you get that excess of water vapor up there, it just can't come from the Earth. It must come from space.

Even so, other physicists are reluctant to accept Frank's icy comets---that would be too much "crow" to eat! One point levied against Frank's icy comets is that they would introduce more than three times the amount of water vapor actually measured. M. Summers, a theoretician at the Naval Research Laboratory, summed up mainstream opinion as follows:

> There's definitely something very unusual going on in the mesosphere that we don't understand at all, but I'm not even close to saying this supports the small-comet hypothesis.

References. For the forgoing article (R34, R39). The preceding section, GWC19, also deals with the subject, as does The Big Splash, by L.A. Frank aided by P. Huyghe. (R20)

X11. Broadside against small icy comets (SF#118, 1998)

In a late-1997 issue, Geophysical Research Letters published a group of five papers that detailed five different lines of evidence that are inconsistent with the claim by L.A. Frank and J.B. Sigwarth that the earth is bombarded daily by 30,000 house-size icy comets. If such bombardment has really been occurring, scientists would have to rethink the origins of the earth's oceans, terrestrial life, and the formation of the solar system. No wonder the icy-comet hypothesis is strongly challenged!

Three of the more interesting points made by this group of papers are as follows (R36-R40):

(1) Our moon could not escape the icy-comet bombardment. Roughly 1,000 craters 50 meters in diameter and splashes of debris 150 meters in diameter must occur each day. There is no evidence that the moon is thus afflicted.

(2) Comets also carry the noble gases argon, krypton, and xenon. These gases should accumulate in the atmosphere as the comets disintegrate. The amounts of these gases actually measured are 10,000 times less than those the postulated bombardment would produce.

(3) The icy comets should break up near the earth and produce clouds of ice crystals. Sunlight reflected from such 30-ton clouds would be brighter than Venus and easily visible before they disperse. Such objects are rarely seen, implying that small icy comets do not exist in the numbers claimed.

Preceding this series of five papers is one by Frank and Sigwarth in which they describe their detection of atomic oxygen trails near earth. These they attribute to small icy comets. (R37)

Supplementary information. Of the above three criticisms, the first is the most serious. Scientists should detect visually or with their instruments some effects of the copious rain of icy comets on the moon.

In particular, the seismometers left behind by the Apollo astronauts should, one supposes, register the impacts of house-size icy comets. (R6, R25)

Frank counters this argument at great length in The Big Splash (R20) and elsewhere with the following basic argument.

> Frank says there is a major flaw in this argument: it assumes that minicomets hit like rocks, and generate seismic jolts capable of being detected by the Apollo instruments. 'Small comets are like fluffy snowballs,' he objects. 'It is the seismometers lack of sensitivity to the impact of small comets that accounts for the discrepancy. (R20)

X12. No house-size snowballs (SF#125, 1999)

Beginning back in 1981, L.A Frank and his colleagues saw dark spots on satellite ultraviolet images of the earth's dayglow. Frank interpreted the spots as huge splotches of water vapor created by incoming house-size cometary snowballs.

Although some other data supported Frank's theory, most scientists scoffed. After some mildly acrimonious debate, a mainstream science consensus decided that the spots on the satellite photos were merely instrument artifacts.

Any lingering doubts as to Frank's house-size snowballs or "icy minicomets" impacting our atmosphere seem to have now been dispelled definitively by a radar search by S. Knowles and his colleagues at the Naval Research Laboratory. Using the Naval Space Surveillance System's powerful radar, their scans of the upper atmosphere detected nothing resembling giant snowballs. (R55) According to Frank's estimates of the flux of incoming minicomets, the radar should have seen 800-5,000 of them. (R48)

Comment. The radar search did not end the icy minicomet controversy. See X13 following.

X13. Icy Comets, Oceans, Life (SF#126, 1999)

Our thought, expressed in X12, that the icy-comet controversy might be winding down was premature. P. Huyghe, coauthor with L. Frank of The Big Splash, in response to SF#125 submitted three recent articles from the science literature. Two reply to major criticisms leveled against the icy-comet hypothesis; the third gives geological and geophysical reasons why there must have been icy comets or some other substantial influx of water and carbon to the earth's surface down the geological eons.

No instrumental artifacts. The basis for the 1985 claim of L. Frank et al that small, icy comets continually bombard the earth's upper atmosphere came from photos taken far above the earth from the Dynamics Explorer 1. Large, transient "holes" (really water-vapor clouds) appeared in the upper atmosphere. These were attributed to the water contained in small, icy comets.

Most critics claimed instead that these "holes" were no more than instrumental errors. (R43) L.A. Frank and J.B. Sigwarth have investigated this possibility and have rejected it. (R51)

Navy radar search used incorrect cross sections. A more recent attack on the icy comets came from S. Knowles et al. (X12) They claim that their search of the sky with the Naval Space Command Radar would surely have detected the icy comets if they exist. Frank and Sigwarth respond that Knowles et al used radar cross sections that are significantly different from those typical of icy comets. It is likely that the Navy radar would not have been able to detect the comets. (R55)

Knowles et al replied that the cross sections were accurate and that their conclusion stands! (R57)

Too much water and carbon. Strong, indirect evidence for the steady influx of icy comets comes from the geologists. They find that on and near the surface of the earth there is much more water and carbon than can be ascribed to the weathering of the earth's rocks. For example, the amount of carbon tied up in rocks (carbonates, etc.) is 600 times that now found in the combined atmosphere, hydrosphere, and biosphere. Where did all this extra carbon come from? The same question can be asked about the earth's water inventory.

Geologists have long assumed that this excess water and carbon came from the outgassing of volcanos. But recent quantitative estimates tell us that the volcanic sources are grossly inadequate. So are all other possible terrestrial sources. Therefore, some scientists, such as D. Deming, University of Oklahoma, have been looking spaceward. Deming ventures that extraterrestrial sources of water and carbon may be four or five orders of magnitude greater than suspected.

Obviously, a steady bombardment of icy comets might fulfill Deming's requirements. Down the long eons of geological time, they could have filled the oceans and showered all that excess carbon onto the planet's surface.

Deming ups the stakes in the icy-comet controversy when he links these fluffy snowballs to the well-known vagaries of life on earth.

> The extraterrestrial influx rate may also act as the pacemaker of terrestrial evolution, at times leading to mass extinctions through climatic shifts induced by changes in accretion rates with concommitant disruptions of the carbon and nitrogen cycles. Life on earth may be balanced precariously between cosmic processes which deliver an intermittent stream of life-sustaining volatiles from the outer solar system or beyond, and biological and tectonic processes which remove these same volatiles from the atmosphere by sequestering water and carbon in the crust and mantle. (R50)

Comment. Need we mention the book Living Comets, by F. Hoyle and C. Wickramasinghe? Why stop at water and carbon, when comets might also transport life or its building blocks? (See X1, X2, X3, R20)

X14. Satellite detection of bright trails of water-vapor debris in the upper atmosphere. (Not in newsletter, 1997)

In the May 30, 1997, issue of Science, Richard A. Kerr reviewed some of the evidence supportive of the icy-comet hypothesis. Kerr reported on a phenomenon missing in our newsletter coverage.

> Frank also presented observations of a new phenomenon high above the atmosphere that is presumably linked to atmospheric holes: bright trails of water debris. "I just happened to be looking through the images," says Frank, "and all of a sudden saw these bright oxygen trails. We were shocked." About 10 times a day, Frank concludes, an incoming small comet between 5000 and 50,000 kilometers leaves enough water in its wake that sunlight dislodges a trail of oxygen atoms from the water.
>
> Frank's final line of evidence is visible light images showing hydroxyl, another fragment of water. These trails appear at altitudes of 2000 to 3000 kilometers, just above where small comets are supposed to disrupt to form atmospheric holes, and the trails seem to be about as abundant as atmospheric holes, says Frank. "That's totally independent verification of the ultraviolet measurements," he says. (R26)

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R31. Roylance, Frank D.; "Space Snowballs Theory Gains Credence," Baltimore Sun, May 29, 1997. (X9)

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R41. Powell, Corey S.; "Return of the Space Snowballs," Scientific American, 277:19, August 1997.
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R59. Frank, L.A., and Sigwarth, J.B.; "Atmospheric Holes: Instrumental and Geophysical Effects," Journal of Geophysical Research, 104:115, 1999.
R60. Sigwarth, J.B., et al; "Atmospheric Holes Possibly Associated with Meteors," Eos, p. 281, May 3, 1983. (X1)
R61. Horgan, John; "Death Watch," Scientific American, 262:22, June 1990. (X7)

GWC21 Bizarre Clouds

Description. Clouds, or what seem to be clouds, that not only defy easy explanation, but also have an eerie, UFO-like character about them, including strange luminosity, curious shape, and weird motion. For the present, they are best described as bizarre.

Data Evaluation. The subject observations are all anecdotal and, so far, each seen but once. The data come from newspapers or fringe journals. Rating: 3.

Anomaly Evaluation. While they are bizarre, the clouds described below challenge no current meteorological paradigms and must be relegated to the "curiosity" file. They are outliers but nevertheless still must be cataloged. If verified by additional observations, they would certainly might become anomalous. Rating: 3.

Possible Explanations. None offered except, of course, bad observations.

Similar and Related Phenomena. Will-o'-the-wisps (GLN1); luminous aerial bubbles (GLD7); above-water marine phosphorescent displays (GLW3). All in our catalog Remarkable Luminous Phenomena.

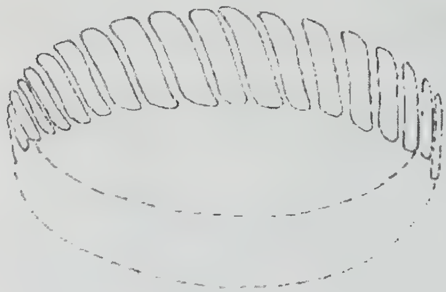
Entries

X1. July 24, 1996. Malborough, South Devon. About midnight on this date, E. Netley and his wife observed a most peculiar cloud formation. It was so well-formed and precisely organized that Netley felt that the term "cloud object" was appropriate. Even so, he was confident that the apparition represented a natural phenomenon. "Natural" probably, but certainly the strangest cloud we have encountered in our more than 40 years of literature research.

The evening of July 23 was warm and a bit humid, with a modest breeze blowing in from the ocean. Netley and wife first saw the "cloud object" from a distance of about a kilometer; they eventually walked to within 400 meters of the phenomenon. The "object" consisted of a slowly rotating ring of thin, vertically oriented clouds. (See figure.) The cloud ring was 80-100 meters across and seemed to rotate in a horizontal plane at the rate of about one revolution per minute.

As though this were not strange enough, the rotating "cloud object" itself moved in a larger circle 8-10 times the diameter of the "cloud object." The "cloud object" took 4-5 minutes to complete a trip around the larger circle. The phenomenon lasted for about an hour before dissipating. (R1)

We have here a remarkable, difficult-to-believe observation of a cloud that bears no resemblance to anything we have seen in the literature before. It is even stranger than many UFO reports.



Sketch of the revolving "cloud object." (Part of the circle has been omitted for clarity.) Like a wheel-within-a-wheel, the whole cloud formation moved en masse in a still larger circle. (R1)

X2. Late May 1997. Taos Valley, New Mexico. A curious cloud hung over the Valley inducing many residents to call emergency services. Some thought it was smoke; others fog. However, no smoke was smelled, and conditions were not favorable for fog formation.

"J. Fambro, who lives southwest of Taos, said he went outside at the time of the "smoke" was reported at about 8:30 p.m. 'I couldn't even see the town from my house...We had a 20-degree temperature drop almost instantly.'"

The temperature returned to normal about 15 minutes later.

An automated weather station in Taos indicated that the cloud dropped visibility from seven to four miles. (R2)

X3. January 29, 2001. Avening, Gloucestershire, England. Testimony of M.J. "McLaughlin as reported to the Journal of Meteorology by C. Roland.

"On Monday, January 29, I took a ride out Stroud way and decided to walk around Woodchester Park. It was a nice day and what better place to take advantage of the weather. I had not been [there] for a couple of years.

"Everything was going as normal until I got down into the park. I took the 'red' path which takes you right round the lakes. I had walked down to the old kennels when I saw what I can only describe as a glowing fog. I thought it must be some sort of peculiar weather phenomenon. I carried on skirting the lake but the 'glow' was still there. I looked around for someone to confirm this odd scene with me but I was alone. I must admit I began to feel a little unnerved by it. I quickened back; the glow could still be seen except it had drifted out over the lake. It was about six feet (two metres) high and three feet (one metre) wide---although not a column. Indeed, at one point I almost thought it looked like a figure.

"I have never seen such a peculiar sight in all my days, and only wish someone else had seen it, too."

It is the luminosity and small size of this phenomenon that makes it so interesting. Could it have been a will- o'-the-wisp? Or it might have been kin to the drifting, luminous "bubbles" described in GLD7 in our catalog Remarkable Luminous Phenomena?

References

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R2. Anonymous; "Odd Cloud Baffles Taos Residents," Santa Fe New Mexican, May 28, 1997. Cr. D. Perkins via L. Farish. (X2)

R3. Roland, Cynthia; "Peculiar Sight in Park," Journal of Meteorology, U.K., 26:229, 2001. (X3)

GWC22 The Mystery Cloud of April 9, 1984

Description. The appearance over the Western Pacific of a huge mushroom cloud with properties inconsistent with those of clouds accompanying nuclear detonations and any recognized meteorological phenomenon.

Data Evaluation. The 1984 mystery cloud was well-observed by three commercial aircraft and one military jet that was sent to investigate. Ample descriptions of the event and the associated discussions appeared in the mainstream science journals. There are likely, however, to be unexamined classified reports. Rating: 1.

Anomaly Evaluation. All reasonable sources of the mushroom cloud have been ruled out. It remains a modest anomaly. Rating: 2.

Similar and Related Phenomena. Cloud plumes over Soviet Arctic islands during the same period (GWC18).

Entries

X0. Introduction. The 1980s saw a huge, unexplained mushroom-shaped "mystery cloud" plus numerous curious cloud-like plumes appear in the Western Pacific. Both of these odd cloud varieties were of particular concern during the Cold War because they could signal nuclear detonations---possibly of Soviet origin.

The large numbers of cloud-like plumes, which rose from Soviet Arctic islands, are sufficiently different from the single mushroom "mystery cloud" to be treated separately in GWC18.

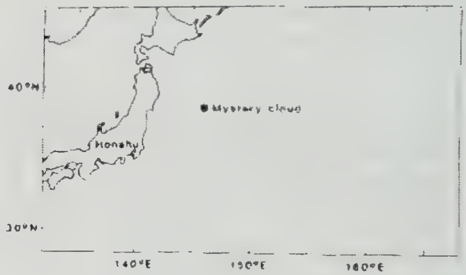
In this section, we focus on the still-mysterious mushroom "mystery cloud" of April 9, 1984, which was also observed near the Soviet Arctic, but which was quite different in size and configuration from the suspicious cloud plumes of GWC18.

X1. April 9, 1984. Western Pacific Ocean. The crews of three airliners en route from Tokyo to Anchorage observed a gigantic mushroom cloud about 180 miles east of Japan. The cloud was moving rapidly up and away from a cloud layer at 14,000 feet. It eventually reached a maximum altitude of about 60,000 feet, at which time its maximum diameter was about 200 miles. No fireball nor flash was seen by anyone.

A nuclear explosion, possibly on a submarine was suspected. One pilot, suspecting a nuclear event, issued a Mayday alert and ordered his crew to don oxygen masks. However, when an F-4 Phantom dispatched from Japan arrived at the scene, it reportedly detected no abnormal levels of radioactivity. Wake Island hydrophones, to the southeast, detected some submarine volcanic activity far south of the cloud, but no detonations in the area where the cloud was spotted. The distance of the volcanic disturbances and the prevailing winds ruled out volcanic sources of smoke. In the absence of any hydrophonic evidence, the authors concluded that the mysterious cloud came either from a man-made atmospheric explosion (a huge one!) or some as yet unknown natural phenomenon. (R1)

A 1985 report in the New York Times amplified the information about the mystery cloud recorded above.

"It was so close to cargo-laden Flight 36 of Japan Airlines that the plane's commander, Capt. Charles H. McDade swerved away from it, began a rapid descent, ordered his crew to put on oxygen masks and radioed a 'May Day' distress call.



First estimate of the location of the "mystery cloud" of April 9, 1984. (R1)

"'Looks like a nuclear explosion, only there was no fireball,' he told flight controllers in Alaska. His plane was slightly jostled. 'I turned tail and ran,' he said later.

"The crews of KLM and Flying Tiger airliners, also heading toward Alaska, saw the cloud, too. All were flying above a 14,000-foot cloud deck from which a bulb appeared, soaring at an estimated 500 miles an hour. The bulb rapidly expanded to a diameter of 200 miles---the distance between New York and Washington---then thinned and disappeared above 65,000 feet." (R3)

No light flash was observed, although the cloud was reported to be slightly luminous. Recourse to seismic records, microbarograph data, and reports from planes monitoring atmospheric radioactivity yielded nothing. Volcanic eruptions and a nuclear explosion seemed to be ruled out. The "mystery cloud" remained just that---"mysterious"---at least publically!

To researchers A.C. Chang and J.A. Burnetti, a high-velocity meteor smashing into the cloud deck appeared to be a reasonable hypothesis. A meteor encountering the cloud deck might have shattered into many fragments, converting the meteor's kinetic energy into heat. The hot gas would then expand into a mushroom shape. No Soviet activity would be involved, and everyone could relax! (R2)

Meteors usually create vivid luminous phenomena when they enter the atmosphere, but none such were seen. To this date, we have not seen a consensus scientific hypothesis on the origin of this event. The truth may still be classified.

In 1986, D.L. McKenna and D.A. Walker presented further information on the mystery cloud based upon consultatons with the other pilots who had had good views of the phenomenon. Their conclusion follows.

"Our conclusion is that the original esitmated positions were in error. Additional data, primarily from Ven den Berg, place the event between the Kurils and Sakhalin. The altitude of the center of the halo at the maximum observed size is estimated to have been greater than 200 miles, and the diameter of the halo is estimated to have been at least 380 miles. It seems unlikely that a ground-based explosion could produce this kind of an effect. It is surprising to us that no official data have been provided by government agencies and that such a significant observations from a region of demonstrated military semsitivity was, and still remains, a mystery. (R4)

Although the modified position of the mystery cloud places it closer to the area of Soviet nuclear testing, the size of the cloud amd the announced lack of nuclear debris seems to eliminate the nuclear-test hypothesis. Neither does the mystery cloud have the characteristics of the cloud plumes described in GWC18. Therefore, the "mystery cloud" of April 9, 1984, remains anomalous---at least in the open literature!

References

R1. Walker, Daniel A., et al; "Kaitoku Seamount and the Mystery Cloud of 9 April 1984," Science, 227:607, 1985. (X1)

R2. Chang, Andre C., and Burnetti, James A.; "Mushroom Cloud the Result of a Meteor?" Nature, 314:676, 1985. (X1)

R3. Sullivan, Walter; "A Mushroom Cloud Remains Unexplained a Year after Sighting," New York Times, May 21, 1985. (X1)

R4. McKenna, Daniel L., and Walker, Daniel A.; "Mystery Cloud: Additional Observations," Science, 234:412, 1986. (X1)

GWC23 Green Clouds

Description. Clouds and cloud-like entities that are green rather than the usual white, gray, yellow, black, etc. Green clouds are customarily rejected on subjective bases.

Data Evaluation. Two generically different green clouds are presented in X1 and X2 below. The first is based on scientific observation; the second is anecdotal and, therefore, suspect. The data evaluations are the first figures given below.

Anomaly Evaluation. The obviously divergent origins of the two clouds described in X1 and X2 require separate attention:

- Green thunderstorms in general (X1). Ratings: 1/3.
- A green cloud with light rays observed in Soviet airspace (X2). Ratings: 3/1.

Possible Explanations. None offered.

Similar and Related Phenomena. The green flash at low sun altitudes (GEL1 in our catalog Rare Halos...); UFOs (XUO in a forthcoming catalog volume).

Entries

X1. Occasional occurrence. Wherever thunderstorms are prevalent.

Unlike the exceedingly strange green cloud described in X2 below, which seems to belong in the fringe literature, green thunderstorm clouds are of unchallenged meteorological origin. They remain, however incompletely understood.

F.W. Gallagher, III, et al have below summarized the "green-thunderstorm" situation as of 1996.

Anecdotes abound that exceptionally severe thunderstorms may appear to emit an eerie, sickeningly yellow-green light. Skeptics scoff at this notion. The excited observers were deluded, or they made it all up. This is, of course, the same knee-jerk response greeting UFO reports and accounts of many other anomalies. Thunderstorms, however, do unquestionably have an objective existence. And it actually turns out that a few storm-watching, professional meteorologists have confirmed that greenish thunderstorms are real.

Such reliable testimony, however, is usually dismissed as due to the reflection of greenish ground vegetation by the storm clouds or, perhaps, the effects of sheets of hail preceding the storms.

In 1995, F.W. Gallagher et al decided to settle the matter. They chased likely-looking thunderstorms armed with a spectrophotometer. Many storms later, they proved, first of all, that some thunderstorms are definitely green. In fact, some gradually change from blue to green in the space of half an hour. Their ground observations, plus more spectrophotometer data taken from aircraft, refute the theory that the green color is from reflected vegetation. Hail may contribute to the green color but is not required. In sum, green thunderstorms really do exist, but no one yet knows where all the green comes from. (R3)

X2. Late January 1985. From an aircraft 120 kilometers from Minsk enroute from Georgia to Tallinn, USSR.

The following anecdotal account should, perhaps, be relegated to our yet-to-be-published catalog on UFOs and like frowned-upon phenomena. However, in the first report collected, a green cloud is mentioned in a way suggesting a meteorological event, and we must, therefore, not discard it here. It is obvious, though, that ~~out~~ first report has led us down the garden path. But it is a fascinating and instructive excursion.

Our first report is an abbreviated and apparently well-expurgated version of the subject event. It appeared in the Baltimore Sun on January 31, 1985. We quote it completely.

"An account of a mysterious 'green cloud' sending out powerful shafts of light and flying in tandem with an airliner appeared in a Soviet newspaper today. The strange cloud was seen over Byelorussia by passengers and crew of a flight from Georgia to Tallinn, and by the crew of an airliner from Leningrad, passing 10 miles away according to Trud. Nikolai Zheltukhin, a corresponding member of the Academy of Sciences, said the object was certainly very big. He rejected the idea that the green cloud was an image caused by far-off atmospheric changes because the airman had fixed its location from the shafts of light it sent to the ground." (R1)

According the B. Maccabee, however, the complete story appeared in full in Russian publications as well as the New York Times and an AP dispatch. The whole story is totally at odds with the Sun's take on the event.

Below, Maccabee has summarized the larger story. It is easily seen that much more than meteorology is involved and that a strong UFO flavor intrudes.

Here is part of Maccabee's condensation of this truly strange encounter.

"While flying at about 10 km at 4:10 A.M. about 120 km from Minsk, the copilot first noticed a bright yellow spot off to the right and above the plane, like 'a static large star'. Suddenly a thin ray of light came out of it and fell directly down to the earth. The ray suddenly spread into a cone of light. From this point on the whole crew witnessed the events. Then a second cone appeared which was wider and less powerful than the first one, and finally, the third---wide and quite bright. The crew members had the impression that the bright 'star' was 40-50 km above the earth. The copilot began to make a sketch of the phenomenon. The surprising thing about these beams of light was that 'Everything...houses and roads ...was seen clearly at the section of the earth surface lit by the conical beam.' Then the beam rose upward from the earth and hit the plane. The pilots saw 'an extremely bright white spot surrounded by concentric color circles. The white spot flashed and a green cloud appeared in its place. The object then appeared to move toward the plane at a rapid rate, crossing the plane's route

"At this time the navigator called Minsk to report the sighting. Just as he reported, the object stopped moving. The green cloud then dropped, crossing the airplane's altitude and 'then swept vertically upwards to settle at an altitude of 10,000 m, exactly on a level with the aircraft where, as one of the pilots remarked ', it remained to accompany it, as if it were an escort, to the end of the flight.' The flight speed was 800 km/hr. There appeared to be blinking lights within the cloud." (R2)

One can see in all this how editorial changes can completely alter the nature of an anecdotal event. Where the truth lies is unknown.

References

R1. Anonymous; "Mysterious 'Green Cloud" Appears near Airliner," Baltimore Sun, January 31, 1985. (X2)

R2. Maccabee, Bruce; personal communication, March 12, 1985. (X2)

R3. Gallagher, Frank W., III, et al; "Green Thunderstorms Observed," American Meteorological Society, Bulletin, 77:2889, 1996. (X1)

GWC24 Exotic-Chemical Clouds

Description. Ephemeral, sometimes seasonal, clouds containing concentrations of exotic chemicals much higher than those in the standard atmosphere. Widespread, unidentifiable odors are included in this category.

Data Evaluation. Concentrations of chemicals, such as sodium and bromine, are detected by scientific instruments. They are usually reported in the scientific journals. Widespread, strong odors---offensive or pleasant---are noticed by the general populace and are generally ignored by science publications, even though they can be very puzzling. Both categories of olfactory phenomena are well-established. Rating: 1.

Anomaly Evaluation. Industrial sources of chemicals and odors are usually quickly located and abated. Natural sources---wide-area plant emissions, meteor disintegration---are more elusive. Some of these sources are never discovered (X3, X4); others remain controversial (X1, X2). Generally speaking, exotic olfactory clouds are very weakly anomalous; curious rather than paradigm-threatening. Rating: 3.

Similar and Related Phenomena. Smoke from distant conflagrations (GWR2); large-scale lake turnovers (ESC6 in Anomalies in Geology); volcanic gases.

Entries

X1. Spring. The Arctic. "Unusually high levels of bromine gas and particles detected in Arctic air samples by ground-based instruments have focussed scientific attention on this heretofore little-studied trace gas. Measurements from 1976 to 1980 show that during the three-month Arctic spring, vast pulses of bromine enter the atmosphere. During these pulses, scientists report, levels of bromine over the Arctic are at least 10 times those found elsewhere in the world." (R1)

Although the notorious Arctic haze also increases in the spring, it is not deemed an important source of the bromine pulses. Rather, it is speculated that marine organisms that bloom in the Arctic spring are the chief producers of the bromine.

X2. Unknown frequency of occurrence. Areal extent undetermined. "Clouds of sodium atoms that rapidly appear and then disappear have been detected high in the sky over Urbana, Ill. While it may seem strange that the vanishing clouds have been noticed only over that city, the scientists from the University of Illinois who observed the phenomenon say that they are not really perplexed, because they have the only machine that can detect the sodium clouds, which are probably coming from meteors as they burn up in the atmosphere." (R2)

T. Beatty and colleagues at the University of Illinois direct lidar (laser infrared radar) beams vertically into the upper atmosphere causing atoms there to emit characteristic radiation. This is detected back on the ground by a sensitive telescope and spectroscope. As of 1988, Beatty's group has detected at least five sudden surges in wavelengths characteristic of sodium atoms located at altitudes around 85 kilometers.

If these sodium bursts are produced by disintegrating meteors, they must certainly occur elsewhere.

X3. Frequent occurrence. Bartlesville, Oklahoma. "A scent squad has been unleashed in Bartlesville, Okla., to trace and identify an elusive odor that has plagued residents for months. The 19-member Bartlesville Odor Mitigation Task Force will distribute about a half dozen devices to trap the smell, which will then be sniffed and characterized by trained noses at a Chicago research company. The city has received 60 calls this year about the odor, described as smelling like rotten eggs or butane, but they have been unable to determine the source." (R3)

So far, no announcement that the source of the Bartlesville stench has been found has reached us.

Stenches such as that afflicting the residents of Bartlesville are invisible clouds of chemicals and, therefore, deserve a place in this catalog under GWC. If their source---usually found to be a manufacturing plant, a dump, farmers' manured fields, decaying swamp vegetation, Chinese chestnut trees in bloom, etc.---cannot be found, we do have an olfactory anomaly. Usually, however, the odoriferous sources are found or, as in X4 next, they just disappear and remain unknown.

Such olfactory clouds---mostly offensive but occasionally pleasant---are very common. We take space to catalog just two that happened to cross our desk (X3, X4)

X4. October 27, 2005. New York City. "On the evening of 27 October, the sticky-sweet smell of maple syrup washed over much of New York. It was first detected around 8 pm in Lower Manhattan but spread rapidly to the Upper East Side, Prospect Heights in Brooklyn and parts of Staten Island. Some thought it smelled more like caramel or freshly baked pie. The aroma sparked hundreds of calls to the city's 311 emergency hot line---was it a terrorist gas attack deviously cloaked in the smell of grandma's kitchen?" (R5)

The odor in this case was harmless and dissipated quickly. The source, though, remains a mystery. Given the size of the area affected and the consternation it evoked, something larger than a bakery must have been involved!

X5. Frequent feature. Southern Hemisphere troposphere. In 1990, NASA satellites first revealed strong concentrations of ozone in the troposphere over South America and Africa. These huge, invisible clouds tend to form over largely uninhabited parts of these land masses at various times of the year. Complex air currents over South America transport some of the ozone out over the Atlantic. The African ozone clouds drift toward Australia.

The sources of the ozone clouds are probably fires (from slash-and-burn agriculture) in the forests of Amazonia and natural and artificial fires in Africa's vast savanna grasslands.

The current thinking is that gases from these burning biomasses, such as nitric oxide and nitrous oxide, react with tropospheric oxygen to create the ozone. (R4)

References

R1 Simon, C.; "Sources Sought for Arctic Bromine Pulses." Science News, 124:151, 1983. (X1)

R2. Raloff, Janet; "Sudden Sodium Surges Seen over Illinois," Science News, 134:238, 1988. (X2)

R3. Newman, Steve; "Malodorous Mystery," Baltimore Sun, July 22, 1990. (X3)

R4. Anonymous; "Puzzle of Mystery Ozone Cloud over Brazil," New Scientist, p. 6, October 10, 1992. (X5)

R5. Anonymous; "Sweet Smell of Mystery," Fortean Times, #205:21, January 2006. Source cited: New York Times. (X4)

GWC25 Layers of Unidentified Material, Not of Natural Origin, in the High Atmosphere

Description. The existence of layers of unidentified material, not of natural origin, in the upper atmosphere.

Data Evaluation. Dust layers in the upper atmosphere have been detected by satellites, aircraft, and terrestrial radars. The specific experiment described below employed laser radar. The results were reported in Nature. We have not noticed confirmations as yet. Rating: 2.

Anomaly Evaluation. Most likely, this unidentified, unnatural material is human pollution of some sort. Its nature, origin, and mode of transportation were not known as of 1985. Rating: 3.

Similar and Related Phenomena. Icy minicomets (GWC20); nebulous meteors (AYO8); interplanetary dust (AZO); both in The Sun and Solar System Debris.

Entries

X0. Introduction. The upper atmosphere is populated by several extensive, shifting layers of dust and other materials. Observations from satellites, aircraft, balloons, and ground-based radar have detected dust layers in the lower mesosphere and upper stratosphere. These layers may be a few kilometers thick, hundreds of kilometers in extent, and reach to over 50 kilometers altitude. Many scientists attribute the dust to disintegrating meteors. (R1)

X1. In 1984, L. Thomas et al reported a layer of unidentified material that appeared to not be of natural origin; that is, probably human pollution of some sort. Here is the abstract of their paper in Nature.

> In this letter we report the results of laser radar measurements at Aberystwyth (52°25' N, 4°04' W) which revealed the presence of a discrete layer of atmospheric material of about 0.5 km thickness near 40 km for at least 3 h during the night of 4-5 July 1983. Wind data indicate that it was moving from the east and has an east-west extent of at least 170 km. We estimate that the layer has a mass content in excess of 100 kg for each degree of latitude width. The layer does not appear to be due to a natural terrestrial source or extraterrestrial material, and it seems likely that it was a result of pollution at upper atmospheric heights. (R1)

If not a "natural" material, we are left with a human source of some sort that emits pollution of still unknown composition that is somehow carried to 40 km. Just what this material is, what its origin could be, and how it got to such high altitudes remain a mysteries.

Reference

R1. Thomas, L., et al; "Observations of a Thin Layer of Material in the Upper Atmosphere," Nature, 312:627, 1984. (X0, X1)

GWC26 Artificial Polarity Inversion of Thunderclouds

Description. The artificial reversal of charge distribution on thunderclouds from the normal negative bottoms and positive tops to positive bottoms and negative tops.

Data Evaluation. Only a single pertinent experiment is in our files at present. This experiment is suggestive only and over two decades old. There may be later, more definitive data. Rating: 3.

Anomaly Evaluation. The artificial inversion of thundercloud polarity would demonstrate that external conditions, such as electrically charged mountain peaks, can greatly modify the thunderstorm engine. In 1984, this possibility was widely questioned. The experiment described below (X1) and later ones may help change entrenched opinions. Rating: 3.

Similar and Related Phenomena. S. Lemstrom's 1881-1882 experiments attempting to create artificial auroras (GLA6); auroras correlated with thunderstorms (GLA9) both in our catalog Remarkable Luminous Phenomena.

Entries

X0. General observations. The great majority of thunderclouds are negatively charged on their bottoms and positive on top. In nature thnderclouds with reversed polarity are rare. Contrary to normal thunderclouds, they produce positive rather than negative lightning bolts.

X1. 1984. New Mexico. C.B. Moore and coworkers at the New Mexico Institute of Mining and Technology, at Socorro, tried to induce polarity reversal in passing thunderclouds by injecting negative ions into the atmosphere. They selected New Mexico's Magdalena Mountains where summer thunderclouds are frequent. Moore et al strung a 2-kilometer wire across a deep canyon and applied -100 kilovolts to it. The wire as-a-whole emitted a negative current of 300 microamperes into the air.

> Out of about 65 clouds that roamed the canyon, the group observed two clear-cut cases of thunderclouds with inverted polarity; negative on top and positive on bottom. These clouds are also thought to have expelled positive charges via lightning. (R1)

It is possible that the negatively charged wire stretched across the canyon did indeed induce polarity reversal in normal passing thunderclouds, but it is also possible that the two reversed-polarity clouds that were observed acquired their polarity naturally, although "how" and "where" are unknown.

The charged-wire experiment is suggestive though. More experiments are planned using a larger power source. Besides polarity inversion, external amplification of thunderclouds may be possible.

Reference

R1. Weisburd, Stefi; "Making Upside-Down Thunderclouds," Science News, 126:306, 1984. (X1)

GWC27 Cloudiness Correlated with Cosmic Ray Intensity

Description. The positive correlation of low-altitude cloudiness with the cosmic-ray flux reaching the earth's atmosphere.

Data Evaluation. The science literature contains several positive correlations that demonstrate this phenomenon. (See bibliography in R2.) Rating: 2.

Anomaly Evaluation. These positive correlations are difficult-to-explain because the total energy content of the cosmic ray flux is only one-billionth that of solar irradiation. The electrical charges on cosmic-ray particles must somehow stimulate cloud-forming processes that greatly exceed their energy contribution. This "microphysics" is still not well-understood. Rating: 3

Similar and Related Phenomena. The cascade effect by which cosmic rays trigger the formation of lightning.

Entries

X0. Introduction. For well over a century, scientists have been debating the influence of sunspots upon terrestrial weather. Skeptics ridiculed the practice as "sunspottery." It is true that solar irradiance does vary with the solar cycle (characterized by sunspot numbers), but terrestrial solar irradiance varies only 0.1% on a decadal scale. (R2) This is too small to have significant effects on the earth's cloudiness.

On the other hand, the combined intensities of cosmic rays from the sun and galaxy vary about 15% over the solar cycle. This variability arises from the changes in the solar wind acting upon the earth's magnetosphere, which is the earth's shield against the cosmic-ray flux. Cosmic rays reaching terrestrial cloud levels thus have a variability that one can compare with the ever-changing cloud cover. However, the energy input to the earth's atmosphere from all cosmic rays is only about that of starlight. It would seem on the surface that cosmic rays lack the energy to have much effect upon cloudiness.

Nevertheless, in 1997, H. Svensmark and E. Fris-Christensen reported a correlation between the earth's cloud cover and cosmic-ray intensity. (R1)

Another positive correlation by N. Marsh and H. Svensmark appeared in 2000 in Physical Review Letters, 85:5004. This study is summarized below in X1 by G. Chin.

X1. The Marsh-Svensmark correlation.

> Marsh and Svensmark have measured global average monthly cloud anomalies for lower, middle, and upper troposphere, and correlated them with changes in the cosmic-ray flux. They found, surprisingly, that cloud cover at altitudes of less than 3.2 kilometers covaries with cosmic-ray fluxes from 1980 to 1995, but no correlations was seen for higher altitude clouds. (R1)

X2. How can cosmic rays affect cloudiness? As pointed out in X0, the energy content of cosmic rays reaching low altitudes is very weak---only one billionth that of sunlight---although much more variable than solar irradiance. How can such a relatively weak flux alter cloud cover? Actually, meteorologists do not yet understand the "microphysics" occurring between the electrically charged cosmic-rays and atmospheric aerosols. K.S. Carslaw et al have examined several physical processes involving cosmic rays that might contribute to cloudiness, such as a rather complex "ion-aerosol clear-air" mechanism.

As of 2002, however, cosmic-ray-forced, cloud-forming mechanisms are not well-understood. (X2)

References

R1. Chin, Gilbert, ed.; "Low Clouds and Cosmic Rays," Science, 290:2033, 2000. (X1)

R2. Carslaw, K.S., et al; "Cosmic Rays, Clouds, and Climate," Science, 298: 1732, 2002. (X0, X2)

GWC28 A Curious Ribbon Cloud

Description. A suddenly-appearing, low-altitude, horizon-to-horizon, ribbon-like cloud that could not be attributed to an aircraft's condensation trail (contrail).

Data Evaluation. The ribbon cloud was observed visually and with optical instruments by the officers and crew of a merchant vessel. The crucial cloud-altitude measurements are difficult-to-make from a single observation point. Rating: 3.

Anomaly Evaluation. The cloud observers were adamant that it could not have been made by an aircraft. A low-level meteor or piece of spacecraft debris also seem unlikely by virtue of their unmistakable luminous effects and sounds. Assuming the accuracy of the observations reported below, the ribbon cloud remains a mystery. Rating: 3.

Possible Explanation. Observer errors and misjudgments as to cloud altitude and dimensions.

Similar and Related Phenomena. The sky-spanning auroral arch (GLA2 in our Remarkable Luminous Phenomena.

Entry

X1. November 18, 1999. North Atlantic Ocean. Aboard the m.v. Waterford en-route from Pto Bolivar, Columbia, to Ijmuiden.

"At 1832 UTC an azimuth of Jupiter was taken shortly after sunset. The sky in the vicinity of Jupiter was completely clear, no cloud of any type, with but a few small cumulus dotted around the horizon.

"About five minutes later, having completed the calculations, the observer again looked out to see a ribbon type cloud, broken in formation, stretching almost from [the] eastern horizon to [the] western horizon. If the estimated height (see below) is reasonably correct, then the bandwidth couldn't have been more than a few hundred feet, apparently more cigar-shaped in cross section than flat, the maximum axis being horizontal, the minimum vertical. The cloud was fairly consistent in density, and at a fairly stable altitude, not undulating or rippled, having the consistency of a small cumulus cloud (white and fleecy), but also translucent.

"Initially, it was thought to be a condensation trail, but this was shortly dismissed as it was considered too low (estimated to be less than 10,000 ft altitude, probably around 7,000-8,000 ft). Both ends of the cloud were checked with binoculars but no aircraft was evident; however, as a yardstick, and by good fortune, one did appear around 1910, presumed to be at the usual 30,000 or so feet, heading west-south-westward." (R1)

If not a condensation trail, the next best guess would be a meteor trail, although the altitude is also very low for one. But a bolide streaking across the sky at such a low altitude at night would have created a spectacular luminous display and probably considerable sound as well. Neither occurred.

Reference

R1. Bennett, Paul; "Ribbons in the Sky," Marine Observer, 70:177, 2000. (X1)

GWD DARK DAYS, FOGS, AND OTHER OBSCURATIONS

Key to Phenomena

GWD0 Introduction

A dark day is not merely the veiling of the sun by ordinary clouds---they at least let through enough light to conduct the business of the world. On a dark day the pall of darkest night descends suddenly, chickens go to roost, and men and women pray and grope for candles, although not necessarily in this order. New England's famous Dark Day of 1780 is typical of the genre.

The standard explanation of the dark day is smoke from forest fires in the hinterlands or perhaps some unrecorded volcanic eruption. These are reasonable surmises because many dark days are accompanied by black rain that is thick with soot and ashes. Wind, goes the theory, carries these combustion products hundreds of miles from their origin and blots out the sun in the process. Sometimes, though, the darkness seems irrational, descending suddenly without the approach of ominous dark clouds. Not infrequently, forest fires commensurate in size with the dark day are never found. In America, they were "out west" somewhere---set by the Indians. This sufficed in the pioneer days when the forests of an entire state could be consumed without New Englanders ever hearing about it. While admitting that forest fires are very likely the cause of most dark days, we should not ignore the fact that some scientists have proposed that some forest-fire-less dark days might have been due to comet tails or cosmic matter obscuring the sun.

Superficially, fogs and mists would seem to present little grist for the anomaly mill. But diligent research among the older journals brings to light the supposedly deadly ice fogs, the pogonips, the curious association of "blue mists" and cholera outbreaks, and certainly not least the near-global, self-luminous dry fogs of 1783 and 1831, when one could read out-of-doors at midnight on the highest mountain and in the deepest valley.

GWD1 Dark Days and Obscurations of the Sun

Description. Periods when abnormal darkness descends upon a region. The sun may be obscured or weakened for anywhere from a few minutes to several days. In some instances, the stars may be visible; in most cases the entire sky is darkened. Many dark days are accompanied by yellowish clouds and black precipitation, signifying considerable particulate matter in the atmosphere. The areas afflicted may be just a few square miles or continent-sized.

Background. Dark days and solar obscurations are some of the oldest recorded anomalies of nature, beginning even before the strange darkness of the crucifixion. Many of the old tales are indeed mysterious, but only because of distortions and poor observation. Most modern dark days are found to have easily explained origins. Since there are several possible origins, this is a composite category lumping weather, incendiary, volcanic, and astronomical events into one class.

Data Evaluation. Dark days and solar obscurations have occurred throughout historical times. Old reports are vague but those of the last century are good. Rating: 1.

Anomaly Evaluation. The reduction of sunlight by smoke, volcanic ash, or menacing clouds can only be considered as curious. But if, during normal daylight hours, the sunlight fails and the stars are seen, common terrestrial obscuring agents can be ruled out, and a significant anomaly exists. An anomaly may also exist if the area afflicted by smoky and/or dust blankets is not commensurate with possible sources; viz., forest fires, volcanic eruptions, etc. Of course, one can always maintain, even today, that dark days are due to some distant, unrecognized source. A century ago, dark days, often as not, were blamed on Indians burning the prairies somewhere "out west." Generally, dark days will have prosaic explanations. Rating: 3.

Possible Explanations. Almost all of those dark days during which both the sun and stars are blotted out can be explained in terms of: (1) forest fires; (2) volcanic eruptions; (3) dust storms; and (4) intense storms, perhaps augmented by natural or artificial air pollution. When the stars appear during a dark day, one must search for extraterrestrial sources, such as cosmic material veiling the sun---a very unlikely situation.

Similar and Related Phenomena. Solar eclipses: dry fogs and dust fogs (GWD4); the white sky phenomenon (GWC1); earthquake fogs and darknesses (GQW5) the last in our catalog Earthquakes, Tides....

Examples of Dark Days and Other Obscurations

X1. 44 BC. Europe. The sun was pale for a whole year. (R12)

X2. 30. Middle East, Egypt. "The crucifixion of Christ was signalised by phenomena in nature the most extraordinary and terror-striking. The material creation seemed to have been moved into convulsive throes of sympathy with the last agonies of the Son of God. The sun refused to shine, and the earth robed herself in mourning. From the sixth hour there was darkness over all the land until the ninth---that is, from twelve o'clock, our mid-day, until three in the afternoon. All the region around Jerusalem was wrapped in a mysterious gloom. This darkness was not a natural event, and it was not a common eclipse of the sun, for it was at the time of the Passover, and that was set at full moon, when an eclipse is impossible. Besides a total eclipse can never last longer than a quarter of an hour. It is reported that Dionysius in Egypt observed this portentous gloom, and exclaimed, 'Either the God of Nature is suffering, or the machine of the world is tumbling into ruin.'" (R19)

X3. 96. Ephesus, Greece. Disc of sun obscured so that Philostratus observed the corona. No eclipse that year. (R39)

X4. August 22, 358. Two hours of darkness followed by an earthquake. Probably in Europe. (R12)

X5. 409. Europe. Stars visible during the day. (R12)

X6. 536. Europe. Stars visible during the day. (R13) This event is the famous 536-A.D. dry-fog/dust-veil phenomenon. Details on this near-global event at GWD4-X7.

X7. 567. Europe. Stars visible during the day. (R12)
X8. 626. Europe. Stars seen during the day. (R12)
X9. August 19, 733. Europe. Sun was darkened. (R12)
X10. 934. Europe. Sun lost its light. (R12)
X11. September 29, 1091. Europe. The sun was darkened for three days. (R12) Many meteors.
X12. February 12, 1106. Europe and Brazil. Sun darkened. Many meteors seen. (R12, R8) An extraterrestrial event? (WRC)
X13. February 28, 1206. Europe. Six hours of complete darkness. (R12)
X14. 1208. Brazil. Solar obscuration. (R8)
X15. 1241. Europe. Stars seen during the day. (R12)
X16. April 23, 1547. Europe, Brazil. Sun the color of blood; many stars appeared during the daytime. (R7, R8, R10, R12, R39) Once again a date coincidence on opposite sides of the Atlantic. Some sort of astronomical event may be inferred here. (WRC)
X17. 1706. Brazil. Obscuration of the sun. (R7, R8)
X18. 1574. Europe. The sun was darkened for 18 days. (R11)
X19. May 12, 1706. New England. (R26)
X20. October 21, 1716. New England. Extraordinary darkness at midday. (R15, R26)
X21. August 9, 1732. New England. (R26)

X22. October 19, 1762. Detroit, Michigan. "A man in business seldom troubles himself about news; yet the following is so uncommon, I cannot neglect acquainting you therewith. Tuesday last, being the 19th instant, we had almost total darkness for most of the day. I got up at daybreak; about 10 minutes after I observed that it got no lighter than before; the same darkness continued until 9 o'clock, when it cleared up a little. We then, for the space of about a quarter of an hour, saw the body of the sun, which appeared as red as blood, and more than three times as large as usual. The air all this time, which was very dense, was of a dirty yellowish green color. I was obliged to light candles to see to dine, at 1 o'clock, notwithstanding the table was placed close by two large windows. About 3 o'clock, the darkness became more horrible, which augmented until half past three, when the wind breezed up from the S. W. and brought on some drops of rain, or rather sulphur and dirt, for it appeared more like the latter than the former, both in smell and quality. I took out a leaf of clean paper and held it out to the rain, which rendered it black whenever the drops fell upon it; but when held near the fire, turned to a yellow color, and when burned, it fizzed on the paper like wet powder. During this shower, the air was almost suffocating with a strong sulphur smell; it cleared up a little after the rain. There were various conjectures about the cause of this natural incident. The Indians and uneducated among the French, said that the English, which had lately arrived from Niagra in the vessel, had brought the plague with them; others imagined it might have been occasioned by the burning of the woods. But I think it most probable, that it might have been occasioned by the eruption of some volcano, or subterraneous fire, whereby the sulphurous matter may have been emitted in the air, and contained therein, until, meeting with some watery clouds, it has fallen down together with the rain." (R26, R40)

X23. May 19, 1780. New England. "This was the famous dark day of Friday, May 19, 1780, that extended over nearly all of New England. One of the many eyewitness reports still extant is a letter by Jeremy Belknap of Boston. He tells that the forenoon had been cloudy, and about 10 or 11 o'clock the clouds assumed a strange yellowish hue, which tinted all the landscape. An hour later the light began to fail, and by 1 o'clock the darkness was so great that candles were lighted and kept burning all afternoon. The atmosphere was not simply dark, said Dr. Belknap, but seemed full of 'the smell of a malt-house or a coal-kiln.'" (R32) The precipitation that fell was found to be thick, dark, and sooty. (R35) Many other articles mention this famous phenomenon. (R3, R14, R15, R26, R27)

X24. October 16, 1785. Quebec, Canada. Several periods of intense darkness. Yellowish clouds came from the northeast. Black rain. Standing water found with a yellow substance floating on the surface, which was thought to be sulfur. (R2, R26) See GWF3 for "sulphur" falls.
X25. July 3, 1814. New England and eastern Canada. Darkness due to clouds carrying dust and wood ashes. (R2, R26) But see X26.
X26. 1814. Borneo. It was pitch black for 3 days due to volcanic dust from Timboro Mountain 300 miles away. (R9) See X25.

X27. November 6-10, 1819. Eastern North America. "The darkness was so great (at Middlebury, Vermont), that a person, when sitting by a window, could not see to read a book, in small type, without serious inconvenience. Several of the students in the college studied the whole day by candle-light. A number of the mechanics in this village were unable to carry on their work without the assistance of lamps. The sky exhibited a pale yellowish-white aspect, which, in some degree, resembled the evening twilight a few moments before it disappears. Indeed we had little else but twilight through the day; and such, too, as takes place when the sun is five or six degrees below the horizon. The colour of objects was very remarkable. Every thing I beheld wore a dull, smoky, melancholy appearance. The paper, on which I was writing, had the same yellowish -white hue as the heavens. The fowls showed that peculiar restlessness that was remarked in them during the total eclipse of the sun in 1806. Some of them retired to roost. The cocks crowed several hours incessantly, as they do at the dawning of day." (R1) The phenomenon began on the 6th in New York State. On the 12th, residents of Georgia experienced a smoky atmosphere that irritated the eyes. (R1, R13, R26)

X28. July 8, 1836. New England. (R26)
X29. March 23, 1857. Europe. Gloom spread over the heavens, followed by 8 minutes of extreme darkness. (R5)
X30. May 20, 1857. Bagdad, Iraq. An extraordinary darkness. Much dust fell. (R4) Very likely a sandstorm. (WRC)
X31. April 11, 1860. Brazil. Several minutes of darkness. Venus visible. (R7, R8) R7 gives the date as April 18, but it is evidently derived from R8, which has April 11.
X32. October 16, 1863. Canada. (R26)
X33. September 15 through October 20, 1868. Western Oregon and Washington. (R26)
X34. September 6, 1881. New England. The Yellow Day. Clouds of smoke from forest fires in Michigan and Ontario made everything seem yellow. (R36)
X35. January 22, 1882. London, England. Not foggy but just like night at midday. (R16)
X36. April 26, 1884. Stonyhurst Observatory, England. Dense black clouds with yellowish tint. Black rain fell. (R17)

X37. March 19, 1886. La Crosse, Wisconsin. "A most remarkable atmospheric phenomenon occurred here at 3 p.m. The day was light, though cloudy, when suddenly darkness commenced settling down, and in five minutes it was as dark as midnight. General consternation prevailed; people on the streets rushed to and fro; teams dashed along, and women and children ran into cellars; all business operations ceased until lights could be lighted. Not a breath of air was stirring on the surface of the earth. The darkness lasted from eight to ten minutes, when it passed off, seemingly from west to east, and brightness followed. News from cities to the west say the same phenomenon was observed there is advance of its appearance here, showing that the wave of darkness passed from west to east. Nothing could be seen to indicate any air currents overhead. It seemed to be a wave of total darkness passing along without wind." (R18) Obviously, this was not the usual low-level concentration of smoke. (WRC)

X38. October 1886. Durkhamshire, England. (R20)
X39. November 19, 1887. Ohio River Valley. The Smoky Day. (R26)
X40. April 2, 1889. Aitken, Minnesota. Darkness accompanied by dirty snow. (R21)
X41. September 2, 1894. New England. (R26)
X42. July 1896. All of Siberia. Immense area covered with smoke for 11 days. No fires or volcanic sources found. (R22)
X43. September 12, 1902. Western Washington. Everything was reddish, and one could not read outdoors. No forest fires found to explain phenomenon. (R23, R26)
X44. June 5, 1903. Saratoga, New York. (R26)
X45. April 15, 1904. Wimbleton, England. Like a tunnel of darkness, with light at either end. Lasted 10 minutes. (R24)
X46. December 2, 1904. Memphis, Tennesee. 15 minutes of darkness. (R26)
X47. June 30, 1908. Caterham Valley, England. Sudden onset of darkness that lasted 1/2 hour. (R25) Note that this dark day coincided with the famous Tunguska Event or Siberian Meteor. (WRC)
X48. August 20-25, 1910. Northern United States from Idaho to St. Lawrence River. (R26)
X49. March 11, 1912. Sussex, England. Inky blackness with blood rain. (R29)
X50. February 28, 1923. New York, New York. So dark that all offices and vehicles had lights on. (R28)
X51. November 1924 or 1925. London, England. At 1145 it got darker and darker, by 1150 it was pitch black, but at 1159 the darkness disappeared in a flash. (R37)

X52. September 18, 1938. Northwestern Siberia, between 70 and 90^{o} east longitude and 65 to 69^{o} north latitude. "The records that Yemilianov has collected from documents and eyewitnesses tell of a darkness like deep twilight, with a yellow cast to the sky, lasting for several hours. This description recalls the New England 'dark day' of May 19, 1780 which is known to have been the result of smoke from forest fires. However the Siberian event cannot be so explained, according to Yemilianov. From a comparison of the times of onset of the darkening at different places, he calculates that it was traveling east north east at approximately 100 kilometers per hour. He believes it probable that the black cloud first appeared nearly simultaneously over an area about 300 kilometers in diameter. He points out further that all but one of the eyewitnesses he interviewed did not mention any odor, such as wood smoke occasion. Yemilianov therefore concludes that the Siberian darkening was probably caused by a dense compact cloud of cosmic dust that entered the earth's atmosphere." (R33, R34)

The above summary description of the "enigmatic Siberian darkness" was distilled from two popular U.S. magazines. Much greater detail is found in Yu.M. Emel'yanov's (the correct translation of his name) full report on the phenomenon. We have now translated this report from the original Russian. Of particular interest are Emel'yanov's personal comments on the probable cause of the enigmatic darkness. This cause, if the correct one, makes the phenomenon highly anomalous.

We quote two paragraphs from the translation of Emel'yanov's conclusions.

"Thus, the only reasonable origin of the black-cloud phenomenon appears to be extraterrestrial space. The black cloud probably originated from a suffiiently dense condensation of cosmic dust falling during a short interval of time (no more than 1.0 to 1.5 hours) and staying suspended in the upper strata of the atmosphere.

"In regard to the transient nature of the fall of cosmic dust, it may be said that after the sudden appearance of the black cloud in the western part of the band of the 'ellipse', all further development of the phenomenon apparently consisted only in the diffusion of this cloud by atmospheric winds in an east-northeast direction with a speed of about 100 km/hr. There is no information at all about the descent at this time of additional cosmic dust in adjacent or more remote regions of the earth." (R42)

X53. January 16, 1955. London, England. Abnormal smoke belt 1 1/2 miles wide caused 6-10 minutes of extreme darkness. (R30)

X54. December 1, 1961. London, England. (R31)

X55. April 30, 1971. Jacksonville, Florida. "An ominous overcast lowered over downtown Jacksonville as the NWS issued a tornado warning in response to a suspicious radar cell 48 km to the west. By 1030 EST, the sky turned nearly black. Lights and street lamps came on and birds circled to roost. An eerie silence fell over the city. There was no thunder and no rain." (R38) A typical darkness due to extreme weather conditions. (WRC)

X56. Circa 1800. Amsterdam, Holland. On a bright summer day, total darkness descended about noon. It was so dark that many lost their lives when they fell into canals. (R6)

X57. September 25, 1950. Ontario. "Inhabitants of southern Ontario were startled on Sunday, September 25, 1950 at a brief glimpse of the sun as a pale, bluish-mauve disc. At the same time the western sky became a dark, terrifying mass of cloud and haze, as though a gigantic storm were approaching, while to the north and east the sky toward the horizon was a clear steel-blue. The darkness was so marked at 3:30 in the afternoon that the writer observed a group of six wild ducks going to sleep quietly in the middle of a pond, with their heads nodding or tucked under their wings.

.....

"We learned on Sunday, even as the eerie darkness descended, that all this was attributable to smoke from heavy muskeg fires in distant Alberta, two thousand miles away. In subsequent days the smoke pall moved eastward, causing similar phenomena to be seen in eastern Canada and the United States, and in the British Isles several days later." (R41)

The smoke cloud thus crossed most of North America and the Atlantic Ocean---a distance of perhaps 6,000 miles. How could it retain its identity over such a great distance?

X58. November 6, 1961. Yugoslavia. "Because of a mysterious cloud, there was complete darkness at 13.30 h in the afternoon of November 6th, 1961, at Vukovar (Northern Yugoslavia).

"A dark-grey cloud of extraordinary shape appeared above the village. The broadcast of the local radio-transmitter was interrupted and absolute darkness set in, which was accompanied by a half-minute long breakdown in the supply of electric power. Instruments showed that the atmosphere was very strongly electically charged. A technician in the studio said that at this moment a series of fluorescent tubes started to give off light, although they were not connected to any power supply. After a short time the cloud was blown away by the wind." (R43 citing Netherland's Einhovensch Dagblad, November 11, 1961)

X59. August 6, 1981. Southern England. On this date, the source of the exceptional darkness experienced is well known: violent thunderstorms. Nevertheless, this darkness was so profound that it is worth recording here.

"The storms of 6 August 1981 were of exceptional darkness and duration, which resulted in solar irradiance levels of less than the 1% percentile [?] and rainfall intensities with return period of over 100 years in many places in south-eastern England. From the evidence provided by the radiation values of twelve sites, there were two major storm systems: the first arrived at Bracknell at about 0730 GMT, moved north and weakened over Bedfordshire and Cambridgeshire. The second system arrived at Bracknell at 0945 GMT and moved northeast producing lower values of global radiation than the first and being associated with the spectacular thunderstorms and blackness of the sky widely reported in the Press. The storms lasted well into late afternoon and probably dissipated over the North Sea after sunset." (R46)

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GWD2 Pogonips and Other Ice Fogs

Description. A winter fog occurring in high elevations characterized by the rapid crystalization of ice on animals and objects. Inhalation of ice fog is reputed to cause death.

Background. Dangerous ice fogs are said to occur in many highly elevated areas, but the pogonip of Nevada is the only such fog treated in the literature examined so far.

Data Evaluation. The few reports found on ice fogs or pogonips have a sensational aspect and cannot be taken too seriously. Rating: 3.

Anomaly Evaluation. The reputed dire biological effects of ice fogs, if true, have not been explained to the compiler's knowledge. Near-instant death upon inhaling fog would certainly tax medical theory. Rating: 2.

Possible Explanations. For the extreme biological effects reported, none.

Similar and Related Phenomena. Mists and epidemics (GWD3), where once again unusual weather conditions are blamed for biological effects.

Examples of Ice Fogs

X1. General observation. Nevada. "A curious phenomenon is often witnessed in the mountainous districts of Nevada. Mountaineers call it 'pogonip,' and describe it as being a sort of frozen fog that appears sometimes in winter, even on the clearest and brightest of days. In an instant the air is filled with floating needles of ice. To breath the pogonip is death to the lungs. When it comes, people rush to cover. The Indians dread it as much as the whites. It appears to be caused by the sudden freezing in the air of the moisture which collects about the summits of the high peaks." (R1, R2) W. J. Humphreys denies that the pogonip can cause death. (R3)

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GWD3 Mists and Epidemics

Description. The correlation of epidemics, particularly cholera outbreaks, with persistent mists or fogs.

Data Evaluation. The evidence linking mists to cholera epidemics is purely circumstantial and unsupported by scientific observations. The tales about "blasting fogs" are extracted from popular histories and are also suspect. Rating: 3.

Anomaly Evaluation. Although swampy and poorly drained areas are often associated with malaria, cholera, and other diseases, fogs and mists in themselves should not be responsible for disease. If blue mists and blasting fogs, as described below, are truly involved in epidemics, we have an important anomaly. Rating: 2.

Possible Explanation. The association of mists and cholera is probably just coincidental. It is possible that extreme cold and dampness (blasting fogs) could weaken plants and encourage rusts and other plant diseases.

Similar and Related Phenomena. The theorized influx of viruses and bacteria from outer space via cosmic dust.

Examples of Fogs or Mists Correlated with Disease

X1. 1832. England. Correlation of a blue mist and cholera. (R1)

X2. 1848-1849. England. Correlation of a blue mist and cholera. (R1)

X3. 1854. England. Correlation of a blue mist and cholera. (R1)

X4. 1866. Greenwich, England. "According to Mr. Glaisher, there was a particular state of the atmosphere during the three epidemics of cholera in 1832, 1848-1849, and 1854, characterised by a prevalent mist, thin in high places, dense in low. On the 30th ult. this gentleman, while looking from the grounds of the Royal Observatory, Greenwich, under the trees towards the boundary walls of the park, saw a dense blue mist (similar to what he had observed in 1854), which continued without intermission to the 6th inst. Ordinary mists pass away with the wind blowing at a pressure of half a pound to the square foot; but this mist was immovable before a wind blowing at a pressure of nine pounds on the same area. It was apparent on all sides, and extended fully to the tops of the trees, though not there so easy to distinguish. It was most easily discernible through as much atmosphere as possible, viewed from under a tree and looking under other trees. Thus seen, the boundary walls of Greenwich park and all objects near them were coloured blue. When looked at through gaps in trees, if there were others at a sufficient distance to form a background, it resembled thin smoke from a wood fire. The intensity of the blue was increased when viewed through a telescope with a low power. The only other mist which Mr. Glaisher knows connected with the prevalence of an epidemic is a yellow mist perceptible when scarlatina is prevalent." (R1) Blue mist seen on the Isle of Wight during the cholera epidemic. (R2)

X5. Early December 1930. Belgium. A dense fog was followed by 40 human and many animal deaths. Mud rains in parts of Europe. The deaths, however, were probably due to a high concentration of industrial pollutants under a temperature inversion. (R3, R4) Much was made of this incident at the time, but it seems identical to modern smog deaths.

X6. August 1694. Scotland. "During the night, a raw east wind from the North Sea blew over the county of Cromarty, to the north of Loch Ness, and was accompanied by a dense sulphur-smelling fog. The superstitious peasants opined that it was coming straight from the mouth of Hell. As dawn broke, this strange fog was already lifting in spots, but in many places it was heaped up in what was said to be like 'mountains of vapor', towering over valleys and dales. Soon, however, these too dissipated under the sun's rays---but a ghastly prospect was presented to the eye in the oatfields where the grain had been ripening with every indication of an early and bounteous harvest. A sort of mildew lay sprinkled on both blade and ear; as the sun shone on it, this mildew whitened and took on the appearance of flour, while the affected parts of the plants shrank and shriveled. In a few hours it was apparent that almost the entire crop had been destroyed---the worst devastation being in those fields over which the poisonous fog had lain the longest." (R5) There is some similarity between these "blasting fogs" and salt storms. See GWF4-X2.

X7. August 1720. Scotland. A "blasting fog" similar to that in X6. (R5)

References

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R3. Alexander, Jerome; "The Fatal Belgian Fog," Science, 73:96, 1931. (X5)

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GWD4 Dry Fogs and Dust Fogs

Description. Widespread hazes consisting of very fine, dry particles, usually dust, suspended in the air. Visibility in dust fogs is frequently severely limited, and the sun and moon are highly colored. Breathing may be impaired, and some experience a general malaise. Dust fogs may cover continent-sized areas and contribute to colored precipitation hundreds of miles from the dust's origin. Some dust fogs have seemed to be self-luminous at night.

Background. The Cape Verde dust fogs or red fogs have been recorded for centuries, not only far out into the Atlantic but far into Europe.

Data Evaluation. The true dust fogs have been described frequently. The more enigmatic dry fogs of 1783 and 1831, which afflicted much of the globe, are often mentioned in the older literature, but no scientific studies have yet been uncovered. Rating: 1.

Anomaly Evaluation. The frequent dust fogs radiating out from North Africa and the East Indies are included in this Catalog because, even though they are well-known and basically understood, they are remarkable in their geographical extent and meteorological effects. The following rating applies only to the great luminous dry fogs (as exemplified by the 1783 episode), which present serious problems in explanation. Rating: 2.

Possible Explanations. It is difficult to come to grips with the global dry fogs. One scientist proposed that the earth passed through a comet's tail in 1783. The luminosity of these dry fogs at night makes them resemble low-level auroras, which may mean they have an electrical origin.

Similar and Related Phenomena. The white sky phenomenon (GWC1); dark days and obscurations (GWD1). Low-level auroras (GLA4), auroral fogs and mists (GLA21), both in our catalog Remarkable Luminous Phenomena.

Examples of Dry Fogs

X1. Summer 1783. Much of the earth. A peculiar fog. "...it began on the 18th of June and at places very remote from each other. It extended from Africa to Sweden, and throughout North and South America. This Fog continued more than a month. It did not appear to be carried to different places by the atmosphere; because in some places it came on with a north wind and at others with a south or east wind, it prevailed in the highest summits of the Alps as well as in the lowest valleys. The rains which were very abundant in June and July did not appear to disperse it in the least. In Languedoc its density was so great that the Sun did not become visible in the morning till it was twelve degrees above the horizon; it appeared very red during the rest of the day and might be looked at with the naked eye. This Fog or Smoke had a diagreeable smell and was entirely destitute of any moisture, whereas most fogs are moist; besides all this there was one remarkable quality in the Fog or Smoke of 1783, it appeared to possess a phosphoric property, or a light of its own. We find by the accounts of some observers, that it afforded even at midnight a light equal to that of the full moon, and which was sufficient to enable a person to see objects distinctly at a distance of two hundred yards, and to remove all doubts as to the source of this light, it is recorded that at the time there was a New Moon." (R2) Also seen in Asia. Blamed on an eruption of Mount Hecla. (R1) First seen in Scandanavia on May 29, 1783. (R11) Also mentioned in many other articles. (R4, R12-R13)

G. White, author of the classic Natural History of Selbourne, mentioned other curious features of the remarkable summer of 1783. W.H. Larrabee quoted White in his summary paper on the 1783 phenomenon in an 1884 number of Popular Science Monthly (the forerunner of today's Popular Science---but more technical).

"The summer of the year 1783 was an amazing and pretentious one, and full of horrible phenomena; for besides the alarming meteors and tremendous thunderstorms that affrighted and distressed the different counties of this kingdom. the peculiar haze, or smoky fog, that prevailed for many weeks in this island,

and in every part of Europe, and even beyond the limits, was a most extraordinary appearance, unlike anything known within the memory of man. By my journal I find that I had noticed this occurrence from June 23d to July 20th, inclusive, during which period the wind varied to every quarter, without making any alteration in the air. The sun, at noon, looked as black as a clouded moon, and shed a rust-colored ferruginous light on the ground and floors of rooms, but was particularly lurid and blood-colored at rising and setting...The country people began to look with a suspicious awe at the red, lowering aspect of the sun, and indeed, there was reason for the most enlightened person to be apprehensive, for all the while Calabria, and part of the Isle of Sicily, were torn and convulsed with earthquake; and, about that juncture, a volcano sprang out of the sea on the coast of Norway." (R15)

X2. August 1821. Western Europe. This dry fog was similar to that of 1783 and lasted 12 days. (R4)

X3. May 1822. Europe. Another dry fog appeared suddenly. (R4)

X4. 1831. Almost worldwide. One could look directly at the sun. Nights were so bright that the smallest print could be read at midnight. (R4, R13, R14)

X5. Frequent occurrence. From Cape Verde hundreds of miles out into the Atlantic plus much of western Europe. The folowing account is from Teneriffe, in the Canary Islands. "From the first hours of the evening of February 15 (1898), there was observed a sensible but light fog; neither the strength of the wind (E. gentle breeze) nor any other phenomenon indicated that the supposed condensed vapours could be African dust transported by air. As the night advanced, the force of the wind increased, until it reached the value of a moderate gale. At about 5 a.m. on the 16th, some large drops of rain fell, but were inappreciable in the rain gauge. For a very short time the wind subsided, by and by again becoming a gentle breeze during the day and blowing due E. The fog became more dense, causing depression and a disagreeable feeling produced by its dryness. The sun, on account of its light being pale and feeble without the usual rays, was confounded with the moon; and it reminded one of the light of a voltaic arc seen through a frosted glass. The flame of a match appeared with a very marked violet hue. The drinking waters became salty and coloured as by oxide of iron. The dust was grey and extremely fine, and deposited itself on every object." (R6) (R3, R5, R7, R10)

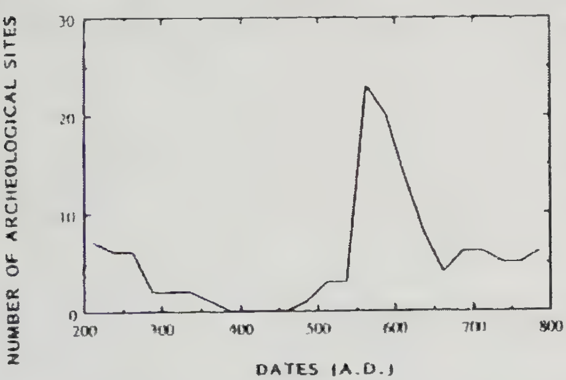
X6. Frequent occurrence. East Indian Archipelago. The dry fog of 1914. "The fog had a grey colour, and was most intense in the month of September, and especially in October, and disappeared when the rains fell. In its most typical form it appeared in Sumatra, in the neighborhood of Ambon and the islands to the southeast....In the morning the sun was not visible before eight o'clock, when it appeared as a dim red disc. Objects in general were barely visible at 500 metres' distance, and on the thickest days invisible within half this distance; the mountains had disappeared entirely from view." (R9) Another major recurrence in October 1902. (R8)

X7. 536 A.D. and 537 A.D.. Much of Europe and the Middle East. We introduce this catastrophic event of ancient times with an overview by R.B. Stothers fron the January 26, 1984 number of Nature.

"Dry fogs appear in the atmosphere when large volcanic eruptions inject massive quantities of fine silicate ash and aerosol-forming sulphur gases into the troposphere and stratosphere. Although the ash gravitationally settles out within weeks, the aerosols spread around the globe and can remain suspended in the stratosphere for years. Because solar radiation is easily absorbed and backscattered by the volcanic particles, a haziness in the sky and a dimming of the Sun and Moon are produced. Very dense and widespread dry fogs occur, on the average, once every few centuries. The sizes and intensities of some of the largest of them before the modern scientific era have been estimated by several indirect methods. The densest and most persistent dry fog on record was observed in Europe and the Middle East during AD 536 and 537. Despite the earliness of the date, there is sufficient detailed information to estimate the optical depth and mass of this remarkable stratospheric dust cloud. The importance of this cloud resides in the fact that its mass and its climatic consequences appear to exceed those of any other volcanic clouds observed during the past three millennia. Although the volcano responsible remains a mystery, a tropical location (perhaps the volcano Rabaul on the island of New Britain, Papua, New Guinea) can be tentatively inferred."

As seen in the quote from Stothers' paper above, volcanism has long been considered the primary cause of the 536-A.D. "dry fog" or "dust-veil event." M.G.L. Baillie challenged this consensus explanation in 1994. The London Times expanded on Baillie's contrary extra-terrestrial thesis:

"Now tree-ring data, published by Professor Mike Baillie of Queens University of Belfast, has brought catastrophes almost into modern times. The tree rings show that in the mid 530s---just about the time civilisation on Earth suffered a sharp setback---there was a sudden decline in the rate of tree growth which lasted about 15 years. Clearly, something dramatic had happened.



Following the dry fog of 536 A.D. there was a sudden, difficult-to-explain increase in the number of European archeological sites. The implication is that the catastrophe somehow reversed the downward trend of European civilization existing prior to the 536 event (noted in R20). Interestingly, rebounds in biological diversity are often seen in the fossil record after major catastrophic events! (R19)

"There are two possibilities: a huge volcanic eruption or a collision between the Earth and a solid object: an asteroid or comet. Ice-cores drilled from Greenland show no evidence of large-scale volcanic activity at that time, so Professor Baillie and others now believe a cosmic impact is more likely. The result would have been to throw up a huge veil of dust and debris, cooling the Earth and producing widespread crop failures."

In the scientific literature (R19), Baillie has elaborated on the cosmic-projectile theme, adding also that the dust veil could also have been created when the solar system passed through a cloud of cosmic dust.

The scientific literature hints at dust-veil events in more recent times:

(1) the white-sky phenomenon of 1912;

(2) the "dry fog" of 1783.

See details in GWC1 and GWD4-X1.

X8. General observations. The extraterrestrial explanation for the 536-A.D. dry fog advanced by Baillie in X7 has been contradicted by an historical survey by R.B. Stothers. He surveyed the historical data and shows that episodes of terrestrial volcanism correlated well with the major dry fogs, including that of 536 A.D. (R17)

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GWF FALLS

Key to Phenomena

GWF0 Introduction

Anomalous rain, snow, and hail are treated in the next chapter. Beyond these "nearly normal" forms of precipitation are those falling materials that do not belong aloft at all: large chunks of ice, living animals, non-meteoric stones, and many other nominally terrestrial materials. Charles Fort made much of falling materials, even though most of them can be explained rationally by appealing to recognized meteorological mechanisms; i.e., whirlwinds, waterspouts, tornados, etc. Fort did have a point, however, any small minority of falling material not succumbing to conventional explanations would require truly revolutionary explanations. Such is the claim of residual anomalies in all areas of science---and this claim is perfectly valid in this chapter.

The overwhelming majority of falls consist of terrestrially derived material and earth-dwelling animals. So-called sulphur falls almost invariably turn out to be wind-blown pollen. The sensationalized falls of fish and frogs, which are well-verified in the literature, are easily explained in terms of whirlwinds, waterspouts, and tornados. Immense falls of hay, leaves, and insects, though startling, are scarcely anomalous. Nature provides ready sources of such material as well as natural vacuum cleaners to snatch up light-weight objects and deposit them somewhere else. Even so, these types of falls present some enigmatic aspects: (1) The descent of some species of animals is so overwhelming in quantity that scientists are hard-pressed to explain where they could have all been collected; (2) The "purity" of the falls; that is, the absence of coexisting species and debris from the falling animals' habitat.

Falls of cobwebs and the so-called gelatinous meteors (or "pwdre ser") introduce a more unsettling factor. While admitting the reality of ballooning spiders, it seems that some of the great web falls involve a substance that may not be insect-produced---it is too strong and quickly evaporates away. It also falls in strands hundreds, even thousands of feet long. Some gelatinous meteors, too, seem to evaporate away strangely. If these properties can be verified, we have something more anomalous than a simple fish fall.

Another pair of phenomena with related characteristics will conclude this introduction: the large hydrometeors and the much-maligned thunderstone. Both phenomena typically occur during thunderstorms. A peal of thunder rings out and something strikes the ground nearby. If one finds a large chunk of ice, a passing plane can always be blamed; but if one finds a stone or even a meteor emotional disbelief takes charge. Yet, no physical reason bars the fall of meteorites during thunderstorms, nor can one deny the possibility of a strong whirlwind picking up a stone of several pounds weight and releasing it during a thunderstorm. After all some large hailstones reach several pounds, too. The point here is that the possibility of stonefalls should not be dismissed out-of-hand because of any innate distrust of legends carried over from ancient times.

The data presented below show rather conclusively that odd things do fall from the sky on occasion. Regardless of the sensationalism usually attached to these falls, most of them are not really very anomalous. A rain of frogs may be rare and certainly Fortean, but meteorology is well-equipped to deal with most aspects of this phenomenon.

GWF1 Ice Falls or Hydrometeors

Description. Chunks of ice that are substantially larger than the largest recognized hailstones; that is, more than 5 inches across and weighing more than 2 pounds. These ice masses often fall from a clear sky (sometimes with a whistling sound), or they may descend after a powerful bolt of lightning. The ice chunks may be crystal clear or layered or aggregations of small hailstones. Large blue-colored ice chunks are eliminated from consideration as having likely originated in leaky aircraft lavatories.

The diversity of fallen ice structures and the different meteorological conditions associated with them suggests that they may have several different origins.

Background. Today, the fall of large ice chunks is customarily blamed upon aircraft passing overhead. Blueish-ice "bombs" from leaky lavatories doubtless falls, off aircraft on rare occasions, but there are many pre-Wright examples of ice falls a.k.a. "hydrometeors". Nevertheless, most scientists discount these early reports and are satisfied with the aircraft explanation. The general public is, too. Other origins, especially extraterrestrial sources; that is, true ice meteors; are routinely rejected by meteorologists, who doubt their survival in the heat of atmospheric reentry.

Data Evaluation. Some of the pre-1900 ice falls recorded below may be apocryphal, but there is no denying the many modern reports of ice falls. Unfortunately, these data are mainly anecdotal. Yet, their sheer number and the quick preservation of some of the ice masses for analysis, make it hard to deny that large ice masses do indeed sometimes fall from the sky---even from clear skies with no aircraft detectable by eye or radar in the affected areas. Rating: 1.

Anomaly Evaluation. Many of the fallen ice masses under discussion are so large that the theory of hail formation is inadequate. By our definition, aircraft blue ice "bombs" are also eliminated. Indeed, some ice falls are so large that aircraft performance would be compromised. Conventional explanations, therefore, do not suffice here. Rating: 2.

Possible Explanations. (1) Vertical winds in storm cells may be much stronger than currently recognized---strong enough to support very large hailstones. (2) Some unappreciated storm mechanism may cause the aggregation of many small hailstones. (3) Despite scientific doubts, some hydrometeors may be the remains of reentering extraterrestrial ice masses; that is, true ice meteors. Modern close-up observations of comets and even some asteroids reveal that pieces of ice do exist in outer space in a wide range of sizes.

Similar and Related Phenomena. The fall of meteor-like objects during thunderstorms (GWF2); giant snowflakes (GWP2); giant hailstones (GWP5); icy minicomets (GWC20).

Examples of Ice Falls

X1. Late 1700s. Seringapatam, India. A block of ice as big as an elephant fell during the reign of Tippoo Sahib. It took three days to melt. (R1-R3) This purported event has always been a subject of derision. (WRC)

X2. May 8, 1802. Hungary. Mass of ice 3 feet long, 3 feet wide, and more than 2 feet thick fell during a storm. (R4, R5)

X3. May 12, 1811. Derbyshire, England. Lumps of ice a foot in circumference. (R4)

X4. July 24, 1818. Orkney Islands, Scotland. Jagged pieces of ice, some a foot long. When melted they emitted a sulphurous odor. (R4)

X5. 1826. Khandeish, India. A block of ice with a volume of a cubic yard. (R2, R4) The date is sometimes given as 1828.

X6. June 15, 1829. Cazorla, Spain. A block weighing 2 kilograms. (R5)

X7. April 1838. Dharwar, India. A mass of hailstones measuring 20 feet in its largest dimension. (R1, R2)

X8. May 22, 1838. Near Bangalore, India. Immense mass of hailstones cemented together found in a well. (R2, R3)

X9. October 1844. Cette, France. A block of ice weighing 5 kilograms fell. (R4, R5)

X10. August 1849. Scotland. "A curious phenomenon occurred at the farm of Balvullich, on the estate of Ord, occupied by Mr Moffat, on the evening of Monday last. Immediately after one of the loudest peals of thunder heard there, a large and irregular-shaped mass of ice, reckoned to be nearly 20 feet in circumference, and of a proportionate thickness, fell near the farmhouse. It had a beautiful crystalline appearance, being nearly all quite transparent, if we except a small portion of it which consisted of hailstones of uncommon size, fixed together. It was principally composed of small squares, diamond-shaped, of from 1 to 3 inches in size, all firmly congealed together. The weight of this large piece of ice could not be ascertained; but it is a most fortunate circumstance, that it did not fall on Mr Moffat's house, or it would have crushed it, and undoubtedly have caused the death of some of the inmates. No appearance whatever of either hail or snow was discernible in the surrounding district." (R4-R8)

X11. May 22, 1851. Bangalore, India. Ice masses as large as pumpkins. (R4)

X12. August 1857. Cricklewood, England. 25-pound mass of ice found on ground. Assumed to have fallen there. (R4)

X13. March 16, 1860. Upper Wasdale, England. Blocks of ice fell in a snowstorm. Looked like a flock of sheep on the ground. (R4)

X14. June 1881. Iowa. Mass of ice 21 inches in circumference falls with hail. (R4)

X15. August 1882. Salina, Kansas. An 80-pound hailstone. (R4, R9)

X16. December 6, 1893. Texas. A 4-pound lump of ice fell. (R4)

X17. August 1897. Scotland. "...a thunderstorm accompanied by heavy hail, although the hailstones were generally noted to be no larger than usual. However, shortly after the storm had passed away, at about 5 p.m., a shepherd saw what appeared to be a sheep lying prostrate on the ground. On closer inspection he found it to be a block of ice which he estimated to weigh about 50 kg. By the next morning this hadn't melted away but had broken up into smaller pieces."(R10)

X18. September 11, 1949. Stephens County, Texas. A 40-pound chunk of ice lands 15 feet from a Dr. Robert Botts. (R4)

X19. November 10, 1950. Bristol Channel, England. A chunk of ice weighing 14 pounds kills a sheep. Other large chunks found on ground. (R4)

X20. November 24, 1950. London, England. A piece of ice about a cubic foot in size smashes through a garage roof. (R4)

X21. November 30, 1950. Hampstead Norris, England. An ice block, 15 inches long, 7 inches wide, 4 inches thick, falls into a garden. (R4)

X22. December 26, 1950. Dunbarton, Scotland. Man sees a mass of ice fall on road and smash to pieces. 112 pounds of ice collected. (R4)

X23. 1951. Kempten, Germany. A carpenter working on a roof was killed by a piece of falling ice 6 feet long and 6 inches round. (R4)

X24. June 4, 1953. Long Beach, California. Fifty ice lumps, some weighing 75 kilograms each, fell. Total weight about 1 ton. (R5)

X25. January 1955. Los Angeles, California. Large chunks of ice fall, weighing between 6 and 26 pounds. (R4)

X26. July 30, 1957. Reading, Pennsylvania. Man and wife see a piece of ice 2 feet in diameter fall near them. (R4)

X27. January 26, 1958. San Rafael, California. Slab of ice, 2 feet square and several inches thick fell through the roof of a house. (R4)

X28. September 8, 1958. Chester, Pennsylvania. Large ice chunk crashes through the roof of a warehouse. (R4)

X29. 1959. Toccoa, Georgia. 30-pound ice chunk falls. (R4)

X30. September 11, 1959. Buffalo, New York. Ice chunk 1 foot long narrowly misses a child. (R4)

X31. December 1959. London, England. Basket-ball-sized ice mass damages a house. (R4)

X32. October 16, 1960. Melbourne, Australia. Two ice lumps the size of footballs just miss two golfers. (R4)

X33. February 1965. Woods Cross, Utah. 50-pound ice mass fell through the roof of the Phillips Petroleum Plant. (R4)

X34. February 1965. Aptos, California. A foot-long ice chunk falls on a house. (R4)

X35. February 5, 1968. Washington, D. C. A piece of ice 7-8 inches in diameter fell through an awning. (R4)

X36. February 22 or 23, 1969. Bracknell, England. Large ice mass crashes through the roof of a parked van. (R5)

X37. August 16, 1970. London, England. Large ice mass crashes through the roof of a house. (R5, R8)

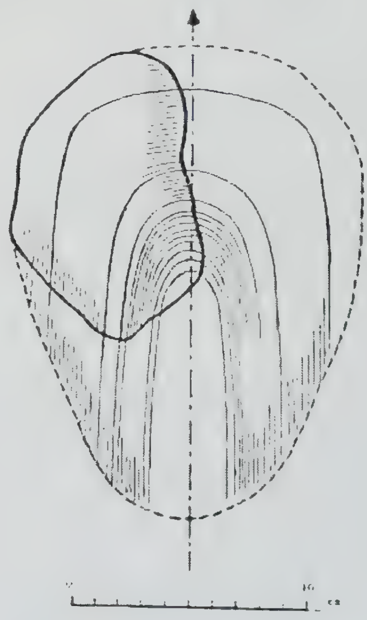
X38. August 19, 1971. Brive, France. A hailstone the size of a grapefruit injures a girl. Other hailstones weighing up to 3 pounds crashed through the roofs of houses. (R5)

X39. January 23, 1972. Surrey, England. A 4-foot, square block of ice fell. (R5)

X40. May 24, 1972. Riverside, California. "Building damaged by ice 'bomb': A chunk of ice weighing between 30 and 50 pounds fell from the sky and ripped through the roof of a downtown Riverside law office building and landed on a third floor hallway. No one was injured but damage to the building was estimated at several hundred dollars. Observing the evidence before it melted, authorities theorized it might have fallen from a passing plane, but a spokesman for the Federal Aviation Administration said he knew of no aircraft in the area at the time." (R12) Attributed to the Los Angeles Times.

X41. January 9, 1973. West Wickham, England. 10-pound block of ice shatters a front porch. (R5)

X42. April 2, 1973. Manchester, England. "A fragment of a very large hydrometeor was analysed in the laboratory where standard thin-section techniques were used to reveal its structure. The ice fell at the time of a severe lightning stroke which occurred in Manchester on 2 April 1973, a day when heavy rainfall was recorded in the area. Inquiries have revealed the pattern of nearby



Layered structure of a large hydrometeor (X42) aircraft movements at the time, and it is suggested that the lightning was triggered off by an aeroplane which flew into the storm. No definite conclusion as to the origin of the sample has been arrived at, except that it was composed of cloud water." The ice chunk fell 3 meters from the observer and scattered pieces around. Weight estimate of the composite mass was about 1-2 kilograms. (R5, R8, R13) One theory proposed that such large hydrometeors may form in the lightning discharge channels with the help of the electrostatic acceleration of matter. (R14-R17)

X43. September 22, 1973. Wombwell, England. A ball of ice crashes through a house roof. A fragment weighed 6 pounds. (R5, R8)

X44. December 13, 1973. Fort Pierce, Florida. An ice chunk roughly 10 inches in diameter fell through the roof of a house almost simultaneous with the launch of a Titan 3-C rocket from Cape Canaveral. Chemical analysis showed an unusual concentration of heavy metals. Since the rocket trajectory was out over the Atlantic rather than Fort Pierce, it was suggested that the chunk came from an airplane passing overhead. (R18)

X45. March 25, 1974. Pinner, England. A cuboidal mass of ice about 18 inches in diameter crashed into a car. A bucket of yellowish-brown ice was collected. May have fallen from an aircraft. (R5)

X46. January 24, 1975. London, England. A block of ice weighing about 50 pounds fell on an apartment roof. (R5, R19)

X47. March 7, 1976. Timberville, Virginia. Two blocks of ice fall. One was about the size of a basketball. It smashed through a tin roof. Chemical tests showed the pieces to be similar to local tapwater. (R20)

X48. January 2, 1977. Middlesex, England. A large ice chunk crashes through a bedroom ceiling. Size estimate: 3 feet long, 12-15 inches wide, 6-8 inches thick, weight more than 100 pounds. (R5, R21)

X49. May 1979. Forked River, New Jersey. "Robert Cloupe and his son Robbie were out in their garden in Forked River, Ocean County, New Jersey planting some vegetables on an overcast Memorial Day, 1979, when they were startled by a whistling sound in the sky. The sound, 'like a firecracker makes before it explodes,' Mr. Cloupe said, occurred around 3:45 p.m. Robbie told his father to look above them and together they observed 'something' falling several hundred feet to land in a field next to their neighbor's house a short distance away.... The object, they discovered, was apparently an ice ball. Having left a six-inch deep depression in the ground where it landed, the main mass had then broken up into 'grapefruit-sized chunks' six to eight inches in diameter which were spread over an area some 25 feet across." The object consisted of semihard ice and compacted snow. (R22)

X50. March 1982. Tecumseh, Oklahoma. An ice mass estimated at 30 pounds fell on the land of A. C. Hinson. Investigating meteorologists said that it was not a hailstone but might have fallen from an airplane or even come from outer space. (R23)

X51. September 1964. Transvaal, South Africa. "A large lump of ice fell from a cloudless sky one morning in September 1964 and landed only ten yards from a farmer in the Brits district of the Transvaal, South Africa. A whirring sound shortly before the impact alerted the farmer so that he saw the ice as it struck the ground. The lump was flattish-shaped and irregular, estimated at 11 x 9 x 6 inches, and gave off a peculiar odor, The farmer also observed that the ice was composed of numerous layers and that parts of its interior were brownish-coloured. He did not recall noticing aircraft in the vicinity at the time of the incident." This ice fall was later correlated with the passage overhead of an aircraft descending for landing. (R11)

X52. October 30, 1959. Beechwood, Missouri. Two basketball-size chunks of ice fell in this locale. One smashed through the roof of a house; the other on a fairway about 100 yards from two golfers. The Weather Bureau stated that conditions that day were not conducive to ice forming on aircraft. (R24)

X53. April 11, 1983. Wuxi, China. "Around midday (1250), on 11 April 1983, Sheep's Skin Lane, the east China city of Wuxi, was bustling with passers-by. Suddenly, a block of ice hurtled from the sky and splintered on the pavement in front of them. The block was 50-60 centimeters in diameter and 50 kilogrammes in weight." Chinese scientists presumed that the ice block came from outer space and estimated that before the heat of atmospheric reentry, the ice mass probably weighed about a ton. (R25, R26)

X54. June 824 A.D., Autun, France. The following quotation comes from a very old record of major European events. "A few days before the summer equinox, an enormous chunk of ice is said to have fallen with the hail in the country around Autun. It is said to have been 15 feet long, 7 feet wide, and 2 feet thick." (R27)

A fabulous and marvelous account, and perhaps apocryphal.

X55. August 1984. Kazan, U.S.S.R. "A Russian vacation camp supervisor was narrowly missed being struck by a block of ice falling from a cloudless sky has provided Soviet scientists with their first sample of an "ice meteorite," a Soviet report said yesterday.

"Anatoly Kozhukhov heard a whistling noise and jumped out of the way as the chunk of ice thudded into the sand two paces away from him at a camp near Kazan on the Volga River, the news agency Tass reported." (R28)

X56. June 26, 1985. Hartford, Connecticut. "Scientists yesterday tried to determine the origin of a 1,500-pound mass of ice that mysteriously dropped from the sky and smashed into a backyard fence.

"David H. Menke, director of the Copernican Observatory, said the ice was probably 6 feet long, 8 inches thick and moved at about 200 mph.

"'It's unusual in the fact that it fell from the sky,' said Craig Robinson, curator of the planetarium. 'That does not happen often.'

"A 13-year-old boy was in his yard Monday with a friend when the ice came 'whirring' from the sky and smashed into the fence about 10 feet away from them."

Robinson doubted that such a large mass of ice could have come from an airplane. (R29)

X57. June 1990. Jerrys Run, West Vigginia. "Heisel and Alice Amos, and their grandson, Aaron Hupp, had just turned on a movie on television when the house was jarred with what Mrs. Amos thought was an explosion.

"Looking out the front door, they saw their son, Donald, 43, looking in the direction of their television satellite dish some 30 yards away where something had hit the ground with a terrific impact.

"Inspecting that area, they found a hole some 24 inches long and 18 inches wide, and about four to six inches deep filled with large chunks of broken ice. Amos said pieces of baseball- and marble-size ice were scattered in a 30-foot radius around the hole."

Further facts from this newspaper account:

1. Several other chunks of ice were found in an area about 1 mile long;
2. Some chunks made whistling sounds as they fell;
3. The larger chunks were completely transparent except for a yellowish-brown streak;
4. Many of the chunks had sand in them;
5. Some contained holes;
6. The weather was clear;
7. The Federal Aviation Administration stated that if the ice originated in aircraft toilets it would have been blue due to the chemicals used. (R30)

X58. June 15, 1993. New Monterey, California. A report from a local paper: "On June 15, 1993, two large, basketball-sized chunks of ice fell from the sky and came down in two separate locations in New Monterey, California. The two incidents occurred at 12:30 p.m., two blocks apart. Battalion Chief Mike Cooley of the Monterey Fire Department said two men working on a nearby roof told firefighters they heard a whistling sound and then saw something smash through the roof of an apartment house at 803 Hawthorne Avenue. It made a bowling-ball-size hole in the building's roof and ceiling and landed on a bed in an apartment below, where it shattered.

"The second iceball landed with 'a big whomp'and splattered on the sidewalk in front of the Knapp Mill and Cabinet Company, located at 775 Foam Street." (R31)

The FAA stated that no aircraft were in the vicinity of Monterey at 12:30 P.M.

X59. March 23, 1995. Yaodou Village, Zhejiang Province, China. On April 3, 1995, The Reuter news agency provided some interesting details on this ice fall.

"Chinese experts have recovered what they believe to be chunks of a meteoric ice that fell to Earth in Zhejiang Province, Xinhua news agency said.

"Amateur geologist Zhong Gongpei was nearby, [on] March 23, when farmers saw three large chunks of ice crash with a whoosh into paddy fields at Yaodou village, Xinhua said late Saturday.

.....

"According to witnesses, [they] fell with a 'whoo-ing' sound, [left] a cloudy streak, then came crashing down into three fields about one kilometre apart, Xinhua said.

"Zhong rushed to the scene, recovered two pieces and sent both to Purple Mountain [Observatory] on March 29 with the aid of a frozen-food company, which kept them from melting.

"The largest chunk, now about the size of a fist, left a crater about one metre in diameter.

.....

"They are white, semi-transparent, with an irregular shape and what are apparently air bubbles on both the surface and inside the ice. Unlike manmade ice, the ice has air bubbles, is relatively light and doesn't have the layered structure of hailstones." (R32, R33)

X60. March 1996. Ecclesfield, United Kingdom. Most of the ice falls admissible to this catalog are either excessively large or have properties that essentially eliminate an aircraft origin. A good example of a prosaic origin for falling ice is a blue color created by leaking aircraft lavatories. Said color being due to the addition of chemicals to aircraft toilet water.

The Ecclesfield ice fall is anomalous not so much for its lack of the tell-tale blue color but rather for its tear-drop shape. Weighing about 4 pounds (2 kilos), one calculates its volume as about 2 liters, or approximately the size of two one-quart milk bottles. Teardrop ice masses of this volume defy explanation, especially if a leaking aircraft aircraft lavatory can be eliminated. (R34)

An outer-space origin, however, is not as easy to rule out. The atmospheric reentry of a large, irregular chunk of space ice could explain the Ecclesfield teardrop. By way of analogy, we refer to the the common teardrop-shaped tekites of Australasia, which were apparently shaped by aerodynamic forces acting upon droplets of molten rock reentering the earth's atmosphere. (See ESM3 in our catalog Neglected Geological Anomalies)

Of course, without more facts and (ideally) scientific testimony, one cannot rule out a hoax here.

Photograph of the teardrop-shaped ice mass that reportedly fell in Ecclesfield, U.K. in 1996. Weight: about 4 pounds. (X60)

X61. July 4 and 15, 1997. Near Campinas, Sao Paulo State, Brazil. "Two large blocks of ice which crashed into Brazil's Sao Paulo state from clear skies are believed to be part of a meteor. According to Brazilian researchers. The first chunk weighed more than 110 pounds and tore through the tiled roof of a bus factory July 11 in Campinas. The second plummeted to the ground July 15 about 37 miles north of Campinas, causing a small crater. Officials at the local airport ruled out the possibility that the ice may have fallen off passing aircraft as none were in the area when the two chunks fell." (R35)

Once again multiple, nearly simultaneous falls of large ice masses in the same area. Also, still another roof was an ice chunk's target.

X62. July 26, 1998. Rue, Switzerland. "On Sunday July 26, 1998, at around 9^h45^m Central European Daylight-Saving Time (7^h45^m UT), a Rue farming couple were in front of their house when they heard a whistling sound 'like a big rocket on August 1' (Swiss national holiday). They just had time to see a block of ice the size of a 'football' pass in front of their field of vision and crash into the tarred path near to their farm. The block broke up into thousands of pieces and the witness recuperated [sic] the largest which was 'the size of a skittle.' The ice was 'very hard' and 'snow-colored.'

"The witness estimated the weight of the ice block at 7-8 kg and the piece he was able to recuperate [sic] at 6-7 kg. Unfortunately, he did not think of conserving the block in the freezer, and let it melt near his house after having shown it to his neighbor, who had also heard the noise."

Swiss aviation officials claimed they could not identify any aircraft that might have been responsible "because of incertitude over the time of the incident"! (R62)

X63. January 2000. Various localities in Spain. The June-2000 ice falls in Spain were numerous and well-observed. Some of the reports were also accompanied by preserved specimens.

This series of ice falls attracted the attention of scientists---who usually ignore ice-fall anecdotes---and, in consequence, led to serious professional consideration of the possible reality of ice meteorites or "hydrometeors". However, as indicated below, the Spanish "hydrometeors" are not thought to have been of extraterrestrial origin. But how they might have been formed within the earth's atmosphere (assuming that is really where they originated) is a major meteorological mystery.

Our newsletter Science Frontiers followed the story of the Spanish falls with three articles in 2000, 2002, and 2003. These have been edited and reproduced below.

TARGET: SOUTHERN SPAIN [date: 2000] Early in January 2000, southern Spain was bombarded with at least 30 rather large blocks of ice, some weighing 4 kilos (about 9 pounds). Chemists at the University of Valencia found none of the microorganisms that would identify the ice chunks as falling off aircraft with leaky toilets. One frozen projectile hit an automobile, but the driver was not hurt; another glanced off the shoulder of an elderly woman living in Almeria.

As to be expected, the Spanish newspapers played the phenomena for all they could. Also to be expected were a few fraudulent reports. It was all great fun, but scientific explanations for the apparently bona fide hydrometeors are lacking. (R38)

REVISITING THE SPANISH HYDROMETEORS OF JANUARY 2000 [date: 2002] The hydrometeors we reported above involved about 30 ice blocks in the kilogram range. They fell on a sunny day in southern Spain. Happily, some of these large ice chunks were retrieved and preserved by Spanish scientists. Some of the findings have been reported in Science, which is in itself an anomaly, considering the scientific community's disdain for events of a Fortean nature.

The analysis of the preserved ice blocks revealed none of the contaminants typical of aircraft lavatories. In fact, no large aircraft were overflying the region when the ice blocks crashed to the ground. Neither were the ice masses extraterrestrial in composition (i.e.; no typical cometary debris or the like). To all appearances, they were simply frozen terrestrial rainwater.

When sawn up, the blocks were seen to be chock-full of air bubbles. Some onion-skin layering also appeared. The contained gases, such as ammonia, and particulates suggested that---despite their size and the clement weather---they were just hailstones! But they were certainly not ordinary hailstones and where could they have come from?

A radical "hailstone" theory has been advanced, based upon the unusually cold and moist upper atmosphere present at the time. If ice nuclei existed, say 19 kilometers high, and they took 10 minutes to fall to earth; it is conceivable that hailstones of the size collected might form. Given the fair weather, the only ice nuclei one can imagine would be in the lingering contrails of high-flying jets. These can persist for days.

However, few meteorlogists are buying the clear-sky hail theory. (R40)

NEVER, NEVER, NEVER!! [date: 2003] C. Fort and his disciples have collected hundreds of reports of large ice chunks falling from cloudless skies. Some accounts go back centuries. Such ice falls, or "hydrometeors," are automatically sloughed off by mainstream meteorologists, who inevitably pass them off as ice detached from leaky aircraft lavatories.

The bombardment of Spain in 2000 by a couple dozen hydrometeors did attract some scientific attention. The Spanish hydrometeors fell from stormless skies, weighed several kilos, and had the onion-skin structure of normal hailstones. Their chemistry was also that of hailstones, not aircraft lavatories. Additionally, the presence of air bubbles seemed to rule out an extraterrestrial origin.

Now [2003], four years later, we know that hydrometeors are not aiming only at Spain but may fall anywhere---as Forteans have always claimed. Some of the recent, non-Spanish hydrometeors weigh 25-35 pounds and have possessed enough kinetic energy to punch holes in roofs and windshields.

Even so, scientists are reluctant to accept the existence of massive hailstones bombarding the earth in fair weather. C. Knight, a hail expert at the University Corporation for Atmospheric Research, Boulder, Colorado, is quoted as saying, "I would be tempted to say 'never' on this." (R42)

X64. January 2002. Charleston, South Carolina. This ice fall, like so many others, crashed through a roof. The target in Charleston was an Acura car dealership. M. Higgins, the parts-and-service manager testified as follows:

"'There was a 2½-foot-by-3½-foot piece---a pretty big slab---on the floor, with lots of little chunks,' said Higgins, who added the ice was clear and pure, like normal ice."

The FAA reported that there were no aircraft in the area at the time of the fall, nor were meteorological conditions conducive to ice formation. (R39)

X65. November 4, 2005. Kent, Washington. The Halte family returned home to find a hole in the ceiling of their daughter's bedroom. Five chunks of crystal-clear ice lay on her bed. Three were grapefruit-size. Three additional ice chunks were found in the backyard. FAA investigators confirmed that the ice chunks could not have come from aircraft because they were not bluish like aircraft lavatory water. (R43)

X66. December 10, 1980. Birmingham, England. An ice lump weighing 1 pound, 6 ounces (626 grams) fell into a garden at Kings Norton. The lump was almost spherical and had a circumference of 12 inches. No storm in area mentioned. (R46)

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GWF2 Stone Falls

Description. The fall of stones, singly or in showers, larger than coarsest wind-carried sand, (say, more than ¼-inch in diameter). Most stone falls are recorded during powerful thunderstorms and often in conjunction with loud peals of thunder. The luminous streaks associated with the falls of meteorites have sometimes been reported. Nevertheless, the recovered stones are usually of indisputable terrestrial origin and do not bear the marks of atmospheric reentry.

Background. Such observations are the basis of the discredited thunderstone belief. Many ancient peoples believed that lightning and thunder were accompanied by a missile, often shaped like an ax head, that was hurled by some supernatural agency. So strong is scientific antipathy towards these supernatural overtones that stone-fall reports are usually rejected with contempt regardless of their merits.

Data Evaluation. Stone-fall data are weak. Almost all testimonial. These data are gathered under stressful conditions that encourage distortion and exaggeration. Other phenomena, such as ball lightning and ordinary meteors, have similar characteristics, thus confusing the situation. Finally, it is always difficult to be sure that recovered stones are not just indigenous rocks that happened to be in the area where the phenomenon occurred. Rating: 3.

Anomaly Evaluation. Two kinds of anomaly may be present here: (1) If the fallen stones are terrestrial in origin and have been picked up by small whirlwinds, the weights of the stones infer higher vertical wind velocity components than generally allowed in thunderstorms; and (2) If the stones are meteoric and fall preferentially during thunderstorms, a cause-and-effect relationship is inferred. Rating: 2.

Possible Explanations. (1) The stones are levitated by exceptionally powerful winds during violent storms; (2) The stone falls are hoaxes; and (3) A few may be truly extraterrestrial objects that have somehow escaped the heat trauma of atmospheric reentry.

Similar and Related Phenomena. The similarities of stone-falls and ice-falls (GWF1) cannot be ignored. Both are frequently accompanied by loud claps of thunder and in size greatly exceed the dimensions allowed by meteorology for wind-levitated stones and hail. Some ball-lightning phenomena may resemble those of stone-falls (GLB1 in Remarkable Luminous Phenomena in Nature). True meteorites (AYO in The Sun and Solar System Debris and ESM2/ESM3 in Neglected Geological Anomalies.

Examples of Stone Falls

X1. July 1681. North Atlantic Ocean. The reknowned Arago stated: "Without having the slightest wish to revive antiquated ideas regarding thunder-stones, I shall simply remark here, that it is not proved that we should absolutely regard as false the whole of the narratives, in which the fall of various matters is related to have accompanied thunder storms. What pretext, for example, is there for considering as untrue the following fact, which I extract from the works of Boyle. 'In July 1681, a thunderstorm produced a great deal of damage near to Cape Cod, upon the English ship the Albemarle. A flash of lightning was followed by the fall of a burning bituminous matter into the boat hanging at the stern, which gave out an odour similar to that of gunpowder. This substance was consumed on the spot, and it was in vain that they attempted to extinguish it with water, and to sweep it overboard with a broom.'" (R1, R29, R30)

X2. Summer 1846. Richland, South Carolina. A 6 1/2 ounce stone, almost perfectly round, fell during a violent thunderstorm. The exterior was coated with a reddish brown glaze; the interior was like firebrick. (R2)

X3. September 1850. Barcelona, Spain. Conical stone. Specific gravity: 8. 12. Fell during thunderstorm. (R3)

X4. September 25, 1851. Bombay, India.

"On the 25th of September a violent explosion occurred in the air at Bombay, followed by a wild rushing sound overhead, heard at various points over an area of thirty miles in length and eight in breadth, followed by a severe concussion, as if a heavy body had fallen, just before the occurrence of which a large fire-ball was seen plunging into the sea." A thunderstorm was in progress. (R4) This account sounds as if a true meteor had fallen during a thunderstorm, either through coincidence or some unappreciated connection between thunderstorms and meteoric activity. Note also that India is also famous for remarkable ice falls (GWF1) and fish falls (GWF9).(WRC) A much more detailed account of the X4 fall may be found in R5.

X5. March 18, 1851. Dhatmah, India. During a heavy thunderstorm, a meteor-like object was seen to fall and hit the ground, with considerable noise. (R4)

X6. April 30, 1851. Kurrachee (sic), India. A violent explosion was heard during a thunderstorm and, about half a minute later, a meteor was seen falling into the sea. (R4)

X7. May 13, 1856. Bremervorde, Germany. "A fall of meteoric stones took place near Bremervorde a short distance from Hamburg, on the 13th of May last, at 5 o'clock, P. M. It took place during a storm accompanied by thunder and lightning. A number of stones have been found. One of them weighed nearly 7 lbs., another 3 1/3 lbs., a third two-thirds of a pound. They were covered with a black crust apparently the effect of fusion. In the fracture, the stone has a gray color, and shows several minerals, among which there is a large quantity of native iron and pyrites." (R6)

X8. April 29, 1868. Birmingham, England. A violent thunderstorm. "There was an extraordinary phenomenon during the deluge of rain. From nine to ten, meteoric stones fell in immense quantities in various parts of the town. The size of these stones varied from about one-eighth of an inch to about three-eighths of an inch in length, and about half those dimensions in thickness. They resembled in shape broken pieces of Rowley ragstone. A similar phenomenon visited Birmingham ten years ago." (R7) Subsequent analysis of the stones confirmed that they were similar to the Rowley ragstone, a common local formation. (R8) The date of this event is given as May 30, 1869, conflicting with R7 and R8. (R10) The Birmingham fall is a possible case of levitation by a whirlwind or tornado.

X9. May 25, 1869. Wolverhampton, England. Many pebbles, about 3/4 of an inch in diameter, fell during a powerful thunderstorm. (R9) Meteoric origin of the stones doubted. (R10)

X10. June 12, 1858. Birmingham, England. Shower of stones during a violent thunderstorm. (R7, R10)

X11. June 26, 1880. Chelsea, England. About 3 p. m., in the midst of many peals of thunder, one clap was heard which sounded far louder and sharper than the others, and gave one the idea of a conservatory being shattered. At this time, what appeared like a ball of fire fell on the chimney stack of 180 Oakley street. The servants sitting in the kitchen were suddenly alarmed by the room being filled with smoke and a heavy black mass falling down the chimney into the grate, where it appeared to break and scatter fragments over the room. They naturally rushed from the room, but as soon as they recovered from their fright, and the smoke had somewhat dispersed, they returned to the kitchen to ascertain what had really happened. Among the debris in the grate a piece, apparently of a ball about 8 or 9 inches in diameter was found, like a cinder with here and there fragments of metal in it." Investigators thought that lightning had perhaps fused material in the grate. (R11-R12)

X12. Circa 1883. Guildford, England. An iron sphere was found at the bottom of a ten-inch-deep hole where lightning had been seen to strike. The hole had charred sides. (R13) Like so many old tales, this one is impossible to evaluate. (WRC)

X13. No date given. Canton de Vaud, Switzerland. Stones up to 1 1/2 centimeters in diameter fell. No storm mentioned. (R14)

X14. No date given. Chateau Landon, Switzerland (?). Small calcareous stones 3 centimeters in diameter carried 150 kilometers by the wind. No storm mentioned. (R14)

X15. 1883. Sweden. Stones the size of filberts enveloped in large ovoid hailstones. The stones were apparently carried 60 kilometers. (R14)

X16. August 1887. Harrowgate, England. Simultaneous with a sharp crack of thunder, a white light fell to earth. A small dense stone was found where the earth had been disturbed. (R15)

X17. October 15, 1890. South Pacific Ocean. A bulky mass was seen falling into the sea during a violent thunderstorm. (R16)

X18. 1892. Hereford, England. A bolt of lightning fell into a yard, leaving a sulphurous smell and fragments of a metal-bearing material. (R17)

X19. No date given. Casterton, England. "I have frequently been struck by the fact of thunderbolts falling during violent storms, and of their simultaneous appearance with flashes of lightning. That masses of matter occasionally accompany the electric fluid when it reaches the earth there is no question; they have been seen and described as 'balls of fire,' and I have in my possession one that fell some time ago at Casterton, in Westmoreland. It was seen to fall during a violent thunderstorm, and, killing a sheep en route, buried itself about six feet below the surface, and when dug out shortly after it was still hot. It appearance it much resembles a volcanic bomb; it is about the size of a large cocoa-nut, weighs over 12 lbs., and seems to be composed of a hard ferruginous quartzite. I have not yet submitted it to a technical analysis, but hope to do so shortly. There is an external shell of about an inch in thickness, and this contains a nucleus of the same shape and material as the shell, but is quite independent of it, so that the one is easily separated from the other; I attribute this separation of the parts to an unequal cooling of the mass." (R18)

X20. July 13, 1909. Ongar, England. "During the severe thunderstorm on the 13th inst. a meteoric stone fell in the stable yard here with a terrific explosion when within a few feet of the ground, embedding itself in the gravel about 8 inches, the ground around for several feet being perforated with small holes caused by the fragments. The main part and fragments which we could collect weighed 1 lb. 13 oz. The fall was witnessed by my daughters, who were sheltering about eight yards away." (R19)

X21. March 4, 1912. St. Albans, England. During a heavy thunderstorm which ensued on March 4 between 2.30 p.m. and 4.15 p.m., an aerolite was observed to fall at Colney Heath, near St. Albans. The observer, who has placed the specimen in the hands of Mr. G.E. Bullen, of the Hertfordshire Museum, for examination, stated that the stone fell within a few feet from where he was standing, and that it entered the ground for a distance of about 3 ft. Its fall was accompanied by an unusually heavy clap of thunder. The example, according to Mr. Bullen, who describes it in Nature, weighs 5 lb. 14 1/2 oz., and measures 6 3/4 in. by 5 5/8 in. at its greatest length and breadth respectively. The mass is irregularly ovate on the one side, and broken in outline on the other. The actual surface throughout is fairly deeply pitted, and under magnification exhibits the usual chondritic structure of the crystalline matter, with interspersed particles of what appears to be nickeliferous iron. Mr. Bullen has since written to Nature to say that he has since submitted the stone for examination to Dr. George T. Prior, of the British Museum (Natural History), who informs him that it is not of meteoric origin." (R20, R21)

X22. March 27, 1921. Rome, Italy. (R22)

X23. General observations. A review of the thunderbolt theme in literature. No specific examples. (R23)

X24. General observation. The concept of the thunderbolt is only the childish belief of unenlightened peoples. (R24, R25)

X25. General observation. Review of the thunderbolt theme in Maori folklore. (R26)

X26. General observation. A general history of the thunderbolt belief. (R27, R28)

X27. July 17, 1860. Wolverhampton. England. A violent rainstorm was accompanied by "torrents" of so many small, black angular stones that shovels had to be used to collect them. (R31)

X28. May 22 and 23, 1884. Bismarck, North Dakota. About 9 P.M. on the 22nd. and around noon on the 23rd, pistol-like sounds were heard throughout the city. The sharp noises were determined to be due to the fall of small flinty stones. A meteoric origin was proposed. (R32)

X29. June 6, 1891. Pel-et-Der, France. A fall of irregularly shaped stones, 2.5-3.5 centimeters in size. The fall covered an area 50 x 200 meters. (R33)

X30. November 1921-March 1922. Chico, California. One of the most widely popularized stone falls seems to have been a hoax, although this was never proven. Chico's long series of stone barrages made good newspaper copy and the town's dilemma was widely heralded; even the staid New York Times allowed a few items on the months-long phenomenon. (R34)

Briefly, beginning in November 1921, this small California town was pelted with stones whose source was never found. The short showers of small stones ---some weighing up to a pound---continued sporadically for several months. Some windows were shattered, but mainly the stones fell on roofs, damaging some.

Townspeople searched everywhere for the source, suspecting that small boys were bombarding the town. The supposed perpetrators were never found. More likely, it was thought, some hoaxers had rigged up a powerful catapult and flung the stones (and occasionally some almonds!) into the town from its outskirts. (R36) No such apparatus was ever found despite the many showers over several months of time. (R35)

The Chico stone showers were real enough. A poltergeist was suggested; some spiritualists called them "apports" (things that materialize out of nowhere). Most, however, bet on hoaxers. In any case, the showers stopped suddenly in March 1922. To our knowledge, they have not recurred.

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GWF3 Sulphur/Pollen Falls

Description. The fall of a yellowish substance in chunks, in the form of dust, or in yellow rain. On rare and questionable occasions, the substance has been said to be burning as it fell. In other circumstances, the collected matter can be burnt and seems to have some of the properties of sulphur. Most often, though, the fallen material is quickly identified as pollen, particularly pine pollen.

Background. Sulphur/pollen falls bring to mind the Biblical falls of fire and brimstone. Indeed some sulphur/pollen falls have been linked with the imminent end of the world. As in the case of thunderstones, scientists have gone out of their way to deny the possibility of sulphur falls, blaming all such phenomena on pollen falls. A few cases do not yield to this explanation so easily. We present these here along with a few run-of-the-mill cases of misidentified pollen falls.

Data Evaluation. The data supporting the reality of true sulphur falls are old and very weak. The eye-witness accounts are old and shaky; the purported chemical analyses are presented without adequate detail. Rating: 3.

Anomaly Evaluation. The fall of free sulphur, which is rarely found in surface deposits where winds could pick it up, would seem to be very unlikely although not impossible. Volcanic eruptions might also contribute sulphur. A significant anomaly would be posed only if the remarkable tales of falls of burning sulphur were true. Overall rating: 3.

Possible Explanations. It cannot be denied that almost all so-called sulphur falls are really pollen falls. Yet, as mentioned above, real falls of free sulphur are definitely not impossible---just improbable. Falling, burning matter might conceivably be meteoric. (See X8, for example.)

Similar and Related Phenomena. Rain colored other than yellow (GWP10). Dust falls with various hues are so common and well-understood that they are not included in this Catalog. Exceedingly rare are reports of falls of other types of burning materials (GWF2-X1). Ball and bead lightning on occasion seem to leave behind residues of burning material (GLB and GLL23).

Examples of Sulphur/Pollen Falls

X1. June 1642. Magdeburg, Germany. Burning lump of sulphur the size of a man's fist. (R7) Too large to be pollen? (WRC)

X2. May 16, 1646. Hasnia, Italy. Heavy rain leaves sulphurous powder. (R17) This is a more typical observation. Pine pollen is the usual verdict. (WRC)

X3. March 1832. Kourianof, Russia. "In March last, there fell in the fields of the village of Kourianof, thirteen versts from Wolokolamsk, a combustible substance of a yellowish color, at least two inches thick, and covering a superficies of between six and seven hundred square feet. The inhabitants, at first, thought it was snow, but on examination, it appeared to have the properties of cotton, having, on being torn, the same tenacity; but, on being put into a vessel full of water, it assumed the consistency of rosin. On being put into the first, in its primitive state, it burnt and sent forth a flame like spirits of wine; but in its resinous state, it boiled on the fire, without becoming inflamed, probably because it was mixed with some portion of snow, from which it had been taken. After a more minute examination, the rosin had the color of amber, was elastic like indian (sic) rubber, and smelt like prepared oil, mixed with wax." (R2) Obviously, one cannot do much with a datum such as this, but the time of year and reported properties militate against the pollen theory. (WRC) Item first published in R1.

X4. June 1841. Pictou, Nova Scotia, Canada. Yellow matter fell on a vessel in Pictou harbor. Swept up by the bucketsfull. Examination proved it to be pollen. (R3)

X5. 1850. Napoleon, Arkansas. Rain had the appearance of liquid sulphur and left a thick scum on surfaces. Pollen suspected. (R4)

X6. October 18, 1867. Thames Ditton, England. "The inhabitants of the village of Thames Ditton, Surrey, were, on Friday night, October 18th, 1867, a good deal startled at witnessing a very strange phenomenon, which had the appearance of a shower of fire. The shower lasted about ten minutes, and during its continuance afforded a brilliant light. Next morning it was found that the waterbutts and puddles in the upper part of the village were thickly covered with a deposit of sulphur." (R5) Pollen would hardly burn while falling, but neither would particles of free sulphur. (WRC) See also X8.

X7. February 14, 1870. Genoa, Italy. A remarkable rain of yellowish matter that proved to be pollen. (R6)

X8. June 17, 1873. Proschwitz, Austria. "It is remarkable that perfectly authentic statements were received of the deposition, soon after, or about the time of, the meteor's explosion over Zittau and its neighborhood, of a mass of melted and burning sulphur the size of a man's fist, on the roadway of a village, Proschwitz, about 4 miles south of Reichenberg, where the meteor exploded nearly in the zenith. It was stamped out by a crowd of the villagers, who could give no other explanation of its appearance on the spot other than that it had proceeded from the meteor; on examination at Breslau some remnants of the substance proved to be pure sulphur." (R7)

X9. April 18, 1883. Iowa. An abundance of pine pollen was found floating on a pond. Pines in nearby forests not in bloom, so the pollen must have travelled at least 300-400 miles. (R8)

X10. May 12, 1886. Munich, Germany. Heavy rains cover pools and streams with a yellow matter. Local populace thought it was sulphur and betokened the end of the world. Scientists identified it as fir pollen. (R10)

X11. March 4, 1892. Balearic Isles. A violent north wind brought a rain that covered the ground with a yellow coating that proved to be sulphur. (R11)

X12. April 13, 1894. Adissan, France. (R12)

X13. March 21, 1898. Mount Vernon, Kentucky. A supposed sulphur fall. The fallen substance burned and gave off sulphur-like fumes. Editor of journal insists it must have been pine pollen. (R13)

X14. June 1, 1902. England. (R15)

X15. May 4 and 21, 1908. Orleans. France. (R16)

X16. General observations. The so-called "sulphur rains" are nothing more than pollens falls. (R9) Except where real sulphur may be blown from volcanos. (R14)

X17. General observations. "Pollen of various plants, as previously noted, is one of the most common constituents of atmospheric dust; for instance, Miquel found that there are often a thousand pollen grains to each cubic meter of air. But pollen deserves more extended notice because it is really showers of pollen that have been so often reported as showers of sulphur. The yellow color suggested sulphur; pollen, especially of pine, is highly inflammable, the imagination supplied the smell of brimstone, and superstition jumped at the conclusion that the devil had been busy. The occasional phosphorescent appearance of pollen falls at night also has encouraged preternatural speculations." (R18)

X18. April 11, 1832. Europe. 'This substance fell from the sky on the 11th April, 1832, 13 werstes from the town of Wolokalamsk, and covered to the thickness of 1 to 2 inches a space of 8 to 10 square rultres. It was of a wine yellow, transparent, soft, and smelling like rancid oil. Its sp. gr. was 1.1. It melted in a close (sic) vessel, and yielded the common products of vegetable substances, leaving a brilliant charcoal. It burnt with a blue flame, without smoke. It is insoluble in cold water, but melts in boiling water, and then swims on the fluid. Boiling alcohol dissolves it. It dissolves also in carbonate of soda, and the acids separate from the solution a yellow viscous substance, soluble in cold alcohol, and which contains a peculiar acid." (R19)

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Examples of Falls of Manna

X1. 1824. Persia. Ground covered in some regions by edible lichens, called manna. (R1)

X2. 1828. Persia. Edible substance said to fall from the sky. "It occurred in such abundance that the ground was of a sudden entirely covered by it over a great extent. In some spots it was five or six inches deep. It was eaten by cattle, and particularly sheep; and bread was made of it, which afforded nourishment to man. Such were the accounts furnished to the French Consul in Persia, by a Russian general, who was an eye-witness." (R1) The fallen substance was later identified as the plant Parmella esculenta. (R2, R10) This classic example said to occur in 1829. (R3)

X3. Spring 1841. Lake Van, Turkey. The ground was covered to depths of 3 or 4 inches by a gray, granular substance that was pleasant to the taste. Bread was made from it. (R10)

X4. January 1846. Jenischehir, Turkey. Edible substance falls during a time of famine. "It lasted some days, and the pieces of lichen were of the size of hazel-nuts. They were ground into flour, the bread from which was pronounced little inferior to wheat bread. Another account says that the manna was of greyish-white colour, rather hard and irregular in form, inodorous and insipid." (R10, R17) Another report puts this fall in April 1846. (R3)

X5. April 18, 1848. Byazid, Turkey. Edible lichens said to have fallen from the skies. (R4)

X6. July 1864. Diarberker, Turkey. Manna appeared. Said to be lichen. (R5, R6)

X7. Circa 1887. Turkey. The following description was provided by a Mr. Cole, an American missionary. "We travelled for four days through a region where had newly fallen a remarkable deposit of heavenly bread, as the natives sometimes call it---manna. There were extensive forests of scrubby oaks, and most of the deposit was on the leaves. Thousands of the poor peasants, men, women, and children, were out upon the plains gathering the sweet substance. Some of them plunge into kettles of boiling water the newly cut branches of the oaks, which washes off the deposit until the water becomes so sweet as to remind the Yankee of a veritable sugaring off in the old Granite State as he takes sips of it. Other companies of natives may be seen vigorously beating with sticks the branches, that, having been spread on the ground, have so dried that the glistening crystals fall readily upon the carpet spread to receive them. The crystals are separated from the pieces of leaves by a sieve, and then the manna is pressed into cakes for use." (R8)

X8. August 1890. Diarbekir(sic), Turkey. "The director of the central dispensary at Bagdad has sent to La Nature a specimen of an edible substance which fell during an abundant shower in the neighbourhood of Merdin and Diarbekir (Turkey in Asia) in August 1890. The rain which accompanied the substance fell over a surface of about ten kilometres in circumference. The inhabitants collected the 'manna,' and made it into bread, which is said to have been very good and to have been easily digested. The specimen sent to La Nature is composed of small spherules; yellowish on the outside, it is white within. Botanists who have examined it say that it belongs to the family of lichens known as Lecanora esculenta." (R9)

X9. General observations. Sinai, Egypt. An expedition from the Hebrew University was sent out to determine the true nature of the Biblical manna. It found that two scale insects in the region excreted a clear, sweet fluid that crystallized into grains and fell to the ground from the trees. (R16)

X10. March 1900. Chanda, India. During a great famine, bamboo trees exuded a type of edible manna. (R13)

X11. General observation. "Our Consul in Jerusalem states that manna is found now in the regions of upper Mespotamia and Kurdistan and along the Persian frontier. It falls, he says, in the form of dew during September, October, and November, and lodges upon the leaves of oak trees. It immediately hardens and assumes the form of a grain. Early in the morning before the heat of the day it is gathered by spreading sheets beneath the trees, which are shaken, and the manna is then collected and stored for winter to be used as a food or shipped to Bagdad for sale in the bazaar. The manna falls on other vegetation, including the grass, but all of it is lost except that which is gathered from the oak leaves. The manna is sweet and is eaten by the natives as a substitute for sugar or honey." (R15) Such widespread occurrences would seem to indicate that the manna is not the product of a specific tree. See X12 and X13.

X12. General observation. A kind of manna is produced by the linden in Europe. (R7)

X13. General observations and controversy. No agreement reached on whether the manna of the Israelites was lichens or a product of the tamarisk tree. (R10, R11, R12, R14)

X14. General observations. "An account of manna 'rains' certainly pertains to the discussion of showers of vegetable matter, for the substance manna consists of lichens of the genus Lecanora, but in none of the numerous recorded instances of manna 'rains' is there any direct evidence that the substance really fell from the sky. These lichens form, small, round bodies that are easily blown over the surface of the ground and accumulate in depressions; they are very buoyant also and hence easily drifted into masses during the run-off of rain water. Manna 'rains' have not occurred except in countries where these lichens are common, and as for statements of their falling down upon roofs or upon people, or for any other proofs that they really rained down, I have seen none." (R18)

X15. General. North Africa, Middle East, Southwest Asia. The edibility of lichens and the many tales of manna were addressed briefly in a 1971 technical book by J.H. Bland dedicated to mosses and lichens in general. Bland wrote:

"The Manna Lichen (Lecanora esculenta), a desert species of Crusty Lichen, probably fed the Israelites in their plight in the desert. It is still eaten by desert tribes, who mix it with meal to one-third of its weight and make it into bread. In southwest Asia, it is used as a substitute for corn." (R20)

Windstorms can sweep up loosely attached lichens and deposit them elsewhere to provide one basis of "falls of manna."

"In recent times a remarkable deposit of lichens occurred in Mesopotamia during a sudden hailstorm. When the hail melted, the ground was covered with lichens; speciemens were sent to a scientist named Errera who identified them as Lecanora culenua. His opinion was that two kinds of manna are referred to in the Bible; in one case (Exodus XVI:4) it is the sweet gum of the tamarisk, a graceful evergreen shrub or small tree, with slender, feathery branches in southern Europe and western Asia; the other kind (Numbers XI:7-9) plainly refers to the lichen." (R20)

X16. August 1980. Hawley, Pennsylvania. On an early summer evening, P.W. Becker, a census taker, was sitting in his car consulting a map. The car was parked on a dead-end street. No people or other cars were in sight. Becker reported:

"Suddenly there was a horrific bang and the car rocked. A missile from the the sky lay in plain view, square in the center of my car's hood.

"I cautiously got out to examine the fallen object. Tiny pieces had broken off, but it was largely intact and measured four to five inches across. I smelled it---yes, it still carried a faint scent---of pizza! It was a slice of pizza, solid as a rock and stone cold. This was no ordinary meteorite. I thought of God feeding the Israelites manna from heaven, but God knows I prefer pepperoni. This was plain, tomato and cheese, on a thin crust. (R21)

Who said science does not have its humor?

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GWF6 Unusual Falls of Hay and Leaves

Description. The fall from a clear sky or with normal precipitation of large quantities of hay or dead leaves. Many of these falls begin at great heights and may continue for hours. The sources of these materials may be miles from the place-of-fall. A curious feature of this type of fall is the apparent lack of debris among the hay or leaves and, in the latter case, the presence of only one type of leaf.

Background. Virtually every country lad has seen cut hay suddenly whipped aloft by whirlwinds and deposited on roofs and telephone wires. The falls meriting mention here are notable for the heights involved, great quantities of materials, long distance of travel, and long duration of fall.

Data Evaluation. This phenomenon is well-documented in the older literature. Rating: 1.

Anomaly Evaluation. This phenomenon, as defined above, is merely an extreme case of well-known pranks of whirlwinds. The only possible mystery is the high selectivity of the transporting agency; i.e., the lack of debris and more than one species of leaf. Rating: 3.

Possible Explanation. Whirlwinds and tornados.

Similar and Related Phenomena. Other falls in the GWF section, especially GWF10 and GWF11 where the falls are usually devoid of other animal species and also the natural debris (plant matter, etc.) that one would expect from an animal's habitat.

Examples of Unusual Falls of Hay and Leaves

X1. Circa 1845. England. Quoting a letter from Sir John F.W. Herschel. "In the hay season, some three or four years ago, the day being clear and hot and calm (at least in the immediate neighbourhood of our house), our attention was excited by what first seemed to be strange-looking birds flying; but though presently assured they were not birds, it was by no means clear what they were. They were irregular wispy masses sailing leisurely up and settling down again, apparently over a hay field on the east of our grounds, and about a quarter or three-eighths of a mile from our house. Some of these were of considerable size, and their general appearance was convex downwards and taily upwards. After wondering awhile, I got a telescope and directed it to the flying phaenomenon when it became evident that they were masses of hay---some of very considerable size, certainly not less (allowing for the distance) than a yard or two in diameter. They sailed above leisurely, and were very numerous. No doubt wind prevailed at the spot, but there was no roaring noise, nor any sign of a whirlwind, and all about us was quite calm." (R1)

X2. September 1861. Putney, England.

Clumps of hay fell from great heights. (R2)

X3. July 27, 1875. Monkstown, Ireland. "About half-past nine o'clock this morning, as I was standing at a window facing east, in Monkstown, my attention was called by the Rev. T. Power to a number of dark flocculent bodies floating slowly down through the air from a great height, appearing as if falling from a very heavy, dark cloud, which hung over the house. On going to the hall door, a vast number of these bodies were discerned falling on all sides, near and far, to as great a distance as their size permitted them to be seen---over an area whose radius was probably between a quarter and half a mile. Presently, several of these flocks fell close to my feet. On picking up one, it was found to be a small portion of new hay, of which I enclose a sample. When it fell it was as wet as if a very heavy dew had been deposited on it. The duration of this phenomenon, from the time my attention was first called to it till it had entirely ceased, was about five minutes, but how long it may have been proceeding before this I cannot tell. The flocks of hay, from their loose, open structure, made a large appearance for their weight, but the average weight of the larger flocks was probably not more than one or two ounces, and, from that, all sizes were perceptible down to a single blade. There was no rain from the dark cloud overhead, though it had a particularly threatening appearance at the moment of observation. The air was very calm, with a gentle undercurrent from S. E. The clouds were moving in an upper-current from S. S. W." (R3, R4, R5, R10, R12, R17)

X4. June 17, 1884. England. During fine weather, considerable hay passed overhead. Some fell, but some armful-sized bunches sailed along until out of sight. (R6)

X5. July 26, 1891. Boraston, England. "We had a curious sight from this house yesterday. It was a dead calm, but in a field just below the garden, with only one hedge between us and it, the hay was whirled up high into the sky, a column connecting above and below, and in the course of the evening we found great patches of hay raining down all over the surrounding meadows and our garden. It kept falling quite four hours after the affair. There was not a breath of air stirring as far as we could see, except in that one spot." (R7)

X6. June 30, 1897. Belchamp St. Paul, England. A whirlwind carries hay out of sight at Halstead. It falls (apparently) at Belchamp St. Paul, 3 miles distant. Some of it was in large bunches. (R8)

X7. June 7, 1906. Sprimont, France. A cloud of hay obscures the sun. (R9)

X8. July 31, 1920. Stone, England. Wisps of wet hay, larger than dinner plates, fall. (R11, R19)

X9. June 28, 1931. Spa, France. (R13)

X10. October 1889. Dumfriesshire, England. "I was struck by a strange appearance in the atmosphere, which I at first mistook for a flock of birds, but as I saw them falling to the earth my curiosity quickened. Fixing my eyes on one of the larger of them, and running about 100 yards up the hill until directly underneath, I awaited its arrival, when I found it to be an oak leaf. Looking upwards the air was thick with them, and as they descended in an almost vertical direction, oscillating, and glittering in the sunshine, the spectacle was as beautiful as rare. The wind was from the north, blowing a very gentle breeze, and there were occasional showers of rain. On examination of the hills after the leaves had fallen, it was found that they covered a tract of about a mile wide and two miles long. The leaves were wholly those of the oak. No oak trees grow in clumps together nearer than eight miles." (R14) Same incident placed in 1890. (R10)

X11. April 7, 1894. Clairvaux, France. It rained dead leaves for half an hour. (R15)

X12. April 1, 1900. Wallingford, England. "At about four o'clock on the afternoon of Sunday last (April 1st), my attention was arrested by the fall of numbers of dried beech leaves. On looking up I found that the leaves were passing in large numbers from east to west, and as high as the limit of vision. Many appeared to be mere specks, whose height and motion promised them a journey of some miles at least. The shower continued for perhaps twenty minutes. The fall was noticed by many persons here, who were unable to account for it, as there are no beech trees within two miles at nearest. Probably the leaves had been raised by a whirlwind, and at a very considerable distance east of this neighborhood." (R16)

X13. August 17, 1883. Aarao, Switzerland. On a windless day, clouds alternating with sun, a deluge of hay rained down on this Swiss town. The stalks covered roofs, trees, roads, and gardens. The clumps fell slowly, like snow. A seemingly infinite number of long stalks could be seen at great heights among the clouds, which were drifting north. The high-altitude flight of hay persisted for 3 hours. (R18)

X14. April 19, Blois, France. The wind at the surface was calm when leaves began raining down in quantity from a slow-moving cloud hundreds of meters above. The leaf fall lasted for 6 hours. (R19)

X15. July 28, 1992. Essex, England. "The mystery downpour started after lunch yesterday, with eyewitnesses claiming to have seen large lumps of straw falling from hundreds of feet up.

"No rational explanation could be offered by sceptical Met Office spokesman Barry Park.

"Mr. David Jenkins of Commonhall Lane said: 'There were large handfuls of straw, like you would put in a rabbit hutch, falling out of the sky.'

"Mr. Jenkins, who is retired, added: 'There were hundreds and hundreds of them, they must have been whipped up by the wind or something.'"

Mr. Paul Moore of Hall Crescent claimed to have seen hundreds of lumps from the size of a quarter bale falling from 1,000 feet up, looking as if they had dropped from a cargo plane, and clumps of straw were in the trees of nearby John Burrows recreation ground where they landed.

A baffled Mr. Park at the London Meteorlogical Office said although tornadoes or even dust devils could pick up straw, weather conditions were unsuitable and could not lift up the amount described to such great heights. (R20)

Once again, it is the total quantity of straw, the large lumps, the great heights involved, and the slow rates of descent that impress the anomalist.

X16. July 1994. Wooburn Green, United Kingdom. In mid-July, about 10 tons of hay fell on Wooburn Green. Some lumps were as large as bales. They seemed to float down gently, like balloons, to the ground. A large area surrounding the town was covered. (R21)

X17. July 22, 1997. South Molton, United Kingdom. About 3:30 P.M., F. Holcombe was sitting in his garden "when a large clump of hay about the size of a football landed next to him. He was bewildered as to where it had come from and looked up into the sky and saw that it was full of hay of different size lumps as far up as the clouds." There was no wind at the surface. (R22)

X18. August 1999. Lincolnton, North Carolina. Leaves from corn stalks up a yard long fell from great heights in many parts of Lincolnton. The weather was fair. Winds were light. No thunderstorms were in the area. (R23)

How did the corn leaves become detached from their stalks? Usually, stalks and leaves are ground up together for ensilage.

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GWF7 Gelatinous Meteors or Pwdre Ser

Description. The fall of gelatinous masses, usually accompanied by luminous phenomena. The substance is soft and jelly-like, odiferous, and has a tendency to evaporate away rapidly. Gelatinous meteors range from a few inches to four feet in diameter according to reports.

Background. The idea that offensive masses of jelly-like substance can fall from the sky is firmly entrenched in folklore, as confirmed by many colorful names, such as pwdre ser (a Welsh term, more correctly spelled pwdr ser), star shot, rot of the stars, etc. In the examples that follow, the reader will find two different phenomena confused: (1) The observed fall of something from the heavens; and (2) The discovery in fields of gelatinous masses. The latter phenomenon possesses a simple biological explanation---assuming the mass did not fall. The actual fall of jelly-like substances admits to no easy solution, assuming its reality.

Data Evaluation. With few exceptions, the observations of gelatinous meteors in flight are old and rather shaky. Many examples profferred as cases of gelatinous meteors are weakened by the strong possibility of misidentification and coincidence; that is, one sees a luminous body descend nearby, searches the next morning, discovers a gelatinous mass in the general direction of the visual phenomenon, and calls it a gelatinous meteor. Meteor impact points are easily misjudged, and natural gelatinous masses seem rather common in fields. Nevertheless, many cases cannot be eliminated easily, and there is much internal consistency. Rating: 3.

Anomaly Evaluation. The confirmed descent of gelatinous masses from outer space would constitute a significant anomaly, for (quite obviously) they do not fall into any recognized class of meteorites. Rating: 2.

Possible Explanations. Most of the so-called gelatinous "meteors" are most likely just terrestrial substances, such as plasmodia, decaying fungi, water-swollen and distorted animal remains, and even man-made materials. True gelatinous meteors/meteorites, if they exist, have no easy explanation.

Similar and Related Phenomena. Animal falls (GWF10-14); signs of extraterrestrial life in meteorites (panspermia theory).

Examples of Gelatinous Meteors

X1. October 21, 1638. Dartmoor, England. A thunderstorm of great extent and fury. A church was struck and wrecked by lightning. A loathsome odor accompanied the phenomenon. "It seems that some person who ventured to go up into the wrecked tower, there discovered 'a round patch as broad as a bushel, which looked thick, slimy, and black, to which he put his hand, and found it soft, and bringing some from the wall, came down and showed that strange compound. It was like a slimy powder, tempered with water; he smelling thereto, it was odious beyond expression, and in a far higher degree of loathsomeness than the scent which was in the church when they first smelt it, being of the same kind,' and the discoverer was shortly after attacked with severe colic." (R20)

X2. March 24, 1718. Isle of Lethy, India. Gelatinous matter fell along with a ball of fire. (R3, R5)

X3. March 8, 1796. Lusatia, Europe. A viscous matter fell with a meteor. It had the color and odor of varnish. (R3, R5)

X4. January 21, 1803. Silesia, Germany. A meteor fell with a whizzing sound and seemed to lie burning on ground. On the next day a jelly-like mass was found on the snow.

X5. August 13, 1819. Amherst, Massachusetts. "On the 13th of August, 1819, between eight and nine o'clock in the evening, a fireball, of the size of a large blown bladder, and of a brilliant white light, was seen in the atmosphere. It fell near a house, and was examined by Rufus Graves, esq. former lecturer of chemistry at Dartmouth College. It was of a circular form, resembling a solid dish, bottom upwards, about eight inches in diameter, and about one in thickness, of a bright buff colour, with a fine nap upon it, similar to that of milled cloth. On removing this nap, a buff-coloured pulpy substance, of the consistence of soft soap, appeared, having an offensive suffocating smell, producing nausea and giddiness. After a few minutes exposure to the air, the buff-colour was changed to a livid colour, resembling venous blood. It attracted moisture readily from the air." (R1, R2, R13, R31) Probably the observers just thought they saw the meteor land where the jelly was found, and that they actually found only a terrestrially-produced plasmodium. (R19)

X6. November 13, 1833. Rahway, New Jersey. During the incredible meteor shower seen over much of the eastern United States. People saw a fiery rain and upon examination discovered lumps of jelly. (R6)

X7. November 13, 1833. Newark, New Jersey. A mass of gelatinous matter, like soft soap, was found after the great meteor shower. Force of impact disturbed the ground. Substance evaporated readily when heat was applied. (R6)

X8. November 13, 1833. West Point, New York. Woman sees a round, flattened mass, the size of a coffeecup, fall. It was transparent and quickly evaporated. (R6)

X9. 1830s. Lincoln, England. Man sees a meteor fall in a field, found nothing but a lump of jelly. (R14)

X10. October 8, 1844. Coblentz, Germany. "...a German gentleman (a friend of Mr. Greg's), accompanied by another person, late in the evening, walking in a dry ploughed field, saw a luminous body descend straight down close to them (not 20 yards off), and heard it distinctly strike the ground with a noise; they marked the spot, and returning early the next morning as nearly as possible where it seemed to fall, they found a gelatinous mass of a greyish colour so viscid as 'to tremble all over' when poked with a stick. It had no appearance of being organic." (R9)

X11. November 11, 1846. Loweville, New York. "...the most remarkable meteor ever seen in that section made its appearance from the west. It appeared larger than the sun, illumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was witnessed by a great number of the inhabitants of the village, and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found a body of fetid jelly, four feet in diameter." (R7)

X12. 1914. Russia. A brilliant cigar-shaped object crossed the sky. An unpleasant jelly-like substance fell near the house of a peasant. It evaporated in several hours. (R22) (Attributed to Znannya ta Pratza, no. 1, 1967.)

X13. February 3, 1980. Hemel Hempstead, England. "Mr. Philip Buller found lumps of a colourless gel lying close together on his lawn. The lumps lay so near to one another that their common origin was not in doubt. The total volume was considered to be approximately sufficient to fill a yoghurt carton, say 75 ml." A sample submitted for analysis was thought to be of amphibian origin and perhaps regurgitated by some predator. (R26)

X14. No date given. Wales. A mass of jelly fell on a man working in a field. No storm or luminous phenomena reported. (R13)

X15. No date given. Lowell, Massachusetts. A man sees a brilliant shooting star fall to earth near him. Upon investigation he found a jelly-like mass with an offensive smell. (R16)

X16. Table of "doubtful" meteorites. Falls of viscid matter with luminous meteors reported in the years 850, 1110, 1548, 1557, 1652, 1686, 1718, 1796, 1811, 1819, 1844. (Since no details are given, and the observations are said to be questionable, no separate entries are provided. WRC) (R8)

X17. General observations. The analysis of substances found in a field and thought to be gelatinous meteors were found to be of animal origin and similar to snail jelly. (R4) The source of pwdre ser observations is probably the Tremella Nostoc, a jelly-like substance seen in wet places. (R10)Jelly-like masses, called 'pwdre ser' in Welsh, are frequently mentioned in literature and often associated with luminous phenomena. (R12) The jelly-like masses found in the fields are undoubtedly plasmodia of a myxocete. (R15, R18)

X18. General observations. Gelatinous masses found in fields may be food disgorged by herons. Such matter may sometimes be luminous. (R18) These masses are probably the viscera of toads and frogs that have become swollen with moisture. Herons may disgorge such matter and other predators may disembowel frogs and toads before consuming them. (R21)

X19. 860. Balch. Germany. (R27) See discussion under X22.

X20. 1406. Lucerne, Switzerland. See discussion under X22. (R27)

X21. 1548. Mannsfeld, Germany. (R27) See discussion under X22.

X22 1557. Schlage, Germany. "These cases were first observed some time after they were believed to have fallen from the atmosphere upon the earth; and it hence remains doubtful whether they were ever in the atmosphere. Meteoric stones, indeed, suggest indications of atmospherical formation, but these gelatinous masses point out no indications of the kind. Indeed botanists themselves are at variance with philosophers about the matter of shot-stars, which is commonly colourless, and the Tremella meteorica, which Meyen recently described as Actinomyce, may be readily taken for a shot-star, if both are generally capable of being discriminated. It may be conceived that this is not necessary, and that the meteoric mass might assume the organic and vegetable structure. To this it may be objected, that the specimens of Tremella meteorica, are frequently found of different sizes, without it being probable that they are remains of a shot-star, especially where they are small, and, as is commonly the case, occur attached to animal bodies, and even incorporated with them. It is therefore improbable that it is sometimes formed terrestrially and sometimes meteorically, because the body exhibits too little characteristic peculiarity to owe its origin to circumstances so very dissimilar. Besides, this supposes that the sudden origin of organic bodies from unorganized materials may be proved. As to the two cases of Lucerne and Mannsfeld, it is to be remembered, that, in the latter case, the blood-spots found on the soil, on the morning after the appearance and explosion of a fire-ball, admit of a very simple explanation, that, in searching for something extraordinary, as the sign of a mass that had fallen, another fungus was found, the Telephora sanguinea, which Agardh calls Palmella cruenta; and which, on account of its entirely superficial extension on moist ground, and from its striking colour, exhibited completely the appearance of spots of blood. The thick gelaninous masses of both the other cases is distinguished from the usual matter of shot-stars, the Tremella meteorica, by their red colour. It would therefore be of importance to examine whether similar appearances are any thing else than this, with a particular difference of colour; whether they are definitely marked by a peculiar structure; or whether, in the absence of any structure, it can be perceived to be an inorganic meteoric concrement,---a matter hitherto undecided." (R27)

X23. June 23, 1978. Cambridge, England. "I wonder if you could tell me what the substance was that alighted on my lawn during a very heavy rainstorm last Friday evening (23 June). It glided down about the size of a football and settled like a jelly. It was white and gloy-like, but cellular. It did not appear to disintegrate, but had completely disappeared by the morning. I came down north-south." This observation was subsequently confirmed in writing by a neighbor. (R23)

X24. August 11, 1979. Frisco, Texas. "Two purple blobs that Sibyl Christian found on her front lawn have defied analysis by space scientists, who say they haven't ruled out the possibility they could be a rare form of meteorite. 'It's kind of like a plum pudding,' according to Doug Blanchard, a geochemist at the National Aeronautics and Space Administration near Houston. 'It has round, solid chunks in it that remain after the goo goes away. We don't know what it is,' he said yesterday." (R24) "The mysterious purple blobs found in a yard in this North Texas town and turned over to the nation's top space scientists for study are the chemical leftovers of a battery reprocessing plant, a Texas museum official says. And officials at the National Aeronautics and Space Administration say it looks like the museum official is right." (R25)

X25. Poetic references. Somehow, poets of the last few centuries could not resist inserting star jelly (or pwdre ser) into their lines. From the many examples, we quote just two.

From Cowley:

"So stars appear to drop to us
 from sky,
And gild the passage as they fly;
But when they fall, and meet th'
 opposing ground,
What but a sordid slime is found."

From Suckling:

As he, whose quicker eye doth trace
A false star shot to a market place
 Doth run apace,
And thinking it to catch,
A jelly up does snatch.

The point here is that the association of shooting stars with terrestrial lumps of jelly-like substances was deeply engrained in the human mind not too long ago. This fact is emphasized again in the next entry ((X26). Of course, the poems and folklore only hint at a causal connection between a falling star and a jelly; they cannot prove the reality of this ancient claimed phenomenon.

X26. Folklore references. Star jelly, in all its many names, has pervaded the folklore of Europe over the ages. A 1984 review of belief in this scientifically unlikely phenomenon, by H. Belcher and E. Swale, concludes with 102 references. The range of their literature search was immense. The reason for the ubiquity and longevity of belief in star jelly is probably due to the large number of apparent coincidences on record of observations of shooting stars followed by immediate discoveries of jelly-like masses nearby.

Belcher and Swale devote most of their article to history; that is, the literary trail of star jelly. They present only a few brief anecdotes. (R29)

X27. 1994. Oakville, Washington. The mysterious appearance of gelatinous material on the earth's surface persists in modern times. However, shooting stars are not usually seen beforehand. The terrestrial substance, though, is still usually presumed to have fallen from the sky.

A case in point is that of D. Hearn, the owner of a small farm near Oakville, Washington. Hearn saw no falling star, but one day she did find a suspicious deposit of a jelly-like material. She testified:

"After a rain shower I stepped out onto my back porch and there was this white clear gelatin-like substance all over everything...It was in chunks about the size of grains of rice." (R30)

The widespread deposit of smallish bits of jelly-like substance does not match the larger single blobs of classical star jelly. The presumed "fall" on Hearn's farm, though, was curious enough to earn an airing on Arthur C. Clarke's Mysterious Universe TV program.

X28. General observations. Like the Oakville event (X27), gelatinous masses are still found in fields and marshes today, but none of their observers link them to shooting stars. A 2004 issue of New Scientist printed several letters on the subject of pwdre ser or star jelly.

Yesterday's natural philosophers and today's biologists have always associated these actually rather common gelatinous lumps with female frogs. Frogs are great favorites of herons, crows, raccoons, and other marsh predators. The gelatinous masses are claimed by we modern rational people to be only frog spawn regurgitated by frog-eaters. Falling stars are no longer part of the equation!

A problem remains, though. Today's gelatinous masses are almost always devoid of frog eggs and are often much larger than the average female frog. These could be formidable scientific enigmas.

Happily, a reasonable explanation came to the mind of A. Gray:

"The predator swallows the frog before ovulation. The predator regurgitates only the oviduct lining which swells enormously when in contact with water. Voila! A largish gelatinous mass sans eggs."

Today, the pwdre-ser enigma seems to have been rooted out of the modern mind. But can we really completely ignore the following oldish anecdote written in Scientific American (2:79, 1846)?

"...the most remarkable meteor ever seen in that section [Loweville, NY] made its appearance from the west. It appeared larger than the sun, illumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was witnessed by a great number of the inhabitants of the village, and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found a body of fetid jelly, four feet in diameter."

Not only is the size of the Loweville star jelly remarkable, but so is the long life of the "meteor"! It could not have been a normal shooting star nor a frog's oviduct lining.

In 1846, anecdotes were often embellished.

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X19. June 18, 1860. Amesbury, Massachusetts, and Prospect, New York. After a thunderstorm, the ground was covered with "sulphur." It burned with a blue flame and smelled like common sulphur. The writer noted that such observations are usually due to pine pollen. (R20)

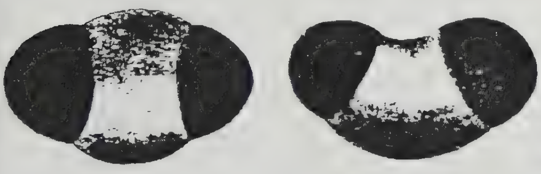
X20. March 12, 1867. South Union, Kentucky. A yellow substance falls with rain. (R21)

X21. February 14, 1870. Genes, France. A remarkable yellow rain. Analysis yielded mostly sand, clay, iron oxide, and some organic debris. (R22) See also X7.

X22. April 25, 1880. Bonneville, Switzerland. A rain made yellow by vegetable debris, which included spores but no pollen. (R23)

X23. April 8, 1906. Central China. The air was filled with dust. A subsequent rain left puddles ringed with a yellow substance that the local doctor identified as sulphur. (R24)

X24. April 10, 1907. Sanary, France. A yellow substance fell with rain. When dried it resembled "flowers of sulphur," and was generally believed to be that form of pure sulphur. Application of a microscope, however, showed that it was only pine pollen. (R25)



The so-called "sulphur rains" get their yellow color from pollen grains such as these from pine trees. Diameters: 75 microns. (X24)

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GWF4 Falls of Miscellaneous Inorganic Substances

Description. The fall from a clear sky or with normal precipitation of inorganic substances, such as crystalline material and cinders, but excluding sulphur-like substances (GWF3), stones (GWF2), dust, and ashes. The criteria employed in choosing examples here are: (1) Unusual chemicals not expected in precipitation; (2) Materials that do not seem to exist in the immediate vicinity of the fall; and (3) Anomalous meteoric material. Coal is considered "inorganic" here.

Background. Dust and ash falls are common and generally well-explained. They are omitted.

Data Evaluation. The data are rather convincing and minus the sensationalism associated with sulphur falls and thunderstones. Rating: 2.

Anomaly Evaluation. Most of the substances mentioned here are common in nature. The anomaly consists primarily of finding reasonable sources and transporting mechanisms. Since winds fit the bill quite well, the only mystery remaining is locating nearby sources or explaining transportation over long distances. Rating: 3.

Possible Explanations. Salt storms are easily attributed to the evaporation of wind-blown seawater. The other falls are likely wind-blown debris or incoming meteoric particles.

Similar and Related Phenomena. All falls, especially stone falls (GWF2).

Examples of Falls of Miscellaneous Inorganic Substances

X1. Date of fall indeterminate. Arctic. From the log of the *Vega* expedition. "Lieutenant Nordquist observed small yellow specks in the snow, which I asked him to collect and hand over for investigation to Dr. Kjellman. For I supposed that the specks consisted of diatom ooze. After examining them Dr. Kjellman however declared that they did not consist of any organic substance, but of crystallized grains of sand. I too now examined them more closely, but unfortunately not until the morning after we had left the ice-field, and then found that the supposed ooze consisted of pale yellow crystals (not fragments of crystals) without mixture or foreign matter. The quantity of crystals, which were obtained from about three litres of snow, skimmed from the surface of the snow on an area of at most 10 square metres, amounted to nearly 0.2 gram. The crystals were found only near the surface of the snow, not in the deeper layers. They were up to 1 mm. in diameter, ... and appeared to belong to the rhombic system, as they had one perfect cleavage and formed striated prisms terminated at either end by truncated pyramids. Unfortunately, I could not make any actual measurements of them, because after being kept for some time in the air they weathered to a white noncrystalline powder. They lay, without being sensibly dissolved, for a whole night in the water formed by the melting of the snow. On being heated, too, they fell asunder into a tasteless white powder. The white powder, that was being formed by the weathering of the crystals, was analysed after our return---21 months after the discovery of the crystals---and was found to contain only carbonate of lime." (R1) It is assumed that these crystals fell onto the Arctic snow. (WRC)

X2. 1916. Northern Ireland. "The great barometric depression that developed from the 16th to 18th with its prolonged south-easterly blast, has brought a great shower of salt that I have traced as far inland as the Lough Neagh district. It was first detected on 18th, dimming the windows facing eastward, but some of the more succulent and absorbent forms of vegetation have also revealed its presence by wilting under the poisonous blast." (R2) See also X3. Obviously this phenomenon is caused by wind-blown seawater that is evaporated, leaving salt behind. See also the effects of the so-called "blasting fogs" (GWD3-X6).

X3. Circa 1815. Massachusetts. After a high wind and heavy rain, all homes and objects within a mile of the water were coated with salt. (R3)

X4. August 20, 1872. Zurich, Switzerland. "Prof. Kenngott, of Zurich, states that in a hailstorm, on the 20th of last August, the stones, some of which weighed twelve grains, consisted essentially of common salt, mainly in imperfect cubical crystals. He supposes that the salt had been taken up from the salt plains of Africa, and brought over the Mediterranean." (R4)

X5. June 1893. Daduzai, India. "A few days ago in a village named Daduzai (a tehsil in the Peshawar district) rain fell, preceeded by a wind storm, and with the rain came a shower of hailstones; which lasted a few minutes. The most curious part of this occurrence is that the hailstones when touched were not at all cold, and when put in the mouth (as is the custom in this hot country) tasted like sugar. I am further told that the hailstones were extremely fragile, and as soon as they reached the ground they broke into pieces. These pieces when examined looked like broken sticks of crystallised nitre. My informant tasted them, and was struck with their purity and sweetness." (R5)

X6. March 2, 1940. Springfield, Missouri. "Immediately after the hail storm Mr. R. F. Buchanan of #808 S. Douglas Street in this city called the office and advised me that it had 'hailed coal in his part of town' and that he was bringing some of the hail stones to my office. He arrived shortly but the hail had melted before he got here. He showed me his car which he had just finished washing previous to the storm. It was literally covered with small pieces of coal, varying from one sixteenth to one eighth of an inch cube size. Each little piece of coal was encased in a small muddy circle on his car where the hail had melted. There were thousands of them on the car top and surface. He said that each hail stone was black in the center before it melted. His lawn, sidewalk and the street in his section of the city were covered with the bits of 'coal' while several blocks away others advised me that they had noticed the same thing only it was mostly a black dust deposit after the rain. In all other sections of the city the deposit was a yellow dust." Author surmised that a small tornado might have carried the coal from strip mines a hundred miles away. (R6)

X7. November 14, 1856. South Pacific Ocean. Spherules of magnetic material the size of birdshot fell on a ship. It was supposed that this was meteoric dust. (R7)

X8. Circa 1885. Pelham, New Hampshire. Metallic dust and granules, identified as meteoric dust, found on a sidewalk after a thundershower. (R8)

X9. November 14, 1968. Jurmenha, Portugal. A rain of 'sand' accompanied the fall of the so-called Alandroal meteor. (R9)

X10. June 17, 1857. Ottawa, Illinois. "The cinders fell in a northeasterly direction in the shape of the letter V. The weather had been showery, but I heard no thunder and saw no lightning. There appeared to be a small, dense black cloud hanging over the garden in a westerly direction, or a little to the south of west. The cinders fell upon a slight angle within about three rods of where I was at work; there was no wind at the moment, or none perceptible. My attention was called first to the freak the wind had in the grass, the next moment to a hissing noise caused by the cinders passing through the air. The larger ones were considerably imbedded in the earth, so much as only to show a small part of it, while the smaller ones were about half buried. I noticed at the time that the ground where I afterwards picked up the cinders showed signs of warmth, as there was quite a steam or fog at that particular point." The cinders were glassy with a cellular interior. They were a little over an inch long. Color: black. (R10, R11) The "cinders" do not appear to be meteoric because of their cellular structure, although in 1857 there were probably few sources of real cinders in this region. The black cloud, however, resembles those frequently seen in the vicinity of descending meteors.

X11. January 31, 1686. Courland, Russia (?). "A meteoric substance like black paper is said to have fallen near Handen in Courland, on the 31st January 1686. This fact led M. Von Grothus to recognize it in a substance in his own museum, which had a label attached to it, stating it to be of meteoric origin. It is a mass of black leaves resembling burnt paper; but it is harder, brittle, and coheres together. It has been found to consist of silica, magnesia, iron, some nickel, and traces of chromium, the same ingredients as those of meteoric stones." (R12)

Note that in 1686 the words "meteoric origin" meant anything associated with weather. In those days, extraterrestrial objects did not fall from the sky!

X12. January 6, 1909. Santa Cruz, California. Mrs. W.H. Burns was alerted to a singular phenomenon by children playing in front of her house. They told her that "hot shot" was falling from the sky.

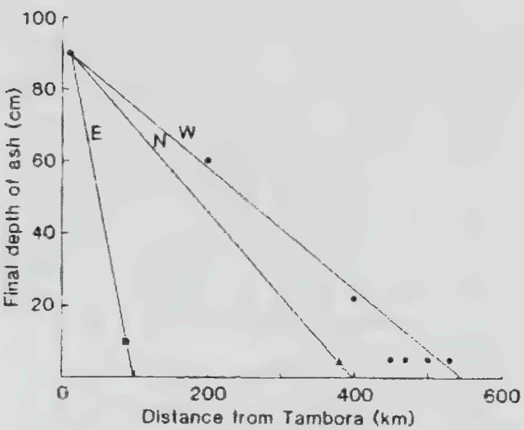
"Then she heard the clatter on the housetop like hail and saw little white threads of steam rising from neighboring roofs. This steam was found to be the result of the dropping of little hot globules on the damp shingles.

"This peculiar rain continued from about 3 to 4 o'clock in the afternoon, and varied in intensity. At one time the children, who were bareheaded and unshod, were compelled to take cover." (R13)

The purported "shot" referred to bird shot such as that used in shotgun shells. Apparently, none of these hot bits of metal were saved or examined by scientists. Something hot did fall, but its nature and origin remain unknown.

X13. April 10, 1815 and some days thereafter. Mount Tambora, Indonesia, and much of Southeast Asia were exposed to a masssive fall of volcanic ash. The amount of ash falling in the first few days after the eruption was estimated to be 40-90 cubic kilometers. Some of the ash remained suspended in the atmosphere for months and heavily impacted the weather in the Northern Hemisphere. Temperatures were depressed and North America and Europe experienced in 1816 the famous "year without a summer."

The Tambora volcanic eruption was the largest volcanic event and ash fall since the last Ice Age. (R14)



Estimated thickness of Tambora ash fall as a function of distance in the east, north, and west directions. (X13)

X14. March 11, 1984. Duncan, British Columbia. At 8:30 P.M., D. Thompson spotted a burning object falling from the sky. It landed in the street about 200 feet from him. He testified: "There was a flame for about three seconds and then it went out. I kind of ran up to it and I could hear it sizzle." The sizzle was due to the wet pavement.

When the flame had burnt out, a hard yellow, nearly circular mass, about ½-inch thick remained. Thompson scraped up most of the substance along with bits of asphalt. The substance was odorless and soluble in water.

A sample was reportedly sent to the University of British Columbia. We have seen no results from any analysis. (R15)

X15. June 5, 1983. Bournemouth, United Kingdom. A report of a fall of coke was sent to the Journal of Meteorology by P.A. Rogers, the Meteorological Registrar for Bournemouth.

"After the severe thunderstorm of 5 June 1983, it was brought to my attention that large amounts of coke had fallen in a gentleman's garden. After being reported in the local press and on local radio that evening, my telephone never stopped ringing with reports of coke having fallen all over the Bournemouth, Poole and Christchurch area. I investigated several reports and found the pieces to be the same, all having been discovered over lawns, paths, etc. and all found after the storm of the 5th. At one lady's house I picked up 92 pieces of coke and there were still many pieces left. The largest piece of coke measured 6.0 by 4.6 cm. At one investigation I was given small roof-like clippings which the lady said she saw in melting hailstones." (R16)

Piles of coke are not uncommon in industrial areas. It would, however, require powerful winds to pick up such large pieces and distribute them over such a wide area.

X16. June 16, 1979. Mississauga, Canada. On a hot, sunny afternoon in 1979, T. Hatchett and his daughter were working in their backyard, when they heard a loud thump followed by a crackling sound. A molten blob of "something" about 4 inches high had landed on their picnic table. A column of flame was shooting upward from it. Hatchett's daughter quickly doused the flames with a garden hose. The cooled, solidified residue was a small, flat, green mass weighing about 4 ounces.

The incident was reported to the Toronto Sun and stirred considerable interest. Queries indicated that no commercial nor military aircraft overflew when the event occurred. A sample analysis by the Ontario Ministry of the Environment proved that the substance was the common plastic polypropylene. The source of the burning blob was never found. (R17)

Note that the Mississauga "blob" resembles the curious burning mass that fell on a street in Duncan, British Columbia in 1984. (X14)

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GWF5 The Fall of Manna

Description. The fall from the sky of large quantities of edible substance. Manna is generally granular in form and may appear in various colors, consistencies, and flavors. Almost all reported falls of manna come from Asia Minor.

Background. Discussion of the possible fall of manna is inescapable due to its prominence in Biblical history and folklore.

Data Evaluation. The actual fall of manna from the skies is claimed only in a few old and questionable sources. More sober observers tell of: (1) The collection or fall of edible substances from trees and bushes; (2) The sudden appearance of edible plants and lichens due to natural population explosions; and (3) Wind-blown lichens. In sum, the data supporting actual falls of manna from the skies is very shaky. Rating: 4.

Anomaly Evaluation. Even if manna did fall from the sky or arrived with normal precipitation, it is light enough to be carried long distances by meteorological agencies. The large, localized falls, however, are curious. Rating: 3.

Possible Explanations. Two varieties of manna seem to exist: (1) Lichens, wind-blown and indigenous; and (2) Sugary granules produced by insects and/or vegetation.

Similar and Related Phenomena. All other falls, particularly the rare prodigious falls of leaves and hay (GWF6).

Examples of Falls of Manna

X1. 1824. Persia. Ground covered in some regions by edible lichens, called manna. (R1)

X2. 1828. Persia. Edible substance said to fall from the sky. "It occurred in such abundance that the ground was of a sudden entirely covered by it over a great extent. In some spots it was five or six inches deep. It was eaten by cattle, and particularly sheep; and bread was made of it, which afforded nourishment to man. Such were the accounts furnished to the French Consul in Persia, by a Russian general, who was an eye-witness." (R1) The fallen substance was later identified as the plant Parmella esculenta. (R2, R10) This classic example said to occur in 1829. (R3)

X3. Spring 1841. Lake Van, Turkey. The ground was covered to depths of 3 or 4 inches by a gray, granular substance that was pleasant to the taste. Bread was made from it. (R10)

X4. January 1846. Jenischehir, Turkey. Edible substance falls during a time of famine. "It lasted some days, and the pieces of lichen were of the size of hazel-nuts. They were ground into flour, the bread from which was pronounced little inferior to wheat bread. Another account says that the manna was of greyish-white colour, rather hard and irregular in form, inodorous and insipid." (R10, R17) Another report puts this fall in April 1846. (R3)

X5. April 18, 1848. Byazid, Turkey. Edible lichens said to have fallen from the skies. (R4)

X6. July 1864. Diarberker, Turkey. Manna appeared. Said to be lichen. (R5, R6)

X7. Circa 1887. Turkey. The following description was provided by a Mr. Cole, an American missionary. "We travelled for four days through a region where had newly fallen a remarkable deposit of heavenly bread, as the natives sometimes call it---manna. There were extensive forests of scrubby oaks, and most of the deposit was on the leaves. Thousands of the poor peasants, men, women, and children, were out upon the plains gathering the sweet substance. Some of them plunge into kettles of boiling water the newly cut branches of the oaks, which washes off the deposit until the water becomes so sweet as to remind the Yankee of a veritable sugaring off in the old Granite State as he takes sips of it. Other companies of natives may be seen vigorously beating with sticks the branches, that, having been spread on the ground, have so dried that the glistening crystals fall readily upon the carpet spread to receive them. The crystals are separated from the pieces of leaves by a sieve, and then the manna is pressed into cakes for use." (R8)

X8. August 1890. Diarbekir(sic), Turkey. "The director of the central dispensary at Bagdad has sent to La Nature a specimen of an edible substance which fell during an abundant shower in the neighbourhood of Merdin and Diarbekir (Turkey in Asia) in August 1890. The rain which accompanied the substance fell over a surface of about ten kilometres in circumference. The inhabitants collected the 'manna,' and made it into bread, which is said to have been very good and to have been easily digested. The specimen sent to La Nature is composed of small spherules; yellowish on the outside, it is white within. Botanists who have examined it say that it belongs to the family of lichens known as Lecanora esculenta." (R9)

X9. General observations. Sinai, Egypt. An expedition from the Hebrew University was sent out to determine the true nature of the Biblical manna. It found that two scale insects in the region excreted a clear, sweet fluid that crystallized into grains and fell to the ground from the trees. (R16)

X10. March 1900. Chanda, India. During a great famine, bamboo trees exuded a type of edible manna. (R13)

X11. General observation. "Our Consul in Jerusalem states that manna is found now in the regions of upper Mespotamia and Kurdistan and along the Persian frontier. It falls, he says, in the form of dew during September, October, and November, and lodges upon the leaves of oak trees. It immediately hardens and assumes the form of a grain. Early in the morning before the heat of the day it is gathered by spreading sheets beneath the trees, which are shaken, and the manna is then collected and stored for winter to be used as a food or shipped to Bagdad for sale in the bazaar. The manna falls on other vegetation, including the grass, but all of it is lost except that which is gathered from the oak leaves. The manna is sweet and is eaten by the natives as a substitute for sugar or honey." (R15) Such widespread occurrences would seem to indicate that the manna is not the product of a specific tree. See X12 and X13.

X12. General observation. A kind of manna is produced by the linden in Europe. (R7)

X13. General observations and controversy. No agreement reached on whether the manna of the Israelites was lichens or a product of the tamarisk tree. (R10, R11, R12, R14)

X14. General observations. "An account of manna 'rains' certainly pertains to the discussion of showers of vegetable matter, for the substance manna consists of lichens of the genus Lecanora, but in none of the numerous recorded instances of manna 'rains' is there any direct evidence that the substance really fell from the sky. These lichens form, small, round bodies that are easily blown over the surface of the ground and accumulate in depressions; they are very buoyant also and hence easily drifted into masses during the run-off of rain water. Manna 'rains' have not occurred except in countries where these lichens are common, and as for statements of their falling down upon roofs or upon people, or for any other proofs that they really rained down, I have seen none." (R18)

X15. General. North Africa, Middle East, Southwest Asia. The edibility of lichens and the many tales of manna were addressed briefly in a 1971 technical book by J.H. Bland dedicated to mosses and lichens in general. Bland wrote:

"The Manna Lichen (Lecanora esculenta), a desert species of Crusty Lichen, probably fed the Israelites in their plight in the desert. It is still eaten by desert tribes, who mix it with meal to one-third of its weight and make it into bread. In southwest Asia, it is used as a substitute for corn." (R20)

Windstorms can sweep up loosely attached lichens and deposit them elsewhere to provide one basis of "falls of manna."

"In recent times a remarkable deposit of lichens occurred in Mesopotamia during a sudden hailstorm. When the hail melted, the ground was covered with lichens; speciemens were sent to a scientist named Errera who identified them as Lecanora culenua. His opinion was that two kinds of manna are referred to in the Bible; in one case (Exodus XVI:4) it is the sweet gum of the tamarisk, a graceful evergreen shrub or small tree, with slender, feathery branches in southern Europe and western Asia; the other kind (Numbers XI:7-9) plainly refers to the lichen." (R20)

X16. August 1980. Hawley, Pennsylvania. On an early summer evening, P.W. Becker, a census taker, was sitting in his car consulting a map. The car was parked on a dead-end street. No people or other cars were in sight. Becker reported:

"Suddenly there was a horrific bang and the car rocked. A missile from the the sky lay in plain view, square in the center of my car's hood.

"I cautiously got out to examine the fallen object. Tiny pieces had broken off, but it was largely intact and measured four to five inches across. I smelled it---yes, it still carried a faint scent---of pizza! It was a slice of pizza, solid as a rock and stone cold. This was no ordinary meteorite. I thought of God feeding the Israelites manna from heaven, but God knows I prefer pepperoni. This was plain, tomato and cheese, on a thin crust. (R21)

Who said science does not have its humor?

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GWF6 Unusual Falls of Hay and Leaves

Description. The fall from a clear sky or with normal precipitation of large quantities of hay or dead leaves. Many of these falls begin at great heights and may continue for hours. The sources of these materials may be miles from the place-of-fall. A curious feature of this type of fall is the apparent lack of debris among the hay or leaves and, in the latter case, the presence of only one type of leaf.

Background. Virtually every country lad has seen cut hay suddenly whipped aloft by whirlwinds and deposited on roofs and telephone wires. The falls meriting mention here are notable for the heights involved, great quantities of materials, long distance of travel, and long duration of fall.

Data Evaluation. This phenomenon is well-documented in the older literature. Rating: 1.

Anomaly Evaluation. This phenomenon, as defined above, is merely an extreme case of well-known pranks of whirlwinds. The only possible mystery is the high selectivity of the transporting agency; i.e., the lack of debris and more than one species of leaf. Rating: 3.

Possible Explanation. Whirlwinds and tornados.

Similar and Related Phenomena. Other falls in the GWF section, especially GWF10 and GWF11 where the falls are usually devoid of other animal species and also the natural debris (plant matter, etc.) that one would expect from an animal's habitat.

Examples of Unusual Falls of Hay and Leaves

X1. Circa 1845. England. Quoting a letter from Sir John F.W. Herschel. "In the hay season, some three or four years ago, the day being clear and hot and calm (at least in the immediate neighbourhood of our house), our attention was excited by what first seemed to be strange-looking birds flying; but though presently assured they were not birds, it was by no means clear what they were. They were irregular wispy masses sailing leisurely up and settling down again, apparently over a hay field on the east of our grounds, and about a quarter or three-eighths of a mile from our house. Some of these were of considerable size, and their general appearance was convex downwards and taily upwards. After wondering awhile, I got a telescope and directed it to the flying phaenomenon when it became evident that they were masses of hay---some of very considerable size, certainly not less (allowing for the distance) than a yard or two in diameter. They sailed above leisurely, and were very numerous. No doubt wind prevailed at the spot, but there was no roaring noise, nor any sign of a whirlwind, and all about us was quite calm." (R1)

X2. September 1861. Putney, England.

Clumps of hay fell from great heights. (R2)

X3. July 27, 1875. Monkstown, Ireland. "About half-past nine o'clock this morning, as I was standing at a window facing east, in Monkstown, my attention was called by the Rev. T. Power to a number of dark flocculent bodies floating slowly down through the air from a great height, appearing as if falling from a very heavy, dark cloud, which hung over the house. On going to the hall door, a vast number of these bodies were discerned falling on all sides, near and far, to as great a distance as their size permitted them to be seen---over an area whose radius was probably between a quarter and half a mile. Presently, several of these flocks fell close to my feet. On picking up one, it was found to be a small portion of new hay, of which I enclose a sample. When it fell it was as wet as if a very heavy dew had been deposited on it. The duration of this phenomenon, from the time my attention was first called to it till it had entirely ceased, was about five minutes, but how long it may have been proceeding before this I cannot tell. The flocks of hay, from their loose, open structure, made a large appearance for their weight, but the average weight of the larger flocks was probably not more than one or two ounces, and, from that, all sizes were perceptible down to a single blade. There was no rain from the dark cloud overhead, though it had a particularly threatening appearance at the moment of observation. The air was very calm, with a gentle undercurrent from S. E. The clouds were moving in an upper-current from S. S. W." (R3, R4, R5, R10, R12, R17)

X4. June 17, 1884. England. During fine weather, considerable hay passed overhead. Some fell, but some armful-sized bunches sailed along until out of sight. (R6)

X5. July 26, 1891. Boraston, England. "We had a curious sight from this house yesterday. It was a dead calm, but in a field just below the garden, with only one hedge between us and it, the hay was whirled up high into the sky, a column connecting above and below, and in the course of the evening we found great patches of hay raining down all over the surrounding meadows and our garden. It kept falling quite four hours after the affair. There was not a breath of air stirring as far as we could see, except in that one spot." (R7)

X6. June 30, 1897. Belchamp St. Paul, England. A whirlwind carries hay out of sight at Halstead. It falls (apparently) at Belchamp St. Paul, 3 miles distant. Some of it was in large bunches. (R8)

X7. June 7, 1906. Sprimont, France. A cloud of hay obscures the sun. (R9)

X8. July 31, 1920. Stone, England. Wisps of wet hay, larger than dinner plates, fall. (R11, R19)

X9. June 28, 1931. Spa, France. (R13)

X10. October 1889. Dumfriesshire, England. "I was struck by a strange appearance in the atmosphere, which I at first mistook for a flock of birds, but as I saw them falling to the earth my curiosity quickened. Fixing my eyes on one of the larger of them, and running about 100 yards up the hill until directly underneath, I awaited its arrival, when I found it to be <u>an oak leaf</u>. Looking upwards the air was thick with them, and as they descended in an almost vertical direction, oscillating, and glittering in the sunshine, the spectacle was as beautiful as rare. The wind was from the north, blowing a very gentle breeze, and there were occasional showers of rain. On examination of the hills after the leaves had fallen, it was found that they covered a tract of about a mile wide and two miles long. The leaves were wholly those of the oak. No oak trees grow in clumps together nearer than eight miles." (R14) Same incident placed in 1890. (R10)

X11. April 7, 1894. Clairvaux, France. It rained dead leaves for half an hour. (R15)

X12. April 1, 1900. Wallingford, England. "At about four o'clock on the afternoon of Sunday last (April 1st), my attention was arrested by the fall of numbers of dried beech leaves. On looking up I found that the leaves were passing in large numbers from east to west, and as high as the limit of vision. Many appeared to be mere specks, whose height and motion promised them a journey of some miles at least. The shower continued for perhaps twenty minutes. The fall was noticed by many persons here, who were unable to account for it, as there are no beech trees within two miles at nearest. Probably the leaves had been raised by a whirlwind, and at a very considerable distance east of this neighborhood." (R16)

X13. August 17, 1883. Aarao, Switzerland. On a windless day, clouds alternating with sun, a deluge of hay rained down on this Swiss town. The stalks covered roofs, trees, roads, and gardens. The clumps fell slowly, like snow. A seemingly infinite number of long stalks could be seen at great heights among the clouds, which were drifting north. The high-altitude flight of hay persisted for 3 hours. (R18)

X14. April 19, Blois, France. The wind at the surface was calm when leaves began raining down in quantity from a slow-moving cloud hundreds of meters above. The leaf fall lasted for 6 hours. (R19)

X15. July 28, 1992. Essex, England. "The mystery downpour started after lunch yesterday, with eyewitnesses claiming to have seen large lumps of straw falling from hundreds of feet up.

"No rational explanation could be offered by sceptical Met Office spokesman Barry Park.

"Mr. David Jenkins of Commonhall Lane said: 'There were large handfuls of straw, like you would put in a rabbit hutch, falling out of the sky.'

"Mr. Jenkins, who is retired, added: 'There were hundreds and hundreds of them, they must have been whipped up by the wind or something.'"

Mr. Paul Moore of Hall Crescent claimed to have seen hundreds of lumps from the size of a quarter bale falling from 1,000 feet up, looking as if they had dropped from a cargo plane, and clumps of straw were in the trees of nearby John Burrows recreation ground where they landed.

A baffled Mr. Park at the London Meteorlogical Office said although tornadoes or even dust devils could pick up straw, weather conditions were unsuitable and could not lift up the amount described to such great heights. (R20)

Once again, it is the total quantity of straw, the large lumps, the great heights involved, and the slow rates of descent that impress the anomalist.

X16. July 1994. Wooburn Green, United Kingdom. In mid-July, about 10 tons of hay fell on Wooburn Green. Some lumps were as large as bales. They seemed to float down gently, like balloons, to the ground. A large area surrounding the town was covered. (R21)

X17. July 22, 1997. South Molton, United Kingdom. About 3:30 P.M., F. Holcombe was sitting in his garden "when a large clump of hay about the size of a football landed next to him. He was bewildered as to where it had come from and looked up into the sky and saw that it was full of hay of different size lumps as far up as the clouds." There was no wind at the surface. (R22)

X18. August 1999. Lincolnton, North Carolina. Leaves from corn stalks up a yard long fell from great heights in many parts of Lincolnton. The weather was fair. Winds were light. No thunderstorms were in the area. (R23)

How did the corn leaves become detached from their stalks? Usually, stalks and leaves are ground up together for ensilage.

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GWF7 Gelatinous Meteors or Pwdre Ser

Description. The fall of gelatinous masses, usually accompanied by luminous phenomena. The substance is soft and jelly-like, odiferous, and has a tendency to evaporate away rapidly. Gelatinous meteors range from a few inches to four feet in diameter according to reports.

Background. The idea that offensive masses of jelly-like substance can fall from the sky is firmly entrenched in folklore, as confirmed by many colorful names, such as pwdre ser (a Welsh term, more correctly spelled pwdr ser), star shot, rot of the stars, etc. In the examples that follow, the reader will find two different phenomena confused: (1) The observed fall of something from the heavens; and (2) The discovery in fields of gelatinous masses. The latter phenomenon possesses a simple biological explanation---assuming the mass did not fall. The actual fall of jelly-like substances admits to no easy solution, assuming its reality.

Data Evaluation. With few exceptions, the observations of gelatinous meteors in flight are old and rather shaky. Many examples profferred as cases of gelatinous meteors are weakened by the strong possibility of misidentification and coincidence; that is, one sees a luminous body descend nearby, searches the next morning, discovers a gelatinous mass in the general direction of the visual phenomenon, and calls it a gelatinous meteor. Meteor impact points are easily misjudged, and natural gelatinous masses seem rather common in fields. Nevertheless, many cases cannot be eliminated easily, and there is much internal consistency. Rating: 3.

Anomaly Evaluation. The confirmed descent of gelatinous masses from outer space would constitute a significant anomaly, for (quite obviously) they do not fall into any recognized class of meteorites. Rating: 2.

Possible Explanations. Most of the so-called gelatinous "meteors" are most likely just terrestrial substances, such as plasmodia, decaying fungi, water-swollen and distorted animal remains, and even man-made materials. True gelatinous meteors/meteorites, if they exist, have no easy explanation.

Similar and Related Phenomena. Animal falls (GWF10-14); signs of extraterrestrial life in meteorites (panspermia theory).

Examples of Gelatinous Meteors

X1. October 21, 1638. Dartmoor, England. A thunderstorm of great extent and fury. A church was struck and wrecked by lightning. A loathsome odor accompanied the phenomenon. "It seems that some person who ventured to go up into the wrecked tower, there discovered 'a round patch as broad as a bushel, which looked thick, slimy, and black, to which he put his hand, and found it soft, and bringing some from the wall, came down and showed that strange compound. It was like a slimy powder, tempered with water; he smelling thereto, it was odious beyond expression, and in a far higher degree of loathsomeness than the scent which was in the church when they first smelt it, being of the same kind,' and the discoverer was shortly after attacked with severe colic." (R20)

X2. March 24, 1718. Isle of Lethy, India. Gelatinous matter fell along with a ball of fire. (R3, R5)

X3. March 8, 1796. Lusatia, Europe. A viscous matter fell with a meteor. It had the color and odor of varnish. (R3, R5)

X4. January 21, 1803. Silesia, Germany. A meteor fell with a whizzing sound and seemed to lie burning on ground. On the next day a jelly-like mass was found on the snow.

X5. August 13, 1819. Amherst, Massachusetts. "On the 13th of August, 1819, between eight and nine o'clock in the evening, a fireball, of the size of a large blown bladder, and of a brilliant white light, was seen in the atmosphere. It fell near a house, and was examined by Rufus Graves, esq. former lecturer of chemistry at Dartmouth College. It was of a circular form, resembling a solid dish, bottom upwards, about eight inches in diameter, and about one in thickness, of a bright buff colour, with a fine nap upon it, similar to that of milled cloth. On removing this nap, a buff-coloured pulpy substance, of the consistence of soft soap, appeared, having an offensive suffocating smell, producing nausea and giddiness. After a few minutes exposure to the air, the buff-colour was changed to a livid colour, resembling venous blood. It attracted moisture readily from the air." (R1, R2, R13, R31) Probably the observers just thought they saw the meteor land where the jelly was found, and that they actually found only a terrestrially-produced plasmodium. (R19)

X6. November 13, 1833. Rahway, New Jersey. During the incredible meteor shower seen over much of the eastern United States. People saw a fiery rain and upon examination discovered lumps of jelly. (R6)

X7. November 13, 1833. Newark, New Jersey. A mass of gelatinous matter, like soft soap, was found after the great meteor shower. Force of impact disturbed the ground. Substance evaporated readily when heat was applied. (R6)

X8. November 13, 1833. West Point, New York. Woman sees a round, flattened mass, the size of a coffeecup, fall. It was transparent and quickly evaporated. (R6)

X9. 1830s. Lincoln, England. Man sees a meteor fall in a field, found nothing but a lump of jelly. (R14)

X10. October 8, 1844. Coblentz, Germany. "...a German gentleman (a friend of Mr. Greg's), accompanied by another person, late in the evening, walking in a dry ploughed field, saw a luminous body descend straight down close to them (not 20 yards off), and heard it distinctly strike the ground with a noise; they marked the spot, and returning early the next morning as nearly as possible where it seemed to fall, they found a gelatinous mass of a greyish colour so viscid as 'to tremble all over' when poked with a stick. It had no appearance of being organic." (R9)

X11. November 11, 1846. Loweville, New York. "...the most remarkable meteor ever seen in that section made its appearance from the west. It appeared larger than the sun, illumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was witnessed by a great number of the inhabitants of the village, and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found a body of fetid jelly, four feet in diameter." (R7)

X12. 1914. Russia. A brilliant cigar-shaped object crossed the sky. An unpleasant jelly-like substance fell near the house of a peasant. It evaporated in several hours. (R22) (Attributed to Znannya ta Pratza, no. 1, 1967.)

X13. February 3, 1980. Hemel Hempstead, England. "Mr. Philip Buller found lumps of a colourless gel lying close together on his lawn. The lumps lay so near to one another that their common origin was not in doubt. The total volume was considered to be approximately sufficient to fill a yoghurt carton, say 75 ml." A sample submitted for analysis was thought to be of amphibian origin and perhaps regurgitated by some predator. (R26)

X14. No date given. Wales. A mass of jelly fell on a man working in a field. No storm or luminous phenomena reported. (R13)

X15. No date given. Lowell, Massachusetts. A man sees a brilliant shooting star fall to earth near him. Upon investigation he found a jelly-like mass with an offensive smell. (R16)

X16. Table of "doubtful" meteorites. Falls of viscid matter with luminous meteors reported in the years 850, 1110, 1548, 1557, 1652, 1686, 1718, 1796, 1811, 1819, 1844. (Since no details are given, and the observations are said to be questionable, no separate entries are provided. WRC) (R8)

X17. General observations. The analysis of substances found in a field and thought to be gelatinous meteors were found to be of animal origin and similar to snail jelly. (R4) The source of pwdre ser observations is probably the <u>Tremella Nostoc</u>, a jelly-like substance seen in wet places. (R10)Jelly-like masses, called 'pwdre ser' in Welsh, are frequently mentioned in literature and often associated with luminous phenomena. (R12) The jelly-like masses found in the fields are undoubtedly plasmodia of a myxocete. (R15, R18)

X18. General observations. Gelatinous masses found in fields may be food disgorged by herons. Such matter may sometimes be luminous. (R18) These masses are probably the viscera of toads and frogs that have become swollen with moisture. Herons may disgorge such matter and other predators may disembowel frogs and toads before consuming them. (R21)

X19. 860. Balch. Germany. (R27) See discussion under X22.

X20. 1406. Lucerne, Switzerland. See discussion under X22. (R27)

X21. 1548. Mannsfeld, Germany. (R27) See discussion under X22.

X22 1557. Schlage, Germany. "These cases were first observed some time after they were believed to have fallen from the atmosphere upon the earth; and it hence remains doubtful whether they were ever in the atmosphere. Meteoric stones, indeed, suggest indications of atmospherical formation, but these gelatinous masses point out no indications of the kind. Indeed botanists themselves are at variance with philosophers about the matter of shot-stars, which is commonly colourless, and the Tremella meteorica, which Meyen recently described as Actinomyce, may be readily taken for a shot-star, if both are generally capable of being discriminated. It may be conceived that this is not necessary, and that the meteoric mass might assume the organic and vegetable structure. To this it may be objected, that the specimens of Tremella meteorica, are frequently found of different sizes, without it being probable that they are remains of a shot-star, especially where they are small, and, as is commonly the case, occur attached to animal bodies, and even incorporated with them. It is therefore improbable that it is sometimes formed terrestrially and sometimes meteorically, because the body exhibits too little characteristic peculiarity to owe its origin to circumstances so very dissimilar. Besides, this supposes that the sudden origin of organic bodies from unorganized materials may be proved. As to the two cases of Lucerne and Mannsfeld, it is to be remembered, that, in the latter case, the blood-spots found on the soil, on the morning after the appearance and explosion of a fire-ball, admit of a very simple explanation, that, in searching for something extraordinary, as the sign of a mass that had fallen, another fungus was found, the Telephora sanguinea, which Agardh calls Palmella cruenta; and which, on account of its entirely superficial extension on moist ground, and from its striking colour, exhibited completely the appearance of spots of blood. The thick gelaninous masses of both the other cases is distinguished from the usual matter of shot-stars, the Tremella meteorica, by their red colour. It would therefore be of importance to examine whether similar appearances are any thing else than this, with a particular difference of colour; whether they are definitely marked by a peculiar structure; or whether, in the absence of any structure, it can be perceived to be an inorganic meteoric concrement, ---a matter hitherto undecided." (R27)

X23. June 23, 1978. Cambridge, England. "I wonder if you could tell me what the substance was that alighted on my lawn during a very heavy rainstorm last Friday evening (23 June). It glided down about the size of a football and settled like a jelly. It was white and gloy-like, but cellular. It did not appear to disintegrate, but had completely disappeared by the morning. I came down north-south." This observation was subsequently confirmed in writing by a neighbor. (R23)

X24. August 11, 1979. Frisco, Texas. "Two purple blobs that Sibyl Christian found on her front lawn have defied analysis by space scientists, who say they haven't ruled out the possibility they could be a rare form of meteorite. 'It's kind of like a plum pudding,' according to Doug Blanchard, a geochemist at the National Aeronautics and Space Administration near Houston. 'It has round, solid chunks in it that remain after the goo goes away. We don't know what it is,' he said yesterday." (R24) "The mysterious purple blobs found in a yard in this North Texas town and turned over to the nation's top space scientists for study are the chemical leftovers of a battery reprocessing plant, a Texas museum official says. And officials at the National Aeronautics and Space Administration say it looks like the museum official is right." (R25)

X25. Poetic references. Somehow, poets of the last few centuries could not resist inserting star jelly (or pwdre ser) into their lines. From the many examples, we quote just two.

From Cowley:

"So stars appear to drop to us
from sky,
And gild the passage as they fly;
But when they fall, and meet th'
opposing ground,
What but a sordid slime is found."

From Suckling:

As he, whose quicker eye doth trace
A false star shot to a market place
Doth run apace,
And thinking it to catch,
A jelly up does snatch.

The point here is that the association of shooting stars with terrestrial lumps of jelly-like substances was deeply engrained in the human mind not too long ago. This fact is emphasized again in the next entry ((X26). Of course, the poems and folklore only hint at a causal connection between a falling star and a jelly; they cannot prove the reality of this ancient claimed phenomenon.

X26. Folklore references. Star jelly, in all its many names, has pervaded the folklore of Europe over the ages. A 1984 review of belief in this scientifically unlikely phenomenon, by H. Belcher and E. Swale, concludes with 102 references. The range of their literature search was immense. The reason for the ubiquity and longevity of belief in star jelly is probably due to the large number of apparent coincidences on record of observations of shooting stars followed by immediate discoveries of jelly-like masses nearby.

Belcher and Swale devote most of their article to history; that is, the literary trail of star jelly. They present only a few brief anecdotes. (R29)

X27. 1994. Oakville, Washington. The mysterious appearance of gelatinous material on the earth's surface persists in modern times. However, shooting stars are not usually seen beforehand. The terrestrial substance, though, is still usually presumed to have fallen from the sky.

A case in point is that of D. Hearn, the owner of a small farm near Oakville, Washington. Hearn saw no falling star, but one day she did find a suspicious deposit of a jelly-like material. She testified:

"After a rain shower I stepped out onto my back porch and there was this white clear gelatin-like substance all over everything...It was in chunks about the size of grains of rice." (R30)

The widespread deposit of smallish bits of jelly-like substance does not match the larger single blobs of classical star jelly. The presumed "fall" on Hearn's farm, though, was curious enough to earn an airing on Arthur C. Clarke's Mysterious Universe TV program.

X28. General observations. Like the Oakville event (X27), gelatinous masses are still found in fields and marshes today, but none of their observers link them to shooting stars. A 2004 issue of New Scientist printed several letters on the subject of pwdre ser or star jelly.

Yesterday's natural philosophers and today's biologists have always associated these actually rather common gelatinous lumps with female frogs. Frogs are great favorites of herons, crows, raccoons, and other marsh predators. The gelatinous masses are claimed by we modern rational people to be only frog spawn regurgitated by frog-eaters. Falling stars are no longer part of the equation!

A problem remains, though. Today's gelatinous masses are almost always devoid of frog eggs and are often much larger than the average female frog. These could be formidable scientific enigmas.

Happily, a reasonable explanation came to the mind of A. Gray:

"The predator swallows the frog before ovulation. The predator regurgitates only the oviduct lining which swells enormously when in contact with water. Voila! A largish gelatinous mass sans eggs."

Today, the pwdre-ser enigma seems to have been rooted out of the modern mind. But can we really completely ignore the following oldish anecdote written in Scientific American (2:79, 1846)?

"...the most remarkable meteor ever seen in that section [Loweville, NY] made its appearance from the west. It appeared larger than the sun, illumined the hemisphere nearly as light as day. It was in sight nearly five minutes and was witnessed by a great number of the inhabitants of the village, and finally fell in a field in the vicinity, and a large company of the citizens immediately repaired to the spot and found a body of fetid jelly, four feet in diameter."

Not only is the size of the Loweville star jelly remarkable, but so is the long life of the "meteor"! It could not have been a normal shooting star nor a frog's oviduct lining.

In 1846, anecdotes were often embellished.

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GWF8 Prodigious Falls of Web-Like Material

Description. The fall from great heights of large quantities of cobweb-like material in long strands, tangled sheets, and balls. Hundreds of square miles may be covered as if by snow by fallen gossamer. Strands thousands of feet long have been reported. Some observers say the strands are tough, hard-to-break, and sometimes seem to evaporate away. Web falls occur mainly in the fall. Rarely are spiders reported attached to the webs.

Background. Gossamer falls are nothing new; but the association of UFO sightings with the fall of 'angel hair' is a modern development.

Data Evaluation. Ordinary gossamer falls are rather common, but the observation of 1000-foot strands, ephemeral material, toughness of strands, and falls of immense areal extent are curious and rare. The rating applies only to such falls. Rating: 3.

Anomaly Evaluation. If all falls of web-like material can be attributed to spiders, no anomaly exists. The immense falls would simply follow from population explosions of spiders. If, however, the strands are not of animal origin, a serious anomaly emerges. Rating: 2.

Possible Explanations. The great majority of falls of web-like material can probably be blamed on ballooning spiders. Reports of unusual web properties may be erroneous, although they are internally consistent. Mats and very long strands of cobweb may be due to the clumping and sticking of smaller webs.

The occasional modern association of gossamer falls with UFOs could be due to the sun's reflection off high-altitude, shiny sheets of silken gossamer.

Similar and Related Phenomena. Some gelatinous "meteors" also seem to evaporate away (GWF7); ant-population explosions (BAD in another volume); and the other falls in this section.

Examples of Prodigious Falls of Web-Like Material

X1. September 21, 1741. Selbourne, England. "Thunder, ebb and flood, and mist, are now pretty well understood, and even the mystery of gossamer is no longer referred to the superstitious imaginations of our forefathers. Yet the whole cause is not wist. We wot not how the spiders cast off their holdfasts and scud away, nor how they adjust themselves for flight, and regulate their movements; we only know that they do it. No one knows at present why, on particular days, flakes of gossamer should fall so fast upon the trees and hedges, that a diligent collector might gather basketfuls. Gilbert White, being on a visit to a friend and intent on field-sports, rose before daybreak on the morning of the 21st September, 1741, and, on coming into the enclosures, found the stubbles and clover-grounds matted all over with a thick coat of cobweb, in the meshes thereof a copious and heavy dew, so plentiful that the whole face of the country seemed as it were covered with two or three setting-nets drawn one over the other. When the dogs attempted to hunt, they, blinded and hoodwinked, were obliged to lie down and scrape the cobwebs from their faces with their fore-feet. As the morning advanced, the day became bright, calm, cloudless, warm, one of the loveliest of autumn days, until about nine o'clock, when a shower of cobwebs began to fall from the skies, which continued without interruption until the close of the day. These cobwebs were not single threads, but flakes or rags, which, as they fell, twinkled as they turned their sides to the sun. They were about an inch broad by five or six long, and considerably heavier than the air, as they fell with some velocity. This shower was of a surprising extent, reaching Bradley, Selbourne, and Airesford, three places lying in a sort of triangle, the shortest side being about eight miles in length. At Selbourne, a gentleman, thinking he could get above the shower, rode three hundred feet above his fields to the highest point he could reach; but the cobwebs seemed still as much above him as before, still descending into sight successively, and always twinkling in the sun." (R3, R6)

X2. October 1, 1820. Wigan, England. The countryside was covered by a substance that was taken for cotton. It came down like a sheet on Wigan. It contained flies so small that a magnifying glass was required to make them perceptible. (R7) Attributed to the London Times of October 9, 1820. See GWF8-X3 for a time-correlated fall in Brazil.

X3. Early October 1820. Pernambuco, Brazil. "... at the beginning of the preceding month there was a shower from the sky, consisting of a substance resembling silk, of which many persons preserved specimens. This phenomenon extended to the distance of 30 leagues inland, and nearly as many off to sea. A French vessel was covered with the silky material." (R1) See GWF8-X2 for a time-correlated fall in England.

X4. October 1881. Milwaukee, Wisconsin. "In the latter part of October the good people of Milwaukee (Wis.) and the neighboring towns were astonished by a general fall of spider webs. The webs seemed to come from a great height. The strands were from two feet to several rods in length. At Green Bay the fall was the same, coming from the direction of the bay, only the webs varied from sixty feet in length to mere specks, and were seen as far up in the air as the power of the eye could reach. At Vesburg and Fort Howard, Sheboygan, and Ozaukee, the fall was similarly observed, in some places being so thick as to annoy the eye. In all instances the webs were strong in texture and very white. Curiously there is no mention, in any of the reports we have seen, of the presence of spiders in this general shower of webs." (R4)

X5. September 20, 1892. Southeastern United States. "The postmaster of Gainesville, Florida, writes as follows: 'I enclose you something which has created a great deal of curiosity in our community; it was first discovered late this afternoon floating in the air or falling from the clouds. I have seen people, who live at least ten miles apart, who tell the same story---that it sometimes falls in long strands like spider webs, two and three thousand yards long, then doubled up into strands and wads.' The following letter, written by a correspondent from Gainesville, Fla., to our fellow-member Judge L. C. Johnson, or Meridian, Miss., refers to the same phenomenon; this letter is dated September 21, 1892: 'Of all the curious things in nature the inclosed webs are among the strangest. Yesterday great white sheets were seen floating with the daily showers, resembling large, pure white spider-webs, some of them fifty yards or more in length. The trees in many cases are covered. Near the small stream, about 100 yards from the house, some of it extended as an immense web; in other places it rolled up into a ball.'" (R5)

X6. September 26, 1948. Port Hope, Ontario, Canada. "'This day was warm and the sky cloudless. We had had dinner in the garden and I was lying on my back on the lawn, my head just in the shade of the house, when I was startled to see an object resembling a star moving rapidly across the sky. The time was 2 o'clock, Eastern Standard Time. At first it was easy to imagine that recent reports of 'Flying Saucers' had not been exaggerated. More of these objects came sailing into view over the ridge of the house, only to disappear when nearly overhead. With field glasses I was able to see that each was approximately spherical, the center being rather brighter than the edges. The glasses also showed quite a number at such heights that they were invisible to the naked eye. With only a gull flying in the sky for comparison, I should estimate the elevation of the lower objects to be about 300 ft. and the higher ones 2,000 ft.; the size was about one foot in diameter and the speed about 30 m.p.h., in a direction SW. to NE. Also visible now and then were long threads, apparently from spiders. Some of these were seen to reflect the light over a length of three or four yards, but any one piece may of course been longer. Each was more or less horizontal, moving at right angles to its length. In one case an elongated tangled mass of these gave the appearance of a frayed silken cord. These threads appeared only in the lower levels." (R8)

X7. October 11, 1950. Butte County, California. The sky was filled with hundreds of silvery white balls speeding north. They seemed to divide, unite, and disappear. Size: about that of a dinner plate. The next day a mass of gossamer was found caught in a tree. (R9)

X8. October 10, 1962. Montreal, Quebec, Canada. "At 2000GMT while the Roxburgh Castle was moored to her berth (Section 24) in Montreal, I was walking around outside my accommodation and noticed fine white filaments of unknown kind hanging around stanchions and topping lift wires of derricks. Calling the attention of the Chief Officer, I pulled one of these strands from a stanchion and found it to be quite tough and resilient. I stretched it but it would not break easily (as, for instance, a cobweb would have done) and after keeping it in my hand for 3 or 4 minutes it disappeared completely; in other words it just vanished into nothing. Looking up we could see small cocoons of the material floating down from the sky but as far as we could ascertain there was nothing either above or at street level to account for this extraordinary occurrence." (R10) High strength and disappearance are not among the usual properties of spider's webs. This account resembles those of "angel hair" in the UFO literature.

X9. October 1969. St. Louis, Missouri. "Great globs of spider-web-like material descended from the sky, alarming numerous citizens. As Donald Pecsok, director of the county's air pollution control division, remembers hundreds of calls poured into the newspapers and his office. People thought the material was from an exploded test airplane from nearby McDonnell Douglas plant; thought it was from a flying saucer; or thought it was a divine sign, etc. According to nearby rural residents, says Pecsok, the globs contained a few eggs of 'balloon spiders,' which spun the material at the tops of trees and left it there for the wind to catch. Unfortunately, most of the material dissolved as it hit the ground. Some that was retained and put under a microscope resembled a spiderweb, but Pecsok is reluctant to make any great claims because he could not get any local scientists to investigate.... Although the event is listed as a 'spider invasion', Pecsok notes that he found only one spider, a small browish creature, about an eighth of an inch in diameter and about the size of a quarter with its legs stretched out." Attributed to the Washington Post, March 28, 1970. Later tests made on the strands indicated that it was not of biological origin. (R11)

X10. Circa May 1971. Near Melbourne, Australia. "A mysterious rain of fine thread fell over the Kilmore area on Saturday. (Kilmore is 35 miles north of Melbourne.) Farmers said it looked like snow as the thread, up to 20 feet long, floated to earth, carpeting paddocks and hanging from trees, telegraph lines and fences. The elastic, synthetic-type thread stuck to objects and rolled up into balls when gathered. Sheep and cattle were covered by the mystery thread." One report mentioned the presence of spiders. Attributed to the Melbourne Sun, May 10, 1971. (R12)

X11. No date or place given. Curious statement that auroras are sometimes accompanied by the fall of silken threads. (R2) See also GLA17.

X12. April 28, 1957. Woolston, New Zealand. A mysterious gossamer-like substance floated down upon many of the suburbs of Christchurch. One resident with a telescope found the sky to be filled with sheets of the material "the size of a dinner table". From his telescope focus-settings, he estimated the highest sheets to be at about an altitude of 15,000 feet.

The potentially anomalous characteristic of this "gossamer" material was not so much its great quantity nor even its remarkable height.

> To the uninitiated it appeared to be spiderweb. But its texture was very different. When handled it immediately dissolved into nothing; though apparently light, it was not light enough to defy gravity except with the help of a very high wind. (R13)

Normal spider web does not "dissolve" so readily. Otherwise, it would be useless for snagging insects. Could spiders spin a different kind of subliming web just for the purpose of "ballooning?

X13. March 12, 1993. South Pacific Ocean. Aboard the m.v. Alam Selamat. At 0630, as a frontal system passed the vessel, there was a sudden rain shower lasting about 25 minutes. Captain J.N. Gowrie reported:

> As the rain began to dry on the warm decks, we noticed patches of what first looked like slime but after it had dried appeared to be wool or cotton. We send you a sample of the material and the facsimile chart of the relevant surface analysis, showing my additions of ship's position at the time as 41° 43'S, 167° 40'W, course 100°, speed 13 knots. (R14)

While not the classical long strands "gossamer," this "fiber" fall seems to fit best in this GWF section. The vessel was about 100 miles from land. Where could these fibers have originated and what was their composition? Interestingly, they did not sublimate!

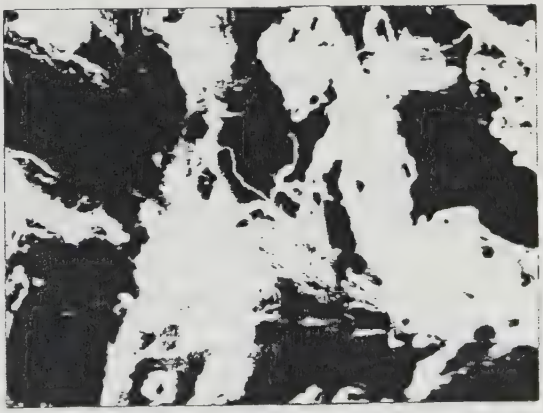
X14. October 25, 1997. Overton Down, England. A notably large "eruption" of tiny spiders each trailing long threads of gossamer. Borne by the wind they were "captured" by a 400-foot-high ridge near Overton. Many were caught and entangled by vegetation. T. Meaden walked across one of their major landing sites and wrote:

"At first, the gossamer was sparse, but I was soon in a region which was a veritable "field of silk". Over an area of more than two hundred square [?] acres the gossamer was so dense as to almost obscure the grass. It lay in sheets composed of millions of separate strands made by millions of tiny spiders, of the type that locals call 'money-spinners'. When the wind was force 1 or 2 the sheets billowed gently in the wind like waves on a white ocean." (R15)

Here the gossamer source is obvious and there is no quick sublimation. The great quantity is interesting but not anomalous.

X15. General observations concerning that silky, web-like material called "angel hair" that sometimes falls from the skies. While small spiders often accompany gossamer falls, so also do UFOs! Unlikely though it may seem, angel hair is a staple of ufology. Could there be a reasonable gossamer-UFO connection?

From a physics standpoint, the answer is "yes". There is a strong possibility that airborne, shiny sheets of entangled gossamer could reflect flashes of light toward an observer when the sun's angle is just right. A UFO-interpretation is possible.



"Angel hair" from a 1999 UFO event as seen at 60X through a microscope. There is little resemblance to spider gossamer here. (Courtesy P. Budinger)

Coincident UFO sightings and angel-hair falls cannot prove a causal relationship. However, the UFO waves of 1954 and 1981, particularly the former, were accompanied by many joint sightings of UFOs and gossamer falls. Ufologists consider these multitudinous coincidences an important proof of a causal connection.

Lastly, the gossamer strands in some large falls apparently vanishes (sublimates?) quickly. This seems to prove that at least some falling gossamer is not spider-produced but might instead originate with some UFOs---or some other still-unrecognized source! (R16)

For two specific angel hair-UFO reports, see X16 and X17 following.

It is conceivable, however, that ballooning spiders might spin gossamer strands that have a different composition and thus possess different properties from the sticky, long-lasting strands they use in their webs to catch prey.

X16. October 17, 1952. Oloron, France. "At 12;50 p.m. on a cloudless day, October 17, 1952, witnesses in Oloron reported a long, narrow, white-colored cylinder. In front of this cylinder were an estimated 30 featureless balls. These balls [UFOs?] moved in pairs and traveled in a zig-zag fashion. Material fell from them and dropped to the ground, where for several hours it covered trees and the roofs of houses?" (R17)

Note the fairly rapid disappearance of the "material."

X17. October 27, 1952. Gaillac, France. "Ten days later, at 5:00 p.m., at Gaillac, about 100 people saw a long plumed [?] cylinder traveling slowly among about 20 saucers. After 20 minutes, the whole spectacle passed over the horizon. However, before it did, masses of white thread fell to earth. The material became gelatinous, sublimed, and disappeared." (R17)

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R11. "A Classic Case of 'Angel Hair'," Pursuit, 3:72, 1970. (X9)
R12. "Webs...," INFO Journal, 3:24, 1972. (X10)
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R16. Boldman,Brian; "An Analysis of Angel Hair, 1947-2000," International UFO Reporter, 26:10, Fall 2001, (X15)
R17. Basterfield, Keith; "Angel Hair: An Australian Perspective," International UFO Reporter, 27:6, Spring 2002. (X16, X17)

GWF9 Falls of Miscellaneous Organic Substances

Description. The fall of seeds, berries, feathers, butter-like substances, and various other organic materials. Such falls, like most others in this section, are usually observed during or just after heavy rain or hail.

Background. So great is the variety of organic substances reported to fall from the sky that this catch-all section must be provided to record the less-common types.

Data Evaluation. Many of the data are old and anecdotal; and too many are one-of-a-kind. Yet, there are some basic similarities, such as material and species selectivity. Many, but far from all, GWF9 "falls" are associated with stormy weather. A few bear the marks of hoaxes; e.g., some stones, corn kernels. It's a mixed bag of easily debunked events! Rating: 3.

Anomaly Evaluation. Most of the substances and objects cataloged below are undeniably of terrestrial origin and therefore probably accessible to whirlwinds and tornados. Some, however, do take place during fair weather when natural levitating forces are absent. In addition we have these puzzling aspects: (1) The magnitudes of some falls (numbers of items and/or areal extent); and (2) The surprisingly common selectivity and monophyletic nature of many falls. Rating 3.

Possible Explanations. The whirlwind/tornado hypothesis is reasonable in many instances. Rarely, objects and fluids will fall from high-altitude aircraft. Strong winds can blow particulates and liquid droplets great distances from their origin in industrial areas that discharge smoke and vapors. Finally, we have to admit the strong suggestions of hoaxes in some bizarre falls; e.g., some falls of stones and corn kernels.

Similar and Related Phenomena. Colored precipitation (GWP10); anomalous falls of hay and leaves (GWF6); falls of organic substances (GWF9); the long-distance transportation of giant dust particles (GWF15).

Examples of Falls of Miscellaneous Organic Materials

X1. Circa 1879. Fifeshire, Scotland. After a heavy hailstorm, the hills were covered with a substance resembling seaweed. It hung from trees and shrubbery. (R1, R2)

X2. January 31, 1686, Rauden, Germany. A substance called "mourning paper" fell in great quantities. "It consisted of black leaves, having the appearance of burnt paper, but it is harder, coheres together, is somewhat brittle; and when examined by chemical reagents is found to be a mineral mass, composed of the same ingredients as meteoric stones; for it consists of silica, magnesia, iron, and some nickel, and exhibits also traces of chromium. It may be compared to the black crust which covers the surface of the meteoric stones. Black substances, like beans, are described as having fallen along with this matter, but these bodies have not yet been recognized." (R3)

X3. August 17, 1841. Lebanon, Tennessee. A shower of flesh and blood reported in a tobacco field. (R4) A hoax was later admitted. (R5)

X4. No date given. Kentucky. A shower of flesh (no details given) was considered to have been nostoc. (See GWF7) (R6) But a microscopic examination of the substance proved it to be of animal origin. (R7)

X5. No date given. Cumberland, Kentucky. "While we were in that land of water-fowl below Cumberland, I witnessed a shower of feathers; as we sailed up a reach of the river with a fresh breeze, without the knowledge of a human being within many miles of us, it appeared to be snowing; this was nothing more than small feathers, and we supposed that at some Indian camp in the swamps to windward the operation of goose-plucking must be going on; these feathers had likely travelled many miles, and would continue while the breeze lasted." (R8, R9) The state of Kentucky is assumed here, but the original article does not specify which of the several Cumberlands in the United States is meant.

X6. September 24, 1848. Lyon, France. "On a calm evening, about sunset, Lortet observed, near Lyon, a thick and rapid shower of fossil Ostracods (Cypridinia), and heard the minute shells rustle the withered leaves. They had no doubt been caught in an ascending air-current from some of the regions in North Africa, where they are found." (R10, R11) Once again, the selectivity of the meteorological mechanism is intriguing.

X7. May 9, 1867. Dublin, Ireland. "On the night of May 9, during a violent rainstorm, a remarkable shower of 'berries' fell in Dublin, on both sides of the river. They were described as having the form of a very small orange, about half an inch in diameter, black in colour, and when cut across seeming as if made of some hard dark brown wood. They fell with such force that even the police were forced to seek shelter. The 'berries' were afterwards identified as hazel nuts which had been partially fossilized in a peat bog. How they came into the air is not known." (R12, R13)

X8. No date given. Warminster, England. Fierce wind and hailstorms deposited ivy berries around Westminster and areas within 6 or 8 miles of it. (R14)

X9. No date given. Macerata, Italy. A heavy fall of seeds occurred during a heavy storm, covering the ground up to a depth of about half an inch. One naturalist stated they were the seeds of the Judas Tree, found in Central Africa and the Antilles. Some of the seeds had begun to germinate. (R15)

X10. April 28, 1893. Jafferabad, India. A fall of seeds simultaneous with the descent of a meteorite. (R16)

X11. No date given. Spain. Wheat fell like rain. Author suggests it was blown over from North Africa. (R17)

X12. March 24, 1840. Rajket, India. A shower of an unknown type of grain during a thunderstorm. (R18)

X13. June 24, 1911. Eton, England. "On the morning of Saturday, June 24, the ground here was found to be covered with small masses of jelly about as large as a pea. There had been a heavy rain on Friday night, and it was raining at 7 a.m., when, so far as I could ascertain, the phenomenon was first seen. On being examined microscopically the lumps of jelly turned out to contain numerous ova of some insect, with an advanced embryo in each. The egg itself is very minute---an elongated oval 0.04 mm. in length. Yesterday and the day before many larvae emerged, and were obviously those of some species of Chironomus, though colorless, having no hemoglobin, as is the case with the larvae of C. plumosus. Not being an entomologist, I am at a loss to understand how these egg-masses could have appeared where they did unless they were conveyed by the rain, as it does not seem likely that the midges would have laid their eggs on pavements, gravel paths, tombstones &c." (R19)

X14. Fall and winter 1695. Cos. Limerick and Tipperary, Ireland. "We have had of late, in the County of Limerick, and Tipperary, showers of a sort of matter like butter or grease. If one rubs it upon one's hand it will melt, but lay it by the fire and it dries and grows hard, having a very stinking smell. And this last night some fell at this place, which I did see myself this morning. It is gathered into pots and other vessels by some of the inhabitants of this place." The preceding account was amplified by the Bishop of Cloyne, who described a similar phenomenon occurring in Munster and Leinster, Ireland. "For a good part of last winter and spring, there fell in several places, a kind of thick dew, which the country people called butter, from the consistency and colour of it, being soft, clammy, and of a dark yellow. It fell always in the night, and chiefly in moorish low grounds on top of the grass, and often on the thatch of cabins. 'Twas seldom observed in the same places twice. It commonly lay on the earth for near a fortnight without changing its colour, but then dried and turned black..... It fell in lumps, often as big as the end of one's finger, very thin and scatteringly. It had a strong, ill scent, somewhat like the smell of churchyards or graves; and indeed we had during most of that season very stinking fogs, some sediment of which might possibly occasion this stinking dew, though I will by no means pretend to offer that a reason of it." (R20) The spelling and punctuation have been modernized to some extent. See also the blasting fogs (GWD3) and gelatinous meteors (GWF7).

X15. September 5 and 6, 1978. Washington, D. C. "An unexplained green slime fell on Washington, D. C., 5 and 6 September 1978. The affected area is generally bounded by Rock Creek Parkway on the west, Pennsylvania Avenue on the north, G Street on the south and 23rd Street on the east. The slime was discovered injuring plants and animals, soiling automobile windshields, angering residents and baffling city health officials. About half the flowers in one resident's back-yard garden simply wilted and died in the two-day period during which the substance fell." The substance was a green liquid that apparently fell from quite a height because the roof of a 12-storey building was coated with the substance. (R21)

X16. November 11, 1953. North Atlantic Ocean. The wind coated the lookouts of S.S. Caxton with a phosphorescent substance that gave off a greenish glow. It was readily brushed off and could be transferred to other objects. It might have been wind-blown bioluminescent organisms. (R22)

X17. December 1870. Venezuela. After a heavy rain, plant leaves were covered with a great many yellow specks, which microscopic examination proved to be fresh-water plant cells; species Triceratium and Cosmarium. (R23)

X18. Frequent occurrence. Bath, England. "I should be very glad if I could obtain information as to the cause and nature of certain 'purple patches' which I have noticed from time to time for many years past, but have been unable to get explained. The patches in question occur during, or immediately after, rain, on the pavement or roadway; dashes of vivid purple, or rather violet, varying in size from small splashes or drops to patches as large as the palm of one's hand, but most commonly they are about the size of a shilling. When quite fresh, sometimes a little clot is observable in the centre of the splash. Sometimes I find one patch completely isolated, sometimes two or three in close proximity; sometimes, again, numerous little drops scattered over a certain space; once I counted twenty or thirty tiny dashes in about ten yards of pavement. When quite wet the violet colour can be rubbed up with a handkerchief or paper, which it stains as with 'aniline purple' dye, as it does the pavement, and when once dry it is quite inerasible, and lasts till it is worn away by exposure, or the feet of passers-by. I observe it to occur chiefly during warm rain after a dry or cold spell; never during dry weather, whether in summer or winter. During the past hot summer there was none to be found, but directly the weather changed in July, I saw it in various localities. This was also the case in the long cold winter of 1895, when on the breaking up of the frost there were plentiful patches to be seen up and down the streets; there was also a complete absence during the following summer, till the drought gave, and then again I found this appearance recur." (R24) One letter to Nature suggested the patches were droppings from berry-eating birds. (R25) The purple patches, however, seem to be found all seasons of the year in many localities. But there is probably some similar prosaic explanation.

X19. 1876. Bath Co., Kentucky. An extensive shower of jelly-like substance. Thought to be the dried spawn of fishes or frogs. (R26) See X4, which may be the same incident.

X20. May 5, 1786. San Domingo. "Manna is the bread of organic showers; but what is the meat? Showers of flesh have often been recorded and they have proved to be precipitations of a glairy substance, which upon partial drying formed enough of a skin on the outside to induce people to call it flesh. When found fresh, this material has been compared to butter. Probably most if not all of it is the material known as zooglea formed on the surface of water where bacteria are actively multiplying. The substance known as zoogen or xoiodin is probably the same." (X19 described here) "Such spawn really has rained down also, if we may believe the account of M. Moreau de St. Mery, relating to an observation in San Domingo. 'From November, 1785, to the 5th day of May, 1786, there was experienced a terrible drought. The last day, viz, May 5, 1786, there fell during a strong east wind, in several parts of the city of Port au Prince.... a great quantity of black eggs, which hatched the following day. M. Mozard preserved about 50 of these small animals in a flask half full of water, where they shed their skins several times. They resembled tadpoles.'" (R26)

X21. No date given. Lake Providence, Louisiana. "It is stated that during a heavy thunder-storm near Lake Providence, Louisiana, a number of small bodies were found on the ground, immediately after the shower, scattered along the shore of the Mississippi River for a distance of forty miles above the lake; as many as half a bushel being collected around one house. These, on being submitted to critical examination, proved to be the scales of the common gar-fish of the South (Lepidosteus). The species inhabits the shallow, muddy waters of the South and sometimes attains a length of five or six feet, and is especially characterized by being enclosed in an almost impenetrable coat of mail (the scales in question), so compact as almost to resist the penetration of a bullet. It is very difficult to give credence to this story; as the gar-fish are not particularly abundant, and the method of aggregation of so large a number of detached scales would be a problem extremely difficult of solution. Perfectly authentic instances are on record of small fish, shells, etc., being taken up in storms and scattered over the earth; but when it comes to special portions of fishes which weight from 5 to 50 lbs. each, the draft upon one's faith is rather too severe." (R27)

X22. June 8, 1901. Sart lez-Spa, France. On this date, the correspondent of the Meteorological Service reported that at about 2 P.M. a liquid substance fell from the sky that was neither rain nor snow, nor hail. This liquid stuck to the leaves and made them sparkle like little mirrors. Upon closer investigation, the substance also stuck to one's fingers.

This anomalous precipitation lasted only 5-7 minutes. No clouds could be seen above the village.

It was speculated that this sticky material originated in a conflagration at Amers, 140 kilometers away, during which great quantities of sugar had been consumed and, perhaps, partly vaporized and discharged into the atmosphere. (R28)

X23. May 1930. Danville, Virginia. Broken seashells fell with hail. (R29)

See GWF14 for falls of live shellfish.

X24. September 1938. Washington, D.C. "A mysterious green chemical descended on parts of Foggy Bottom last week, wounding flora and fauna, soiling automobile windshields, angering residents, and baffling city health officials."

Some garden plants were killed. Cats and dogs became nauseous.

The liquid apparently fell from a great height because it was found on the roof of a 12-storey building. (R30)

Compare X29, San Francisco's 1994 green rain of airplane deicer. But airplane deicer is an unlikely explanation for this 1938 fall at Washington.

X25. July 9, 1984. Brasschaat, Belgium. "At Brasschaat (8 km N.E. of industrial plants at Antwerp), small dark-bluish or purple, jelly-like, sticky fragments came down during severe wind gusts. According to a meteorologist interviewed by Het Volk, they might have been sucked up from a chemical factory by levitating winds." (R31)

X26. July 24, 1984. Winton, Bournemouth, United Kingdom. A report from E.J. Hodge. "I was in my car waiting at traffic lights in Winton, Bournemouth, when a sheet of off-white or dove-gray liquid fell from the blue sky on to the roof, windscreen, and bonnet of my car. A yellow bus next to me and the road around were also affected." (R32)

X27. December 1989. North Reading, Massachusetts. "Some time between the 12th and 18th of December (1983), the west end of North Reading in Massachusetts was bombarded with blobs of jelly-like goo, greyish-white and oily-smelling. The first blob---two feet in diameter---was found by Thomas Grinley in his driveway. He thought something was leaking from his car until he found similar blobs on Main Street and on the gas station pumps. State officials denied that the blobs were dropped by a plane. They were soon absorbed into the pavement, but a little goo was saved and was being studied at the state's Department of Environmental Quality Engineering. Preliminary results showed that they were not toxic." (R33)

However, no precise identification followed, nor was a source indicated! Such is common in "substance" falls.

See GWF7 for "gelatinous" meteors and pwdre ser, which bear some similarity to the above "blobs."

X28. Extended period in the early 1980s. Evans, Colorado. A series of problematical accounts of small handfuls (10-25) corn kernels falling on and around houses in Evans. Some individuals claimed to have actually seen the falling corn. On two occasions, pinto beans rather than corn kernels fell! No unusual weather phenomena were involved. (R34)

This item closely resembles the famous stone falls at Chico, California (GWF2-

X30). Hoaxes seem indicated in both series of events. In this instance, the introduction of pinto beans suggests a hoaxer at work.

X29. February 17, 1994. San Francisco, California. About 2:30 P.M., sheets of a bright green liquid fell along Mission Street. Automobiles and buldings suddenly turned green. The celestial dye was quickly washed away and down the gutters by an ensuing rainstorm. (R35)

The green rain was analyzed and found to be aircraft deicer fluid. It was theorized that it fell from an incoming aircraft that had been deiced at its (colder) point of origin. Some of the deicer might have collected in the wing flaps and frozen in flight. The descent into warmer California air melted it. (R36)

Here, we have a very reasonable explanation.

X30. April 9, 1999. Salt Lake Valley, Utah. The following is an item from an eastern newspaper.

"Maybe it's a bird, maybe it's a plane. But it is certainly sewage.

"And it's no joke in the Salt Lake Valley, where gobs of thick, raw sewage falling from the sky a dozen times since April 9 have soiled up to seven houses at once." (R37)

"The smell in the area was "terrible" according to the mayor of Taylorsville. Sheriff's deputies were studying the 'splatter pattern' and firemen were hosing down the houses. One house required 500 gallons of water and 30 gallons of bleach.

"Aircraft landing at the Salt Lake City airport sometimes pass over the afflicted area, but the Federal Aviation Administration stated---as they always do---that jet toilet tanks can only be flushed using an external valve. Furthermore, the bluish disinfectant used in aircraft toilets was not present in the sewage samples."

The repetition of the phenomenon (a "dozen" times) in the same area is curious. Assuming that aircraft were at fault, was a single plane responsible, or did a dozen have the same defective valve? Did this sewage fall really happen?

X31. May 31, 2004. Lawrence, New York. "A holiday boat party in an exclusive area of Long Island was interrupted---when a severed human hand mysteriously dropped out of the sky onto the deck of a boat, police said yesterday."

This gruesome event took place on a boat anchored just off the exclusive Lawrence Village Marina. The hand was not decomposed and was apparently that of a male Caucasian. Some speculated that the hand had been severed from a stow-away on an aircraft landing or taking off from J.F. Kennedy Airport. the retraction or lowering of a plane's landing gear might have done tha damage. (R38)

Although the tale sounds doubtful, the police were apparently involved. However, no further information was forthcoming from them. There should have been something recorded officially!

X32. August 31, 1981. North Wales, United Kingdom. Testimony of Mrs. R. Colegate. "...between 1400 and 1430 hours, my husband and 28-year old daughter saw to their amazement and disbelief earth falling out of the sky in the shape of sods about 6 inches high which would fit into the palm of your hand, and others were larger. There was grass growing out of one side. The weather at the time was sunny and bright, windy, and on the cool side. (R39)

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GWF10 Fish Falls

Description. The fall of fish from the sky, often by the thousands, and usually along with heavy downpours. With rare exceptions, the fish are native to the area and alive when they hit the ground, roofs, and other structures. However, falls of dead, decaying, and dry fish have been reported. Fallen fish average 2-4 inches in length, although specimens up to a foot are on record. The area of a fish fall is typically long and narrow---a hundred feet to several miles in length.

Background. Fish falls have long been ridiculed by the scientific world and debunkers of strange phenomena, even though perfectly reasonable meteorological mechanisms exist for levitating fish and transporting them long distances.

Data Evaluation. Most reports of fish "falls" are really announcements that fish have been found out of their element; viz. on dry land or isolated pools of water. Observations of fish in free fall are rare. Nevertheless, the circumstantial evidence is very strong in many instances and when combined with the high-quality accounts of people seeing fish in the air and even being hit by them makes a strong case for the reality of the phenomenon. Rating: 1.

Anomaly Evaluation. No one argues that whirlwinds, tornados, and waterspouts can pick up objects, carry them long distances, and then release them so that they seem to fall from the sky. There are, however, several anomalies associated with fish falls: (1) The rare falls of dead, decaying, and dried fish; (2) The frequent species-selectiivity of falls, wherein only one species falls sans plants and environmental debris; (3) The great travel distances as inferred by the falls of alien species native to locations hundreds, even thousands, of miles away; and (4) The large sizes of some fallen fish; i.e., more than 2-3 inches. These facts strain the whirlwind hypothesis. Rating: 3.

Possible Explanations. Whirlwinds, waterspouts, and tornados probably account for most fish falls. Even dead and decaying fish along a shore may be picked up and transported. Some instances of supposed fish falls may result from the temporary overflowing of fish-containing bodies of water and the release of fish buried in the mud.

Similar and Related Phenomena. All other falls of living animals, especially frogs and toads (GWF11).

Examples of Fish Falls

X1. 689. Saxony, Germany. A rain of fish during a storm. (R34, R35)

X2. Spring 1666. Kent, England. "About Easter, in the year 1666, a pasture field in this parish, which is a considerable distance from the sea or any branch of it, and a place where there are no fish ponds but a scarcity of water, was scattered over with small fish, in quantity about a bushel, supposed to have been rained down from a cloud, there having been at that time a great tempest of thunder, hail, wind, etc. These fish were about the size of a man's little finger; some were like small whitings, others like sprats, and some smaller like smelts. Several of these fish were shown publically at Maidstone and Dartford." (R10, R26, R31, R44, R47) One of the classic accounts. It is typically vague in that it does not say positively that fish were seen to fall---they were simply found on the ground.

X3. 1673. Island of Kolter, Great Britain. Many herring found on mountain top. Whirlwind postulated. (R34)

X4. 1691. Ecuador. Mud and fish erupt from volcano. (R1)

X5. June 19 and 20, 1698. Ecuador. "When the summit of the mountain Carguairazo, to the north of Chimborazo, and 18,000 feet high, fell, in the night between the 19th and 20th of June, 1698, the surrounding fields, to the extent of about 43 English square miles, were covered with mud and fishes... I recur to these facts, because they throw some light on the difference between the eruption of ashes, and that of mud-like masses of tufa and trass, which contain wood, coal, and shells." (R1, R10, R26, R31) This is not an example of a true fish rain, being geological rather than meteorological, but it does underscore the fact that fish can be deposited on the ground in many ways.

X6. September 2-3, 1771. Cotbus, Germany. Fish 5-6 inches long reported to have fallen during a heavy thunderstorm. (R31)
X7. 1795. Lake Muritz, Germany. Heavy shower passed over lake, scattering fish over surrounding fields. (R31)
X8. July 25, 1795. Steuer, Germany. (R31)
X9. 1796. Lorn, Great Britain. Herring fry. (R2, R31)

X10. Circa 1809. Pondicherry, India. "In a heavy shower of rain, while our army was on the march, a short distance from Pondicherry, a quantity of small fish fell with the rain, to the astonishment of all. Many of them lodged on the men's hats; when General Smith, who commanded, desired them to be collected, and afterwards, when we came to our (camping) ground, they were dressed, making a small dish that was served up and eaten at the general's table. They were not flying fish, they were dead, and falling from the common well-known effect of gravity; but how they ascended, or where they existed, I do not pretend to account." (R31)

X11. March 1817. Appin, Scotland. After abundant rain, herring fry 1 1/2 to 3 inches in length found scattered over the ground. About 3 barrels full. (R2, R31)
X12. 1821. Melford House, Scotland. Shower of large herring fell during boisterous weather. (R2, R31)
X13. July 1824. Meerut, India. Fish fell on soldiers at drill. (R10, R17)
X14. Summer 1824. New York, New York. Fish found in the streets. (R47)
X15. 1825. Kinross-shire, Scotland. (R2, R10, R26, R31)
X16. July 1826. Moradabad, India. Live fish were seen to fall on the grass. (R10, R17)
X17. May 28, 1828. Kratzburg, Germany. (R31)
X18. April 21, 1828. Strathpeffer, Ireland. Ground covered with herring 3-4 inches long. (R3, R10, R21, R31, R29)
X19. Summer 1828. Cambridge, Maryland. Large fish were found in rain-filled ditches 1 mile from a river. (R4, R31)
X20. July 20, 1829. Moradabad, India. Fish were seen flipping about on the grass after a shower; one was 2 1/4 inches long. (R20, R31)

X21. February 19, 1830. Nokulhatty Factory, India. "On the 19th of February, 1830, at noon, a heavy fall of fish occurred at Nokulhatty Factory, in the Dacca zillah; depositions on the subject were obtained by nine different parties. The fish were all dead; most of them were large; some were fresh, others rotten and mutilated. They were seen at first in the sky like a flock of birds descending rapidly to the ground. There was rain drizzling at the time, but no storm." Some of the fish were headless. Some witnesses were hit by falling fish; others found them on their roofs. (R6, R10, R17, R26, R31, R40)

X22. 1830. Dunkeld, Great Britain. (R10)
X23. March 9, 1830. Argyleshire, Great Britain. Small herring scattered over the fields. (R10, R26, R44)
X24. May 16 or 17, 1831. Futtehpur, India. After a storm several thousand fish were found strewn over a wide area. They were all dead and dry. (R31) Date for this fall said to be 1833. Some of the fish weighed 3 pounds. (R10, R17, R26)

X25. 1833. Lake Gwynant, Wales. (R44)
X26. May 1835. Allahabad, India. Dead and dry fish found after storm. (R10, R17)
X27. 1835. Louisville, Kentucky. After a heavy rain, a great number of sun-perch, 2-3 inches long, found swimming in the gutters. (R44) Date given as 1837. (R7)
X28. 1838. Calcutta, India. Fish taken out of a pluviometer. (R17)
X29. September 1839. Calcutta, India. Fish, about 3 inches long, fell in a long straight line. (R10, R31) Event occurred on September 20, according to R50.
X30. June 30, 1841. Boston, Massachusetts (?). One fish 10 inches long with smaller specimens. (R10, R31, R47)
X31. July 8, 1841. Derby, England. Fish and ice fall. (R10, R31) Frogs also reported to have fallen. (R8)
X32. October 1841. Dunfermline, Great Britain. Many small fish during a heavy thunderstorm. (R9, R34)
X33. July 25, 1850. Kattywar, India. After 35 inches of rain in 26 hours, the ground was literally covered with fish; some on the tops of haystacks. (R10, R17, R31)
X34. August 3, 1852. Poonah, India. Multitudes of fish on ground after heavy rain. (R10, R17)

X35. February 9, 1859. Aberdare, Great Britain. "On Wednesday, February 9, I was getting out a piece of timber for the purpose of setting it for the saw, when I was startled by something falling all over me---down my neck, on my head, and on my back. On putting my hand down my neck I was surprised to find they were little fish. By this time I saw the whole ground covered with them. I took off my hat, the brim of which was full of them. They were jumping all about. They covered the ground in a long strip about 80 yards by 12, as we measured afterwards. That shed (pointing to a very large workshop) was covered with them, and the shoots were quite full of them. My mates and I might have gathered bucketsful of them, scraping with our hands." (R11, R12, R13, R17, R29, R31, R34, R48) J. E. Gray, of the British Museum, thinks it was all a practical joke. (R14) R. Drane, who investigated the fall carefully asserts that it could not have been a practical joke because the fall occurred over a considerable tract of country, with testimony from widely separated areas. (R15)

X36. February 20, 21, and 26, 1861. Singapore. "When the sun came out again I saw numbers of Malays and Chinese filling their baskets with fish contained in the pools formed by the rain. They told me the fish had 'fallen from heaven,' and three days later, when the pools were all dried up, there were still many dead fish lying about. I found them to belong to the Clarias batrachus, which can live a considerable time out of water, and even move to some distance on dry land. As they lay in my courtyard, which is surrounded by a wall, they could not have been brought in by the overflowing of a torrent, nor is there any considerable one in the neighborhood. The space covered by these fishes might be about fifty acres. They were very lively and seemed to be in good health."(R16, R26, R31, R34, R47)

X37. June 9, 1868. Dolitz, Germany. (R31)
X38. May 24, 1873. Bremen, Germany. Great number of whitefish. A waterspout was seen in the area. (R31)
X39. Circa 1875. Woodbury, New Jersey. Small fish found flapping about after a heavy rain. (R34)
X40. 1879. Berrybank, Australia. Thousands of minnows found swimming in pools left by a rainstorm. The track of the storm was only 100 yards wide by half a mile long. (R34)
X41. December 15, 1883. Airdric, Scotland. A shower of live perch, which are usually deep-water swimmers. (R19)
X42. Circa 1886. Aberdeen, South Dakota. Small fish found on the roofs of office buildings after hard rain. (R34)
X43. January 24, 1887. Walgett, Australia. Many fish about 3 inches long found in standing water on a road after heavy storms. After the water dried up there were thousands of dead fish counted. (R20)
X44. 1888. Near Little Rock, Arkansas. Fish found in ponds that were dry before a heavy rain. (R34)
X45. 1889. Steyl-Teegelen, Holland. A waterspout formed and then retracted itself into a cloud, disintegrating with a couple loud detonations. A huge quantity of water and many fish fell immediately after. (R34)
X46. Summer 1890. Grape Creek, Illinois. Small sunfish and small frogs covered a field after a heavy rain. (R25)
X47. May 29, 1892. Coalburg, Alabama. So many eels fell in a shower that farmers came with carts to take them away for fertilizer. (R47) Why only eels?
X48. 1893. Winter Park, Florida. Sunfish 2-4 inches long fell with rain. (R22)
X49. June 15, 1895. Co. Clare, Ireland. Many fish 1 1/2-2 inches long fell with a few drops of rain. (R23)
X50. July 26, 1896. Essen on the Ruhr, Germany. A hailstone the size of a hen's egg contained a crucian carp 40 mm long. (R31, R44)
X51. May 15, 1900. Providence, Rhode Island. During a severe thunderstorm, perch and bullpouts 2-4 inches long fell on yards and streets. (R35. R47)
X52. Summer 1900. Buffalo, New York. Street puddles filled with small fish. (R34)
X53. June 27, 1901. Tillers Ferry, South Carolina. Hundreds of little catfish, perch, trout, etc., fell during a heavy rain and were found swimming in the pools between cotton rows. (R24, R26, R31, R47)

X54. April 14, 1909. Newcastle, Natal. "The locality of this rain was near the borough of Newcastle, Natal, and the area covered was about 400 yards long by 100 wide. This area lies between two running streams ---Osborne Spruit, 400 yards away and at about 50 feet lower level, and Indanda River, a mile away and about 80 feet below the level of the region where the fishes fell. Thus there was no possible chance that the fishes had been brought on the land by an inundation. Mr. Nesbit did not actually witness the fall, since it took place some time between midnight and 6 o'clock of the morning of April 14, 1909, but he did see and pick up some of the fishes alive at 7:30 A.M. on this day. He reported that there were literally hundreds of fishes, some alive and comparatively unhurt, some dead, and some smashed almost to a pulp. The largest fishes were 3 inches long, the average length about 1.5 inches. There were several kinds of fishes, and Dr. Warren notes that the largest were Barbus gurneyi." (R34, R36) The varying amounts of damage done to the fishes is curious. Why are some unhurt while others are smashed to a pulp? (WRC)

X55. 1915. Kelantan, Malaya. A terrific thunderstorm; water was ankle-deep in 10 minutes. Many small fish about 1 1/2 inches long seen in water covering hard-baked fields. They were not mudfish because the water ran off before mud was formed. (R34)

X56. August 24, 1918. Hendon, England. "About 3 o'clock on the afternoon of Saturday, August 24 last, the allotment-holders of a small area in Hendon, a southern suburb of Sunderland, were sheltering in their sheds during a heavy thundershower, when they observed that small fish were being rained to the ground. The fish were precipitated on three adjoining roads and on the allotment-gardens enclosed by the roads; the rain swept them from the roads into the gutters and from the roofs of the sheds into the spouts.... The precipitation of the fish, we were told, lasted about ten minutes, and the area involved Commercial Road, Canon Cocker Street the portion of Ashley Street lying between these streets, and the adjoining gardens. The area measured approximately 60 yards by 30 yards, and was thus about one-third of an acre. It is not easy to say how many fish fell, but from the accounts it may be gathered they were numerous; there were apparently several hundreds." The fish were identified as sand-eels. All were dead when they fell. They were, in fact stiff and hard; and some broke when they hit the ground. (R27, R28, R34, R45, R47) If the sand-eels were dead and stiff they must have been aloft for many minutes, perhaps hours. (WRC)

X57. 1919. Argylshire, Great Britain. A waterspout burst, precipitating herrings in heaps on pavements and roofs. (R30)

X58. June 11, 1921. Gulf of Mexico. A cloud to which a waterspout had been attached dumped a torrent of water upon a fishing boat. Between 30 and 50 menhaden 2-3 inches long came down with the deluge. (R34)

X59. 1924. Gulargambone, Australia. Hundreds of small gudgeons found in the gutters after heavy rain. (R33)

X60. May 29, 1923. Drumbirk, Ireland. After an exceptionally violent thunderstorm, dozens of tiny red fish were discovered on the roof of a house. (R38)

X61. May 18, 1928. Tarboro, North Carolina. Hundreds of small fish were found swimming in puddles in the fields after a heavy downpour. (R35)

X62. July 10, 1933. Muzaffapur District, India. (R39)

X63. September 1936. Guam. "While stationed on the island of Guam in September, 1936, I witnessed a brief rainfall of fish, one of the specimens of which was identified as the tench (Tinca tinca) which, to my knowledge, is common only to the fresh waters of Europe. The presence of this species at a locale so remote from its normal habitat is worthy of note." (R43)

X64. October 23, 1947. Marksville, Louisiana. "A rainfall of fish occurred on October 23, 1947, in Marksville, Louisiana, while I was conducting biological investigations for the Department of Wild Life and Fisheries. In the morning of that day, between seven and eight o'clock, fish ranging from two to nine inches in length fell on the streets and in yards, mystifying the citizens of that southern town. I was in the restaurant with my wife having breakfast, when the waitress informed us that fish were falling from the sky. We went immediately to collect some of the fish. The people in town were excited. The director of the Marksville Bank, J. M. Barham, said he had discovered upon arising from bed that fish had fallen by hundreds in his yard, and in the adjacent yard of Mrs. J. W. Joffrion. The cashier of the same bank, J. E. Gremillion, and two merchants, E. A. Blanchard and J. M. Brouillette, were struck by falling fish as they walked toward their places of business about 7:45 a.m. There were spots on Main Street, in the vicinity of the bank (a half block from the restaurant) averaging one fish per square yard. Automobiles and trucks were running over them. Fish also fell on the roofs of houses." The several species that fell were native to local waters. They were cold when picked up; one person claimed they were frozen. The fish fell in a strip 75-80 feet wide and about 1,000 feet long. The weather was foggy but comparatively calm. (R42) The calm weather is an unusual aspect of this report. (WRC)

X65. July 13, 1949. Wellington, New Zealand. (R45)

X66. 1824. Fifeshire, Great Britain. (R34)

X67. No date given. Gulargambone, Australia. Many fish found in gutters after a heavy rain. (R34) Same as X59?

X68. No date given. Argentina. It is not unusual for heavy rains in the Chaco region to include fish falls. (R34)
X69. No date given. Shaw, Mississippi. Minnows found swimming between cotton rows after a heavy rain. (R34)
X70. No date given. Galloway, Scotland. A shower of herrings. (R2)
X71. No date given. Near Paris, France. Streets covered with fish up to 6 inches long. (R31)
X72. General observation. In the arctic live fish are occasionally found in dry places. They may get there during migration, when they often leap (like salmon) over obstructions. (R32)
X73. General comment. Fish found alive in fields did not fall there but were stranded after heavy rains inundated the areas. (R18)
X74. General comment. Evidence for fish falls is all hearsay. They never occur in fact. (R41) The author of this letter to Science, Bergen Evans, was a well-known debunker of unusual phenomena. (WRC)
X75. Superficial descriptions of the fish-fall phenomenon. (R37, R46)
X76. No date given. Bullia, India. A water-spout broke and produced heavy rain along with a shower of fish and turtles. (R21)
X77. July 5, 1825. Kingwood, New Jersey. A four-inch sunfish, still alive, during a violent rainstorm. (R49)
X78. November 1931. Bordeaux, France. (R51)
X79. January 20, 1936. Florence, Italy. Fish seen spinning in the air in violent whirlwinds. (R52)

X80. November 1931. Bordeaux, France. "Live perch rained from the sky when a waterspout broke over Bordeaux Saturday.

"The downpour lasted less than 30 seconds, but so many fish fell wriggling in the streets that motor cars were compelled to halt after having crushed hundreds. The fish were from four to five inches long.

"Housewives with baskets and basins picked up all that they could find before they were swept down the drains." (R53)

X81. 1912. Muzaffarpur District, India. G.T. Gill was the observer of several fish falls is this part of northeastern India near the Nepal border. When commenting on the 1933 Indian fish falls

"...nothing as compared with the one which occurred at Bunhar Factory in 1912, where I then was, I actually observed this with my own eyes, that is to say when the rain was actually falling I did not notice fish coming down with it, but the rain, which was very heavy, ceased very suddenly, just like the rain on the 10th July last [1933], and when it did, my tennis lawn and the road in front of the bungalow were simply white with mounds of fish, so much so that at first, before I went outside to investigate the matter, I thought it must be hail lying on the ground. To my amazement I saw it was fish. They were also all over the indigo factory which was one-third of a mile from the bungalow. None of the fish were of any size, none of them being more than two inches long." (R54)

Gill also referred to other well-observed fish falls that occurred in the same area since 1912. He testified that in some falls there were several species of fish, thus contradicting the common assertion that fish falls are monophyletic.

X82. July 11 to September 1, 1933. Muzaffarpur District, India. These fish falls were surpassed by that of 1912 (X81), as now confirmed by S.L. Hora.

"The recent falls were not so big but plenty of fish were to be had for the picking up. What is the explanation? My correspondence suggests that the fish were sucked up out of a river by a waterspout and then discharged again during a heavy thunderstorm. The objection to this theory is best put by means of a question. Where are the fish in the interval between the breaking up of the water-spout and the thunderstorm? What keeps them suspended in the air?" (R54)

X83. Spring, no year given. Thunder Bay, Lake Huron. The engaging tale of a smelt storm.

"It happened during a smelt storm in early spring with the Rhonda K foundering dead in the icy water amid terrifying six- and eight-foot waves off Lake Huron's Thunder Bay light near Alpena."

"Spookiest thing I even saw," Stiles said of the small fish carried from the water by the winds. 'Something I never heard of before. Smelt started falling from the sky. Thousands of smelt falling like a silver rain, and thousands of gulls were all around our heads picking up the smelt." (R55)

X84. About May 16, 1983. Chippenham, England. A group of students at Chippenham Technical College reported that a lot of tadpoles had fallen during a thunderstorm. The river Avon is nearby; and a waterspout or small tornado was suspected. (R56)

Of course, tadpoles are not fish, although there is some resemblance, so we dutifully add this to the legitimate tadpole falls in GWF11.

X85. March 1989. Rosemont, Australia. A widespread fall of sardines "like a sheet of silver rain." They were all dead. Some hit H. Degan on the head. The kookaburras gobbled them up, but the family cat wouldn't touch them. (R57)

Cats not eating sardines? That seems anomalous!

X86. About 1997. Somewhere in the U.S. We copy here the caption beneath a remarkable photograph from the February 1998 issue of QST, a magazine for radio amateurs.

"When Dave, K1WHS, checked the SWR of his 432-MHz beam last spring, he could tell that something was wrong---it was much higher than normal. From the ground he thought he could see something dangling in the elements. Upon closer inspection he discovered the desiccated remains of a catfish! No one knows how the hapless catfish ended up 60 feet in the air, and miles from any lake or stream." (R58)

While the catfish probably did fall from the sky, it was most likely dropped by an osprey or some other large fish-eating bird.

X87. May 31, 2000. Ethiopia. In southern, drought-stricken Ethiopia, the struggling farmers were treated to a deluge of fish.

"The unusual rain of fish, which dropped in millions from the air---some dead and others still struggling---created panic among the mostly religious farmers." (R59)

Storms in the Indian Ocean were said to be the source of the fish---the usual explanation---but the numbers claimed are impressive.

X88. August 2000, Great Yarmouth, United Kingdom. "Britain's Meteorological Office said a shower of dead, but still fresh, sprats rained down on the fishing port of Great Yarmouth, in eastern England, after a thunderstorm. The baby fish fell more than a kilometre inland, on the houses behind the resort's seafront, lining lawns and pathways with bite-size sprats." (R60)

X89. 2002. Korona, Greece. (A translation from the Austrian newspaper Kurier by O. Stummer) After a heavy storm, it rained sardines in northern Greece. A whirlwind had sucked water out of the sea at Thessaloniki and carried the tiny fish along several kilometers into the interior. "We could not believe our eyes. The fields and woods were covered with tiny fish," reported an inhabitant of the village of Korona. (R61)

We enter this example to illustrate that the foreign-language literature also contains many accounts of fish falls.

X90. February 1994. Dunmarra, Northern Territory, Australia. There were two notable fish falls around Dunmarra in February. The second is the more interesting.

"This second flight of fish were up to 4 in. (10 cm)-long and proved to be the freshwater spangled grunter previously mentioned. Ashley Patterson, senior forecaster at the Darwin Bureau of Meteorology, trotted out the mini-tornado theory, but admitted in this case it seemed a little lame as Lake Woods, the nearest sizeable body of water is more than 65 miles (100 km) away." (R62)

The distance from the probable source is, of course, what makes this example verge on the anomalous.

X91. April or May 1956. Chilatchee, Alabama. The weather was clear and hot with a slight westerly breeze. No tornados or whirlwinds were in the area.

"The witness and her husband were surprized to notice a small and very dark cloud form in the sky. The dark cloud was almost overhead when it started to rain, the rain falling in a very localized area about 200 feet square. As the rain continued, the cloud changed in color from very dark to almost white. The witness and her husband actually saw fish falling with the rain, which lasted for about 15 minutes. The fish were alive and flopped about on the ground. As the rain stopped, the cloud completely dissipated.

"The fish that fell were of three types: catfish, bass, and brim, all indigenous to the area and all freshwater fish. There were enough fish to fill a #3 washtub. (A #3 washtub is 3 feet in diameter and about a foot deep.)" (R63)

This is one of the rare cases where the fish are actually seen to fall.

X92. June 11, 1938. Queenston, Ontario. "On the morning of June 11, farm-workers in Queenston, Ontario, found thousands of fish, from two to three inches long, strewn about the orchard of Colonel Harold C. Sheppard. A heavy rain had fallen the night before. Many of the fish were lodged in the branches of fruit trees. A hundred were found alive." (R64)

The full article (R64) relates ten additional fish falls in the same general area from 1859 to 1940.

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GWF11 Falls of Frogs and Toads

Description. The descent of frogs or toads from the sky, usually by the hundreds or thousands. Frog and toad falls are inevitably associated with heavy summer rainstorms. The falling animals are usually alive, although some die upon impact, and average about a half inch in length. These falls are generally "pure"; that is, not accompanied by other aquatic species or plant debris.

Data Evaluation. Rather surprisingly, many very good cases of frog/toad falls are on record, although they tend to be concentrated in the Nineteenth Century, when science openly discussed such events without fear of ridicule. While the bulk of the cases involve animals actually seen in flight, some reports may be due to population explosions and mass migrations, with no actual levitation involved. Rating: 1.

Anomaly Evaluation. As in the case of fish falls (GWF10), whirlwinds, waterspouts, and tornados are believable meteorological mechanisms for collecting and transporting small frogs and toads. The anomalous features of this phenomenon are: (1) The very large number of individuals involved, which infers that the levitating mechanism must strip very large areas of toad/frog habitat and then concentrate its cargo; (2) The selectivity of the phenomenon; i.e., the general lack of debris and other species typical of the animals' habitat. Rating: 3.

Possible Explanations. The conventional explanation---whirlwinds, waterspouts, tornados ---seems the only reasonable one at this time.

Similar and Related Phenomena. The other animal falls in this section, particularly fish (GWF10); turtles and shellfish (GWF14).

Examples of Falls of Frogs and Toads

X1. Summer 1794. Lalain, France. "It was very hot. Suddenly, at about 3 o'clock in the afternoon, there fell such an abundance of rain that 150 men of the grand guard, in order not to be submerged, were obliged to leave a large depression in which they were hidden. But what was their surprise when there began to fall on the ground all about a considerable number of toads, the size of hazelnuts, which began to jump about in every direction. M. Gayet, who could not believe that these myriads of reptiles fell with the rain, stretched out his handkerchief at the height of a man, his comrades holding the corners; they caught a considerable number of toads, most of which had the posterior part elongated into a tail, that is to say, in the tadpole state. During this rain storm, which lasted about half an hour, the men of the grand guard felt very distinctly on their hats and on their clothing the blows struck by the falling toads. As a final proof of the reality of this phenomenon, M. Gayet reports that after the storm the three-cornered hats of the men of the guard held in their folds some of the reptiles." (R18)

X2. August 1804. Near Toulouse, France. "Many accounts of showers of frogs have been reported to the French Academy. In August, 1804, two gentlemen, returning from Toulouse, noticed a black cloud, which burst upon them, and they were surprised to see an immense shower of frogs, which fell on their cloaks and covered the road and the fields, so that a diligence passing along killed a large number." (R11)

X3. 1804. Windham, Connecticut. (R21)

X4. June 23, 1809. France. Little toads, the size of hazelnuts, fell during a rain storm. (R18)

X5. August 1814. Fremon, France. During a storm with strong winds. Small frogs fell upon people. (R18)

X6. August 1822. France. A heavy shower of large raindrops also brought toads the size of walnuts. Some of the toads fell upon the hat of the observer. (R18)

X7. Circa 1830. Bushmills, England. A shower of half-formed frogs. No rain mentioned. (R1)

X8. Circa 1830. Rouen, France. Innumerable small, perfectly formed, frogs fell on roofs, window sills, and walks. (R1)

X9. June 1833. Jouy, France. "I saw toads falling from the sky; they struck my umbrella; I saw them hopping on the pavement, during about 10 minutes in which time the drops of water were not more numerous than the toads. The space upon which I saw the multitude of these animals was about 200 fathoms." (R18)

X10. July 30, 1838. London, England. After a heavy shower dozens of young frogs were discovered hopping on the pavement. (R12)

X11. June 1841. Tutbury, England. A shower of frogs fell during a severe thunderstorm. They fell in countless numbers from the housetops. (R11)

X12. 1841. Derby, England. A heavy thunderstorm deposits hundreds of fish and frogs along with half-melted ice. Many of the frogs were killed by the impact. (R2)

X13. 1844. Selby, England. "In the course of the afternoon of Monday last, during the prevalence of rather heavy rain, the good people of Selby were astonished at a remarkable phenomenon. It was rendered forcibly apparent, that with the descent of the rain, there was a shower of another description, viz., a shower of frogs. The truth of this was rendered more manifest by the circumstance that several of the frogs were caught in their descent by holding out hats for that purpose. They were about the size of a horse-bean, and remarkably lively after their aerial but wingless flight. The same phenomenon was observed in the immediate neighborhood." (R3, R10)

X14. Summer 1846. Humber River, England. Frogs fell on vessels in the river and the coast near Killinghome lights. (R18)

X15. 1847. Venton, France. A shower of toads. (R4)

X16. 1859. Waveney River, England. "I was out insect-catching by the side of the river Waveney, about a quarter-past 9 on Friday night, when a thunderstorm came on. I ran for shelter to the buildings at Aldeby Hall. The rain came down in torrents. Just before I was clear of the fens I observed some small toads on my arms, and several fell in my net, and on the ground and paths there were thousands. I am quite sure there were none in my net before I started, as I took out a Leucania pudorina out of it. I believe they fell with the rain out of the clouds." (R5)

X17. 1860s. Briton Ferry, Great Britain. Shower of frogs. (R15)

X18. 1864. Pontiac, Michigan. A small green frog found in a hailstone. (R6)

X19. August 12, 1871. No place given. A shower of small green frogs. (R7)

X20. July 1873. Kansas City, Missouri. A shower of frogs darkened the air and covered the ground for a long distance. (R9)

X21. June 16, 1882. Dubuque, Iowa. Small, still-living frogs found in hailstones. (R8)

X22. Summer 1890. Grape Creek, Illinois. After a heavy rain, the ground was covered with small perch and frogs 3/4 to 1 inch long.

X23. Circa 1891. Bournemouth, England. "One day we had a violent thunderstorm. Having no shelter, I was wet to the skin in a few minutes, and saw small yellow frogs, about the size of a florin or half-crown, dashed on the ground all around me. I ran to shelter under a large mortar-pan, and, after the storm was over, found in this pan hundreds of these small frogs... Thousands were impaled on the furze bushes on the common close by, and days afterwards the stench from the decomposing bodies was very noticable." (R14)

X24. June 30, 1892. Moseley, England. A furious storm brought a shower of nearly white frogs. (R18)

X25. Circa 1894. Dunfermline, Great Britain. (R10)

X26. August 1894. Thatto Heath, England. Great numbers of frogs or toads found on the ground after a rain. (R11, R24)

X27. 1901. New York City. Tadpoles. (R21)

X28. 1911. Twickenham, England. Tadpoles found in a rain barrel. (R13) A weak bit of evidence. (WRC)

X29. May 25, 1915. Gibraltar. "During a thunderstorm near Gibraltar on May 25, a cloud is said to have belched forth millions of small frogs which had apparently been drawn up from a lake twenty miles away." (R16)

X30. July 21, 1933. North Chelmsford, Massachusetts. Shower of small toads. (R21)

X31. June 16, 1939. Trowbridge, England. "Mr. E. Ettles, superintendent of the municipal swimming pool stated that about 4.30 p.m. he was caught in a heavy shower of rain and, while hurrying to shelter, heard behind him a sound as of the falling of lumps of mud. Turning, he was amazed to see hundreds of tiny frogs falling on the concrete path around the bath. Later, many more were found to have fallen on the grass nearby." (R19-R21, R25)

X32. July 26, 1947. Towyn, Great Britain. Frog fall. (R20)

X33. August 28, 1977. Canet-Plage, France. Thousands of frogs, the size of peas, fell just prior to a heavy rain shower. (R22)

X34. No date given. Ham, France. A statement by M. Peltier. "I cite an incident I observed in my youth; a storm advanced on the little village of Ham, Department of the Somme, where I lived, and I observed its menacing march, when suddenly rain fell in torrents. I saw the village square covered everywhere with little toads. Astonished by this sight, I held out my hand and was struck by several of the reptiles. The dooryard was also covered; I saw them fall upon the slate roof and rebound to the pavement.... Whatever the difficulty of explaining the transport of the reptiles, I affirm, without doubt the fact which made such a profound impression upon my memory." (R18) The observer may have been the scientist Peltier, but this has not yet been established definitely.

X35. No date given. Godalming, Great Britain. The town was swarming with small black frogs. Inhabitants said that they had come with the rain. (R11) Population explosions can often account for the sudden appearance of large numbers of animals. Some species mature and migrate in incredible numbers.

X36. 1834. France. (R23) Same as X4?

X37. 1922. Chalon-sur-Saone, France. Frog fall disproved. Due to migrating swarms of frogs. (R24)

X38. June 24, 1979. Bedford, England. Fall of small frogs. Tornados reported

X39. October 20, 1834. Ham, France. Circa 1800, according to M. Peltier, testifying at a meeting of the Academy of Sciences, Paris, in 1834, his home town of Ham was hit was a severe storm. The rain fell in torrents. "He then saw the market-place, or 'place de la ville,' covered with little toads. Astonished at what he saw, he stretched forth his hand, and received on it the shock of a number of these creatures. The courtyard of the house was filled in the same manner as the 'place.' He saw them fall on a roof of slates, and thence rebound on the pavement." (R26)

X40. September 1804. Senlis, France. Daylight was suddenly obscured by an enormous black cloud, "A clap of thunder of extraordinary force broke the cloud, which poured upon us a torrent of toads, mingled with a little rain." (R26)

X41. August 1804. Fremard, France. M. Duparcque, in a letter to the Academie des Sciences, described a violent storm in which little toads fell in great numbers upon the village as well as himself and the village curate who was accompanying him. (R26)

X42. December 6, 1883. Haiti. A correspondent of La Nature wrote that on this date toads rained down upon the plain of Miragoane. (R27)

X43. June 16, 1937. Frackville, Pennsylvania. "Astonished householders of this little mining town, ten miles north of Pottsville, went out with brooms and swept bullfrogs off their open porches after a thunderstorm today.

"The tiny frogs sounded like the thudding of hailstones as they dropped by hundreds on tin roofs." (R28)

The "bullfrog" identification is questionable in this instance. They were doubtless frogs though.

As usual the whirlwind theory was advanced to explain the frog fall. It is hard to imagine, however, how hundreds of dispersed tiny frogs can be "vacuumed up" without also levitating plant debris and other marsh dwellers along with them.

X44. May 1981. Nafplion, Greece. The inhabitants of this town woke up to find it raining thousands of little green frogs. Scientists at the Athens Meteorological Institute opined that they were sucked up from North African marshes and carried by winds 500-600 miles across the Mediterranean. The frogs were remarkably sound and most were uninjured by the long flight. (R29)

X45. May 16, 1983. Chippenham, Wiltshire, England. Students at the Chippenham Technical College reported the fall of many tadpoles during a thunderstorm. (R30)

A whirlwind could be a reasonable explanation here since the Avon river was nearby.

X46. Summer 1919. Northamptonshire, England. J.W. Roberts recalls a boyhood experience in the Journal of Meteorology.

"I saw a dark, almost black, cloud coming towards me. It was a whirlwind. It picked up some of the loose straw laying about, and when it reached the buildings it seemed to stop, and the dark cloud suddenly fell down and I was smothered all over with small frogs---thousands of them about 1¼ to 1½ inches long." (R31)

X47. Summer 1932. Rode, Somerset, England. A myriad of tiny frogs fell upon a farmboy and his dog. (R32)

X48. June 1949. Near Gallup, New Mexico. His reading of our Handbook of Unusual Natural Phenomena encouraged R.A. Schuler to write (somewhat vividly) of an experience he and his wife had.

They were driving on Route 66. The temperature was 104° F; the sky was blue from horizon to horizon.

"Out of nowhere---without warning---it poured, extremely hard rain, hail and toads. The hail balls were maybe the size of grapes to the size of peas.

"The toads were a medium brown in color and approx. the size of an adult's thumb nail.

"This whole incident lasted for less than 5 minutes, if my memory is correct.

.....

"After a short period of time, maybe one or two miles, we (my wife and I) ran into [another] tremendous rain and hail storm.

"The highway and the desert sands seemed to be alive and moving.

"By now we were down to a very slow speed and under closer observation we noticed the area was littered with millions of hailstones and those toads were hopping all over.

"The storm stopped as fast as it started, and the toads disappeared just as fast.

"I'll never forget how slippery the road was as we drove over those toads and the popping of their bodies under the tires of my automobile." (R33)

The standard explanation of such sudden appearances of toads in rainstorms is that the rain brings them out of hiding for mating purposes. But the writer above states that it "rained" toads. It does seem, however, that the toads came out of hiding very quickly and in numbers exceeding a reasonable population density for a desert area. We favor here, therefore, a "fall" rather than an "emergence."

X49. October 1987. Stroud, Gloucestershire, United Kingdom. Perhaps most remarkable about this example of a "fall" is that it was printed in the mainstream journal Weather.

"Bemused locals were not only stunned to witness frogs raining from the sky, but also these frogs were pink! Startled scientists identified them as a rare albino strain indigenous to southern Spain and North Africa, speculating that they were carried there by the same high-level winds that occasionally leave our car windshields with a sprinkling of Saharan sand." (R34)

The transportation of light-weight, exotic species hundred of miles by strong winds is not as anomalous as the wind's careful selection and collection en masse of a single species minus traces of any of the other light-weight fauna and flora of its native habitat. How is this selection process accomplished?

References

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R4. Jobard, M.; Comptes Rendus, 47:159, 1847. (X15)
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R6. King, Wm.; "Hail-Storm in Pontiac," Canadian Naturalist, 2:1:307, 1864. (X18)
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R12. Hale, C.P.; " A Shower of Frogs," Notes and Queries, 8:7:437, 1895. (X10)
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R14. Hinder, F.S.; "Tadpoles," English Mechanic, 94:62, 1911. (X23)
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R16. Nature, 95:378, 1915. (X29)

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R18. McAtee, Waldo L.; "Showers of Organic Matter," Monthly Weather Review, 45:217, 1917. (X1, X4, X5, X6, X9, X14, X24, X34)
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R22. "Frog and Grass Showers in August 1977," Journal of Meteorology, U.K., 2:300, 1977. (X33)
R23. Comptes Rendus, 47:159, 1858. (X36) (Cr. L. Gearhart)
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R26. Martin, W.C.L.; "On the Fall of Frogs, Toads, and Fishes from the Sky," Recreative Science, 3:328, 1862. (X39-X41)
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R28. Anonymous; "Bullfrogs by the Hundred Fall in Pennsylvania Rain," New York Times, June 17, 1937. Cr. M. Piechota. (X43)
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GWF12 Insect Falls

Description. The fall of flightless insects from the sky. Worms and caterpillars are the most common occupants of this category.

Data Evaluation. Only a few accounts of rather poor quality exist. Some cases are suspect because some insect species migrate in immense numbers and shed their wings immediately upon landing. There are as a consequence many opportunities for labelling natural insect movements as "falls." Rating: 3.

Anomaly Evaluation. Since insects may appear in great profusion and are very light in weight, wind transport is a reasonable explanation in almost all cases; and insect falls are really more curiosities than anomalies. Rating: 3.

Possible Explanations. Whirlwinds, waterspouts, tornados, and even strong, non-rotating winds seem adequate here.

Similar and Related Phenomena. Other animal falls in this section (GWF). Insect population explosions (BI).

Examples of Insect Falls

X1. June 1819. Riga, Latvia. "During a strong north west wind, an immense quantity of young caterpillars fell upon the great meadows on the south bank of the Duna, and devoured the grass, with the roots, upon a very extensive tract." (R1) A classic case, but one in which the word "fell" might only mean "appeared."

X2. November 1854. Turin, Italy. Several thousand insects, both larvae and adults, fell during a violent wind. There were a species of hemiptera known only on Sardinia. (R7)

X3. May 1871. Bath, England. "A most violent storm of rain, hail, and lightning visited Bath on Saturday night. The rain descended in torrents, causing the Avon to overflow its banks in the lower districts, especially at Salford, where whole tracts of land were laid under water. The storm was accompanied by a similar phenomenon to that of the previous Sunday; myriads of small annelidae enclosed in patches of gelatinous substance, falling with the rain and covering the ground. These have been microscopically examined, and show, under a powerful lens, animals with barrel-formed bodies, the motion of the viscera in which is perfectly visible, with locust-shaped heads bearing long antennae, and with pectoral and caudal fin like feet. They are each and inch and a half long, and may be seen by the curious at Mr. R. Butler's, The Derby and Midland Tavern, where scientific men, on inspecting them, pronounce them to be marine insects, probably caught up into the clouds by a waterspout in the Bristol Channel." (R2)

X4. July 25, 1872. Bucharest, Romania. "A letter from Bucharest, given in the Levant Times, reports a curious atmospheric phenomenon which occurred there on the 25th of July, at a quarter past nine in the evening. During the day the heat was stifling, and the sky cloudless. Towards nine o'clock a small cloud appeared on the horizon, and a quarter of an hour afterwards rain began to fall, when, to the horror of everybody, it was found to consist of black worms of the size of an ordinary fly. All the streets were strewn with these curious animals."(R3, R10)

X5. Circa 1897. Hutchinson, Minnesota. A luminous cloud "rose majestically from the eastern horizon, shown with a uniform, vivid whitish light and passed directly over the town. When the cloud was overhead a great shower of insects descended to earth covering the ground all around to the number of about 50 to 100 per square foot. These insects proved to be a species of hemiptera and were nonluminous. They had apparently been induced to take wing by the bright object in the sky." (R5) Since these insects were winged, it is the possible association with the cloud that is of interest here.

X6. No dates given. Galatz and Bucharest, Romania. (R4)

X7. October 14, 1934. Rock Creek, British Columbia, Canada. "It rained beetles at Rock Creek, B. C., Oct. 14. The downpour of tiny brown insects lasted intermittently for three hours. The beetles had wings, but seemed unable to use them." (R6) Another weak example, obviously.

X8. July 21, 1887. Nancy, France. Toward 5 o'clock in the afternoon, a veritable rain of a species of forest ant swept down on the streets and places of Nancy. Both winged and wingless ants fell like clouds of snowflakes for hours. The phenomenon was attributed to whirlwinds that preceded a great storm that arrived that night. (R8)

Since some of the ants were said to be wingless, this event is classified as a "fall" rather than a common cloud of winged ants on mating flights. However, since most ants on mating flights discard their wings upon alighting, this entry remains suspect. Observers could have only assumed that some of the falling ants were wingless.

X9. February 15, 1950. Innsbruck, Austria. About 9:30 A.M., a citizen was walking from Wattens to Kolsass when he encounted a heavy snow shower. Falling with the flakes were thousands of small, dark caterpillars, 1.5-2.0 centimeters long. They were hairy and felt like velvet to the touch. For at least 300 meters, the fallen snow was dark with them. They turned out to be the larvae of local insects called Weichkaefers. (R9)

The larvae were flightless and seen to fall with the snow. They were presumed to have been levitated by the usual whirlwinds.

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R9. Anonymous; "Raupen Schneien von Himmel?" Tiroler Tagezeitung, February 15, 1950. Cr. L. Schonherr. (X9)
R10. Burt, Christopher C.; Extreme Weather, New York, 2004, p. 199. (X4)

GWF13 Bird Falls

Description. The fall of live or dead birds from the sky. Bird falls are usually associated with severe weather conditions. During spring and fall migrations, many birds are killed by impact with tall buildings, TV antennas, and other obstructions. Except for a couple extreme cases, which may involve anomalous factors, such normal bird mortality is excluded here.

Background. We consider birds to be masters of the air, but it is obvious that they are sometimes overwhelmed by the elements and have their navigational senses confused, resulting in immense numbers being killed.

Data Evaluation. Excluding the common reports of dead birds found around tall obstructions during migration leaves only a few difficult-to-explain cases, many of which come from suspect sources. Rating: 2.

Anomaly Evaluation. Most of the bird falls or kills described below seem understandable in the context of severe weather and, though huge numbers of birds are involved, they are more curious than anomalous. Examples X1, X3, and X6, however, have puzzling characteristics that make the "weather" explanation seem simplistic. Rating: 3.

Possible Explanations. Dead birds found around tall obstructions typify "impact kills" and need no further explanation. Dead birds falling from an unobstructed sky are frequently found to have suffered decompression effects and were probably carried to great heights by storms. Lightning has also been advanced as a factor in some bird falls.

Similar and Related Phenomena. None.

Examples of Bird Falls

X1. 1896. Baton Rouge Louisiana. "On Friday morning last early risers in the little capital witnessed a peculiar sight in the shape of a shower of birds that fell from a clear sky, literally cluttering the streets of the city. There were wild ducks, catbirds, woodpeckers, and many birds of strange plumage, some of them resembling canaries, but all dead, falling in heaps along the thoroughfares, the singular phenomenon attracting many spectators and causing much comment." In the neighborhood of National Avenue, children collected 200 birds. (R1)

X2. March 20, 1941. Shreveport, Louisiana. "Blackbirds by the hundreds dropped dead from the sky at Barksdale Field. They cluttered the army airbase so thickly that its police were called out to clear the ground. A soldier said large flocks of the birds broke flight suddenly and plopped to the ground." (R2)

X3. March 13-14, 1904. Minnesota. "Roberts tells the fate of migrating Lapland Longspurs on the night of March 13-14, 1904, which 'was very dark but not cold, and a heavy, wet snow was falling with but little wind stirring. Migrating Longspurs came from the Iowa praries in a vast horde, and from 11 P. M. until morning, incredible numbers met their deaths in and about villages by flying against buildings, electric light poles and wires, and by dashing themselves forcibly onto the frozen ground and ice.' In Worthington, Minnesota, an attempt was made to compute the numbers lying dead on two lakes with an aggregate area of about two square miles. 'A conservative estimate showed that there were at least 750,000 dead Longspurs lying on the two lakes alone!' The total area on which dead migrants were found covered approximately 1,500 square miles." (R3) Although some of the birds apparently flew into obstructions, the great majority seems to have been found on relatively featureless terrain. (WRC)

X4. December 13, 1928. Caliente, Nevada. "During an early morning hour (about 2 A.M.) of December 13, 1928, residents of Caliente, Nevada, were awakened by a heavy thumping of something falling on the roofs of their houses. Those who were curious enough to step outside and investigate the unusual occurence found scores of water birds in the new fallen snow. The next morning, several thousand Eared Grebes were found on the ground and on flat roofs of business houses throughout the city....literally thousands of these birds were found in every portion of the town and outskirts....they were forced out of the air by the heavy density of the snow....Caliente had the main bunch, but they were scattered for twenty miles every way." Hundreds more were discovered in various spots in Utah. (R3)

X5. October 7-8, 1954. Warner Robins Air Force Base, Georgia. "On the night of October 7-8, 1954, the largest recorded ceilometer kill in history occurred at Warner Robbins Air Force Base, a few miles south of Macon, Georgia. It involved 53 species and an estimated 50,000 birds, 2552 of which were examined....An advancing cold front in the autumn is believed to have precipitated these mass mortalities by bringing together adverse weather conditions (especially a lowered cloud ceiling), nocturnal migrants, ceilometers and/or tall obstructions.' (R4) These is an extreme example of bird kills that take place around obstructions during every migration period. (WRC)

X6. January 25, 1969. St. Mary's City, Maryland. "On Jan. 25, 1969, something smashed up flocks of ducks flying over Maryland so that their dead and dying bodies rained down around the southern Maryland community of St. Mary's City (about 50 miles SE of Washington, D.C.) Canvasbacks, redheads and scaups were found scattered around St. Mary's City, on the local college campus, in the St. Mary's River and even in the downtown business section. The ducks had sustained widespread hemorrhages and multiple rib fractures." Attributed to the Washington Post of January 26, 1969. (R5)

X7. January 3, 1978. County of Norfolk, England. "136 pink-footed geese were killed in flight in the county of Norfolk. They dropped dead out of the clouds along a track 45 km in length, orientated WNW to ESE between Castleacre and Swardeston. Their deaths occurred at the same time as a tornado-bearing cold front was sweeping southeastwards across East Anglia." Autopsies showed extensive hemorrhaging of the lungs, ruptured livers, and massive internal fracures and bone damage. It was postulated that the decompression effects experienced in a tornado and falls from a great height could account for all the damage noted. (R6)

X8. November 1973. Stuttgart, Arkansas. "On the day after Thanksgiving, hefty, mature mallards came crashing out of the sky. Many of them were frozen stiff....The day the ducks came tumbling down was a wild and turbulent one in Arkansas. Several twisters were sighted over the state and several touched down amid violent springlike thunderstorms, wind flurries and hail storms. ....'It was about 4 PM,' said Lloyd McCollum, chairman of the State Game & Fish Commission, who lives here. 'Within 10 to 15 minutes all of them had come down, all mature, fairly heavy ducks.' The ducks came down with a lot of hail and several were completely ice-encrusted, according to witnesses. Possibly they may have been picked up higher than normal and frozen along with the hail. 'They got up there in colder atmosphere and, like an airplane, got iced over,' Mr. McCollum said. 'They got ice on their wings and couldn't fly. In short, they just froze to death.'" (R7)

X9. December 10, 1991. Minersville, Utah. About 9:30 P.M., the skies of Minersville were filled with the cries of grebes. According to V. Hollingshead: "They were just falling out of the sky, hitting the church, cars, the ball parks. Hundreds of them fell all over the streets. You could hear them hitting each other in the air, and hitting the ground."

Minersville Elementary School Secretary S. Taylor reported that the birds landed everywhere, including the roofs of houses; they even broke some automobile windshields. Hundreds were killed, but many survived their fall and were taken to bodies of water where they could rest and take off. (Grebes cannot take off from land.)

The birds were identified as Eared Grebes, which were migrating from Great Salt Lake to Baja California. It was theorized that a snowstorm and fog had exhausted and disoriented them.

X10. October 1998. Tacoma, Washington. About 300 starlings dropped out of the sky on this date. Neither poison nor disease was the cause. The birds all suffered crushed chests and blood clots in hearts and lungs. Since starlings fly in tight formations, some speculated they had smashed into the side of a large truck [?], or perhaps a wind gust had thrown them to earth violently. (R9, R10)

Compare this even with X7, where decompression produced similar injuries to birds in flight.

X11. February 2005. Newcastle, Australia. If pizza can fall from the sky (GWF5-X16), why not plucked, frozen chickens. Two such cases have been reported from the same city in Australia. One even smashed roof tiles and wasn't discovered until the smell of decay gave it away! (R11, R12)

References

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R2. "Rain of Dead Blackbirds," Fortean Society Magazine, 1:4, October 1941. (X2)

R3. Hochbaum, H. Albert; Migrations of Waterfowl, 1955, p. 168. (X3, X4) (Cr. L. Gearhart)

R4. Johnston, David W., and Haines, T.P.; "Analysis of Mass Bird Mortality in October, 1954," The Auk, 74:447, 1957. (X5) (Cr. L. Gearhart)

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R6. Meaden, G.T.; "Tornado on a Wild Goose Chase," Journal of Meteorology, U.K., 4:77, 1979. (X7)

R7. "Frozen Ducks Fall from the Sky onto Town," Buffalo Evening News, December 5, 1973, p. III-60. (X8) (Cr. L. Gearhart)

R8. Christensen, Kathleen; "Thousands of Grebes Fall from the Skies," Spectrum, December 12, 1991. Cr. D.H. Palmer. (X9)

R9. Anonymous; "300 Starlings Drop out of Sky Dead," October 31, 1998. Cr. M. Piechota. (X10)

R10. Anonymous; "Bird Deaths Still a Mystery," Houston Chronicle, October 31, 1998. Cr. D. Phelps. (X10)

R11. Anonymous; New York Post, February 11, 2005. Cr. M. Piechota. (X11)

R12. O'Shea, Francis; "Fowl Play," Sydney Daily Telegraph, February 10, 2005. Cr. L.M. Nash. (X11)

GWF14 Falls of Miscellaneous Living Animals

Description. Falls of living animals other than those described in earlier sections. Included here are purported falls of shellfish, snails, snakes, lizards, and similar reptiles and amphibians. As with the other reported animal falls, the miscellaneous falls are generally concurrent with heavy rainfall. Very large numbers of individuals may be involved. These falls usually consist of one species only, with no accompanying debris.

Background. Heavy precipitation may drive terrestrial animals out of their hiding places and, in other instances, stimulate population explosions or mass movements. Most humans have little appreciation for the immense numbers of animals living hidden around them. Thus, when a storm drives these creatures abroad in great numbers, anomalous falls from the sky are claimed erroneously.

Data Evaluation. Most reports of animal falls recorded below are suspect because the animals were not actually seen in flight. The evidence for a "fall" is therefore circumstantial. A few cases are rather convincing (X1, X2, X6, X7); and these generally involve water-dwelling species. Composite rating: 2.

Anomaly Evaluation. The best cases, which include water-dwelling animals, yield readily to the usual whirlwind-waterspout-tornado explanation. It is curious though how shellfish, for example, are separated so cleanly from the sand in which they live. The weakest cases concern rather large animals, snakes, turtles, etc., and would require very strong winds to whisk them aloft. The puzzling aspects here are minor, and a composite rating of 3 is all that is justified. Rating: 3.

Possible Explanations. The familiar trio: whirlwinds, waterspouts, and tornados.

Similar and Related Phenomena. All other animal falls in GWF. See also "population explosions" in BI, BR, etc.

Examples of Falls of Miscellaneous Living Animals

X1. June 8, 1881. Salem, Iowa. "'On the night of June 8, 1881, there was a heavy rain-fall, and on the morning of the 9th, the ground was covered, in places, with something that looked like blood. I found that they were living creatures, and with a spoon took up a pint of the muddy water containing them.' Upon examining the sample received, I found it to be swarming with Cyclops quadricornis, or what I take to be that species. The only thing peculiar about them, is, that the body is full of bright red corpuscles, which accounts for their imparting a red appearance to the water containing them.... While it might not be considered remarkable that a few of these animals should be found in pools of rain-water, I am puzzled to understand how they came here in such immense numbers, unless we suppose that they were distributed through the whole body of rain that fell, and were afterwards concentrated by the draining away of surplus water. There were not less than five hundred in the sample of water sent me, of which about one-third were alive when received, after having been tightly corked for several days." (R8)

Cyclops quadricornis is a small crustacean.

X2. August 1894. Bath, England. "During a recent thunderstorm at Bath there fell many thousands of small jelly fish, and the pavements and roads were splattered with them. They were of about the size of a shilling." (R16)

X3. No date given. Monastereen, Ireland. A shower of shells. (R1)

X4. August 9, 1834. United States. A fall of molluscs. (R18)

X5. 1835. Montpelier, France. A fall of Bulimus truncatus, a type of mollusc. (R18)

X6. June 6, 1869, Chester, Pennsylvania. "Mr. John Ford exhibited to the Conchological Section, Academy of Natural Sciences, Philadelphia, specimens of Gemma gemma, remarkable as having fallen, accompanied by rain, in a storm which occurred at Chester, Pennsylvania, on the afternoon of June 6, 1869. The specimens were perfect, but very minute, measuring one-eighth inch in length by three-sixteenths of an inch in breadth. Though most of the specimens which fell were broken, yet many perfect ones were collected in various places, sheltered from the heavy rain which followed their descent. A witness of the storm, Mr. Y.S. Walter, editor of the Delaware County Republican, assured Mr. F. that he noticed the singular character of the storm at its very commencement, and, to use his own words, "it seemed like a storm within a storm." A very fine rain fell rapidly, veiled by the shells, which fell slower and with a whirling motion. Judging from the remains of animal matter attached to some of the specimens, together with the fresh appearance of the epidermis, it is highly probable that many of them were living at the moment of transition. This minute species resembles a quahaug shell, and is common on the seashore between tide marks." (R5)

X7. August 9, 1892. Paderhorn, Germany. "A yellowish cloud attracted the attention of several people, both from its colour and the rapidity of its motion, when suddenly it burst, a torrential rain fell with a rattling sound, and immediately afterwards the pavement was found to be covered with hundreds of mussels." The mussels were still alive and were identified as Anodonta anatina L. (R13, R19)

X8. Summer 1821. Bristol, England. A supposed shower of periwinkles. A resident of the area thought it was just the annual pilgrimage of Helix virgata looking for a mate. (R3)

X9. May 1851. Bradford, England. A heavy shower of snails, which might have been gathered by the bushel. (R2)

X10. 1885. Pembroke Dockyard, England. A thick shower of small snails fell during a downpour of rain over a space about 100 yards in diameter. (R9) Another observer believed the snails were there all the time and emerged from hiding after the rain. (R10)

X11. 1886. England. "Having heard that a fall of shell snails had taken place a few miles from here, I visited the place and found from a man who lived on the spot, that about 9 p.m. just as it was nearly dark, what appeared to be a very black thunder cloud rose from the west, and he went in for shelter. Next morning, on going to work, the roads, fields and stone hedges were plentifully strewn with small living shell snails, the fall extending over about three acres of land, but beyond these limits no shells were to be found." (R11) Once again, the snails were not seen to fall, and sudden emergence after a rain remains a viable explanation.

X12. July 8, 1886. Redruth, England. "After a rather prolonged period of dry hot weather, a heavy thunder-shower fell on the north side of the parish of Illogan, about three miles from Redruth, Cornwall, about 9 P.M. on Thursday, July 8th, the wind being N.N.W. On the following morning, a farmer resident in the district, going to his work about 6 A.M., noticed that the roads and fields in the track over which the shower extended were strewed with small snails of a kind quite different to any previously observed in the district. They were then, he states, lying about in such numbers, that he could gather them together in handfuls." (R12) Actual fall of snails not observed, as usual with this class of animal. (WRC)

X13. January 20, 1894. Nashville, Tennessee. During unusually heavy rain, seven young men sheltering under an awning heard a splash and saw a living creature 5 feet from the pavement. They captured a full-grown salamander (Amblystoma xiphias) 10 3/4 inches long. The animal was not actually seen to fall. (R17)

X14. December 1857. Montreal, Quebec, Canada. A shower of live lizards fell upon the sidewalks and streets. (R14, R21)

X15. July 3, 1860. South Granville, New York. During a very heavy shower, observer hears sound at his feet, looks down and finds a stunned snake. He assumed it fell there during the rain. (R4)

X16. January 15, 1877. Memphis, Tennessee. "Morning opened with light rain; 10:20 a.m. began to pour down in torrents, lasting fifteen minutes, wind SW; immediately after the reptiles were discovered crawling on the sidewalks, in the road, gutters and yards at Vance street, between Lauderdale and Goslee streets, two blocks; careful inquiry was made to ascertain if anyone had seen them descend, but without success; neither were they to be found in the cisterns, on roofs, or any elevations above the ground; Vance street is comparatively new, has no pavements, gutters merely trenches; I heard of none being found elsewhere; when first they were a very dark brown, almost black; were very thick in some places, being tangled together like a mass of thread or yarn." (R6) The foregoing is an on-the-spot report by a weather observer. The famous Memphis snake shower seems best explained in terms of emergence after heavy rain. But a later report in Scientific American (R7) claims that thousands of snakes 12-18 inches long fell after being "carried aloft by a hurricane."

X17. 1873. Minnesota. Shower of unidentified reptiles. (R18)

X18. May 11, 1894. Bovina, Mississippi. A gopher turtle, 6 by 8 inches, entirely encased in ice, fell with the hail. (R15, R20, R22, R23, R18)

X19. During World War II. Salonika, Greece, along the British position. "...the sky rained small turtles, so thick that it was impossible to move about without crushing two or three of them at every step." (R24)

X20. March 21, 1983. Dilborne, N. Staffordshire, England. Sea shells fell with heavy hail: "They extended for an area of about 50 by 20 metres and occurred in thousands on lawns, flower beds, paths and even the road. Roy was kind enough to give me half-a-dozen specimens for identification. They turned out to be small gastropods, almost certainly of marine origin." (R25)

Recourse to field guides did not result in positive identification, so samples were sent to the Bristol Museum. The specimens turned out to be Dove Shells, family Columbellidae, genus Pyrene, which are normally inhabitants of the tropical seas. Their most likely origin was the Philippines!

It's a very selective whirlwind that can identify and pick up so many shells of the same species!

X21. June 19, 1984. Thirsk, North Yorkshire, England. After a heavy thunderstorm, a small area was covered with winkles (shellfish), some still alive, and starfish. Thirsk is 45 kilometers from the sea! (R26, R28)

R28 gives the date as June 16.

X22. June 5, 1984. Brighton, England. A large spider crab dropped out of a storm cloud in front of Julian Cowan. The crab measured 25 cm across and had a 7-8-cm shell. It was dead and lacked two legs and one claw. The fall was followed almost immediately by wind-driven hailstones. (R24)

References

R1. "Shower of Shells in Ireland," Edinburgh New Philosophical Journal, 1:187, 1826. (X3)

R2. Douglas, J.W.; "Shower of Snails," Zoologist, 9:3176, 1851. (X9)

R3. Baker, Wm.; "Shower of Snails," Zoologist, 10:3187, 1851. (X8)

R4. Ruggles, Wm.; "Raining Snakes," Scientific American, 3:112, 1860. (X15)

R5. "A Shower of Shell-Fish," Scientific American, 22:386, 1870. (X6)

R6. "Reptiles," Monthly Weather Review, 5:8, 1877. (X16)

R7. "A Snake Rain," Scientific American, 36:86, 1877. (X16)

R8. Beal, F.E.L.; "A Shower of Cyclops Quadricornis," American Naturalist, 15:736, 1881. (X1)

R9. Reynolds, B.; "A Shower of Snails," Knowledge, 8:253, 1885. (X10)

R10. "Shower of Snails," Knowledge, 8: 299, 1885. (X10)

R11. Jenkin, Alfred Hamilton; "A Shower of Snails," Symons's Monthly Meteorological Magazine, 21:101, 1886. (X11)

R12. Connech, R.J.; "Showers of Shells," Science Gossip, 22:238, 1886. (X12)

R13. Nature, 47:278, 1893. (X7)

R14. Baxter, Charles R.; "A Shower of Frogs," Notes and Queries, 8:6:104, 1894. (X14)

R15. Nature, 50:430, 1894. (X18)

R16. Penny, C.W.; "A Shower of Frogs," Notes and Queries, 8:6:190, 1894. (X2)

R17. Osburn, Wm.; "Do Earth Worms Rain Down?" Science, 23:66, 1894. (X13)

R18. McAtee, Waldo L.; "Showers of Organic Matter," Monthly Weather Review, 45:217, 1917. (X4, X5, X18)

R19. "Showers of Fishes and Other Things," English Mechanic, 108:118, 1918. (X7)

R20. Nature, 125:728, 1930. (X18)

R21. Martin, M.W.; "Crazy Rains or Animals That Fall from the Sky," Science Digest, 67:32, January 1970. (X14)

R22. Meaden, G.T.; "The Giant Ice-Meteor or Superhailstone," Journal of Meteorology, U.K., 2:201, 1977. (X18)

R23. "Remarkable Hail," Monthly Weather Review, 22:215, 1894. (X18)

R24. Hora, Sunder Lal; "Rains of Fishes in India," Asiatic Society of Bengal, Journal, 39:95, 1933. (X19)

R25. Swinhoe, P.J.; "Unusual Events along the Squally Cold Front of 21 March 1983," Journal of Meteorology, U.K., 8:233, 1983. (X20)

R26. Rickard, R.J.M.; "A Remarkable Fall of Fish...," Journal of Meteorology, U.K., 9:290, 1984. (X21)

R27. Meaden, G.T.; "The Remarkable 'Fall' of a Crab at Brighton, 5 June 1983," Journal of Meteorology, U.K., 9:56, 1984. (X22)

R28. Elsom, Derek; "Catch a Falling Frog," New Scientist, p. 38, June 2, 1988. (X21)

GWF15 Fall of Giant Dust Particles from Distant Sources

Description. The fall of giant dust particles thousands of miles from their place of origin. Established meteorological laws cannot account for the transportation of such large dust particles (over 20 microns) for such great distances.

Data Evaluation. So far, we have only one pertinent scientific study that was published in a mainstream journal. Rating: 2.

Anomaly Evaluation. The particles' size and distance-of-travel suggest that there exist unrecognized ascending air currents and/or unsuspected aerial suspension forces. Rating: 3.

Possible Explanation. Unidentified buoyant air currents.

Similar and Related Phenomena. The long-distance transportation of pollen (GWF3) leaves and hay (GWF6); seashells (GWF14).

Example

X1. March 1986. Wake Island, Hawaii. A dust cloud originating in China reached these islands after traveling 6,000 miles in 9 days. The fact that dust stirred up in the Asian deserts is sometimes carried thousands of miles is not unusual. But the March 1986 cloud contained quartz particles of giant dimensions---far too large to be explained by currently accepted meteorological laws describing dust transport.

More than 80% of the quartz granules measured more than 70 microns in diameter. This is more than four times the calculated maximum size of 16 microns for a cloud that has travelled 6,000 miles. Assuming a maximum starting altitude of 5 miles, the 70-micron particles in the Chinese cloud should have remained suspended only a day or two instead of the 9 days observed. (R1)

Reference

R1. Stevens, William K.; "'Giant' Dust Particles Pose Scientific Puzzles," New York Times, December 13, 1988. Cr. J. Covey. (X1)

GWH ANOMALIES AND CURIOSITIES OF HURRICANES, THUNDERSTORMS, AND REMARKABLE WINDS

Key to Phenomena

GWH0 Introduction

The two major categories of storms dealt with in this chapter are hurricanes and thunderstorms, as announced in the title. There is, in addition, a miscellaneous category including whole-atmosphere oscillations and curious local wind phenomena.

As seen on TV, hurricanes are ponderous, meandering, destructive storms. Despite such negative publicity, hurricanes also possess fascinating fine structure, unexplained internal dynamics, and even unplumbed cyclicity.

Thunderstorms are generally thought to be local weather phenomena. However, some cluster into truly giant storm systems hundreds of miles in dimension. These display complex electrical structure and even relate to the planet's carbon cycle. But even the simple "pop-up" thunderstorms seem to have the power to curdle milk!

Freak winds are legion---some are also anomalous. The wind blasts from giant rock falls and the lengthy wind wakes of the Hawaiian Islands are impressive but not paradigm-shattering. But then, there are those huge, piston-like downbursts that gouge out huge holes in the Amazonian forest but are so scarce elsewhere.

GWH1 Ozone in Hurricanes

Description. The smell of ozone or its instrumental detection at abnormally high levels during powerful hurricanes.

Data Evaluation. A single report of good quality has been uncovered. Rating: 3.

Anomaly Evaluation. Hurricanes are usually not accompanied by significant electrical activity, so the existence of a strong odor of ozone is perplexing. If not electrically generated, where could the ozone originate? Rating: 2.

Possible Explanations. Hurricanes are powerful storms, and it is possible that some diffuse electrical discharge occurs. Such discharges need not be detectable by eye and ear.

Similar and Related Phenomena. The smell of ozone and sulphur frequently attend some of the more concentrated storms, such as tornados and thunderstorms.

Examples of Hurricane Ozone

X1. September 21, 1938. Amherst, Massachusetts. "During the hurricane on September 21, 1938, the smell of ozone was strong during the latter part of the storm. The peak of the storm was shortly after 6 P.M. (D.S.T.); the lowest barometer 28.41 (corrected) at Amherst, Mass., being at 6:05, and the highest wind velocity, 80 miles, at 6:17. During the heavy rain, about 6 to 6:30, the ozone was strong, and later, when the rain stopped, the ozone was so strong I was uncomfortable. At this time my watch said 7 o'clock. No odor of ozone was noticed in the first part of the storm nor was any noticeable in the house. My colleague in chemistry, in the Massachusetts State College, Dr. Walter S. Ritchie, independently reports similar observations." (R1)

References

R1. Peters, Charles A.; "Ozone in the '38 Hurricane," Science, 90:491, 1939. (X1)

GWH2 Hurricane Geographical Anomalies

Description. Prior to 2004, the absence of any historical record of hurricanes in the South Atlantic Ocean. This long record was broken in 2004, when a storm called Catarina, with hurricane characteristics, came ashore in Brazil.

Data Evaluation. The pre-2004 absence of South Atlantic hurricanes was first noted in a popular book (R1) but was quickly confirmed in the McGraw-Hill Encyclopedia of Science and Technology. Notice of the major features of hurricane Catarina appeared in science journals and magazines. Rating: 1.

Anomaly Evaluation. The North Atlantic spawns many hurricanes and the Pacific, both north and south of the Equator, develops its typhoons, the equivalents of hurricanes. From the standpoint of symmetry, one would expect at least a few South Atlantic hurricanes during recorded history. For some reason, however, the meteorological conditions in the South Atlantic are not conducive to hurricane formation. Exactly why they are not is a debatable problem. The appearance of Catarina in 2004 is either itself an anomaly or is indicative climate changes we do not yet understand. Rating: 3.

Possible Explanations. The "official" explanation for the dearth of hurricanes in the South Atlantic is that the waters are too cold and the wind distribution with altitude are not conducive to intense tropical storms. An appealing and, to many, a reasonable explanation for the anomalous appearance of Catarina is that a climate change (global warming) is in progress. Some radical thinkers, however, contend that extraterrestrial influences (see GWS5) may actually influence where hurricanes and typhoons occur.

Similar and Related Phenomena. To our knowledge, the Indian Ocean does not spawn hurricane-like storms, although monsoons afflict the area.

Examples of Hurricane Geographical Anomalies

X1. General observations. "There is no record of a tropical cyclone of hurricane intensity ever having occurred in the South Atlantic Ocean." (R1)

X2. March 27, 2004. South Atlantic Ocean. The media largely ignored the storm called Catarina. After all, it was equivalent to only a Category-1 hurricane and did not threaten North America. But Catarina was unique.

It swept ashore March 27, 2004--- not in North America or the Caribbean but in Brazil's state of Santa Catarina, from which it derived its name. Catarina was the first hurricane ever recorded in the South Atlantic. Some see it as a portent of the future and associate it with global warming.

The anomalousness of Catarina can be seen in the meteorological records. Many hurricanes ("typhoons" in the Pacific) plague the North Atlantic and North Pacific during their summers and autumns. The South Pacific sees an occasional typhoon in that hemisphere's summers and autumns. The South Atlantic, though, had been totally spared, for reasons uncertain, until 2004.

Catarina is blamed upon a slightly warmer ocean surface and an unusual combination of meteorological features. Nevertheless, NASA's J. Halverson asserted that Catarina "looks like a hurricane, with strong winds, heavy rain, and a well-structured eye." (R3)

In a few years, we should be able to determine if Catarina was a freak occurrence or the beginning of a trend.

References

R1. Helm, Thomas; "Anatomy of Hurricanes," Hurricanes: Weather at Its Worst, New York, 1967, p. 16. (X1) (Cr. L. Gearhart)
R2. Chin, Gilbert, ed.; "The First of Many?" Science, 309:1302, 2005. (X2)
R3. Hecht, Jeff; "The Strange Tale of the Hurricane That Wasn't," New Scientist, p. 16, April, 2004. (X2)
R4. Anonymous; "Catarina's Shock Message," New Scientist, p. 10, September 24, 2005. (X2)

GWH3 Polygonal Eye Walls in Some Hurricanes

Description. The polygonal geometry of some hurricane eye-walls and surrounding rain bands.

Data Evaluation. The science literature contains many supporting satellite photographs and radar-data analyses. Rating: 1.

Anomaly Evaluation. At present, we have no consensus hypothesis as to how polygonal structures are formed in hurricanes. Rating: 3.

Possible Explanation. The polygonal structures are interference patterns formed by the storm's internal gravity waves.

Similar and Related Phenomena. The occasional honeycomb appearance of flowing water (GHC9 in *Earthquakes, Tides*, etc.).

Entry

X1. General observations. It is widely believed that hurricane eye walls and surrounding rain bands are nicely round or sometimes a bit elliptical. At least, this is what we usually see on satellite photos of powerful storms displayed on TV! There are, however, numerous exceptions where the eye walls are polydonal; i.e., square, hexagonal, etc. These polygonal forms appear too often to be merely fortuitous. As B.M. Lewis and H.F. Hawkins relate, analyses of radar data confirm the geometries that the satellite eyes see.

"It was noted from analysis of radar data obtained in hurricanes that both the spiral bands and the inner boundaries of the wall cloud were frequently composed of a series of straight-line segments. Indeed, the eye of a strong hurricane is frequently polygonal rather than circular or elliptical. These features may have a possible kinematic explanation based on interference among differing wave numbers and frequencies of internal gravity waves." (R1)

Reference

R1. Lewis, B.M., and Hawkins, H.F.: "Polygonal Eye Walls and Rainbands in Hurricanes," *American Meteorological Society, Bulletin*, 63:1294. 1982.

GWH4 Hurricane Internal Fine Structure

Description. Selective ground damage by hurricanes and radar-detection of tubular-wind internal structure. The latter is thought to be the cause of the former.

Data Evaluation. Relevant post-hurricane surveys of ground damage and doppler-radar analysis of hurricane wind patterns have been reported in the science literature. Rating: 1.

Anomaly Evaluation. The origin of hurricane tubular fine structure is unknown. Rating: 3.

Similar and Related Phenomena. Hypercanes as contributors to environmental catastrophes and biological extinctions (GWH5); tornado "pranks" (GWT7).

Entry

X1. General observations. Some hurricanes display internal fine structure. This fact is obvious when one views ground damage. Although a hurricane may span hundreds of miles, it sometimes leaves behind narrow swathes of damage only hundreds of meters long bordered by land that is comparatively untouched. What is there about hurricanes that can account for such selectivity?

In searching for an explanation, J. Wurman and colleagues, from the University of Oklahoma at Norman, parked a van equipped with doppler radar in the path of Hurricane Fran (September 1996, in North Carolina).

"They detected tubes of wind, like tornadoes turned on their sides, each a few hundred metres across. One side [of each tube] took fast moving wind from on high and spat it toward the ground. 'It blows right down to treetop level,' says Wurman. Areas near the downdraughts were blown over; everywhere else was relatively safe from the storm." (R1)

The origin of these tubular wind structures is at present a mystery.

Reference

R1. Seife, Charles; "Blown Away," New Scientist, p. 15, May 2, 1998. (X1)

See illustration on p. 150.

GWH5 Hypercanes and Global Biological Extinctions

Description. Hypothetical hypercanes ("runaway hurricanes") as extenders of bolide impacts and/or volcanism as mechanisms of global biological extinctions.

Data Evaluation. The hypercane is hypothetical, although computer simulations confirm its possible efficacy in geographically extending the reach of catastrophic events.

Anomaly Evaluation. No anomaly is claimed here.

Similar and Related Phenomena. Anomalies associated with biological extinctions (ESB1 in Anomalies in Geology).

Entry

X1. General observations. Scientists are in fundamental disagreement concerning the relative efficacies of volcanism and giant bolide impacts in causing global biological extinctions. K.A. Emannuel et al add to the armories of each of these two catastropic phenomena the hypothesis of the "hypercane." Hypercanes are "...runaway hurricanes that are capable of injecting massive amounts of water and aerosols into the middle and upper atmosphere, where they may have profound effects on atmospheric chemistry and radiative transfer. Hypercanes are theorized to occur when the sea surface temperature exceeds a critical threshold, which may occur when sea water is locally heated by bolide impact, shallow-sea volcanism, or possibly, by overturning of superheated brine pools formed by underwater volcanic activity. Simulations using a convection-resolving nonhydrostatic axisymmetric model show that hypercanes can indeed develop when the sea surface temperature is high, and that they inject large amounts of mass into the stratosphere." (R1)

The water and aerosols in the atmosphere would be spread far beyond the localized phenomena and foster global temperature and chemical effects impacting the entire planet's biosphere.

We must emphasize that the fundamental anomaly here is not the hypothetical hypercane. Rather, it is the possible inadequacy of localized bolide impacts and volcanic activity to explain global biological extinctions.

The hypothetical hypercane is a mechanism for geographically extending the effects of a bolide impact and/or volcanic eruption. Although it has never been observed and may not be anomalous if it ever is created, we introduce the hypercane idea because of its possible importance and genetic connection to ordinary hurricanes.

Reference

R1. Emannuel, Kerry A., et al; "Hypercanes: A Possible Link in Global Extinction Scenarios, Journal of geophysical Research, 100:13,755, 1995. (X1)

GWH6 Typhoon Cycles

Description. A 50-year periodicity in the landfalls of typhoons in the southeastern Chinese province of Guangdong.

Data Evaluation. The basic data sources are semiofficial records kept locally in southeastern China. Where overlap with modern records occurs, there is consistency with the observations of instrumented stations. Rating: 2.

Anomaly Evaluation. The source of the 50-year periodicity is uncertain. Rating: 2.

Possible Explanations. North Atlantic hurricanes seem loosely connected to the presence of El Ninos in the Pacific as well as to large-scale, long-term tempertrure oscillations in the Atlantic. Such statistical connections probably also exist in the Pacific.

Similar and Related Phenomena. The long-term variability in the frequency of North Atlantic hurricanes; astronomical periodicities in other weather phenomena (GWS1).

Entry.

X1. Statistical Analysis. Reliable, continuous weather records covering an entire millennium are very rare. Such a record has been claimed for the Guangdong Province in southeastern China. The record is in the form of semiofficial, local gazettes called "fang zhi". The general accuracy of recent gazettes has been confirmed by comparing them with modern intrument records. The gazettes clearly distinguish typhoons that impact the Province from other storms for the past millennium.

From 975 A.D. to date [2002], at least 571 typhoons have come ashore in Guangdong Province. Analysis by K. Liu, a geographer at Louisiana State University, point to a puzzling periodicity.

"Guangdong Province's fang zhi show that over the past 500 years, there's been a 50-year cycle in the frequency of typhoons there. That periodicity matches matches a long-term variation in atmospheric conditions in the northern Pacific Ocean region." (R1)

The origin of the 50-year cycle has not been positively identified. It seems unrelated to any obvious astronomical periodicity, although, as with North Atlantic hurricanes, there is probably a connection to El ninos and ocean temperature changes---themselves poorly understood.

Reference

R1. Anonymous; "Chinese Records Show Typhoon Cycles," Science News, 162: 174, 2002. (X1)

GWH7 Unexplained Rapid Intensification of Some Hurricanes

Description. The explosive increase in intensity of some hurricanes.

Data Evaluation. Primary source: NOAA (National Oceanic and Atmospheric Administration). Rating: 1.

Anomaly Evaluation. Rapid hurricane intensification is a poorly understood phenomenon, not a paradigm challenger. Rating: 3.

Possible Explanation. Energy in the encircling rain bands is transferred to the eye wall, but the physics of this energy exchange is still under investigation.

Entry

X0. General observations. Hurricane forecasters have become more expert in predicting the paths and landfalls of North Atlantic storms. In contrast, the turbulence and complex dynamics of hurricanes have stymied the accurate prediction of changes in a storm's intensity.

Particularly puzzling are the frequent rapid spin-ups of some hurricanes. In the space of just 24 hours a low-strength tropical storm can explode to a Category-5 hurricane---the highest intensity category. A puzzling factor in such rapid spin-ups is the observation that such exploding storms do not seem to extract most of their additional energy from the warm ocean water beneath them, which is normally a hurricane's primary source of energy. Rather, the eye-walls seem to derive their increased energy from the energy stored in the surrounding rain bands. [An apt analogy occurs when a spinning ice-skater suddenly pulls in his or her arms and thus dramatically increases the spin-rate.] How similar feats might be accomplished in a strengthening hurricane still puzzles meteorologists. (R1)

X1. October 2005. North Atlantic Ocean.

In just one day, Hurricane Wilma transformed herself from a tropical storm into the most powerful Atlantic storm on record. (A Category-5 hurricane, of course.) (R1)

X2. September 2005. North Atlantic Ocean. Modest Hurricane Rita spins up to Category-5 in just 8 hours. (X1)

Reference

R1. Schrope, Mark; "Winds of Change." Nature, 438:21, 2005. (X0-X2)

GWH8 Unexpected Geographical and Electric-Charge Organization of Large-Scale Electrical Storms

Description. The unexpectedly complex physical and electrical organization of massive electrical storms.

Data Evaluation. The crucial data come from satellite observations and ground-based magnetic lightning-detectors. Results have been published in mainstream science journals and magazines. Rating: 1.

Anomaly Evaluation. Neither the large-scale clustering of thunderstorms nor their electric-charge distribution are well-understood at present. Rating: 3.

Possible Explanation. An (unconvincing) appeal has been made to the wind distribution in large storms.

Similar and Related Phenomena. Lightning superbolts (GLL17); cyclic flashing of lightning (GLL18); dual lightning discharges (GLL19); the bipolar nature of large-scale electrical storms (GLL28, actually a rerendering of X2 below). All of the foregoing sections are to be found in our catalog volume Remarkable Luminous Phenomena in Nature).

Entries

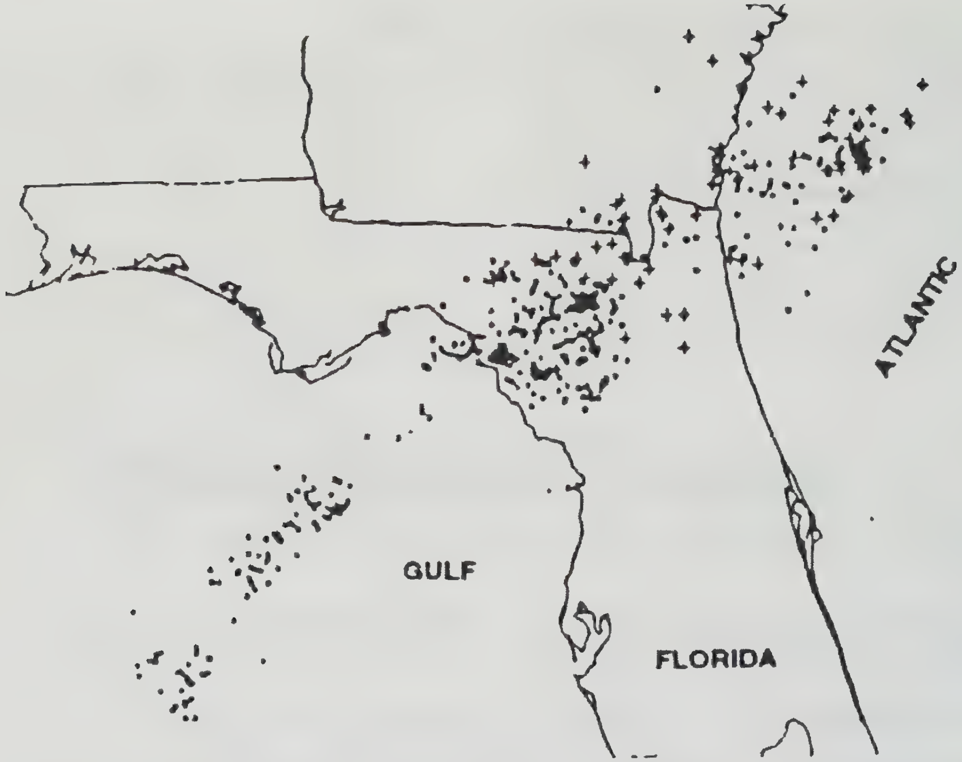
X0. Introduction. Hot summers always bring localized, "pop-up" thunderstorms. Not so routine are giant electrical storms that may span hundreds of miles. These massive meteorological formations are full of surprises in terms of their large-scale physical organization and bipolar electrical structure.

X1. Giant thunderstorm clustering. Conventional wisdom has it that thunderstorms are small-scale phenomena 50-100 miles across. However, J.M. Fritsch and R.A. Maddox of NOAA have announced that satellite photos show a radically different situation.

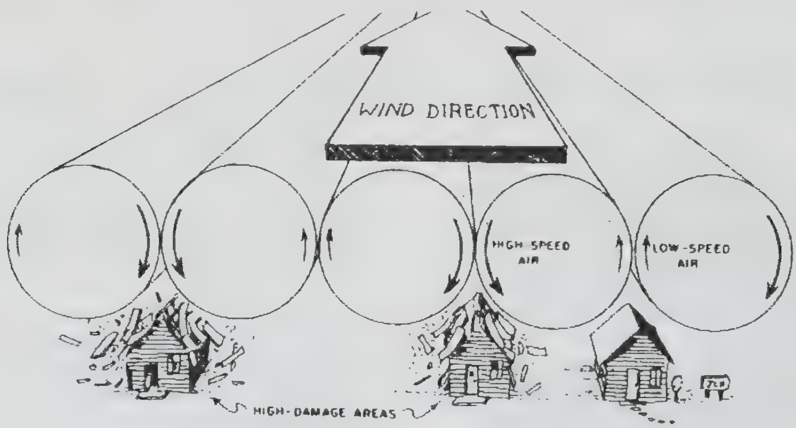
The more violent thunderstorms are often organized into roughly circular clusters that may span 1000 miles. Previously, all thunderstorms were considered local convective storms that were regulated by upper air patterns. This view must now be changed because the newly recognized giant thunderstorm clusters actually modify planetary upper air flow. (R1)

X2. Bipolar nature of large electrical storms. Ground-based observers see only a few of the anvil-shaped clouds that comprise a giant electrical storm. The entire storm may stretch for hundreds of kilometers---and it is not a simple structure.

The latest surprise is that all large electrical storms are bipolar; that is, the rare positive lightning strokes are concentrated at the northeast end of



February 22, 1987. Lightning distribution 8:00-9:00 P.M. in a massive thunderstorm system across Florida. The plus signs, designating positive strokes, are concentrated in the northeast, indicating the storm system's bipolar nature. (X2)



Horizontal wind tubes observed by radar during Hurricane Fran, September 1996, North Carolina. The tubes were about 100 meters in diameter and as low as treetop level. (X1) the storm complex, while the negative strokes are everywhere else along a northeast-southwest line. This bipolar structure persists for several hours, and it has been found in all North American storms analyzed so far. This insight into the structure of large electrical storms was provided by magnetic lightning detectors that have now been installed over nearly 75% of the United States.

The positive lightning strokes are of longer duration and more liable to start fires than the common negative strokes. But why are they concentrated at one end of the storm complex? R. Orville ventures that in a big mesoscale electrical storm, the prevailing winds blow the positively charged upper portions of the clouds to the northeast, thus establishing bipolarity. (R2)

References

R1. Bardwell, Steven; "Satellite Data Show New Class of Thunderstorms," Fusion Magazine, p. 50, September 1981. (X1)

R2. Orville, Richard E., et al; "Bipolar Patterns Revealed by Lightning Locations in Mesoscale Storm Systems," Geophysical Research Letters, 14:129, 1988. (X2)

GWH9 Hot-Air Blasts in Intense Electrical Storms

Description. Hot-air blasts experienced during intense electrical storms by individuals and vegetation.

Data Evaluation. Testimony from individuals and post-storm surveys of damage to crops and other vegetation. In the science literature, we have only allusions to human experiences. A newspaper account provides graphic effects on crops and other vegetation. Based on our literature searching, the case for this claimed phenomenon is rather weak. Rating: 3.

Anomaly Evaluation. If electrical heating of the air is assumed (rather than aerodynamic heating), the formation and propagation of hot-air bursts are not well-understood. This is particularly so when broad areas of vegetation are affected (X2). Rating: 3.

Possible Explanation. Lightning releases considerable thermal energy and winds in storms could conceivably transport heated masses of air to spots well away from the lightning strike points.

Similar and Related Phenomena. Hot-air blasts associated with lightning (GLL12, which includes X1 below); tornado burning and dehydration (GWT2).

Entries

X0. Introduction. Claims have been made that bursts of intense heat have occasionally been experienced during thunderstorms. We have collected some general observations and one specific example. This claimed phenomenon should be compared with the burning and dehydration effects reports in some tornados (GWT2).

X1. General observations. E.W. Crew suggests that two rare classes of meteorological observations may be created by the intense electrostatic accelerating forces present in lightning channels.

The first class of observations consists of blasts of hot air noted some distance from violent lightning strikes but seemingly associated with the discharges. Second, some superhailstones (hydrometeors, GWF1) also seem to be correlated with violent lightning. The physical mechanism for the concentration and propulsion of matter is the electrostatic force naturally present in lightning discharge channels; it functions much the same as the particle accelerators in the physics lab. (R1)

The observations of hot air blasts and superhailstones collected by Crew to support his theory are indeed suggestive, but more are needed.

X2. June 1900. Kopperl, Texas. Thunderclouds and lightning gave way to winds in excess of 75 mph, with temperatures of up to 140°F. Surveying the storm damage later:

"Aside from the expected remains of a severe wind storm---uprooted trees, snapped telephone poles, roof damage and banged-up boats docked lakeside---the area had the ironic appearance of having been stung by a June freeze. Tree leaves, shrubs, hanging plants and crops were curled and wilted, as if frost-bitten. Uncut Johnson grass was dried and ready to bale, although the hay normally required two or three days of drying time after being cut. Perhaps the most startling remains of the storm was in what had been the cotton patch at Pete and Inez Burns' farm. The cotton was about knee high and a 'luscious crop' the day before, according to the couple. The next morning all that was left were carbonized stalks peeping out of the ground. The corn fared little better." (R2)

References

R1. Crew, E.W.; "Meteorological Flying Objects," Royal Astronomical Society, Quarterly Journal, 21:216, 1980. (X1)

R2. Glaze, Dean; "Kopperl's Close Encounter with Satan's Storm," Meridian (Texas) Tribune, May 12, 1983. Cr. J. Mohn. (X2)

GWH10 Thunderstorm Serial-Triggering of Other Thunderstorms

Description. The triggering of new thunderstorms by those that are fading away. A west-to-east trail of thunderstorm death and birth has been observed.

Data Evaluation. This triggering effect is seen in a massive collection of weather-radar data. Our reference is from a science magazine. Presumably more detailed information exists in unexamined specialist journals. Rating: 2.

Anomaly Evaluation. The details of the "triggering" process is poorly understood. How are the conditions conducive to lightning discharges carried for many miles? Rating: 3.

Possible Explanation. See X1 below. Atmospheric waves may somehow be involved.

Similar and Related Phenomena. Dual lightning discharges (GLL19); cyclic flashing of lightnng (GLL18); correlation of lightning with cosmic rays (GLL16). All of these cross references are to be found in our catalog Remarkable Luminous Phenomena.

Entry

X1. Radar observations. Thunderstorms do not always fade away to nothingness. Apparently some dying thunderstorms can, in some undetermined way, trigger new storms some distance away, in effect extending their lives.

R. Carbone et al, at the National Center for Atmospheric Research in Boulder, analyzed 50,000 radar images of thunderstorms occurring between 1997 and 2000. A surprising pattern emerged.

"'As systems die, they cause the birth of new groups of thunderstorms in a very systematic way.' he [Carbone] says. One storm triggers another and so on, creating ripples of rain that move west to east from the eastern edge of the Rockies to the Appalachian Mountains." (R1)

Carbone speculates that the rippling progress of thunderstorms is related to "enormous" atmospheric waves.

Reference

R1. Svitil, Kathy A.; "Rolling Thunder," Discover, 23:13, October 2002. (X1)

GWH11 Lightning and the Plant-Volatile Discrepancy

Description. The possible role of lightning in the loss of the bitumen from plant volatiles through geological time.

Data Evaluation. The three natural phenomena described below (X1) are well-known and supported by the science literature. In this regard, see the Bibliography in R1. Rating: 1.

Anomaly Evaluation. The unknown fate of bitumen derived from plant volatiles in the global carbon cycle must be considered an important anomaly. Rating: 2.

Possible Explanation. See X1 below.

Similar and Related Phenomena. The geographical preferences of lightning (GLL13) in our catalog Remarkable Luminous Phenomena).

Entry

X1. General observations. This catalog entry associates three widely recognized natural phenomena with global thunderstorm activity and, as a consequence, explains the bitumen discrepancy now outlined.

(1) The loss of bitumen from plant volatiles. "Per year approximately 1.75 x 10^8 tons of volatile matter is formed, of which most should return to earth as bitumen if the above condensation mechanism is correct. This would have resulted in 10^{17} tons of nonreactive bituminous material in the earth's crust during the 5 x 10^8 years that land plants have existed on earth. This is several orders of magnitude more than what is actually known to exist. Therefore mechanisns must exist which destroy the major portion of this organic material." (R1)

(2) An unappreciated source of thunderstorm energy. "Both tornadoes and the lightning in thunderstorms depend on the instantaneous release of very large quantities of energy, making it unlikely that they are controlled by local heat and wind supplies. In both cases, stored chemical energy in the form of condensed volatile organic matter released by vegetation can account for this energy." (R1)

(3) The geographic distribution of thunderstorms. "Since thunderstorms develop predominately in areas where volatile organic matter occurs in the air and their frequency is about proportional to the organic matter released, it seems attractive to trace the electric charge formation in the thunderstorm to organic matter." (R1)

A possible and reasonable conclusion has thunderstorms comsuming plant volatiles as fuel and thereby greatly reducing the amount of bitumen returning to the earth from the atmosphere.

Reference

R1. Went, F.W.; "Thunderstorms as Related to Organic Matter in the Atmosphere," National Academy of Sciences, Proceedings, 48:309, 1962. (X1)

GWH12 The Supposed Sudden Souring of Milk during Thunderstorms

Description. The hoary assertion that exposed milk will quickly sour during a thunderstorm.

Data Evaluation. So far, we have found only anecdotes of the phenomenon in a science magazine. These are rather convincing but, lacking any scientific tests, we cannot say the phenomenon is well-established. However, more literature searching may be more illuminating. Rating: 2.

Anomaly Evaluation. Home separators and creameries routinely separate the fatty constituents of whole milk to produce cream, low-fat milk, etc. Centrifugation of milk has been the common technique for many years. The question is whether the natural forces in a thunderstorm (electromagnetic and acoustical) can also somehow separate the fatty globules from the aqueous component of milk. It seems quite certain that they can if we choose to rely on anecdotes. Here, however, we insist upon a quantitative exploration of the phenomenon. We have yet to find such technical confirmation. Rating: 3.

Possible Explanations. See above discussion.

Simular and Related Phenomena. Home cream separators, industrial emulsion separation.

Entries

X0. Introduction. In 1996 a reader of New Scientist resurrected the ancient claim that thunderstorms will cause exposed milk to sour quickly. At first glance, this has the flavor of an old wive's tale. But modern informal tests are so convincing that the claimed phenomenon should be investigated more thoroughly. In fact, it would not surprise to learn that this matter has long ago been resolved in literature we have not yet searched.

We begin with two examples.

X1. Summer 1994. United Kingdom. "One evening in the summer of 1994, I retired to bed with a glass of milk. During the night there was a tremendous thunderstorm with plenty of lightning and the following morning the remainder of the milk had curdled into a solid mass. (R1)

X2. 1996. Amersham, Bucks, United Kingdom. V. Dawson wrote New Scientist as follows on this matter: "I decided to test it myself and deliberately left a covered glass of fresh, pasteurized milk taken straight from the frige on the back doorstep during a thunderstorm. Within 15 minutes the milk in the glass had separated into a clear whey-like layer overlaying a layer of curd. Tasting the remixed milk confirmed that it had not turned sour, only curdled. (R1)

X3. Possible explanations. P. Wilson, responding to the New Scientist anecdotes, suggested that the strong electric fields of thunderstorms might polarize emulsions and separate them into fatty and aqueous components. (R2)

The spectrum of intense low-frequency sounds during a thunderstorm seems a more likely separator of fatty globules.

References

R1. Dawson, Val; "Sour Cream," New Scientist, p. 93, November 30, 1996. (X1, X2)

R2. Wilson, P.; "Sour Cream," New Scientist, p. 89, February 15, 1997. (X3)

GWH13 Giant Windstorms in the Upper Atmosphere

Description. The existence in the earth's mesosphere (30-60 miles altitude) of continent-size windstorms.

Data Evaluation. The data come from the Upper Atmosphere Research Satellite. The Sourcebook Project files contain only an article from the New York Times bearing on this subject. Without doubt, technical reports can be found in the science literature. But we have not yet assimilated them. Rating: 2.

Anomaly Evaluation. Unquestionably, meteorologists were surprised at the size of the mesosphere windstorms, but surprise is not equivalent to anomalousness. The rationale for the formation of the mesospheric storms seems sound (X1 below); so these giant storms must be classified as only curiosities. Rating: 3.

Possible Explanation. See X1 below.

Similar and Related Phenomena. The gross expansion of the sizes of weather balloons as they ascend into the low pressures of the stratosphere.

Entry

X0. Introduction. The mesosphere is a poorly studied layer of the earth's atmosphere residing between 30 and 60 miles altitude. It is too high for study by aircraft and balloons and too low for most research satellites. To explore this thin-aired, relatively unknown region, NASA, in 1991, launched from a Space Shuttle the Upper Atmosphere Research Satellite. This spacecraft carried ten instruments into the mysterious mesosphere.

X1. General observations. Meteorologists were greatly surprised when the new satellite mapped out via its instruments continent-size wind storms. The biggest of these stretched from Western Australia, covered Africa, and terminated half-way across the Atlantic Ocean.

The postulated source of this large-scale weather phenomenon, marked by 200 miles-per-hour winds, lies in the lower atmosphere. Low-altitude weather generates small wind waves that expand in size as they ascend through the thin air of the stratosphere. When they enter the near-vacuum of the mesosphere, they expand even more and become the monstrous windstorms encountered by the Upper Atmosphere Research Satellite. (R1)

Reference

R1. Anonymous; "Huge Windstorms Seen in Upper Atmosphere," New York Times, December 17, 1991. Cr. P. Gunkel. (X1)

GWH14 Unknown Origin of Slow Atmospheric Oscillations

Description. The unexplained presence along a path 10° north and south of the Equator of an atmospheric oscillation with a period of 40-50 days.

Data Evaluation. The phenomenon can be followed from satellites and ground-based meteorological instruments. It is well-established in the science journals. Rating: 1.

Anomaly Evaluation. The cause(s) of this oscillation with its relatively stable period has no consensus explanation. Rating: 3.

Possible Explanations. As with the El Ninos, variations of sea-surface temperature. An undefined connection to the the atmospheric heat engine carrying energy away from the tropics.

Similar and Related Phenomena. El Ninos (see our Science Frontiers II, pp. 46, 54-55, 211).

Entry

X0. Introduction. The large-scale atmospheric oscillations known as El Ninos have been recognized by meteorologists for decades. Associated with warmings of Pacific Ocean waters, El Ninos generate abnormal weather globally every 3-8 years.

Weaker than the El Ninos but much more regular are some puzzling, 40-50-day atmospheric oscillations. These phenomena are not tied to ocean warmings like the El Ninos. Otherwise, they resemble the El Ninos and also have their global reach.

X1. General observations. "From a satellite's perch, the new phenomenon appears as a wave of cloudiness that first develops every 40 to 50 days in the Indian Ocean, intensifies as it sweeps eastward into the Pacific at up to 30 kilometers per hour, and peters out in the eastern Pacific. Other meteorological observations can follow the disturbance through the tropics around the globe." (R1)

This "high-frequency" phenomenon (compared to El Nino) was discovered serendipitously in 1971 by R. Madden and P. Julian of the National Center for Atmospheric Research at Boulder. Although it is a fairly robust phenomenon, its presence had previously been all but obliterated by meteorologists' use of monthly averages in their analyses.

The 40-50-day oscillation is essentially tropical---just 10° north and south of the Equator---but its effects are felt as far away as the poles.

For example, 15 kilometers above Canton Island in the central Pacific, the oscillation can alter the winds by 90 kilometers per hour, even reversing the normal flow. It may also trigger or retard the onset of the much more powerful El Nino.

"Still, what makes it tick remains mysterious. It bears an enticing resemblance to El Nino events. Both involve modulation of the intensity and an eastward shift of the center of convection in the Pacific, and both seem to form similar teleconnections to mid-latitudes." (R1)

Reference

R1. Kerr, Richard A.; "Slow Atmospheric Oscillations Confirmed," Science, 225:1010, 1984. (X1)

GWH15 The Remarkably Long Wind-Wake of the Hawaiian Islands

Description. The 3,000-kilometer-long wind-wake of the Hawaiian Islands---the longest on Planet Earth.

Data Evaluation. The wind-wake of the Hawaiian Islands has been observed for decades by high-flying aircraft and, more recently, by satellites. Rating: 1.

Anomaly Evaluation. None claimed. Nevertheless, an interesting natural phenomenon.

Possible Explanations. None needed. But, it should be added that the steady trade winds and high Hawaiian mountain peaks give Hawaii a large advantage in this competition.

Similar and Related Phenomena. Many oceanic islands create long wind-wakes. They just cannot compete with that of the Hawaiian Islands.

Entry

X0. Introduction. Some phenomena may not be anomalous but are still interesting enough to include in this Catalog. Such is the unexpectedly long wind-wake of the Hawaiian Islands.

X1. Frequent occurrence. From aircraft and satellites, one can see strong contrasts in the roughness of the ocean surface in the lee of the idyllic Hawaiian Islands with their volcanic peaks that poke over 10,000 feet into the Pacific airstreams. These long streaks on the ocean surface are called "wind wakes."

The wind wake leeward the Hawaii is spectacular. These islands are swept by steady northeast trade winds. Mauna Kea (4201 meters), Mauna Loa (4201 meters), and other Hawaiian peaks penetrate high above trade inversion. Together they create a visible wind wake some 3,000 kilometers long to the west---many times greater than any other island wind wakes that can be seen on the planet.

The effects of these soaring peaks are more than visual. Their wind wake drives an eastward ocean current that, in turn, draws warm water away from the Asian coast 8,000 kilometers distant from Hawaii. Thus, a few mid-Pacific island mountains affect the climate of a distant continent a fifth of the way around the globe! (R1)

Reference

R1. Xie, Shang-Ping, et al; "Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean-Atmosphere System," Science, 292:2057, 2001. (X1)

GWH16 Rock-Fall Air Blasts

Description. The unexpectedly violent blasts of air that follow large rock falls.

Data Evaluation. Many eyewitness accounts of a specific rock-fall. These were published in a mainstream geology journal. Rating: 1.

Anomaly Evaluation. No anomaly claimed here. This entry is included for the remarkable magnitude of the event and its consequences. Rating: 4.

Similar and Related Phenomena. Air blasts preceding snow avalanches. Air blasts accompanying large explosions, especially detonations of nuclear weapons.

Entry

X0 Introduction. It is well known that snow avalanches act like pistons and push blasts of air at hurricane speeds ahead of the deluges of snow. In 1996 an unusual rock fall at Yosemite created a similar air blast with severe consequences. The mechanics of this phenomenon are no mystery. This entry is added solely for its unusual character and possible general interest.

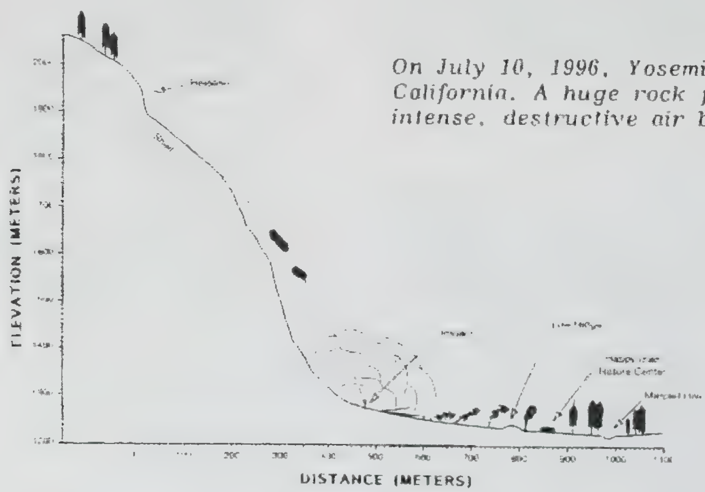
X1. July 10, 1996. Yosemite National Park, California. This remarkable event produced seismic waves, which jostled seismographs at Berkeley and Reno over 200 kilometers distant.

Actually, there were two rock falls 14 seconds apart. The "rocks" fell from a 665-meter cliff at Happy Isles in the eastern part of Yosemite Valley. No pebbles these, with volumes of 23,000 and 38,000 cubic meters.

"Although the impact area of the rock falls was not particularly large, the falls generated an air blast and an abrasive sandy cloud that devastated a larger area downslope of the impact sites toward the Happy Isles Nature Center. Immediately downslope of the impacts, the air blast had velocities exceeding 110 m/s [about 245 mph] and toppled or snapped about 1,000 trees. Even at distances of 0.5 km from impact, wind velociies snapped or toppled large trees, causing one fatality and several serious injuries beyond the Happy Isles Nature Center. A dense sandy cloud trailed the air blast and abraded fallen trunks and trees left standing." (R1)

Reference

R1. Wieczorek, Gerald F. et al; "Unusual July 10, 1996, Rock Fall at Happy Isles, Yosemite National Park," Geological Society of America, Bulletin, 112:75, 2000. (X1)



On July 10, 1996, Yosemite National Park, California. A huge rock fall created an intense, destructive air blast. (X1)

GWH17 Curious Wind-Downburst Damage in Amazonia

Description. The presence in Amazonia (and probably elsewhere) of isolated areas, each several square miles in extent, where trees and other vegetation have been devastated, presumably by violent downbursts of wind. The blasted areas appear like miniature Tunguska Events.

Data Evaluation. The forest scars show up on satellite photos, but ground-truth data are skimpy in our collection. We have no record of eye-witness accounts of the postulated downbursts. Our basic information comes from U.S. newspapers. Rating: 3.

Anomaly Evaluation. Whatever flattened such large tracts of Amazon forest are assumed to have been intense, unrecognized natural phenomena. These remarkable events have been blamed on wind downbursts, which are tentatively associated with distant thunderstorms. This hypothesis seems questionable. Rating: 2.

Possible Explanations. See above, to which we add the possibility of Tunguska-like impacts, due possibly to hydrometeors (GWF1) or above-ground meteor detonations.

Similar and Related Phenomena. Hydrometeor impacts (GWF1); other mysterious craters and analogous terrestrial damage in South America (R3); the Tunguska Event (ETC3-X1 in our catalog Carolina Bays, Mima Mounds...).

Entry

X0. Introduction. The Amazon region seems to be receiving more than its share of natural calamities. We have, for example, not only meteor-devastated swaths of destruction (R3) but the strange "crater" reported in X2 below, which may or may not be related to the subject phenomenon laid out next in X1.

X1. Irregular occurrence. "Scientists studying weather patterns in the Amazon Basin have detected extremely powerful, sudden bursts of wind over the rain-forest. The winds, which appear to be associated with thunderstorms in the northwest part of Brazil, blow downward with tremendous force. Satellite photos indicate that a single episode demolished 10 square miles of jungle in only 20 minutes." (R1)

To our knowledge these hypothesized downbursts have never been described by observers on the ground. Furthermore, the association with very distant thunderstorms is questionable. Given these suspect conditions and also the presence of several additional craters of mysterious origin elsewhere in South America, we add for the purpose of comparison the following event. (R3)

X2. 1995. Northeastern Brazil. Could the hypothesized wind-damaged areas the Amazon Basin (X1), be instead craters left by impacts of hydrometers? Although the connection of the following event to those of X1 is tenuous, it must at least be mentioned here for suspicious minds to consider.

"Scientists on Brazil's northeastern State of Piaui are baffled by a crater that was punched into the tropical rain forest shortly after witnesses reported seeing a bright light streak across the sky. Researchers are uncertain whether the crater, 16 feet wide and 32 feet deep, was left by a meteorite or a piece of a comet. Physicist Paulo Frota of the University of Piaui believes it was caused by a block of ice from a comet because the surrounding vegetation is not burned and the crater's rim is not raised." (R2)

References

R1. Anonymous; INFO Journal, #74:39, Winter 1996. INFO = International Fortean Organization. Source cited: Alexandria (Virginia) Journal, June 30, 1995. (X1)

R2. Anonymous; "Crater Mystery," Anchorage Daily News, October 1. 1955. Cr. J. & L. Nicholsom via L. Farish. (X2

R3. Corliss, William R.; Science Frontiers II, Glen Arm, 2004, p. 177. (X2)

GWH18 Magnetic Precursors of Large Storms

Description. Significant disturbances of the geomagnetic field several days before the arrival of severe storms. Direct causal connections between a brewing storm and distant magnetometers, if they exist at all, are obscure.

Data Evaluation. The successful forecasting of some large storms by magnetometer perturbations despite contrary forecasts by conventional meteorological methods and satellite observations. We rely here upon a brief discussion in a respected science magazine. Rating: 2.

Anomaly Evaluation. It is difficult to identify any direct causal connection between a distant embryonic storm and local geomagnetic fields. Rating: 2.

Possible Explanation. Solar storms, which do jostle terrestrial magnetometers, may affect storminess, too, through the solar wind and cosmic rays. In this, we see a potential indirect connection that may explain the subject phenomenon.

Similar and Related Phenomena. Infrasound from distant severe storms (GSI1 in our catalog Earthquakes, Tides...).

Entry

X1. January 22, 1986. Fredricksburg, Virginia. A magnetometer at the Fredricksburg Magnetic Observatory recorded a sudden jump (of 45 gammas) in the earth's horizontal magnetic-field component. Alerted by this, G. Wolin, at the Lamont-Doherty Geological Observatory, immediately predicted that a major snowstorm or flooding rains would hit northeastern states within six days. Wolin contacted the weather people in the region, but they discounted the prediction because satellite pictures and conventional weather indicators implied nothing of the sort.

A three-day storm began on January 25, depositing 3 feet of snow in northern New England and 4 inches of rain along the coast from Washington to Boston. Wolin has had similar successes, without even looking at a weather map!

Obviously Wolin's forecasting techniques are not yet part of the Weather Bureau's arsenal. This is not too surprising because even Wolin does not understand why major storms should be preceded by several days by nervous magnetometers. He talks in a tentative way about solar storms, which do affect terrestrial magnetism, dumping energy into the oceans and thence into the atmosphere. But this is mainly speculation.

Historically we know that long-term changes in the earth's magnetic field are linked to global temperature levels; but here, too, cause and effect are not obvious. (R1)

Reference

R1. Gribbin, John; "Magnetic Pointers to Stormy Weather," New Scientist, p. 70, December 25, 1988. (X1)

GWI ANOMALOUS INCENDIARY PHENOMENA

Key to Phenomena

GWI0 Introduction

Later in this volume, Chapter GWS, we describe several purported, cause-and-effect connections between terrestrial weather and astronomical phenomena. The sun, as we all know, sets our clocks and determines our seasons. Besides the sun's annual influence on weather, the 11-year sunspot cycle also affects rainfall, dry seasons, and storminess. Since dry seasons provide fuel for fires and storms with lightning add ignition sources, we would expect to see both annual and 11-year signals in natural brush and forest fires. Actually, there are much longer, more enigmatic cycles of terrestrial conflagrations, the longest reaching far down the geological column. These are of interest to anomalists.

We find that solar storms also provide terrestrial fire-ignition possibilities. The fluctuations in the geomagnetic field caused by intense solar storms can generate strong electrical currents in natural and human-made conductors. Some of these electrical disturbances can ignite fires.

Down the 4.6-billion-year history of our planet there have been many great conflagrations. These are evidenced by layers of soot in the geological column. (See ESC in Anomalies in Geology.) Within human times, there have also been natural conflagrations worthy of cataloging. In this chapter, we choose the largely forgotten great firestorm of 1871 that set North Central North America, including Chicago, ablaze; and in addition generated some impressive anomalies.

GWI1 Cyclic Natural Fires in Brush and Forest

Description. The cyclic appearance of natural wildfires, specifically great forest and brush fires.

Data Evaluation. Wildfires, particularly forest fires, are customarily attributed to careless human activities and lightning. But the data also reveal periodicities that can be scientifically attributed (via cause-and-effect) to phenomena associated with solar activity. Mainstream science has paid little attention to such long-period cyclicities in natural incendiary events. Rating: 3.

Anomaly Evaluation. That Nature herself is a cyclic arsonist contradicts popular belief---except perhaps for the usual annual ignitions by summer thunderstorms. Indications that Nature is also behind some long-period fire cycles, therefore, is mildly anomalous. In particular, the proposed dire influences of Coronal Mass Ejections (CMEs) by the sun on natural, terrestrial fire cycles remain controversial. Rating: 3.

Similar and Related Phenomena. Spontaneous, ostensibly inexplicable fires of natural origin (GWI2); colossal, wide-area natural conflagrations (GWI3).

Entries

X0. Introduction. Naturally occurring forest and brush fires are popularly thought to be encouraged by annual meteorological conditions, such as drought and electrical storms. There are "fire seasons" just as there are rainy seasons. However, there also seem to be fire cycles with much longer periods. These are of interest to the anomalist.

Several scientists have hypothesized that some long-period incendiary cycles ---decades and centuries long---may correlate with and be caused by natural phenomena---some still unidentified--- with similarly long periods.

Climate, of course, is affected by the sun's temporal pattern of emissions, especially the drumbeat of the 11-year, long-studied solar cycle. But are there even other longer cycles pertinent to terrestrial wildfire cycles? How do these other phenomena ignite brush and forests?

In the discussions that follow, we do not knowingly include fires due to human arson or carelessness.

X1. Cyclic occurence. Minnesota and probably other northern states and Canadian Provinces. An analysis of the sediments, especially charcoal, of three northern lakes, has enabled J. Clark to identify periodicities of forest fires in this region over many centuries.

"The charcoal series from 1240-1960 was analyzed with a Fourier series that looked for sinusoidal waves contained in the series. Periodicity in the amount and frequency of charcoal deposition became evident. Cycles of forest fires showed up at 10.5-11.5 years, 33-36 years, and 80-90 years, with several minor peaks in the vicinity of 15-25 years. Also indicated was a decrease in number of forest fires from 1600-1890 as a result of the cooler, wetter climate of the 'little ice age.' These cycles can be correlated with the weather patterns and the amount of fuel available." (R1)

All of the above factors are probably associated with long-term variations in solar radiation and the orbit and orientation of the earth's axis. They contrast starkly with the near-real-time incendiary stimuli in X2 following.

X2. October 2003. Western North America. Solar Coronal Mass Ejections (CMEs), which occur more frequently when the solar cycle is near its peak, induce sudden, intense surges of electricity in the earth, especially its crust and surface features.

B.A. Leybourne et al hypothesize that these electrical surges force clouds of ionized gases to be expelled through crustal fractures. These gaseous emissions may be ignited by lightning or even by Joule-heating near the surface. The result is seen in spontaneous wildfires at geologically determined spots on our planet's surface; e.g., fault networks.

Here is one of their proposed examples of such a phenomenon.

"The unprecedented wildfire storm in October 2003 occurred simultaneously with a powerful CME. Geospatial wildfire patterns suggests these wildfires followed fault and geomagnetic anomaly trends associated with the extension of the East Pacific Rise into the North American continent and Pacific fracture zones traversing the west coast of California." (R2)

More spectacular is the 1859 event.

X3. 1859. North America and Europe. "In 1859, during the strongest CME on record, telegraph wires in the western United States and Europe caught fire and were destroyed" (R2)

Terrestrial wildfires, then, can be ignited directly in almost real time by powerful solar emissions interacting with lengthy manmade electrical conductors. The geographic distribution of these wildfires, however, tend to follow human-made patterns of infrastructure rather then natural geological faults and conduction paths.

References

R1. Stumpf, Melinda, and Kokus, Martin S.; "Forest Fire Cycles," Cycles, 41:185, 1990. (X1)

R2. Leybourne, Bruce A., et al; "Gulf of California Electrical Hot-Spot Hypothesis: Climate and Wildfire Teleconnections," New Concepts in Global Tectonics, Newsletter, #38:3, March 2006. (X2, X3)

GWI2 Spontaneous Natural Fires

Description. The spontaneous ignition of brush, forest and especially human infrastructure. Some of these mysterious fires are reported to have been accompanied by electrical activity. Omitted here are arson, spontaneous human combustion (SHC), and those common cases of spontaneous combustion of green fodder in silos and the like.

Data Evaluation. Our data here are almost totally anecdotal and appear in newspapers. Direct observation by scientists are missing, as are thorough studies of most of the phenomena reported. Rating: 3.

Anomaly Evaluation. Some of the anecdotes recounted below seem to belong to the field of parapsychology. For example, one can invoke "fire poltergeists" to explain the spontaneous ignition of human clothing and structures. We will evaluate things parapsychological in P-series volumes of this catalog.

In the anecdotes related below, there are also frequent instances where human infrastructure has been damaged, set afire, or caused to malfunction by the action of natural electricity. Such phenomena can often be attributed to electrical currents induced by solar outbursts, as described in GWI1. Rating: 3.

Possible Explanations. Earth currents induced by solar storms.

Similar and Related Phenomena. Cyclic natural fires (GWI1); wide-area conflagrations (GWI3); spontaneous human combustion (BHC7) in Biological Anomalies II, supposed fire-poltergeist activity (Series P catalogs); natural combustion in geology (ESC4 in Anomalies in Geology); earth-current anomalies (EZC5 in Inner Earth).

Entries

X0. Introduction. Any large collection of Forteana will contain accounts of fires of mysterious origin. Many of improbable fires these seem to involve electricity, natural or should we say "unnatural"?

We catalog here onlt two of these unlikely events, but only because they were given a modicum of credence by the New York Times.

Note that we have attended to the equally suspect phenomenon of spontaneous human combustion (SHC) in BHC7 in our catalog Biological Anomalies: Humans II.

X1. Summer 1945. Almeria, Spain. Termed a "meteorological phenomenon," farmers' clothing, buildings and equipment suddenly burst into flames. A scientist from the National Mining School was sent to investigate."

His assessment:

"The activity is definitely localized in a farming area a short distance from Almeria. Farm laborers working in this area under a traditionally cloudless sky suddenly find their clothing afire. Taking off their clothing and stamping out the fire, they find it beginning to blaze again. The outer walls of white plaster buildings constructed of not readily combustible materials also broke into spontaneous blazes. White objects are most affected." (R1)

Here, one would expect crops and brush to be ignited, not plaster walls. And why were white objects ignited preferentially? We suppose that "something" did happen since a scientist was sent to investigate and the New York Times thought the incident worth mentioning.

X2. Winter 2003. Sicily, Italy. Headlines were made in many newspapers around the world when Sicily seemed to be under attack by an electrical Satan. As in X1, we follow the literary lead of the usually reliable New York Times.

Two days before Christmas: "Fuse boxes blew in houses all along the Via Mare. Air conditioners erupted even when unplugged. Fires started spontaneously. Kitchen appliances went up in smoke. A roomful of wedding gifts was crisped. Computers jammed. Cellphones rang when no one was calling, and electronic door locks in empty cars went demonically up and down."

Scientific authorities were called in from the National Institute of Geophysics and Volcanology, but they could only hypothesize.

"One [hypothesis] was that high pressure from under the crust of this volcanic spit of land on Sicily's northern coast had caused underground shifts that released electrical energy that eventually found its way to the village.

"The supercharged ions, once in contact with made-made electronic devices, may have caused sparks to fly, the scientists say, especially since the hamlet is near transmission lines. But the first could just as easily have been caused by some unexplainable problem in the atmosphere, Mr. Martella said.

"'The cause of the fires seems to have been static electric charges,' he said. 'What we don't understand is why there were these static electric charges.'" (R2)

In the compiler's mind, the reported phenomena and profferred explanations are unsatisfactory to say the least. Perhaps this all belongs in our catalogs on parapsychology, especially a chapter that deals with "fire poltergeists."!

However, harking back to GW11, Sicily is riven by many geological faults. The reported phenomena might have been the consequences of a massive solar outburst that induced terrestrial electrical currents in some susceptible modern human infrastructure.

References

R1. Anonymous; "Spontaneous Combustion Puzzles Spanish Farmers," New York Times, July 5, 1945. Cr. M. Piechota. (X1)

R2. Baker, Al; "Electricity Goes Wild," New York Times, June 24, 2004. Cr. H.H. Henry, P. Gunkel. (X2)

GWI3 Great Natural Conflagrations in North America in Human Times

Description. Within historical times, multistate-wide firestorms that propagate at high speeds and leap natural barriers. Millions of square miles may be involved. As with lightning, earthquakes, and other powerful natural phenomena, electrical phenomena may be involved.

Background. Here, we exclude fire whirlwinds, the weaker natural firestorms and human-created conflagrations, such as the infamous Hamburg firestorm of World War II. Our defining example (X1) is the firestorm that raged through North Central North America in 1871.

Data Evaluation. Several histories of the 1871 Great Chicago Fire and the synchronous "Peshtigo Horror" in Wisconsin have been written. However, scientific analysis of this colossal conflagration have been absent from the literature examined so far. The eyewitness anecdotal evidence, however, is detailed and often incredible. Rating: 3.

Anomaly Evaluation. Intense forest fires frequently advance rapidly and leap wide natural barriers. The incendiary phenomena described below are extreme and spectacular examples. As common with powerful meteorological events, "pranks" and curious occurrences abound, as they do with lightning and earthquakes. What really entices the anomalist to study firestorms are the frequent tales of accompanying electrical phenomena. These encourage a relatively high anomaly rating. Rating: 2.

Possible Explanations. Intense solar storms may induce fire-igniting earth currents.

Similar and Related Phenomena. Whirlwinds of fire and smoke (GLD11 in Remarkable Luminous Phenomena; tornado electricity (GWT1); spontaneous natural fires of mysterious origin (GWI2).

Entry

X0. Introduction. Continent-wide wildfires appear the the geological column. They have coincided with meteor impacts and volcanic eruptions in the deep past, which left behind layers of soot and charcoal in the geologists' historical record.

In human times, the Tunguska Event of 1908 ignited great forest fires in Siberia. This event is well-documented. (ESC1) in our catalog Anomalies in Geology.) We therefore bypass it here.

Here, we catalog a great conflagration that preceded the 1908 Tunguska Event. It did not have Tunguska's global consequences, but few North Americans today are aware of the horrific fire that ravaged North Central North America in 1871. The Great Chicago fire of the same date may linger in some modern minds along with the famous tale of Mrs. O'Leary's cow! But, in truth, the Great Chicago Fire was just a sidebar to the story of a much larger conflagration.

We herewith rectify this gap in our modern brain-stored collective knowledge of the 1871 fiery catastrophy by merging four digests of items that appeared in past issues of our newsletter Science Frontiers. Of course, there is some repitition, but the various descriptions of the 1871 events and the different anecdotes nicely portray the great natural calamity of 1871---a synthesis of the Great Chicago Fire and the so-called Peshtigo Horror, plus the seas of fire that surrounded these two locations.

If town-engulfing fires were the only characteristic of the 1871 event, we would pass it by. However, strange phenomena abounded. Some of these seem to have been electrical in origin. Possible ties exist, therefore with the phenomena recounted above in GWI1 and GWI2.

X1. October 1871. North Central United States. "During the great fire that raged over northern Wisconsin in 1871, and which wiped out not only the prosperous village of Pestigo, but, in the aggregate of farmhouses, half a dozen villages like Pestigo, there were many evidences of electrical phenomena present. The flames were seen to possess that sudden rapidity of action which only electricity can impart. They would leap over wide spaces with the greatest rapidity, leaving many objects in the rear that one would suppose could not escape, and striking others beyond, and least exposed, in the most unaccountable manner. The details of that great disaster would disclose many curious and instructive facts. People were found dead without any apparent injury, though lying out in the open fields, and far from the burnt woods. Of course, it is popularly supposed that these suffocated in the superheated atmosphere. However that may be, one circumstance coming under my own observation proves conclusively the presence of electricity, and a very curious action of the subtle fluid, too. Shortly after the fire, the editor of the Green Bay Advocate exhibited a copper coin taken from the pocket of one of the victims found dead in the middle of a large clearing. The coin was fused, but no sign of injury whatever was discovered on the man's person. (R1)

Describing "...the most disasterous fire period in our nation's history." "In Michigan, 2.5 million acres of timber lay charred, and perhaps 200 people died there. A complete tabulation was never made. In northeast Wisconsin, 1.25 million acres of timber was destroyed, and about 1,300 people died. In Chicago, where a detailed survey was made, 17,450 buildings were destroyed and over 200 people were killed. The major question is: With relatively light winds reported in much of the fire area the evening of the 8th, what caused the rapid, high-burning phenomena in most places? In northeast Wisconsin, the major fire run was finished by 0200, 9 October, leaving a virgin forest in smoldering ruin. In some sections of Chicago, the rate of fire advance was clocked at 100 yards per minute, and there were reports that the whole horizon was one line of fire." (R2)

We now turn our full attention to the northern section of the 1871 event, which also burned as Chicago was consumed.

October 8, 1871. Peshtigo, Wisconsin. The "Peshtigo Horror." October 8, 1871, was the date of two immense North American conflagrations: the infamous Great Chicago Fire and the so-called Peshtigo Horror, the latter a firestorm that incinerated some 2,400 square miles of Wisconsin and over 1,000 human beings. The summer of 1871 had been tinder-

In its November 25, 1871, issue, Harper's Weekly tried to capture the Peshtigo Horror with this sketch. (R6) dry in the upper Midwest, so fires were not surprising; but two colossal fires on the same day? "Just coincidence" is mainstream thought, but others opt for ignition by a comet or perhaps some electrical phenomenon. (See, for example, M. Waskin's 1985 book Mrs. O'Leary's Comet).

We also have at hand a 26-page eyewitness account of the inferno that swept over the small town of Peshtigo and surrounding areas. Three phenomena recounted therein by P. Permin are of interest to anomalists.

(1) "Many circumstances tended to prove that the intensity of the heat produced by the fire was in some places extreme, nay unheard of. I have already mentioned that the flames pursued the roots of trees into the very depths of the earth, consuming them to the last inch. I plunged my cane down into these cavities, and convinced myself that nothing had staved the course of combustion save the utter want of anything to feed on. Hogsheads of nails were found entirely melted though lying outside the direct path of the flames. [Note that the hogsheads were not consumed by the fire!]

(2) "Strange to say there were many corpses found, bearing about them no traces of scars or burns, and yet in the pockets of their habiliments, equally uninjured, watches, cents, and other articles in metal were discovered completely melted.

(3) "When the hurricane burst upon us, many, surprised and terrified, ran out to see what was the matter. A number of these persons assert that they then witnessed a phenomenon which may be classed as marvelous. They saw a large black object, resembling a balloon, which object revolved in the air with great rapidity, advancing above the summits of the trees towards a house which it seemed to single out for destruction. Barely had it touched the latter when the balloon burst with a loud report, like that of a bombshell, and, at the same moment, rivulets of fire streamed out in all directions." (R4)

The preferential melting of metal objects is one of the "pranks" of lightning. The large black "balloon" could have been a fire tornado, a phenomenon sometimes seen in forest fires.

Focussing again on the Wisconsin fires: As Chicago burned, a much greater fire incinerated 2,400 square miles of forest in northern Wisconsin. (This area is twice the size of Rhode Island!)

In 1871, the part of Wisconsin was sparsely populated, yet about 2,500 people failed to reach the relative safety of the many rivers and lakes in the area. Those who sheltered in their storm shelters were cooked. Those who lowered themselves into their wells were killed when the burning structures at the surface fell in on them. Even those lucky enough to reach deep water had to keep ducking under to keep their scalps from being singed. The accompanying fire tornados swept whole houses 100 feet into the air. Residents of Baltimore, over 1,000 miles away, noted the smoke in the western sky.

Bizarre stories emerged after the conflagration. One of the saddest is that of a man who had just seen his wife die horribly. Fearing for himself and his three children, he slit their throats and then his own. In the end the fire skipped over them! (R6)

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R1. Gibson, Geo.; "Electric Eccentricities," Science, 14:305, 1889. (X1)

R2. Haines, Donald A., and Kuehnast, Earl L.; "When the Midwest Burned," Weatherwise, 23:113, 1970. (X1)

R3. Anonymous; "Great Fires of Seventy-One," Wisconsin Magazine of History, 11:96, 1927. (X1)

R4. Permin, Peter; "The Great Peshtigo Fire: An Eyewitness Account," Wisconsin Magazine of History, 54:246, 1971. (X1)

R5. Moran, Joseph J., and Stieglitz, Ronald D.; "Tornadoes of Fire," Weatherwise, 36:298, 1983. (X1)

R6. Tasker, Greg; "Worst Fire Largely Unknown," Baltimore Sun, October 10, 2003. (X1)

GWP ANOMALOUS PRECIPITATION

Key to Phenomena

GWP0 Introduction

What makes precipitation anomalous? The major variables involved are color, shape, size, intensity, and distribution. Huge hailstones, red rain, and prodigious concentrations of rainfall are obvious candidates for this chapter. But any form of precipitation without clouds visible in the sky must also be considered anomalous. True, very fine ice crystals can be frozen out of clear air when the cold is intense, but where does cloudless rain originate? Evidently, the atmosphere can carry considerable moisture without the formation of telltale clouds.

Colored rain, snow, and hail are rather common---so frequent, in fact, and so well-explained that they receive only passing notice here. The European "rains of blood," described since history began to be written down, and made much of in Fortean circles, can usually be blamed on dust blown north from Africa. Black rain is even more common and can be ascribed to forest fires, volcanos, and urban pollution, just as the closely related dark days (GWD) are.

Uncolored rain can, on occasion, be very intriguing. Fantastic examples of "point rainfall" and supposedly collapsing waterspouts have been noted often in meteorological magazines. The naming of the phenomenon does not, of course, explain the unbelievable quantities of water that is sometimes dumped in very small areas. Some sort of meteorological-topographical focussing effect seems to be at work here.

Hail is notable if it is unusually large, if it comes in odd shapes, and if it contains inclusions that should not be present inside ice particles falling from the sky. (Note that isolated ice falls and "hydrometeors" are dealt with in GWF1.) The fantastic variety of hailstone shapes: crystals, discs, large flat plates, spiked spheres, etc., may indicate the work of unappreciated forces in hail formation. Some of these formative forces may be electrical in nature. On a larger scale, the peculiar mesh and parallel-line patterns of some hail falls call for explanation in terms of hailstorm dynamics. Finally, the phenomenon of slowly falling hail is not easy to explain.

As in many other weather phenomena, electricity seems to play a subtle role. Electrically charged precipitation that sparks and snaps upon hitting the ground has been observed on many occasions. Given the powerful electrical-charge-separating mechanism of the active thunderstorm, electrically charged rain is perhaps not too surprising. But can these same electrical forces also initiate the curious gushes of rain correlated with lightning flashes? The possibility of lightning-induced rain gushes has long been debated and may be related to those hydrometeors that fall just after lightning flashes (GWF1) and hot air blasts experienced in thunderstorms (GLL12).

A significant general observation concerning precipitation anomalies will be obvious after perusing this chapter: Precipitation phenomena as a class are not especially anomalous. They are interesting, sometimes startling, but do not really shake the foundations of meteorological theory.

GWP1 Precipitation from a Clear Sky

Description. The fall of rain, snow, or hail from a cloudless or nearly cloudless sky.

Background. The descent of tiny ice needles in the arctic regions and on high mountain ranges is fairly common. In these regions, the extremely low temperatures cause water vapor to crystallize and fall without the formation of visible clouds.

Data Evaluation. Many sound observations of precipitation from cloudless skies are on file. Rating: 1.

Anomaly Evaluation. The thermodynamic conditions for the condensation of water vapor in the atmosphere are well known. What is lacking, except in the fall of ice needles, is a suitable, possibly short-lived, meteorological mechanism that causes precipitation without creating visible clouds. Since several possibilities exist (see below), precipitation from a clear sky is more curious than anomalous. Rating: 3.

Possible Explanations. Transient atmospheric disturbances, such as gravity waves and the sudden expansion and cooling of wind blowing across mountain ranges. Large influxes of meteoric dust may also stimulate precipitation. Some spurious instances of precipitation from a clear sky may derive from wind-blown precipitation from distant, unseen clouds, from ocean breakers, and even from waterfalls. Occasional pseudoprecipitation occurs on warm fall days in wooded areas when sap exudes from leaf scars.

Similar and Related Phenomena. None.

Examples of Precipitation from a Clear Sky

X1. April 23, 1800. Philadelphia, Pennsylvania. "A shower of rain of at least twenty minutes' continuance, and sufficiently plentiful to wet the clothes of those exposed to it, fell when the heavens immediately over head were in a state of the most perfect serenity. Throughout the whole of it, the stars shown with undimished lustre. Not a cloud appeared, except one to the east and another to the west of the city, each about fifteen degrees distant from the zenith." (R3) In this instance wind could have blown the rain horizontally from the extant clouds.

X2. November 13, 1833. Harvard, Massachusetts. "At Harvard, in this state, at about 8 o'clock on the morning of the 13th, there was a slight shower of rain, when not a cloud was to be seen, the weather being what is called perfectly fair." (R1, R3) This observation is significant because it occurred immediately after one of the greatest meteor showers in historical times. (WRC)

X3. August 9, 1837. Geneva, Switzerland. Several short showers of tepid drops of large size. (R3)
X4. May 31, 1838. Geneva, Switzerland. A lukewarm rain lasting 6 minutes. (R2)
X5. April 21, 1842. Flanders, France. (R4)
X6. July 26, 1855. Ostend, Belgium. (R5)
X7. April 17, 1857. Paris, France. (R6)

X8. July 22, 1888. Stevenage, England. Rain from a cloudless sky preceded a violent thunderstorm by 1 1/2 hours. "The appearance was first seen about 7 p. m., and it looked like a shower of luminous particles of a somewhat skim-milky appearance. As soon as I realized the fact of its electrical nature I endeavoured to ascertain if the movement of the particles was upwards or downwards, but without effect. But what I did more successfully observe was that the particles were of the size of tare-seed, and that they moved in remarkably straight lines, so much so that they resembled the warp in a weavers frame. My view extended over about two-fifths of the circle of the heavens, and the appearance within that area was precisely the same." (R7) The luminous nature of the phenomenon is unusual and somewhat resembles low-level auroras and auroral fogs (GLA4 and GLA21). (WRC)

X9. 1892. England. (R8)

X10. February 6, 1895. Surrey, England. "On the 6th February, at 9 a. m., light snow began to fall, sparkling in sunshine from a cloudless sky. Thinking that the snow might be blown off a roof, I went out on the common, clear of houses, and made no doubt that the fall was from the sky. Gradually it clouded over, and at 10 a. m. was quite overcast, the snow continuing as a natural shower for a short time longer. (R9) In Sussex it was a brilliant day, with snow crystals and minute spiculae of ice falling at intervals. (R10)

X11. 1902. Tarbes, France. "...after a day of mist and rain, with low temperature, the sky cleared and the night became fine. This lasted till midnight, when the town was suddenly deluged with hail, the streets being thick with stones of large size. The most singular feature of this meteorological freak was at the time the hail fell there was an absolutely clear star-lit sky."(R11)

X12. July 18, 1925. Boveysand, England. A very short, localized shower from a blue sky. (R13)
X13. December 29, 1929. Grayshott, England. A few minutes of drizzle from a clear sky with bright stars. (R15)
X14. January 3, 1933. Grayshott, England. (R15)
X15. January 20, 1935. Benson, England. Drizzle from a pale, watery-blue sky. (R14)

X16. February 5, 1955. Wrexham, England. "On February 5 there was a period of light rain from 2130 to 2230 G. M. T. The cloud then suffered a complete and rapid dispersal, and from 2235 to 2255 light rain continued to fall from the cloudless sky. Not a trace of cloud could be seen and the stars were as bright as they can be with a nearly full moon, and it was calm at the surface. The rain was not heavy enough to be registered on the autographic rain-gauge, but was sufficient to wet clothing." (R16)

X17. February 15, 1955. Wrexham, England. Snow fell in the absence of low clouds, although high cirrus were present. (R16)
X18. January 1, 1979. Houwaart, Belgium. After an extremely cold night, ice needles fell from a clear sky. (R17)
X19. General observation. The slow fall of ice needles (so-called "diamond dust") from a cloudless sky is rather common in polar regions and on high mountains. (R12)

X20. April 26, 1887. Argentan, France. At 8:00 in the evening, the sky was absolutely clear and the stars shone brilliantly. All of a sudden, rain drops fell in the area for 5 minutes. (R18)

X21. December 28, 1986. Ross Island, Antarctica. No detectable clouds from horizon to horizon. For at least 4 hours, ice crystals fell in the form of hexagonal plates. Many were large----up to a millimeter across. The crystals, being so large, fell rapidly. Their density was estimated at 5-10 crystals per liter.

> The reason the nucleation and crystal growth did not occur in a visible cloud layer is no doubt that whilst the air became saturated with respect to ice, at no stage was was it saturated with respect to liquid water. (R19)

Under such conditions, rather common in the polar regions, ice crystals can form but the liquid droplets that form clouds cannot.

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R1. Olmsted, Denison; "Observations on the Meteors of November 13th, 1833," American Journal of Science, 1:25:363, 1834. (X2)

R2. "Fall of Rain from a Serene Sky," Edinburgh New Philosophical Journal, 25:423, 1838. (X4)

R3. "Rain from a Clear Sky," American Journal of Science, 2:1:178, 1839. (X1, X2, X3)

R4. de Noirfontaine, Bodson; "Note sur de la Pluie Observee par un Ciel Completement Serein," Comptes Rendus, 14:663, 1842. (X5)

R5. "Pluie sans Nuages," Comptes Rendus, 44:786, 1857. (X6)

R6. Phipson, T. -L.; "Sur une Pluie sans Nuages Observee a Paris," Comptes Rendus, 45:906, 1857. (X7) (Cr. L. Gearhart)

R7. Jones, Samuel; "Rain from a Cloudless Sky ("Serein") at Stevenage, July 22nd, 1888," Royal Meteorological Society, Quarterly Journal, 15:123, 1889. (X8)

R8. Godden, William; "Rain without Clouds," English Mechanic, 54:506, 1892. (X9)

R9. Maclear, J. P.; "Snow from a Cloudless Sky," Symons's Monthly Meteorological Magazine, 30:27, 1895. (X10)

R10. Prince, C. Leeson; "Snow from a Cloudless Sky," Symons's Monthly Meteorological Magazine, 30:44, 1895. (X10)

R11. English Mechanic, 76:12, 1902. (X11)

R12. "Snow without Clouds," Monthly Weather Review, 45:13, 1917. (X18)

R13. Applegate, T. H.; "Rain from a Blue Sky," Meteorological Magazine, 60:193, 1925. (X12)

R14. Dines, J. S.; "Drizzle Falling from a Clear Sky," Meteorological Magazine, 70:16, 1935. (X15)

R15. Ashmore, S. E.; "Drizzle Falling from a Clear Sky," Meteorological Magazine, 70:116, 1935. (X13, X14)

R16. Ashmore, S. E.; "Precipitation with a Clear Sky," Meteorological Magazine, 84:156, 1955. (X16, X17)

R17. Goethuys, J. P.; "A Fall of Ice-Prism Dust in Belgium," Journal of Meteorology, U.K., 4:191, 1979. (X18)

R18. Anonymous; "Une Pluie sans Nuage," L'Astronomie, 6:274, 1887. (X20)

R19. Fisher, G.W., et al; "An Incident of Clear Air Precipitation," Weather, 44:55, 1989. (X21)

GWP2 Giant Snowflakes

Description. Large agglomerations of smaller flakes in the form of plate-like masses measuring up to 38 centimeters in diameter.

Data Evaluation. Aggregations of flakes 2-4 inches in diameter are common; those 4-6 inches in diameter are rare but well-verified. The record flake, 38-centimeters across (X2), may be an exaggeration, but no one contests the fact that immense snowflakes do fall under some conditions. Rating: 1.

Anomaly Evaluation. The aggregation of snowflakes by collision poses no problems for geophysicists; large flakes fall faster than small ones and, in so doing, pick up more and more smaller flakes. One observation suggests that electrostatic attraction may play a role, but even here there are no theoretical problems, because it has long been accepted that snowflakes may carry substantial electrical charges. Rating: 3.

Possible Explanations. Large flakes are probably aggregations of smaller flakes created by collision and/or electrostatic attraction.

Similar and Related Phenomena. Electrical discharges observed during snowstorms (GLD5).

Examples of Giant Snowflakes

X1. January 7, 1887. Chepston, England. Some flakes measured 9 centimeters in diameter, larger ones seen. One flake yielded 16 drops of water. The flakes consisted of hundreds of undamaged crystals set together at all angles. The observer thought he saw the large flakes exerting an attractive force on smaller ones. In part, though, the giant flakes could be explained in terms of the huge flakes overtaking and combining with the smaller ones. (R2, R4)

X2. January 28, 1887. Fort Keogh, Montana. Huge flakes "larger than milk pans" and measuring 38 centimeters across bv 20 centimeters thick. (R2, R4, R6)

X3. January 24, 1894. Nashville, Tennessee. Some flakes almost 14 centimeters in diameter. (R2, R6)

X4. March 25, 1900. Richmond, Virginia. "There was nothing unusual about the first falls of flakes, but the sleet immediately diminished in volume and as this occurred the flakes increased in size until they attained unusually large dimensions. They were of irregular shape, usually oblong; several were observed whose greatest diameters could hardly be covered by a teacup (perhaps about 7.6 centimeters). Some of these flakes were caught upon a piece of dry wood and examined: in every instance they showed the center to consist of a soft mass of snow about one-half inch (1.3 centimeters) in diameter, while the outer edges were thin, as though they were separate flakes that had attached themselves to the central mass while it was falling. The greater weight of the center caused the larger flakes to assume the form of an inverted cone as they fell, the outer, thinner edges being bent upward by the resistance of the air." (R2, R4)

X5. January 17, 1912. Bristol, England. Some flakes were 3 1/2 inches in diameter. (R1)

X6. January 10, 1915. Berlin, Germany. "On this occasion a large number of snowflakes had diameters of 8 to 10 centimeters, and these giant flakes fell with both a greater speed and more definite paths than did the smaller flakes. They did not have the complicated, fluttering flight of the latter. In form the great flakes resembled a round or oval dish with its edges bent upward. During flight they rocked to this side or that, but none were observed to turn quite over so that the concave side became directed downward." (R2)

X7. April 13, 1951. Berkhamsted, England. Enormous flakes about 5 inches across. (R3, R4)

X8. March 24, 1888. Chepstow, United Kingdom. 9½ centimeters. (R4)

X9. September 24, 1970. Laramie, Wyoming. 6 centimeters. (R4)

X10. January 30, 1942. Derbyshire.

Snowflakes 38-cm in diameter fall in Montana (X2)

United Kingdom. 5 centimeters. (R4)
X11. December 9, 1950. Sapporo, Japan. 5 centimeters. (R4)
X12. February 22, 1986. Halifax, Canada. 5 centimeters. (R4)

X13. Winter 1971. Bratsk, Siberia. "Now accepted as fact in the weather records was the report that the Siberian town of Bratsk in the winter of 1971 got snowflakes as big as footballs." (R5)

References

R1. Denning, W. F.; "Large Snow Flakes," Symons's Meteorological Magazine, 47: 22, 1912. (X5)
R2. "Gigantic Snowflakes," Monthly Weather Review, 43:73, 1915. (X1-X4, X6)
R3. Hawke, E. L.; "Outsize Snowflakes," Weather, 6:254, 1951. (X7)
R4. Pike, W.S.; "Unusually Large Snowflakes," Journal of Meteorology, (U.K.), 13:3, 1988. (X1, X2, X3, X4, X6-X12)
R5. Anonymous; San Francisco Chronicle, September 25, 1994. Cr. J. Covey. (X13)
R6. Burt, Christopher C.; Extreme Weather, New York, 2004, p. 98. (X2, X3)

GWP3 Snow: Some Anomalous and Bizarre Forms

Description. The creation by meteorological forces of an immense variety of wildly different snow crystals, some with high symmetry and great beauty, all from a single molecule---water.

Data Evaluation. Some forms of snow, notably the stellar dendrites, have been collected, drawn, preserved, and studied for centuries. But some equally perplexing forms of snow, such as the capped columns, have received far less analysis.

While the beauty of snowflakes received much attention, Two of the major anomalous aspects of snow, outlined below, have been mostly ignored by science. Rating: 2.

Anomaly Evaluation. We recognize the following two anomalies connected to snow formation; there may be others:

(1) The primary anomaly is the unexplained and scarcely attended to creation of long-range symmetry in snowflakes; in a nutshell, how do the six arms of stellar dendrites intercommunicate to achieve near-perfect duplication of complex designs when separated by distance? Rating: 1.

(2) The source(s) of the beauty, bizarreness, and complexity of the many forms of snow are not well-known. Admittedly, these are human subjective parameters, but as with biodiversity and the universal love of life forms, we would like to understand how they come about and why. No paradigms are at risk here. We desire to come to grips with the efflorescence of Nature. Rating: 4.

Possible Explanations. Long-range duplication of snowflake geometry may be guided by lattice vibrations, electric fields established by the seed crystals, or, possibly, the currently unaccepted hypothesis of morphic resonance as advanced by R. Sheldrake.

As for beauty, bizarreness, and complexity, the multitudinous forms of water and the vagaries snowstorm conditions probably provide sufficient variables to sculpt ice crystals with the properties presented above. Science finds it difficult to deal with the questions of why Nature is often beautiful and diverse---at least to us. Answers to such questions may always elude us.

Similar and Related Phenomena. The long-range order in all crystals (COC in a future volume); curious and anomalous forms of hail (GWP4); the origin of biodiversity (Series-B catalogs); the self-organization of other simple molecules into other beautiful, bizarre, and complex crystalline forms not associated with snow; hoar-frost and frost figures.

Examples

X0. Introduction. The popular vision of snow is that of the elegant six-armed snowflake. These are common in many, but not all, snowfalls. They come in seemingly infinite, often very beautiful variety. Scientists customarily term these forms of snow "steller dendrites."

Rarely, though, do the popular and science media attend to the several other kinds of snow: the needles, the columns, the sectored plates, the "bullets," etc. These neglected forms of snow are often just as beautiful as the lacy, highly symmetrical, six-sided, dendritic stars that everyone uses to typify snow. To anyone trying to understand snow formation, these other forms are equally challenging and beguiling.

We describe the most interesting types of snow in a general way in X4 below. After intellectually absorbing snow's great variety and structural complexity, one sees how difficult it has been for science to explain exactly how Nature conceives such a wide array of shapes and designs and then manufactures them in immense multitudes in the tumult of a snowstorm.

We begin somewhat indirectly with entries X1-X3. These are event-type entries detailing falls of so-called "conical snow."

Pure conical snow consists of tiny snow crystals packed into soft, easily crushed cones which usually have rounded bottoms. They feel and look like snow. But a taxonomic problem arises here because some conical snow pellets have conical cores of clear ice. These seem to be transitional forms between pure conical snow pellets and the solid ice of conical hail. (See, for example, GWP4-X25.) We have cataloged just three cases of pure conical snow in X1-X3 and continue with the transitional forms and pure conical hail in GWP4, where many additional hail anomalies and curiosities are cataloged.

Are any of the various forms of snow described below anomalous? Some snow shapes, such as the capped columns (X4), certainly perplex those meteorologists trying to identify the specific weather conditions inside a snow storm that can generate untold millions of copies of the various bizarre forms of snow.

While the meteorologists are musing over the many curious forms of snow, a much more serious problem of explanation bedevils most snow geometries, even the common stellar dendrites. It all has to do with our poor understanding the growth of crystals, which of course includes the many crystalline forms of snow. This subject actually transcends meteorology and is therefore covered in more detail in Section COC in a future volume. Here, we only sketch out this problem by quoting J. Maddox writing in the journal Nature.

After reviewing the great difficulties scientists are having in mathematically describing the growth of even the simplest crystal, Maddox homes in on the fascinating puzzle of snowflake growth in technical terms.

"The aggregation of particles into a growing surface will be determined exclusively by local properties, among which surface tension and the opportunities for energetically advantageous migration will be important. But the symmetry of a whole crystal, represented by the exquisite six-fold symmetry of the standard snowflake, must be the consequence of some cooperative phenomenon involving the growing crystal as a whole. What can that be? What can tell one growing face of a crystal (in three dimensions this time) what the shape of the opposite face is like? Only the lattice vibrations which are exquisitely sensitive to the shape of the structure in which they occur (but which are almost incalculable if the shapes are not simply regular)." (R4)

More simply, how does one arm of a six-armed snowflake know what the other growing arms look like so that it can duplicate them? Is some sort of universal duplicating "force" at work?

In his forgoing discussion of the source of snowflake symmetry, J. Maddox invokes mechanical vibrations to communicate structural instructions among the six arms of dendritic snowflakes. In response to Maddox's concerns, two letters to Nature suggest that electric fields established by the snowflake nucleus might enforce the observed symmetry. (R5)

More specifically, W.S. Mortley remarked: "It is unclear to me why there should be any need to invoke lattice vibrations to tell one growing face what the shape of the opposite growing face is like. It does not have the need to know. In a statistically uniform environment of many particles, statistics and electric fields will shape all six growths uniformly." (R5)

We do not know if Mortley's far-reaching claim has been demonstrated experimentally.

It would be remiss not to mention R. Sheldrake's controversial hypothesis of morphic resonance in connection with snowflake symmetry. Sheldrake suggests that the mere presence of a specific shape creates a universal "field" that encourages the duplication of that shape elsewhere. (R10) Needless to say, Sheldrake's hypothesis has been rejected by most scientists.

X1. April 26, 1931. Ann Arbor, Michigan. Three short falls of conical snow. "The crystal formation was that of a solid cone with a round base. The side of the cone made an angle of about 30 degrees with the axis. The round base was part of a spherical surface. The shape was exactly like that of a conical section of a sphere. As nearly as the eye could see into the formation of a snowdrop, the whole structure seemed to be made up of conical needles, packed together, with the upper ends forming the pointed tip of the cone, and the larger lower ends forming the rounded base. The density was very high; a handful of snow, slightly compressed, immediately formed soft ice. The ratio of snow volume to volume when compressed to ice without air included would hardly have been higher than four to one. Hundreds if not thousands of individual snowdrops came under observation on a window sill; irrespective of size, from tiniest to largest, the crystals were of the same form.... Many large crystals fell; one of the largest, by actual measurement, was three eighths of an inch across the base." (R1)

X2. September 1920. Ephraim, Utah. Cones of hard, compacted snow with hemispherical bases---like inverted parachutes. All measured more than 1/4 inch across the base, with many reaching 1/2 inch. They were definitely snow and not ice. (R2)

X3. Regular occurrence. Northern Vermont. Several falls of conical snowflakes recorded each year. They come only from cumulo-nimbus clouds, have a granular texture, and are built up from undercooled cloud droplets that have frozen together. The nuclei are almost always branching tabular crystals. (R3) This description does not seem like that of X1 as far as internal structure in concerned.

X4. A roster of major snow types. All of the types of snow mentioned below are subject to J. Maddox's concern expressed above about our poor understanding of the duplication of shapes in snowflakes. (X0)

Some of the shapes of snow listed below are undeniably bizarre and improbable. But bizarreness is not an indicator of anomalousness. Yet, we still must wonder how a snowstorm's varying meteorological parameters can mold so many different odd shapes in such immense numbers. As with evolution's creation of biodiversity, the snowstorm also seems infinitely inventive but, of course, it is actually very limited. It lacks mutation and natural selection and depends only upon the vagaries of temperature, pressure, humidity, and the amazingly varied properties of water in its solid, liquid, and gaseous forms ---the diverse properties of a single molecule. Life, in contrast has the entire periodical table at its beck and call!

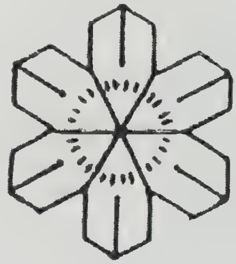
Below, in the review of the forms of snow, we rely upon the classification of K. Libbrecht and his associated definitions. (R7)

•Diamond dust. Hexagonal prisms of ice that form in very cold air, such as is found at very high altitudes and in the polar regions. Diamond-dust crystals are usually less that a millimeter in size ---almost invisible to the naked eye. They may drift to earth when the polar sky seems cloudless.

•Stellar dendrites. These icons of winter are very thin, six-armed ice crystals rarely exceeding ½-inch in breadth. They begin as tiny hexagonal ice prisms. Their longish, highly symmetrical arms grow out radially from the six-sided seed crystals. The seemingly endless variety of arm geometries gives the stellar dendrites a flower-like appearance. Iconic though they are, they are absent in many snowfalls. Their high degree of symmetry, as explained in X0, constitutes their major anomaly. But beyond that the curious among us must also wonder what "forces" introduce such variety and beauty into the six growing arms; that is, "ice-crystal diversity."

Stellar dendrites become more complex, though not more anomalous, when they are found with 12, 18, or 24 arms. The 12-sided dendrites are believed to result from twinned seed crystals twisted 30° apart. The twin crystals grow together, both six-armed, but 30° apart, resulting in a 12-armed stellar dendrite. It is more difficult to account for the rarer 18- and 24-armed varieties.

•Sectored plates, sometimes called "broad-branched" crystals, may be mixed in a fall of stellar dendrites. In fact, many sectored-plate flakes resemble stellar dendrites with six, broad, flat arms, but less elegant in design. At the other end of their shape spectrum the sectored plates are simple hexagonal plates of thin ice divided into six sectors by ice ridges. In between these extremes there is a constellation of six-armed crystals displaying varying degrees of "plate-ness."

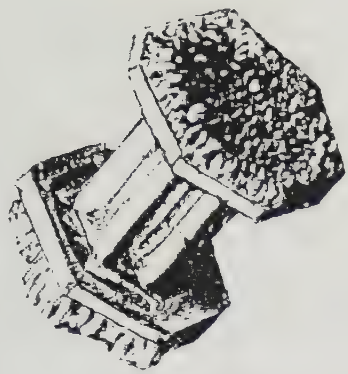


•Needles and columns. Sometimes, the embryonic icy nuclei of snow-to-be grow faster at the two ends of the hexagonal seed crystal. This change from six-fold growth from the faces to two-dimensional end-growth results in long needles and columns rather than stellar geometry. Needles and columns are very common in snowfalls but generally neglected by the media in favor of the more attractive six-armed dendrites and sectored plates.

Some of the falling ice columns may, for some reason, be hollow. Something else that needs explanation.

Sometimes, columnar crystals grow in clumps. When the separate crystal columns break apart and fall, they are often bullet-shaped, each with a pointed end where they were joined to the clump.

•Capped columns. Rather improbable products of Nature are the capped columns. At their cores, they are simple ice columns, but perhaps due to changes in a storm's temperature and humidity, columnar growth ceased and was replaced by the superposition and growth of hexagonal end caps. A truly bizarre form of snow results. None of the snow shapes described above can surpass in strangeness the capped column in the accompanying illustration.

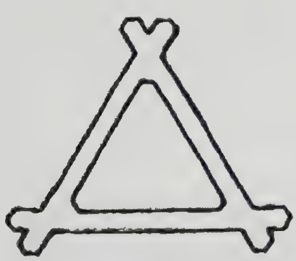


Here we see the hexagonal symmetry retained in columnar core and again in the plates at each end of the icy dumbbell. But what are those peculiar ice-worms projecting from the end plates? The answer is (probably): strands of "rime." (See "Oddities" next.) (R7, R8)

What combination of meteorological mechanisms can scuplt such complex shapes in prodigious quantities?

•Oddities. Capped columns do not end the roster of snow oddities.

Asymmetry frequently is seen in snowflakes, resulting in distorted flakes. Breakage of the delicate stellar dendrites yields so-called "splits," such as 3-armed stars. Snow often falls into regions occupied by tiny droplets of liquid water. These may adhere to the falling flakes and freeze into miniscule beads or even tiny hexagonal plates, thus marring a stellar dendrite's beauty with a deposit of "rime." Heavy deposits of rime completely change the shape of a dendrite. It then becomes a lump of soft snow or "grauple." R7, R9)



In addition to colliding with droplets of liquid water, snowflakes may impact one another. The two flakes may fuse and grow together into confusing hybrids often with grotesque shapes. (R7)

X5. Biological snow! To form at all above -40°F, snowflakes require a solid seed or nucleus around which a seed ice crys- can form---or so scientists have assumed for many years. It was long believed that airborne dust, perhaps augmented by extraterrestrial micrometeoroids, served as the necessary seed crystal nuclei. But cloud studies proved that there are about a thousand times more ice crystals aloft than dust nuclei. Now, some scientists are convinced that bacteria blown off plants by wind and flung into the air from the ocean by breaking waves are the true nuclei of atmospheric ice crystals and, of course, water droplets as well.

Remember this the next time you taste a handful of snow or let raindrops fall on your tongue! (R6)

The possibility that the fall of snow and all other forms of watery precipitation is largely dependent upon airborne bacteria brings to mind the Gaia Hypothesis; that is, all life forms work in unison to further the welfare of life-as-a-whole. In this vein, airborne bacteria support this goal for our planet by fostering precipitation.

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R3. Bentley, Wilson A.; "Conical Snow," Science, 75:383, 1932. (X3)
R4. Maddox, John; "No Pattern Yet for Snowflakes," Nature, 313:93, 1985. (X0)
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R6. Carey, John; "Crystalizing the Truth," National Wildlife, 28:43, December/January 1985. (X5)
R7. Libbrecht, Kenneth; The Snowflake, Stillwater (MN), 2003. (X4-X5)
R8. Kaiser, Jocelyn; "Snow Up Close," Science, 289:503, 2000. (X4)

R9. Amato, Ivan: "The Secret Life of Snow," Discover, 25:50, February 2004. (X4)
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GWP4 Hailstones with Anomalous Geometries

Description. Hailstones that depart substantially from the usual roughly spherical geometry, which is often constructed from concentric shells. The variety of oddly shaped hail is astounding. It ranges from geometrically satisfying hexagonal crystals to bizarre Dali-like shapes. Some of the more common anomalous shapes are cones, pyramids with rounded bases, flat plates, and starfish shapes.

For the reader's guidance, we add here a table of the major vaieties of hail encountered so far in our literature searches. Entry numbers are in parentheses.

Crystalline hail: cubes, long thin hexagonal prisms, aggregates of hexagonal crystals (X1-X7, X9-X11, X14, X53, X62, X63)
Conical hail: rounded bases common, some with ice-needle structure (X19-X25, X61, X70, X71, X73; see also, GWP3-X1-X3))
Spiked and starfish hail: (X26, X27, X32, X33, X36, X52)
Knobbed spheres: knobs arranged geometrically (X28, X29)
Flat plates, sheets, blocks: (X38-X42, X67)
Large, thin flakes: (X43)
Perforated hail: (X44, X45)
Red-blood-cell-shaped hail: (X46)
Cylindrical hail (X47, X63, X65)
Tubular hail: (X74)
Convex-lens hail: (X48, X58)
Button-shaped hail: (X49)
Ringed-spherical hail; i.e., Saturn-like geometry: (X50, X51)
Hail shells filled with water: (X56)
Hemispherical hail: (X57)
Bullet-shaped hail: (X63)
Nested hexagonal pyramids: (X64)
Hexagonally aggregated spheres: (X68)
Teardrop-shaped hail: (X69)
Six-pointed-star-like flakes with hexagonal holes in centers (X75)
Lenticular hail with circumferences of pyramidal crystals (X8)
Spheres with nested tetrahedral pyramids with rounded bottoms. These may break apart into separate crystals (X12, X13, X15-X17, X20)
Irregular and bizarre hail: cataloged only when similar "geometries" fall in large numbers: (X30, X31, X34, X35, X37, X52, X54, X55, X59, X63, X66, X72)

Background. Hail is usually thought of as water droplets that freeze in the atmosphere as they fall to the ground. A storm's air circulation may carry hailstones repeatedly through regions where additional ice is added layer by layer. Crystalline forms of hail, especially in aggregates like those seen in minerological display cases, are considered anomalous because crystals usually require long periods of time to grow to the sizes reported below. Such conditions are not typical of hailstorms.

Data Evaluation. Most of the anomalous and bizarre forms of hail described here have been carefully observed, often drawn, photographed, and accurately measured. The older science literature is full of such hail anomalies. Today's weather journals pay little attention to them. Rating: 1.

Anomaly Evaluation. Our rather large collection of hailstone anomalies focusses on the following challenges to mainstream theories of hail formation.

(1) Large crystals and aggregates of crystals grow to appreciable sizes in the tumult of a hailstorm. This is unexpected. Rating: 2.

(2) Some hailtones are hollow or have holes in their centers, suggesting that they grew without a nucleus or, perhaps, that the nucleus was somehow lost. Crystals (and raindrops) are thought to require nuclei to grow. Rating: 3.

(3) Some hailstones depart from the sixfold symmetry that dominates water-crystals. A major deviation is seen in the many examples of conical hail. Rating: 2.

(4) Bizarre, freakish hailstones are reproduced almost identically in great numbers in some hailstorms. Whatever their mechanism-of-formation is, it repeats churns out the same bizarre shapes seemingly endlessly. This mechanism must be complex and is hard-to-imagine. Rating: 2.

One cannot dismiss all of the anomalous hailstones as occasional freaks. They descend in storms all over the world----repeatedly. Even so, meteorology generally ignores them as more vagaries of Nature.

Possible Explanations. The multifold properties of water and the rapidly changing environment in a hailstorm present a cornucopia of variables with which to fashion anomalous hailstones. Probably, many of the answers we search for in hail formation are inherent in these variables.

Similar and Related Phenomena. Anomalous snowflakes (GWP3); hydrometeors (GWF1); crystal-growth anomalies (COC in a future volume).

Examples of Anomalous Hailstones

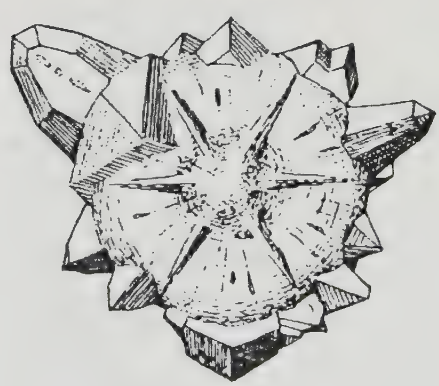
X1. 1769. Paris, France. Crystalline hail falls. (R21)

X2. August 26, 1834. Padua, Italy. Crystals about 1 1/2 inches long in the shape of four-sided prisms, one side of which was very narrow in comparison with the other three sides. Each prism terminated in a four-sided pyramid. (R4)

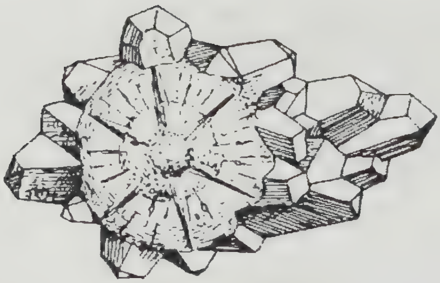
X3. 1819. Southern France. Crystalline hail. (R21)

X4. 1863. Tiflis, Russia. Crystalline hail. (R21)

X5. June 9, 1869. Tiflis, Russia. "...a complete 'shower of ice crystals'---not of fragments of ice of indistinctly crystalline outlines, but of spheroidal crystalloid solids, densely but irregularly set, on the surfaces corresponding to their longitudinal diameter, with limpid regular crystals showing various combinations of forms belonging to the tri- and monoaxial systems---a peculiarity which



Hailstones formed of crystalline me ses (X5)



it seems, has not yet been observed, or at least published. The forms characteristic of calcareous spar and of specular oxide of iron prevailed, especially the scalenohedron, combined with rhombic planes, in crystals 15 to 20 millims. in length. Other crystals exhibit the prism, combined with obtuse rhombohedra, and with the terminal plane perpendicular to the principal axis.... How could indeed the formation of such crystalline aggregations, as regular as those of the calcareous spars of Andreasberg, be possible in the midst of the tumult generally supposed to be necessarily connected with the formation of hail?" (R10, R12, R21, R28)

X6. June 21, 1869. Bely-Klutch, Russia. (R21)

X7. 1876. Italy. (R21)

X8. June 29, 1879. Bale, Russia. Lenticular central mass with pyramidal crystals set around the circumference. (R17, R21)

X9. October 1, 1889. Philadelphia, Pennsylvania. "On some of the stones, though not on the majority of them, well marked crystals of clear transparent ice projected from their outer surfaces for distances ranging from one eighth to a quarter of an inch. These crystals, as well as I could observe from the evanescent nature of the material, were hexagonal prisms with clearly cut terminal facets. They resembled the projecting crystals that form so common a lining in geodic masses, in which they have formed by gradual crystalization from the mother-liquor. They differed, however, of course, in being on the outer surface of the spherules." (R29)

X10. January 26, 1940. Sheffield, England. "...a sudden 'deluge' of sharply edged hard transparent crystals of clear ice. Unaccompanied by any other form of precipitation they fell profusely from a sky generally overcast to form on the ground a thick layer of dry ice grains that were remarkable for the size---some 3-4 mm. in length---to which each had grown as well-developed single hexagonal prisms with basal planes and showing sharply cut crystal faces." (R51)

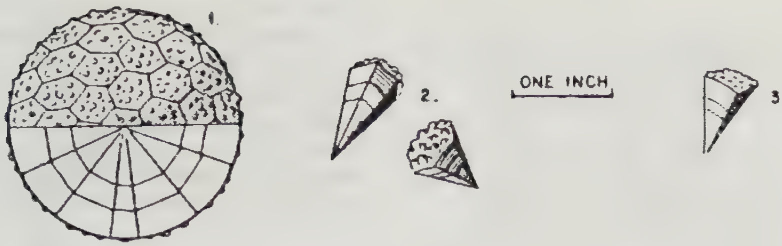
X11. No date given. Clermont, France. Hexagonal prisms terminating in six-sided pyramids. (R5)

X12. July 4, 1819. Baconniere, France. "During ten years, M. Delcross had observed that hail consisted of spherical pyramids or fragments of spheres, which had been broken by some explosion, and the cleavages of which always passed through the centre of the sphere. He frequently looked in vain for the original sphere, but never observed it until the 4th July 1819, during the dreadful hailstorm at Baconniere. Some of the spheres were fifteen inches in circumference." (R2)

X13. June 27, 1823. Aberdeen, Scotland. "The regularity in the shape of the hailstones, and their hard and peculiar consistence, seemed to entitle them to some notice. They were included, almost universally, each by five sides or surfaces, four plane, constituting the sides of an irregular pyramid, and one spherical in place of a base. The length of the longest line did not exceed 1/2 inch in any instance that I observed; but as the hail-stones dissolved very fast, and as they were indeed, for the most part, rounded in the angles before I found them, it is probable they had been larger at first. I however examined them the moment they fell. The spherical surface appeared, to the depth of 1/20 to 1/30th of an inch, to be solid, as it was transparent. The rest of the hailstone was opaque, consisting of crystals or minute columnar forms, perpendicular to the spherical surface." (R3)

X14. August 26, 1834. Padua, Italy. Tetrahedrons. (R4) Same as X2?

X15. March 31, 1876. Leamington, England. "The hail fell from a thick heavy nimbus, coming from the S. E., while the sun in the W. was not obscured. It fell thickly for about 20 minutes, with much noise, both in the air, and from the roofs and trees, and splashed the river considerably on the surface. Everybody ran into shelter, as well they might, considering the size of the stones, which were as big as pebbles, angular, and pointed. They appeared to be shaped like pyramids, with points, and convex bases, studded with tubercules, and had plain sides, either square, pentagonal, or



Tetrahedral hailstones and postulated parent sphere (X15)

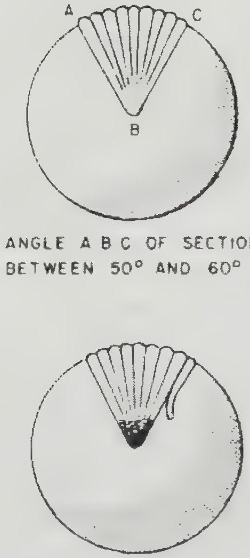
hexagonal. They would have probably belonged to complete spheres, when their sides were adjusted together, and which would have been about 1 1/4 in. in diameter, and these segments were, therefore, about 1/2 in. long. They were of crystalline ice, with concentric bands, and probably the perfect pyramids weighed from 10 to 20 grains, and, as 24 might be estimated to make up a sphere, this, at the least, might have been half an ounce in weight, and at the most about one ounce. As they were tuberculated on the convex bases, the whole sphere would have looked very much like a raspberry, or an oxalate of lime calculus. These spheres of ice must have burst, or become split up into segments somewhere in the fall through the air, as none were actually found perfect on the grass in the gardens." (R15)

X16. November 28, 1888. Edinburgh, Scotland. Pyramids with four flat sides and a convex base. The ice was transparent with numerous liquid-filled cavities. (R26)

X17. October 13, 1919. Chiltern, England. "...a dense mass of hail literally swooped out of the squall cloud. I was out at the time and avoided immediately seeking shelter in order to examine the shape and texture of the hailstones. I found that all those which I caught on the sleeve of my overcoat were white and opaque, and in shape tetrahedral, showing four triangular faces roughly between 1/8 and 1/4 of an inch in length from base to vertex." (R45) Note that these are true tetrahedrons as opposed to the pyramids with rounded bases typified by X15.

X18. June 1958. Fort Collins, Colorado. "In a recent hailstorm on the campus of Colorado State University at Fort Collins, the writer observed a number of hailstones having the shape of a triangular pyramid. The stones were formed from layers of ice of varying opacity in concentric layers about the tip of the pyramid. The measured dimensions of the largest stones are given on the accompanying sketch. (See illustration of X15 for configuration.) The shape of the stone indicated that about 1/4 inch had melted from the tip of the pyramid before measurements were made. The smooth sides of the pyramid indicated that the stone probably was fractured from a sphere that initially was about 3 1/2 inches in diameter." (R57)

X19. April 24, 1887. Marlborough College, England. "On April 24, about 12.30, while walking between Melrose and Kelso, a friend and myself were overtaken by a sudden and very violent hailstorm, accompanied by thunder. The violent burst lasted about two minutes, in which time the ground was completely covered with large hailstones rather more than half an inch long. I say 'long' advisedly, for all the specimens I examined were conical, and were all of them formed the same way. The points had all the appearance of snow, being softer than the main bulk of the 'stones.' These snow portions occupied about one-third of the whole length, being white and non-transparent. The main portions of the hailstones were hard and ice-like, stranded lengthwise with from forty to fifty fibres of ice---each fibre curved separately at the top---and together forming a curved surface, as of a sphere having the snow point for its centre. On melting, the pointed part became translucent, while the other part became more opaque than at first, strands often remaining for a time, partly separated and curving outwards, as though they had been freed from compression in their lower extremities. The above appearances might admit of the hypothesis that these hailstones were fragments of radiated crystalline spheres, but one would expect in that case to find pyramidal rather than conical shapes, or at least to find some shaped so as to complement the cones." (R23)



Conical hailstones made of ice fibers (X19)

X20. June 7, 1902. Cheltenham, England. "At first the hailstones were more or less round and like small crystallised raspberries: but during the latter and main part of the shower they were in the form of wedges or small cones, somewhat varied in shape. Many of these hailstones were about three-quarters of an inch in height and measured about half an inch across. Mr. Swordy suggests that these were only conic sectional parts of what had been much larger hailstones. To test this view he put some selected ice cones in a circle and added two more layers upon the first circle and a key wedge or cone at the top. By this arrangement he obtained half an iceball, consisting of fifteen sections. The hailstones when first formed may therefore have been about the size of 'ping-pong' balls, about an inch and a half or two inches in diameter." (R41)

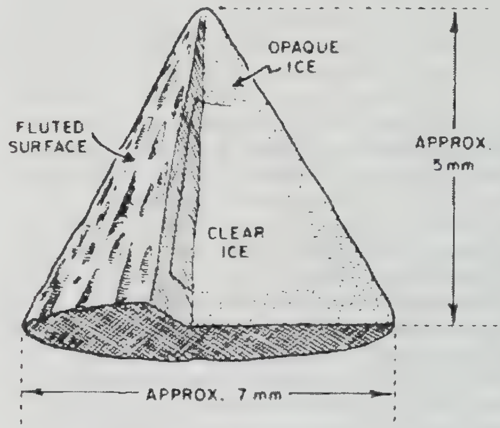
X21. May 1907. Northern Ireland. Conical hail with rounded bases. (R42) The possibility exists that conical hailstones may be pyramids with the edges melted down. (WRC)

X22. May 8, 1910. Epsom, England. Conical hail. (R43)

X23. January 17, 1933. Hastings, England. Cones with round bases about 1/4 inch long. (R50)

X24. February 10, 1945. Uxbridge, England. Conical hail 25-30 mm in height; base, 25 mm in diameter. (R54)

X25. April 3, 1968. England. "Among the hailstones of normal character (i.e. roughly spherical) there occurred a fairly large proportion of stones which had the conical appearance shown in the diagram below. These



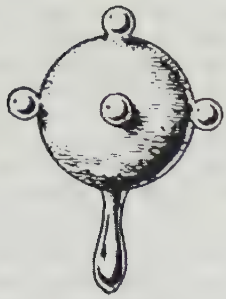
Conical hailstones with fluted sides (X25)

stones had a distinctly fluted outer surface with edges running from base to apex. The stones were soft and easily sliced with a sharp penknife. The central core, shaped like a truncated cone, was of clear ice, the outer layer was opaque. The largest of the stones observed had the dimensions shown in the diagram but the shape was retained down to sizes of 2-3 mm." (R59)

X26. April 11, 1878. Canton, China. Hailstones shaped like starfish. As large as pigeon eggs. (R16)

X27. December 1, 1878. Plains of Troy, Turkey. Roundish hailstones with many sharp projections. (R18)

X28. August 21, 1880. Partenkirschen, Germany. "There had been little or no rain and no visible lightning, and the hailstones fell at intervals and about six feet apart. There were very few of them, my family picking up twenty in a space occupied by a full-sized lawn tennis court. My son made a sketch of their shape and size, which I enclose. The greater part were of the 'tadpole' shape and were clear as glass, perfectly round, the five knobs being at equal distance from one another. The flat stones had more or less a



Hailstones with knob like appendages (X28)

slight nucleus of snow in the convex portion of the stone. My wife and three daughters, and two ladies staying with us, say that the stones looked just like a lady's hand looking glass, with a knob at the top and on either side for ornament. More than twenty, perhaps thirty, were picked up of this shape." (R19)

X29. July 1881. Partenkirchen, Germany. Hailstones like those of X28 again fell in this location, but with a greater variety of odd shapes, including mushroom-like stones. (R20)

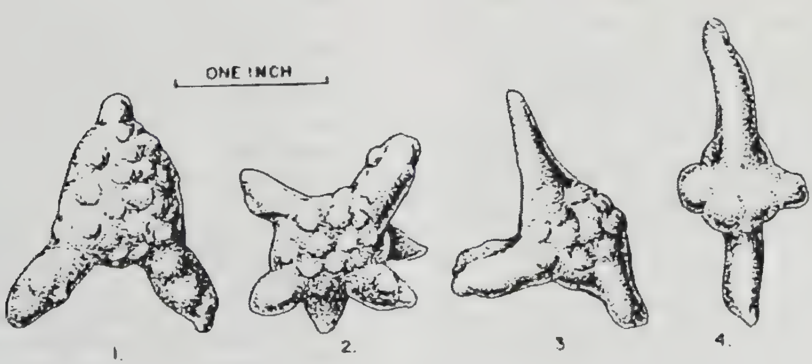
X30. August 22, 1893. Welton-le-Wold, England. A violent hailstorm with large stones bearing irregular projections, as shown in the illustration. (R34)

X31. May 17, 1894. Cleveland, Ohio. Large hailstones, some the size of goose eggs. Shapes varied from spheroidal, to discoidal, to exceedingly irregular. Some of the stones with a knobby or berry-like surface were sectioned and found to be formed about a single nucleus rather then being aggregations of smaller stones. (R31)

X32. February 25, 1900. Harbertsdale, Cape Colony, South Africa. Round hail with spikes, like a hedgehog rolled up in a ball. (R38)

X33. June 21, 1918. King Island, Tasmania, Australia. "The hailstones were like starfish, i. e. with a roughly spherical core and fingers out in all directions, not only on one plane; more like one of those most useful-looking old-time war weapons, spikes protruding from a sphere of iron in all directions mounted on a handle by a short chain! But in the case of the hailstones the spike was much longer, the largest part of the whole. One or two I measured were more than three inches across from point to point, and several were above two inches in two directions; the centre was comparatively small, from 1/2 in. to 3/4 in. in diameter, roughly. They were not heavy, and were clear ice, not opaque as hail usually is, and at the same time each 'stone' appeared to be an agglomeration of ordinary small hailstones." (R44)

X34. July 22, 1925. Plumstead, England. After a hailstorm of great violence. "I went into the garden and collected a few specimens, examined them, and measured the largest. Its length was 3 1/4 inches and in width it was 2 inches. Each hailstone had a central nucleus of white and opaque ice about



Irregular hailstones that fell in England in 1893 (X30) the size of a marble. Round this was a ring of splintery particles embedded in translucent ice. Outside this was a petal-like structure of transparent ice. One side of the stone was concave, the other convex. Some resembled cracknell bisquits in size and curvature." (R46)

X35. June 15, 1929. Urbana, illinois. Grotesquely shaped hailstones that seemed to be agglomerations of smaller stones. One measured 6.5 x 2 x 3.5 cm. (R47)

X36. August 6, 1949. Eldoret, Kenya. "The sky became very dark and large hailstones fell, but in the shape of stars similar to those of snow crystals in shape (when seen under the microscope). They nearly all measured 1 1/2 in. in width. They consisted of large ice balls the size of a very large pea with fine radiating arms of ice. Some of these landed on their sides and stuck sideways on in the grass." (R55)

Iceballs with radiating arms (X36)

X37. August 21, 1963. Indian Ocean. Spherical hailstones with irregular horn-shaped protuberances 1 1/4 inchs long. (R58)

X38. June 15, 1829. Cazorla, Spain. "... hailstones fell in the form of blocks of ice, some of which had a circumference of 20 in. and weighed as much as 4 1/2 lb. Great damage was done, houses being literally crushed beneath the bombardment of ice. (R48) It is the block-like form of the hail that it significant here and in several of the following examples. See GWP5-X4.

X39. January 14, 1860. Indian Ocean. Dur- a squall there was a shower of ice consisting of large, irregular chunks of solid ice---some as large as a brick. (R7, R62)

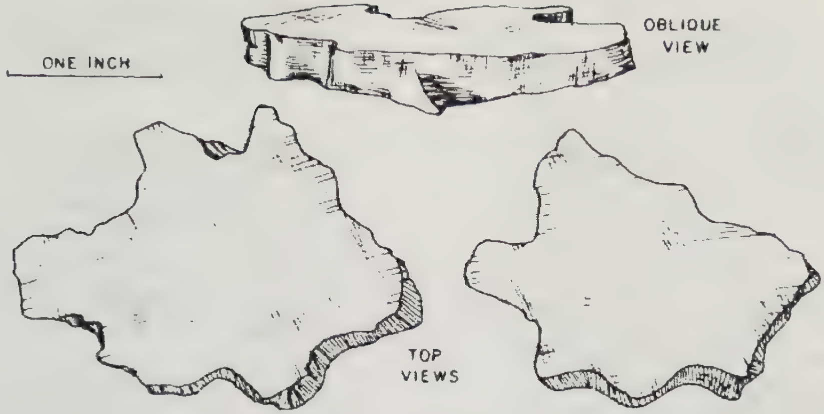
X40. November 15, 1863. South Atlantic Ocean. "At 6.30 p.m. an immense waterspout formed suddenly in the west, about two miles distant, and bore rapidly down upon the ship. She was steered to the south in the hope of clearing it, but it approached within three ships' lengths and discharged pieces of ice upon our decks, about 2 inches square (not in balls, but flat). This was immediately followed by a terrible flash of lightning and sharp rattling thunder, a deluge of rain, and a furious squall." (R35)

X41. June 3, 1894. Eastern Oregon. A tornado was accompanied by unusual hail. "One correspondent states that the formation was more in the nature of sheets of ice than simple hailstones. The sheets of ice averaged 3 to 4 inches square and from three-fourths of an inch to 1 1/2 inches in thickness. They had a smooth surface and in falling gave the impression of a vast field or sheet of ice suspended in the atmosphere and suddenly broken into fragments about the size of the palm of the hand." (R32, R33)

X42. August 10, 1897. Manassas Depot, Virginia. "There was some pretty severe thunder and lightning for a half hour or so, and then came a heavy shower of rain, during which there was the most remarkable fall of hail I have ever witnessed. I hurried out in the rain to examine the stones and picked up several. These were nearly square flattish blocks, say from 3/4 to 1 inch in length and breadth, and from 1/4 to 1/2 an inch in thickness. They suggested, by both shape and size, the ordinary 'chocolate caramels,' of the confectioner." (R36, R37)

X43. July 28, 1979. Hellesdon, England. An unusual fall of large ice flakes measuring 50 x 100 x 3 mm. "Looking out of the front window, we noticed that glistening hail, about the size of large peas to approximately halfpenny round, were falling at about 5 to 7 to the square foot. Then we thought it was 'snowing', so we looked more closely from the open front door and said it must be white rose petals, about two inches by four inches and about an eighth of an inch thick... and about one per square yard. Then they increased in number to about one per square foot, and one landed on the doorstep, and they reached about a palm in size, i.e. four inches round. This size lasted just over a timed minute; then they slowly drifted back to one per square yard, and after a full five minutes or slightly longer there were none." (R61)

X44. 1806. Morris County, New Jersey. "The hail stones were generally about one fourth or three eighths of an inch thick and of sufficient dimension in length and breadth



Flattish blocks of hail (X42)

to hide a shilling, and in many cases a cent, and almost every one perforated in the middle as if they had been held between the fingers, till the fingers by their warmth had melted away the middle and had met. When the perforation was not complete, there was in every case an inclination to perforation." (R1)

X45. June 14, 1880. Russia. Hailstones pierced with hole from side to side. (R21)

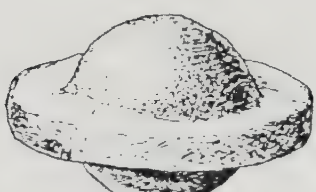
X46. July 12, 1902. Canada. "Many of the pellets, both small and large, were almost perfect spheres, but not infrequently the large ones took the form of disks, thin and transparent in the middle, with thicker edges of snow, reminding one of the shape of the red blood corpuscles or the fly-wheel of a sewing machine. One large pellet of this kind measured 1.75 inches in diameter and the circular rim was one inch thick, the middle portion of the disk being transparent." (R40)

X47. August 8, 1901. On the St. Lawrence River. Cylindrical hail, like pieces of round lead pencils, 3/8 inch long.(R39)

X48. May 29, 1944. London, England. Hail was initially spherical but changed to double convex lenses. "The climax was, however, reached by the sudden appearance of a slab of ice which luckily fell a few yards from where I was standing. This formed one half of a cylindrical mass slpit along its diameter, which measured 1 3/4 in. Its thickness lay between 1/4 and 3/8 in. The central core, of diameter 5/8 in. was of clear transparent ice, the outer annulus being of the opaque variety." (R53)

X49. September 12, 1930. Cyprus. Button-like hailstones the size of an English penny. (R49)

X50. June 25, 1888. Guildford, England. Spherical hail with raised rims, looking like the planet Saturn. (R27)



X51. May 29, 1859. Beeston, England. "The principal forms were round, acid-drop shaped, and a small circular stone attached to a larger one, the general proportional size being as 3 to 1. There were, however, very many closely resembling an appearance of Saturn with his ring, and another prevalent form very like a frying pan with a short handle. Among the more remarkable shapes, one represented a section of an orange; another a close representation of a leg of mutton; another a comma; another a sheet of glass; while others were too grotesque for any pictorial description." (R6)

X52. June 20, 1870. Northampton, Massachusetts. A variety of hailstone shapes, including starfish types, symmetrical ovoids with rough crowns, and one with spiral layers of white and clear ice alternating. (R11,R13)

X53. No date or place. Hail in the shape of exact cubes 7 mm in size. (R22)

X54. May 20, 1887. Penmaenmawr, Great Britain. Pear-shaped hailstones. (R24)

X55. April 8, 1890. Hampstead Heath, England. "A remarkable shower of soft hail occurred here shortly before 1 p. m. on Tuesday last (April 8th). The masses of hail (they were neither 'stones' nor 'balls') were of irregular shape, in some cases half an inch in diameter, and appeared to be made up of small plates of ice adhering like the petals of a double marigold. The last form, on melting, was an irregular disc of ice. A noticeable point was the facility with which the masses adhered on being brought into contact, so that merely by putting them together on a sheet of paper you could get a layer three inches or more in diameter." (R30)

X56. June 28, 1942. Silver Lake, New Hampshire. "...some of the hail consisted of only a hollow shell 1/16 to 1/8 in. thick, but 3/4 in. across and 1/4 in. thick, evidently a hailstone which was still partly liquid when it struck, but which had cracked open and let the water out. I found one stone that had the unfrozen water still in it, for the bubbles moved about as it was tilted. As the hail melted some of the stones became complete rings of ice. The outer edge of the hail had frozen more than the inner portions, presumably because of the greater flow of air." (R52)

X57. February 8, 1954. Persian Gulf. "The stones fell with sufficient force that the brass binnacle cover of the standard compass was badly dented. The stones averaged about 1 1/2 in. diameter, and it was observed that many were perfectly hemispherical in shape, as though split in half, and showing ringed layers of ice on the flat surface." (R56)

X58. May 2, 1887. Kingston, Jamaica. "The hailstones were of clear ice, inclosing a few bubbles of air, varying from mere points to bubbles of the size of a split pea. The shape of the stones was singular. Suppose a shallow and very thick saucer to have a shallow cup, without a handle, inserted in it, and you will have a good idea of the form of the hailstones when unbroken. Many had more or less lost the 'saucer' by violence, while some were entirely without it, presenting the appearance of a double convex lens with faces of different curvature." (R25)

Saucer and lens-shaped hailstones (X58)

X59. May 7, 1862. Headingley, England. A hailstorm of great violence and remarkable for the wide variety of hailstone shapes. Two of the more startling forms are illustrated here. (R8, R9)

Irregular hail, England. 1862 Many examples of each type fell (X59)

X60. General observation. The mechanism for the formation of conical hail or graupel is not well understood, the theories offered having defects. A new theory is presented. (R60)

X61. June 3, 1873. Nottingham, England. Conical hail the size of peas. (R14)

X62. July 2, 1873. Germany. During a journey up the Rhine. "Heavy hailstorms closed just before reaching Strasburg Station, where the paths appeared strewn with cubes of ice like lump-sugar, which I got out and sampled, perfect 'squares.'" (R63)

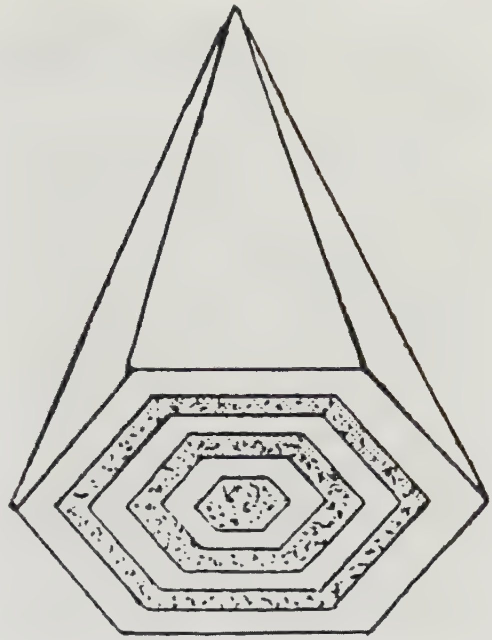
X63. July 16, 1918. Surrey, England. "The lumps were not aggregated separate stones. Knobs nearly an inch long were often a bare quarter inch across at the base. Several had three such round their equator at even distances, with numerous shorter ones all over. In many cases there must have been fifteen to twenty knobs in all, or even more. Further, even the largest lumps had but one nucleus of opaque ice." (R64)

X63. 1961. Byrd Station, Antarctica. Several very long, very thin, straight hexagonal prisms were photographed under a microscope. Length-to-width ratios were greater than 50. One photo shows one of these crystals to be about 1.2 centimeters long. (R63) These and other minute crystals shown in the microphotographs could also be classified in GWP3 under "diamond dust."

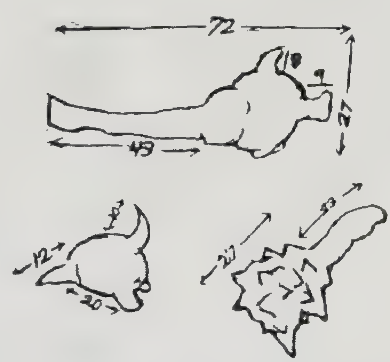
X64. May 20, 1958. Leningrad, U.S.S.R. A 3-minute hailstorm: "...the hailstones were very unusual. They were about 7-10 mm in size, and each hailstone was in the form of a hexagonal pyramid which consisted of six pyramids (one inside the other). Three pyramids were of transparent ice, the other three of milk-white ice." (See sketch.) (R66)

X65. July 1, 1982. Nottingham, United Kingdom. A powerful thunderstorm dumped 1.23 inches of rain in 25 minutes. The rain was accompanied by hail that generally measured 3/4-inch across, but a minority of the hailstones were cigarette-shaped and about 2 inches long. (R67)

X66. October 16, 1993. Tulsa, Oklahoma. From a letter from K.L. Partain. "Funnel-like phenomena were reported by local weathercasters, one of which approached within one mile of the witness [K.L.P.] before it lost its vorticity.



A hexagonal-pyramidal hailstone with nested ice layers. (See also X15) (X64)



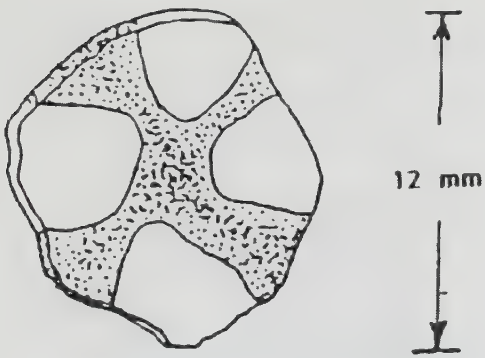
Weirdly shaped hailstones as sketched by K.L. Partain. Many copies of each improbable species were observed. (X66)

This was between 5:00-5:15 P.M. and parenthesized the interval of anomalous hail. In the target interval, numerous hail peppered the area described above. Partain observed shapes which did not conform to spherical and collected several specimens, which he immediately froze. (R68) (See accompanying figure for some shapes and dimensions.)

Often such grotesque hailstones are closely duplicated in immense quantities ---a meteorological factory of the absurd ---and we do not know how this production line operates!

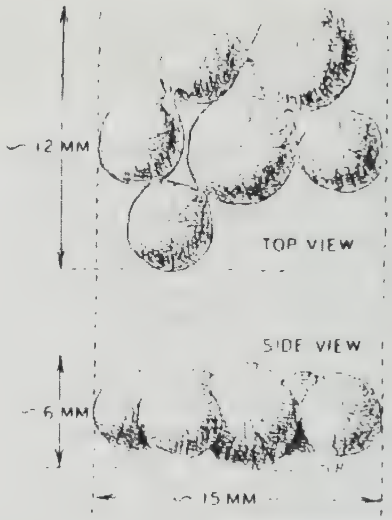
X67. May 17, 1993. Berkshire, United Kingdom. "As the cold front passed over Woodlands St. Mary, West Berkshire (183 meters above sea-level), at 1555 GMT, there commenced a 3-minute duration fall of unusual, flat-plate hailstones, measuring some 12-mm wide by 2-mm thick. These plates were smooth and glassy in appearance (indicating conditions of 'wet' growth) but not perfectly round, taking on an eccentric, wheel-like structure; with a 'hub' and four-spoke formation of transparent ice, having opaque areas in between. (R69)

It is most unusual to find water-based precipitation with four-fold symmetry. It is also difficult to imagine a meteorological process that could create millions of these anomalous hailstones.



A flat-plate hailstone with four icy spokes. A deviation from six-fold symmetry. (X67)

X68. December 24, 1994. North Yorkshire, United Kingdom. The following description comes from the British journal: Weather. "The hailstones were roughly spherical in shape, with a diameter of 4 to 8 mm, and translucent, with a faint, crystalline structure radiating from their centres. There were also some agglomerates of two or three



A flat, quasi-hexagonal aggregation of several spherical hailstones. (X68)

stones and, unusually, a few contained four to as many as eight stones in an irregular but planar arrangement, with the larger ones tending towards a hexagonal conformation and dimensions of approximately 15 x 12 x 6 mm." (R70)

That snowflakes may agglomerate in large pancake-like aggregations has often been observed (GWP2), but this is the first time we have heard of hailstones being welded together in flat, hexagonal configurations. What draws the separate hailstones together into the same quasi-hexagonal geometry displayed by snowflakes?

X69. Mid 1966. Ecclesfield, United Kingdom. (See "amazing" illustration on p. 85.) "This huge tear-drop of ice, weighing four pounds, fell out of the sky and landed on a grass verge near stunned commuters at a bus stop in Ecclesfield, near Sheffield." (R71)

Based on its weight, this "drop" of ice is about 5 inches across. One wonders where in the sky such a large drop of water could form and remain aloft long enough to freeze solid. The hackneyed explanation that such ice falls come from leaky aircraft lavatories seems unlikely here! (GWF1)

Unfortunately, one has to consider the possibility of a hoax here!

X70. March 8, 1997. Buckinghamshire, United Kingdom. "An unusually intense fall of hail occurred in the Milton Keynes area of Buckinghamshire during a sudden early afternoon thunderstorm. The hailstones were at least 18-mm across; the largest probably measured just over 20 mm immediately after the fall. Some of the hail which covered the ground was of the 'soft' spring variety; however some hard conical stones accompanied the fall which disrupted road traffic in 3 Mile Ash. Some leaves and berries were stripped off trees. Conical hail 10-mm in diameter was also reported from Chalgrove (Oxon)." (R72)

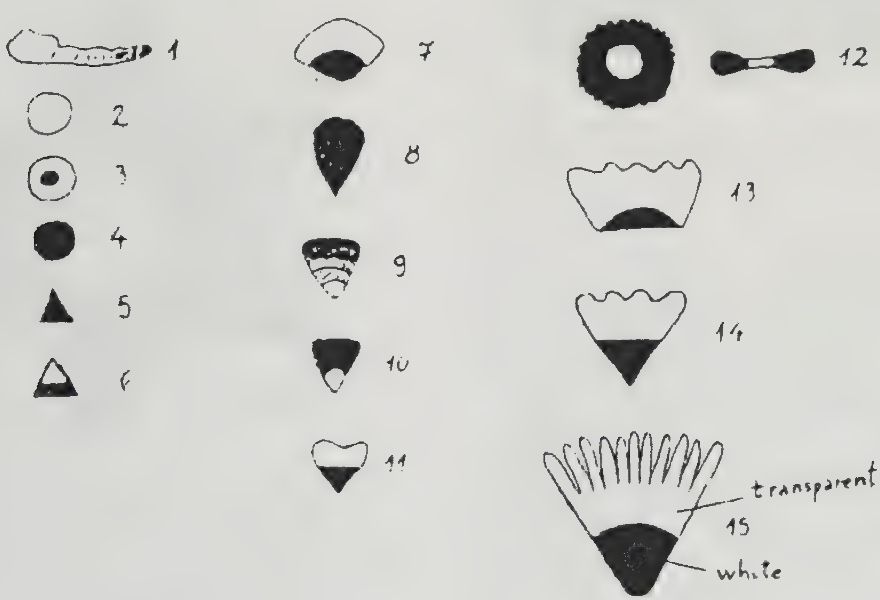
X71. July 31, 1999. Charleston, WV. We quote from a letter from J.B. Dotson. "...on July 31st at 4 A.M. (EDT) we had an early morning thunderstorm that produced conical-shaped hail---about the size and shape of the 'caramel corn' candy sold around Halloween; or slightly larger and less flattened than the actual corn kernel." (R73)

X72. June 29, 1984. Padis Plateau, Romania. This plateau is located in the Transylvanian Western Carpathians. The weather was pleasantly warm even though the ground was still covered with snow. A. Kosa-Kiss described the approach of a thunderstorm.

"A weak shower of rain followed, and then loose-structured 20-mm-diameter discs of ice. Soon afterwards what was to be 30 minutes of 'sky fire' set in. Stone-like pieces of ice streamed to the ground, very heavily and violently. Some of the hailstones were the size of a nut or plum. Within minutes a white carpet covered the plateau of Padis at an altitude of 1200 metres (3900 feet), and the air grew very cool." (R74)

Some of the hail was very oddly shaped. See Kosa-Kiss' appended sketches to appreciate the variety of hailstones that fell in this storm..

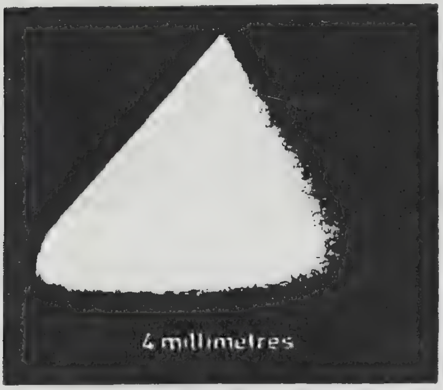
X73. No date. Wales, United Kingdom. A. Mills described in New Scientist a fusillade of hailstones shaped like the



Hailstones sketched by Kola-Kiss. Note especially: the pyramids, 5, 6, 9-11; circular hailstones with holes; and those shaped like badminton shuttlecocks. (X72) popular candy called Hershey kisses.

"During a recent hailstorm in Wales, I was surprised to see that all the hailstones were conical. Each one had an apex angle of about 75°, with a flat or slightly curved base about 4 millimeters across. What caused this? Is this shape common, and is its similarity to an Apollo re-entry capsule coincidental?" (R75)

How conical hail (and conical snow) form rather frequently and in prodigious quantities and in surprising geometric perfection. How this happens in the maelstroms of violent storms is unknown.



A neatly scultped conical hailstone (like piece of Hershey kiss candy!) (X73)

X74. June 26, 2001. South Darenth, United Kingdom. A very rare form of hail was reported in Weather by N. Baker. "At about midnight a very violent wind came, gusting to about 20 m s^{-1}. There was more lightning. Then I heard the clatter of hail against my window. I looked out at the patio. The hailstones were up to 2 cm in diameter, but there were also chunks of ice 1 cm x 4 cm, which must have been fragments of larger stones. Some of the fragments seemed to be hollow tubes." (R76)

Some ice machines make tubular ice shells but how does Nature do it?

X75. February 25/26, 2004. West Sussex, United Kingdom. We have here a real challenge to those who would explain the formation of hailstones. S. Dunlop relates his experience as follows:

"During the night of 25/26 February 2004, there was a moderate frost and a slight fall of ice crystals. (A nearby station recorded air and grass minima of -3.5 and -7°C respectively.) Some of these crystals, which had fallen onto the ice of frozen puddles, were observed to have an unusual structure. They took the form of perfect, six-pointed stars about 5-6 mm across and about 1 mm thick. The striking feature was that they had tiny central hexagonal holes about 1.5 mm across." (R77)

S. Dunlop, the observer of the star-shaped crystals with holes, reminds us that R. Greenler, in his Rainbows, Halos, and Glories, pictures an ice crystal hexagonal in outline with a star-shaped central hole---the reverse of what Dunlop had seen.

Significantly, Dunlop asks how the described ice crystals can grow outwards in hexagonal geometry when they have holes at their centers! Are not central nuclei required to start crystal growth? (R77)

A star-shaped ice flake with hexagonal hole (X75)

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GWP5 Giant Hailstones

Description. Hailstones weighing more than 1 pound and/or exceeding 4 inches in diameter, these being the approximate limits set by meteorological theories of hail formation. Giant hailstones fall along with smaller hailstones during storms and thus differ from the ice falls and hydrometeors (GWF1), which are usually solitary phenomena and often occur in the absence of storms.

Background. Reports of hailstones the size of marbles, hens' eggs, etc. are numerous. Hail of these dimensions pose no problems in explanation, at least in the matter of size.

Data Evaluation. Several believable reports of hailstones larger than 4 inches and weighing more than a pound have been found in the literature. Such reports are few in number, and in no instance do the dimensions greatly exceed the meteorologists' upper limits for hail. As in the case of hydrometeors, however, one finds reports of colossal hailstones, which, like fish stories, must be discounted according to age and locale. Rating for hailstones modestly larger than 4 inches and/or 1 pound: 1.

Anomaly Evaluation. Since the high-quality reports of giant hailstones claim dimensions not significantly greater than theoretical considerations permit, it seems that slight modifications of theory can explain most believable observations. Rating: 3.

Similar and Related Phenomena. Ice falls and hydrometeors (GWF1); hailstones with anomalous shapes (GWP4), some of which approach the acceptable dimensional limits.

Examples of Giant Hailstones

X1. March 1295. Yemen. A great hailstorm that killed many animals. One hailstone, which partly buried itself in the ground, was supposedly so large that men could not see over it. This account was reprinted from the Annals of the Resuli Dynasty of Yemen. (R4) Obviously such a story must be placed in the same class as the Indian hydrometeor that was as big as an elephant. (GWF1-X1)

X2. August 31, 1820. London to the English south coast. Pieces of solid ice 6 x 18 inches fell during a hailstorm. (R6)

X3. April 10, 1822. Bangalore, India. Angular and oval hailstones, as large as pumpkins. Many cattle killed. (R7, R18)

X4. June 15, 1829. Cazorla, Spain. Houses literally crushed under blocks of ice weighing up to 4 1/2 pounds. (R8, R10, R11) See GWP4-X38.

X5. August 13, 1851. New Hampshire. Masses of ice fell weighing 1 1/2 pounds. (R15)

X6. May 22, 1851. Bangalore, India. More hailstones the size of pumpkins! (R15)

X7. March 28, 1867. Adoni, India. "In Adoni to the north of the talook, at Nukkulmittah and other villages, the hail is described as being of the size of cocoa nuts to woodapples, and lying to one foot in depth; in some places destroying the wet and dry crops. In Gooty, at eight p.m. on the 28th, the hail was described as ranging from the size of bullets to limes; some sheep were killed and crops destroyed. . . . .In Anantapur talook the size of the hailstones is apparently incredible. I give, however, the local report, that in a field of the village of Bondalavada some of the stones were two-thirds of a cubic yard in size. In the village of Chadula a cubic span, and in other villages of six seers, or three pounds in weight; this last was verified by the Tahsildar. Two men, 2,470 sheep, and eight cattle were killed, and some thatched houses were destroyed." (R1)

X8. Autumn 1875. Potter, Nebraska. On a Union Pacific train. "The hailstones were simply great chunks of ice, many of them three and four inches in diameter, and of all shapes---squares, cones, cubes, etc. The first stone that struck the train broke a window, and the flying glass severely injured a lady on the face, making a deep cut. Five minutes afterward there was not a whole light of glass on the south side of the train, the whole length of it. The windows in the Pullman cars were of French plate, three eighths of an inch thick, and double. The hail broke both thicknesses, and tore the curtains to shreds." (R2, R16) The same area was visited by another phenomenal hailstorm in 1928. See below. (X17)

X9. May 3, 1877. Texas. Pieces of ice as large as a man's hand killed thousands of sheep. (R15)

X10. June 1881. Iowa. During a hailstorm a mass of ice 21 inches in circumference fell. (R15)

X11. July 12, 1883. Lake Michigan. Ships on the lake northeast of Chicago reported hail the size of goose eggs. One piece, the size of a brick, weighed 2 pounds. (R3)

X12. July 16, 1883. Urbana, Illinois. Many hailstones measuring 12 inches in circumference. (R3)

X13. May 1888. India. Hailstones weighing 1 1/2 pounds. (R15)

X14. December 6, 1892. Gray Hill, Texas. "This remarkable hail fell in large lumps, ranging from three to six inches in diameter. I heard of one piece eight inches in diameter, which weighed four pounds. They were, as a rule, spherical in form, but some were somewhat flat, and nearly all were covered with oval knobs. They fell in small areas, about two feet apart, while in other places only one would fall in a space twenty feet square. The average under my observation was about one hailstone to every three feet square. A most remarkable fact in connection with these large hailstones is that some of them have particles of dirt in the center." (R5)

X15. Summer 1902. Yuwu, China. An English missionary reported a hailstone of ten pounds weight. (R8, R11)

X16. August 10, 1925. Heidgraben, Germany. A 4 1/2 pound hailstone, 10 inches long, fell through a house roof. (R8)

X17. July 6, 1928. Potter, Nebraska. One hailstone weighed 1 1/2 pounds and was 17 inches in circumference. Fragments of another, when pieced together, made a stone as large as a man's head. (R9, R16)

X18. January 24, 1957. Northwood, England. A hailstone 4 x 5½ inches, weighing 13½ ounces fell during a shower of hail. (R17)

X19. April 7, 1961. Persian Gulf, Hailstones estimated to be at least 5 inches in diameter. (R13)

X20. April 20, 1962. Persian Gulf. Hailstones 4 inches in diameter fell on the decks of the s. s. City of Durban. (R14)

X21. General observation. Based upon aerodynamic considerations, the upper limit on the size of spherical hailstones is 1 1/2 pounds. (R12)

X22. August 1931. Chikiang Province, China. A New York Times item. "Hailstones that weighed fifteen pounds and completely demolished the houses of many poor people and badly damaged most of the government buildings are reported from Fuyang, in Chikiang Province. The storm began with a terrifying display of lightning and thunder, followed by heavy rainfall, which soon turned to hail." (R20)

Many such reports of large hail emanate in news items from China. They must be viewed with great caution.

X23. 1843. Mongolia. An excerpt from a travellers' book from the early 1800s by two Lazarist missionaries."Hail is of frequent occurrence in these unhappy districts, and the dimensions of the hailstones are generally enormous. We have ourselves seen some that weighed twelve pounds. One moment sometimes suffices to exterminate whole flocks. In 1843, during one of these storms, there was heard in the air a sound as of rushing wind, and therewith fell, in a field near a house, a mass of ice larger than an ordinary millstone. It was broken to pieces with hatchets, yet, though the sun burned fiercely. three days elapsed before these pieces entirely malted." (R21)

This report could well have been added to GWF1 as a hydrometeor!

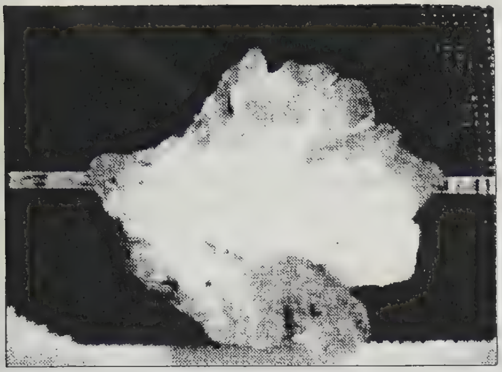
X24. March 1998. Central Louisiana. "Chunks of hail up to 7 inches across slammed onto this Central Louisiana community before dawn Saturday, breaking windows and battering cars.

"Some of the chunks looked like shrapnel from an exploded mountain of ice; others looked like balls of smaller hailstones fused together." (R22)

Note that most giant hailstones turn out to be aggregates with many smaller hailstones.

X25. September 3, 1970. Coffeyville, KS. A hailstone with a diameter of 5.7 inches; circumference, 17.5 inches. An early U.S. record holder. (R23, R24)

X26. June 22, 2003. Aurora, NE. The currently [2006] "officially" recognized largest U.S. hailstone fell on this date. Diameter: 7 inches; circumference, 18.75 inches. (R23, R24)



Photograph of the currently [2006] largest recognized U.S. hailstone. It is 7 inches in diameter. Like most very large hailstones, it is an aggregate of many smaller hailstones, some of which possess crystalline geometry. (X26, NOAA photo)

References

R1. "Severe Hailstorm in India," Symons's Monthly Meteorological Magazine, 2:53, 1867. (X7)

R2. "Remarkable Shower of Ice," Scientific American, 33:217, 1875. (X8)

R3. "Hail," Monthly Weather Review, 11: 158, 1883. (X11, X12)

R4. "Remarkable Hailstorm," Royal Meteorological Society, Quarterly Journal, 10: 303, 1884. (X1)

R5. "Dangerous Hailstones," Scientific American, 68:58, 1893. (X14)

R6. Pratt, F.; "Giant Hailstones," English Mechanic, 84:18, 1906. (X2)

R7. Pratt, F.; "Monster Hailstones," English Mechanic, 84:164, 1906. (X3)

R8. Talman, C. Fitzhugh; "The Biggest Hailstones," American Meteorological Society, Bulletin, 9:131, 1928. (X4, X15, X16)

R9. "The Biggest Hailstones?" American Meteorological Society, Bulletin, 9:184, 1928. (X17)

R10. "Hailstorm," Nature, 125:913, 1930. (X4)

R11. Talman, Charles Fitzhugh; "The Biggest Hailstones," Nature Magazine, 18: 89, 1931. (X4, X15)

R12. Bilham, E. G.; "The Dynamics of Large Hailstones," Royal Meteorological Society, Quarterly Journal, 63:149, 1937. (X21)

R13. Calvert, D.; "Hailstorm," Marine Observer, 32:112, 1962. (X19)

R14. O'Neill, F. C.; "Giant Hailstones," Marine Observer, 33:63, 1963. (X20)

R15. Willis, Ronald J.; "Ice Falls," INFO Journal, 1:12, Spring 1968. (X5, X6, X9, X10, X13)

R16. "Extraordinary Hailstorm in Nebraska," Weatherwise, 29:139, 1976. (X8, X17)

R17. "Another Authentic Superhailstone," Journal of Meteorology, U.K., 3:20, 1978. (X18)

R18. Buist, G.; "A Catalogue of the Most Remarkable Hailstorms Which Have Occurred in India betwixt 1822 and 1850," Bombay Geographical Society, Transactions, 9:184, 1850. (X3)

R19. Anonymous; "Remarkable Shower of Ice," Science Record, p. 535, 1876. (X8)

R20. Anonymous; "15-Pound Hailstones Damage Crops, Kill Animals in China," New York Times, September 27, 1931. Cr. M. Piechota. (X22)

R21. Anonymous; "Remarkable Observations, to Say the Least," Royal Astronomical Society of Canada, Journal, 35:178, 1941. (X23)

R22. Anonymous; "7-Inch Hail Hits Central Louisiana Town," Houston Chronicle, March 8, 1998. Cr. D. Phelps. (X24)

R23. Doe, Robert K.; "Largest Hailstone in US History Found," Journal of Meteorology (U.K.), 28:271, 2003. (X25, X26)

R24. Muirhead, Richard; "Some Worldwide Records of Giant Hailstones," Journal of Meteorology (U.K.), 28:395, 2003. (X8, X18, X25, X26)

R25. Burt, Christopher C.; Extreme Weather, New York, 2004, pp. 159-162. (X25-X27)

GWP6 Hail Strew Patterns

Description. The fall of hail in long, parallel strips or geometrical arrays of patches.

Background. After severe hailstorms, farmers surveying their fields often find long strips where the damage is almost total. These linear patterns are called "hailstripes." Hailstreaks are larger-scale patterns of damage, while hailswaths are larger still, being the result of overlapping hailstreaks. A more general term is "hail strewn" or "hail strew" pattern.

Data Evaluation. Hailstripes are rarely mentioned in the meteorological literature. Yet, recent aerial surveys and closely spaced arrays of hail-monitoring instruments leave no doubt as to their existence. Rating: 1.

Anomaly Evaulation. Hailstripes are thought to originate in long, linear storms features termed "hailstrands." The genesis and precise nature of these hailstrands are unknown, although it seems reasonable that such fine structures of hailstorms will ultimately be encompassed by current meteorological theory. In other words, hailstripes are poorly understood details of hailstorms rather than strong anomalies. Rating: 3.

Possible Explanations. Linear hailstorm structures of obscure origin.

Similar and Related Phenomena. Point rainfall (GWP12); whirlwind and tornado tracks.

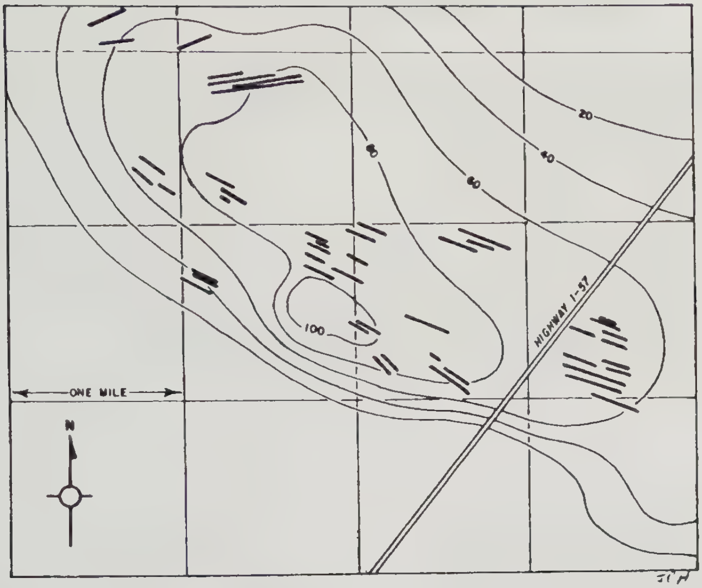
Examples of Hail Strew Patterns

X1. June 9, 1856. Guilford County, North Carolina. A hailstorm of unusual violence. "The hail fell in lines, a field here and a garden there being destroyed, while intermediate ones were left uninjured. The hail had a strong flavor of turpentine. This is the testimony of persons testing it at different and distant localities." (R1)

X2. July 3, 1863. Clermont-Ferrand, France. About 6 P.M. a cloud approached rapidly from the west, at a height estimated as 5000 feet. It resembled a huge net in form, the portion represented by the netting showed violent agitation, and soon after the arrival of the cloud there was a heavy hailstorm lasting about five minutes, the hailstones being as large as nuts. During the fall of the hail there was no wind. The hail caused considerable damage whereever it fell, and M. Lecoq, who saw the storm and described it in the Comptes Rendus, stated that the damage was limited to small patches, which were surrounded by undamaged zones, forming a network the meshes of which were irregular but roughly 60-100 metres apart. The distribution of the hail corresponded with the form of the cloud." (R2, R3)

X3. General observations. Quoting from the Abstract: "A hailstreak is an area of continuous hail with temporal coherence and is considered an entity of hail generated within a thunderstorm. The average hailstreak represents a fast-moving, short-lived, and relatively small phenomenon. Eighty five per cent of all hailstreaks had areas < 16 mi^2 and hail impact energy values < 0.1 ft-lb ft^{-2}, but areal extremes were 0.9-788 mi^2 and energy extremes sampled were 0.0001-12.6 ft-lb ft^{-2}. A hail-producing system in a 1600 mi^2 area normally produced five hailstreaks with an average separation distance of 15 mi. Cold fronts and unstable air mass conditions led in the production of hail systems and hailstreaks, respectively. Hailstreaks produced by different synoptic weather conditions differed considerably. Point durations of hailstreaks averaged 3 min, 43% occurring in the 1500-1900 CDT period. Eighty-five per cent of all hailstones had diameters $\leq 1/4$ inch and only 1% were ≥ 1 inch. A 1-ft^2 area in a hailstreak normally experienced 24 hailstones. Hailstreaks occurred in all locations and stages of age of their associated rain cells, but their preferred location was along the major axis and in the mature stage. Normally, a rain cell produced only one hailstreak, although 20% produced four or more." (R4)

X4. General observations. Hailstripes are microscale hail phenomena that occur on a smaller scale than hailstreaks. "Abstract. Aerial photographs of crop-hail damage areas have revealed a smaller-scale feature of damage patterns than has previously been reported. These features, called 'hail stripes', are long, narrow (15-30 m width) stripes of alternating light and heavy damage. These are believed to be caused by a combination of strong wind and 'hailstrands', long



Strips heavily damaged by hail in Illinois fields (X4)

string-like substructures of the hailshaft." (R5)

X5. No date given. France. "The space ravaged by hailstorms, often indicates the presence of aerial currents, the devastations being frequently confined to a long and narrow strip of country. Sometimes the storm proceeds in two parallel tracks, leaving the intervening region entirely uninjured. Thus a hailstorm once commenced in the south of France in the morning, and in a few hours reached Holland. The places desolated formed two parallel paths from S. W. to N. E.; the length of one was 435 miles; and that of the other 497 miles. The average width of the eastern track was five miles, and that of the western ten; and upon the space comprised between them, which was twelve miles and a half in breadth, no hail fell, but only a heavy rain." (R6)

X6. July 16, 1918. Surrey, England. "Greenhouses were riddled, window panes smashed, trees stripped; vegetables of all kinds destroyed. The stones were like walnuts in size, many 1 1/2 inches across. Cereal crops were beaten down, the straw broken in three or more pieces, the green grain beaten out of the ears. The storm passed from south-west to north-east, the damage being confined to a strip of 800 yards, inside which 'everything growing has been destroyed, whereas the adjoining land remains unscathed.'" (R7)

References

R1. "Hailstorm in Guilford County, N. C.," American Journal of Science, 2:22:298, 1856. (X1)

R2. "Hailstorm at Clermont-Ferrand," Nature, 125:994, 1930. (X2)

R3. Brunt, D.; "Remarkable Hailstorm," Meteorological Magazine, 63:14, 1928. (X2)

R4. Changnon, Stanley A., Jr.; "Hailstreaks," Journal of the Atmospheric Sciences, 27:109, 1970. (X3)

R5. Towery, Neil G., and Morgan, Griffith M., Jr.; "Hailstripes," American Meteorological Society, Bulletin, 58:588, 1977. (X4)

R6. Brocklesby, John; Elements of Meteorology, New York, 1855, p. 128. (X5) (Cr. L. Gearhart)

R7. Clark, J. Edmund; "The Surrey Hailstorm of July 16, 1918," Royal Meteorology Society, Quarterly Journal, 46:271, 1920. (X6)

GWP7 Slowly Falling Hail

Description. Hailstones that seem to float gently to the ground. The terminal velocities of some hailstones have been measured as several times less than one would predict from air resistance and hailstone diameter. All examples of slowly falling hail involve large stones; i.e., an inch or more in average diameter.

Data Evaluation. Several qualitative observations plus one estimate of terminal velocity by a trained weather observer. Rating: 2.

Anomaly Evaluation. Slowly falling hail can be explained by appealing to low-altitude updrafts. This phenomenon is therefore primarily a curiosity, although the genesis of low-altitude vertical winds is not well-understood. Rating: 3.

Possible Explanation. Low-altitude updrafts slow the falling hailstones.

Similar and Related Phenomena. None.

Examples of Slowly Falling Hail

X1. May 29, 1859. Beeston, England. Grotesquely shaped hailstones more than an inch in diameter fell very gently. (R1)

X2. June 27, 1866. Cricklewood, England. A puzzling aspect of this violent hailstorm was the gentle fall of the larger stones. The big hailstones did less damage than the smaller ones. (R2)

X3. Circa 1908. Remiremont, France. The velocities of the hailstones were so slight that they seemed to fall from heights of just a few yards. (R3)

X4. April 24, 1930. Bagdad, Iraq. "The most remarkable features of the hailstorm were the large size and slow terminal velocity of the hailstones and the absence of dust in their composition.....The total diameter (of an average stone) was one and five eighths inch, and in calm air the terminal velocity of hailstones of this size would be nearly 30 miles per hour. The descent of several specimens was actually timed against the wall of a building, and it was found that they fell 40 feet in about three seconds, giving a velocity of only 9 miles per hour. The observer is to be congratulated on his enterprise in obtaining this measurement, which appears to indicate an upward current of air of at least 30 m.p.h. at a comparatively low elevation." (R4)

References

R1. "Extraordinary Hailstorm," Annual Register, 101:70, 1859. (X1)

R2. "The Storms of June 27th, 1866," Symons's Monthly Meteorological Magazine, 1:43, 1866. (X2)

R3. "More about the Hailstones of Remiremont," English Mechanic, 87:436, 1908. (X3)

R4. "Remarkable Hailstorm in Iraq," Meteorological Magazine, 65:143, 1930. (X4)

GWP8 Unusual Inclusions in Hail

Description. Anomalous substances found in hailstones. Inclusions of dirt and sand are so common and so easily accounted for by appealing to windblown dust and sandstorms that they are not treated in this catalog. Somewhat more curious are inclusions of salt, iron sulfide, radioactivity, and small insects. Ice-encased birds, turtles, etc. must definitely be considered anomalous.

Data Evaluation. Excluding inclusions of terrestrial dust and sand, reports of other sorts of inclusions are generally one-of-a-kind. Age and lack of detail also weaken the case for the more fabulous inclusions. Rating: 3.

Anomaly Evaluation. The chapter on falls (GWF) demonstrated the power of whirlwinds and waterspouts to lift a great variety of lightweight objects into the atmosphere. This levitating power combined with hail-forming conditions would seem to make all manner of inclusions possible and, in fact, not very anomalous. Rating: 3.

Possible Explanation. Windblown materials serve as hailstone nuclei.

Similar and Related Phenomena. All falls (GWF).

Examples of Unusual Inclusions in Hail

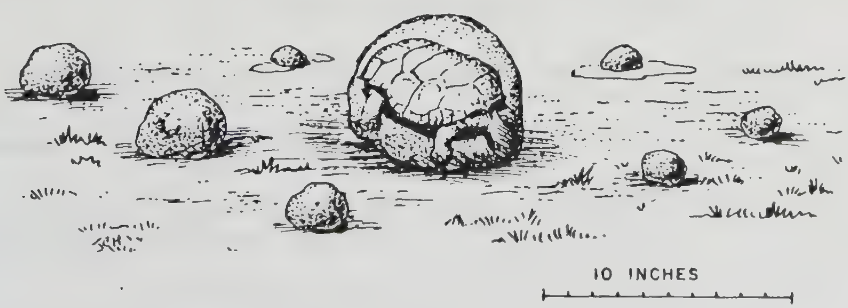
X1. August 26, 1834. Padua, Italy. "...hailstones with nuclei of a dark grey colour. These nuclei, examined by Cozari, consisted of grains of different sizes, the largest of which could be attracted by the magnet, and were found to be composed of iron and nickel. The identity of this matter with that of aerolites can scarcely be open to doubt. An analogous observation has been made at Stockholm by Nordenskiold, who proved the presence of little dark grains of metallic iron in some hailstones." (R4)

X2. June 1842. Nismes, France. The peculiar taste of some hail led to an analysis that revealed the presence of nitric acid. (R1)

X3. 1871. Zurich, Switzerland. Hailstones with salty taste fell. Crystals of salt found inside. (R2,R3)

X4. May 11, 1894. Vicksburg, Mississippi. "During a severe hailstorm at Vicksburg on the afternoon of Friday, May 11, a remarkably large hailstone was found to have a solid nucleus, consisting of a piece of alabaster from one-half to three-quarters of an inch. During the same storm at Bovina, 8 miles east of Vicksburg, a gopher turtle, 6 by 8 inches, and entirely encased in ice, fell with the hail." (R5, R6)

X5. May 26, 1953. Washington, D.C. Following a report of radioactive hailstones in the Washington area. "During the subsequent few days, we obtained a number of the hailstones, which because of their unusual size many people had collected and stored. The average beta activity of eleven of the melted hailstones was 1.4×10^{-10} curie per milliliter. Radiochemical analysis of 41 hailstones gave the characteristic isotopic distribution of a young fission product conglomeration. All hailstones showed the familiar concentric layer formation and most were



Gopher turtle encased in ice falls in Mississippi hailstorm (X4) roughly spherical in shape.....It is clear from our measurements, that the centers of the hailstones contained significantly more radioactivity than the outside layers. Therefore it seems probable that these hailstones were formed in a region of relatively high fission product concentration." (R7) Atmospheric nuclear tests are to be suspected here.

X6. June 14, 1975. Norman, Oklahoma. A small insect (a chalcid) was found in the center of a 3-centimeter hailstones. The authors also refer to birds encased in ice being observed in the past, but no specific reference was given. (R8)

X7. No date or place given. Hailstones reported containing small crystals of "sulphuret of iron." (R2, R3)

X8. June 16, 1882. Dubuque, Iowa. A severe hailstorm that produced hailstones weighing almost two pounds; some measuring 17 inches in circumference. "They exhibited diverse and peculiar formations, some being covered with knobs and icicles half an inch in length; others were surrounded by rings of different colored ice with gravel and blades of grass imbedded within them. The foreman of the Novelty Iron Works, of this city, states that in two large hailstones, melted by him, were found two small living frogs." (R9)

References

R1. Ducres, M.; "Observations on an Acid Rain," American Journal of Science, 2:1:112, 1846. (X2)

R2. "Salt and Iron Hail," Scientific American, 26:128, 1872. (X3, X7)

R3. Nature, 5:211, 1872. (X3, X7)

R4. Schwedoff, Theodore; "On the Origin of Hail," Symons's Monthly Meteorological Magazine, 17:146, 1882. (X1)

R5. "Remarkable Hail," Monthly Weather Review, 22:215, 1894. (X4)

R6. "Enormous Hailstones," Symons's Monthly Meteorological Magazine, 29:151, 1894. (X4)

R7. Blifford, I. H., Jr., et al; "On Radioactive Hailstones," American Meteorological Society, Bulletin, 38:139, 1957. (X5)

R8. Knight, Nancy C., and Knight, Charles A.; "Some Observations on Foreign Material in Hailstones," American Meteorological Society, Bulletin, 59:282, 1978. (X6)

R9. Anonymous; "Hail," Monthly Weather Review, 10:14, June 1882. (X8)

GWP9 Explosive Hail

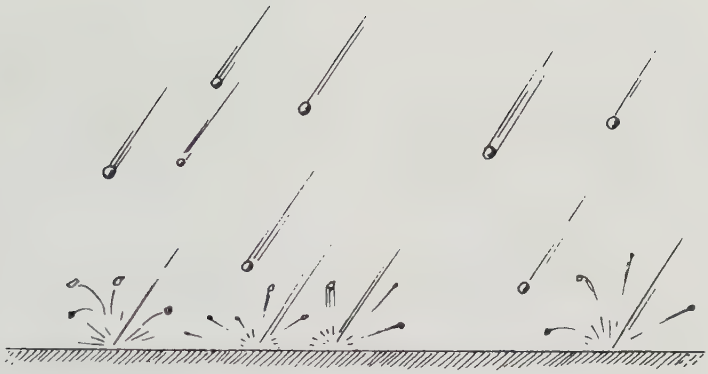
Description. Hail that fragments with pistol-like reports when impacting a hard surface. The fragments fly energetically in all directions.

Data Evaluation. Only two descriptions from the same observer, one of which is presented in good detail. Rating: 2.

Anomaly Evaluation. Explosive hail probably derives its energy from internal stresses accumulated inside the hailstone. The existence of a reasonable explanation for this phenomenon relegates it to the curiosity category. Rating: 3.

Possible Explanation. Internal stresses due to phase and temperature changes.

Similar and Related Phenomena. The shattering of ice cubes when dropped in warm fluids.



Explosive hail (X2)

Examples of Exploding Hail

X1. Circa 1894. Lexington, Virginia. Hailstones fragmented upon impact with the ground and rebounded. (R1)

X2. November 11, 1911. Columbia, Missouri. "The morning had been unseasonably warm; about noon there were the usual sounds of a coming thunderstorm---heavy cumulo-nimbus clouds with a gusty wind---which began about 2.30 p.m. with a slight shower of heavy raindrops; shortly afterwards there were two or three flashes of lightning and thunder, followed by a fall of large hailstones, which on coming in contact with the windows or walls or pavement in many instances exploded with a sharp report, so loud as to be mistaken for breaking window panes or a pistol shot. As the hail fell, the fragments sprang up from the ground and flew in all directions, looking like a mass of 'popping corn' on a large scale. The fall lasted two or three minutes, about half the hailstones being shattered, the ground in some places being nearly covered white with stones and fragments. Of the unbroken stones, seventy were gathered. They weighed roughly 225 grams. A few were ellipsoidal, the longest axis about 25 mm. in length; most of them, however, were nearly spherical, and somewhat smaller, from 15 to 20 mm. in diameter. Practically all of them contained a nucleus. In a few of the stones the nucleus was porcelain-like, raspberry-shaped, surrounded by almost colourless spherical layers of ice, for about five-sevenths of the diameter, and then a shell of porcelain-like, snowy ice. A fair proportion of the stones showed, in addition to the spherical, a radiate structure, which was very apparent as the stones melted in a flat dish, showing the cross section with great distinctness." (R1)

References

R1. Brown, W.G.; "Explosive Hail," Nature, 88:350, 1912. (X1, X2)

GWP10 Colored Precipitation

Description. Rain, snow, or hail colored blue, green, and any other color except red, yellow, brown, gray, and black. The omitted colors are so common in precipitation and so easy-to-explain that they are not even considered catalogable as curiosities.

An exception is made for the still-mysterious red rains of Kerala, India, that fell over a 2-month period in 2001.

Background. Yellow precipitation is classified with the so-called "sulphur falls" (GWF3), which almost always turn out to be pollen falls. It should be recognized, however, that some yellow rain and hail may be the result of yellowish dust and sand being mixed with the precipitation. Black, brown, and gray precipitation is very common. The contaminating substances are usually industrial pollutants and ash and soot from distant forest fires. (R2) Many of the "dark days" (GWD), particularly those in North America, have been accompanied by black rain. Throughout history, red or "blood" rains have been viewed with utmost concern by the superstitious. The coloring matter in blood rains inevitably turns out to be reddish dust and organic matter. (R1) The red precipitation of Europe seems to originate mostly in African dust blown north and is probably linked to the Cape Verde dust fogs (GWD4).

Deposits of red snow have often been observed in the polar regions; for example, the famed Crimson Cliffs of Greenland, described by Captain John Scott early in the Nineteenth Century. Such curious sights are due not to colored precipitation but rather infestation by organic matter. (R4)

Data Evaluation. The accounts of blue and green precipitation are rare and lack scientific attention in the journals. Rating: 3.

On the other hand, the red rains of Kerala are well-documented and have been subjected to laboratory studies. Rating: 2.

Anomaly Evaluation. Like the polar red snows, blue and green precipitation probably owe their hues to entrained organic matter, although scientists have not yet deigned to analyze them. It is doubtful that there is anything more here than mundane curiosities. Rating: 3.

The red rains of Kerala, however, are more puzzling being almost certainly the carriers of yet-to-be-identified biological cells. The Kerala rains even evoke the old hypothesis of panspermia. Rating: 2.

Possible Explanations. Contamination by organic matter or industrial pollutants. In the case of blue snow, one cannot rule out an optical origin, say, the scattering of sunlight by snow particles.

As for Kerala's red rains, it seems likely at present that some terrestrial algae were somehow swept up into the rainstorms.

Similar and Related Phenomena. Dark days and their accompanying sooty rains (GWD1); colored icebergs (ESP3 in our Anomalies in Geology); sulphur/pollen falls (GWF3); blue-green hydrometeors originating from leaky aircraft lavatories (GWF1).

Examples of Colored Precipitation

X1. Permanent feature. Spitzbergen. "When the French meteorologists, Martin and Bravais, traversed a field of snow at Spitzbergen, in 1838, it appeared of a green hue, wherever it was pressed by the foot. The coloring matter seemed to reside just below the surface, which was brilliantly white. Upon another excursion, the first observer beheld green particles spread like dust over the snow, and upon the sides of the field." (R3) Green snow in Arctic said to derive from minute organisms."(R4)

X2. March 1, 1934. Mount Washington, New Hampshire. Holes dug in newly fallen snow were promptly filled with deep blue light. Sky obscured by dense fog, precluding reflection from blue sky. (R5)

X3. April 12, 1934. New Hampshire. Same effect as in X2. (R5)

X4. January 1955. Western New York state. Bluish snow reported in many towns. (R6)

X5. March 26, 1948. Dayton, Ohio. A fall of green rain. "During a spring shower, residents of the eastern part of the city were drenched with it. It discolored umbrellas, clothing and left a greenish tint on white-painted homes."

The green tints were soon washed away. Green pollen and/or algae caught up in the rain by wind were suggested causes. (R7)

X6. 2002. Sangrampur, India. "A sticky green rain showered a town in India last week. There were scenes of consternation in Sangrampur north of Calcutta, as it left clothes and buildings stained."

In the referenced article, this green rain, as well as several uncataloged yellow rains, was [surpringly] attributed to the mass defecation of swarms of bees overhead. An action, according to scientists, promoted by the bees' overheating and stress! (R8)

The descriptions of several other similar fluid releases by bees in the literature give these easy-to-dismiss anecdotes some validity!

X7. July 25, 2001 and following two months. Kerala, India. Ordinarily, we dismiss red rains and snows as due to the nonanomalous inclusion of reddish dust, pollen, and other terrestrial organic matter. However, the 2001 red rains of Kerala, India, are more mysterious and certainly more controversy-evoking. We now record the facts available on Kerala's red rains and some of the scientific discussion that has followed.

The red rains of Kerala seem to have been water suspensions of tiny, red cell-like objects with virtually no dust included. The Kerala rains were intermittent for two months over a wide area of southwestern India. Fort's "blood rains," which he extracted from the old journals preserved in the British Museum seem to have come to life again in today's India.

G. Louis and A.S. Kumar, Mahatma Gandhi University, have examined the abundant reports emanating from these rains and prepared a paper for the journal Astrophysics and Space Science. We quote from their preprint's abstract.

"A red rain phenomenon occurred in Kerala, India, starting from 25th July 2001, in which the rainwater appeared coloured in various localized places that are spread over a few hundred kilometers in Kerala. Maximum cases were reported during the first 10 days and isolated cases were found to occur for about 2 months. The striking red colouration of the rainwater was found to be due to the suspension of microscopic red particles having the appearance of biological cells. These particles bore no similarity with usual desert dust. An estimated minimum quantity of 50,000 kg of red particles has fallen from the sky through red rain. An analysis of this strange phenomenon further shows that the conventional atmospheric transport processes, like dust storms, etc. cannot explain the phenomenon. The electron microscopic study of the red particles shows fine cell structure indicating their biological cell-like structure. EDAX analysis shows that the major elements present in these cell-like particles are carbon and oxygen. Strangely, a test for DNA using Ethidium Bromide dye fluorescence technique indicates absence of DNA in these cells.

"In the context of a suspected link between a meteor airburst event and the red rains, the possibility for the extraterrestrial origin of these particles from cometary fragments is discussed." (R9)

Louis and Kumar venture that the Kerala red-rain inclusions "could" be alien life forms, thereby demonstrating the reality of panspermia; that is, the meteoric propagation of life throughout the universe.

The authors reference a paper by F. Hoyle and N.C. Wickramasinghe, known proponents of panspermia, a news item from Nature (412:670, 2001), and comments (mostly negative) from various journals and magazines. But they mention not Charles Fort, the recorder of many other "blood rains," an omission which surpriseth not!

H. Muir, writing for the science magazine New Scientist summarized the research by Louis and Kumar. (p. 34, March 14, 2006). Readers of Muir's article suggested several possible sources for the red inclusions in the Kerala rains.

V. Liquori remarked that if a link could be found between the Kerala red rains and meteoric activity, the red particles could be organic particles found in some meteorites. Some of these extraterrestrial particles form vesicles when interacting with water and then take on the appearance of biological cells. (R10)

Looking for terrestrial sources, M. Pitt noted that the red-rain inclusions might be liposomes or microcapsules. These are oil bubbles that trap aqueous material. He suggests a mist of such particles might originate on a vessel burning red oil in the Arabian Sea. Such mists could easily be captured by rainstorms. (R10)

K. Gardner suggested Rhodophyceae red algae, which are often seen in bird baths. (R10)

M. Baker examined the absorption spectrum of the red-rain inclusions, as provided in R9, and saw no evidence of terrestrial hemoglobin. (R11) The inclusions, therefore, are probably not red-blood cells, which they superficially resemble.

H. Muir wrote a follow-up article in the April 1, 2006, issue of New Scientist. (R12) There, she summarized analyses of the red-rain inclusions obtained from various laboratories as of that date.

- The red-rain particles are almost certainly biological cells!
- Hemoglobin is absent, as mentioned above.
- Chitin is also absent, making it unlikely that the particles are red algae or fungal spores.
- Chloroplasts are absent.
- Contradicting earlier reports, some DNA is present, although it seems to be of a very unusual nature.
- The presence of "daughter" cells is puzzling.

A typical "cell" that fell in the 2001 red rains of Kerala, India. Magnification: 25000X. (R9)

- Just how many of the cells were caught up in such large quantities in rain storms presents another mystery.

The general scientific opinion in mid-2006 favors a terrestrial origin, perhaps some little-known alga, such as Trentepholia. (R12)

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GWP11 Luminous Precipitation

Description. Raindrops, hailstones, and sleet particles that emit flashes of light and cracklings sounds when they hit terrestrial surfaces. Some reports refer to electrical "sparks," others to phosphorescent "flashes;" so two different light-emitting mechanisms may be at work.

Data Evaluation. Several good reports by experienced observers from the older literature; but, strangely, none from the past 60 years. Rating: 2.

Anomaly Evaluation. At least three light-emitting mechanisms are possible (see below). Even though no one has investigated this phenomenon, satisfactory explanations seem to be at hand. Rating: 3.

Possible Explanations. Electrical discharges when electrically charged precipitation hits terrestrial objects; triboluminescence (as in crushing sugar cubes); sonoluminescence, in which trapped gasses become incandescent due to sudden, violent pressure changes.

Similar and Related Phenomena. Electrical discharges during snowstorms (GLD5); flashes of light at the bases of waterfalls (GLD14); phosphorescence and sparks when sea ice is broken up by ships. (GLD14)

Examples of Luminous Precipitation

X1. October 28, 1772. France. "...as the Abbe Bertholon was traveling between Brignai and Lyons, in the midst of a heavy storm, he was surprised at seeing the raindrops and hail-stones emitting jets of light, as they fell upon the metallic parts of his horse's trappings." (R2)

X2. September 22, 1773. Skara Sweden. drops of rain struck fire and sparkled as they touched the ground. (R2)

X3. January 25, 1822. Freyberg, Germany. Sleet struck the earth with flashes of light. (R2)

X4. November 1, 1844. Paris, France. "It was stated to the French Academy of Sciences, that, on the 1st November 1844, at half-past eight in the evening, during a heavy fall of rain, Dr. Morel-Deville remarked, as he was crossing the court of the College Louis-le-Grand, in Paris, that the drops, on coming in contact with the ground, emitted sparks and tufts (aigrettes) of light, accompanied by a rustling and crackling noise;

a smell of phosphorus having been immediately afterwards perceptible. The phenomenon was seen three times. M. Duplessy saw at the same hour a remarkable brightness in the northern sky." (R1)

X5. 1892. Cordova, Spain. "Rain which on touching the ground crackles and emits electric sparks is a very uncommon but not unknown phenomenon. An instance of the kind was recently reported from Cordova, in Spain, by an electrical engineer who witnessed the occurrence. The weather had been warm and undisturbed by wind, and soon after dark the sky became overcast by clouds. At about 8 o'clock there came a flash of lightning, followed by great drops of electrical rain, each one of which, on touching the ground, walls, or trees, gave a faint crack, and emitted a spark of light. The phenomenon continued for several seconds, and apparently ceased as soon as the atmosphere was saturated with moisture." (R3)

X6. July 16, 1918. Surrey, England. "When the hailstones struck the windows there was a phosphorescent flash of light." (R4)

X7. January 17, 1817. New England. On this date a severe snowstorm struck most of New England. It was attended by considerable thunder and lightning. Although termed a "luminous snowstorm," the snow itself was not self-luminous. Rather, the phenomenon of St. Elmo's fire was observed on the snowy treetops, fence posts, the roofs of homes, and even people. (R5)

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GWP12 Point Precipitation

Description. The concentration of rain, snow, or hail in very small geographical areas. Many inches of rain may fall on just a few acres to the near exclusion of surrounding territory.

Background. The older meteorological literature describes a number of cloudbursts and "waterspouts" that burst against hillsides, carving deep holes and channels, sometimes in solid rock. Probably these concentrated storms are not really waterspouts because they frequently occur far inland and even in desert-dry conditions.

Data Evaluation. Actual measurements of point rainfall are rare, but subsequent surveys of the physical damage wrought are conclusive that precipitation can indeed be highly concentrated. The excavation of great holes and gullies in resistant terrain has been reported often and is taken as proof of point precipitation. In addition, eyewitnesses tell of funnel-like storm structures over the afflicted areas. Rating: 1.

Anomaly Evaluation. No meteorological explanation has yet been discovered for the formation of intensely concentrated storms in hilly terrain and the subsequent rapid release of huge quantities of precipitation. Point precipitation may be the result of an unrecognized type of storm structure or some unappreciated ability of certain terrain to focus or capture storms. Rating: 2.

Possible Explanations. Speaking in vague generalities, certain types of topography may "capture" and concentrate passing storm systems, possibly by augmenting rotary motion much like quasipermanent eddies along a rocky stream bed.

Similar and Related Phenomena. Orographic clouds; the so-called "lake effect" which leads to large snowfalls in the Buffalo area and elsewhere.

Examples of Point Rainfall

X1. May 31, 1682. Oxford, England. Nearly two feet of rain fell in less than a quarter of an hour in a limited area. (R20)

X2. June 9, 1809. London, England. A cascade of water and hail poured in a torrent on an area of 200 acres. (R17)

X3. October 25, 1822. Genoa, Italy. About 32 inches of rain fell on a small area (size not specified) within 24 hours. (R1)

X4. July 8, 1847. Tusquitta Mountain, United States. After the fall of a great waterspout. "An intelligent professional gentleman, who visited the locality soon after the storm, described to me the effects produced. The chasm excavated in the earth, he said, had a depth of several feet, with its sides cut out as vertical as if dug with a spade. The roots of the trees and plants beneath the surface, were cut off as squarely as if done with the knife. At the surface, close up to the sides of the chasm, nothing seemed to be disturbed. The shrubs and grass, and even the fallen leaves upon the soil, remained unmoved, as though no running water had come into contact with them. This was the condition of things where the waterspout first struck the ground; and as the excavation, at the point of origin, had a width of but a few yards, the whole volume of the descending water, he concluded, must have been concentrated within that space, and continued thus contracted till the contents of the cloud were exhausted. In descending the mountain, along the line of the widening chasm, evidences existed that the torrent produced had attained, in places, a depth of sixty feet, uprooting in its course the largest trees, and removing immense rocks from the gulch created in its descent to the valley below." (R3)

X5. 1849. Alpine, Georgia. "A Water Spout, of immense size, the 2d inst., near Alpine, Chattanooga county, Ga. It is said to have made an impression in the earth thirty feet deep, and forty or fifty feet wide, and that it eradicated the largest forest trees, and removed rocks weighing several thousand lbs." (R2)

X6. May 3, 1849. Bredon Hill, England. An enormous body of water rushed down a gully doing considerable damage. "The course of the torrent could easily be traced up the hill for more than a mile, to a barley field of five acres, the greater part of which was beaten down flat and hard, as if an enormous body of water had been suddenly poured out upon it. Beyond this there were no signs of the fall of water to any great amount." (R11)

X7. August 1864. Nevada. "I was travelling from Humboldt mines to Reese river. The whole country was dry and parched, as is usual at that season of the year, and the weather was even warmer than common. About 2 o'clock p.m. I saw what appeared to be a whirlwind. It appeared to be about 25 miles distant, and the spiral column extended from the earth to a very dense cloud, which was nearly as high as the scattered mountains in that vicinity. Soon this column seemed to break, the upper third of it being detached from the rest and bent over to the eastward. I then perceived that this spiral column was not of dust, as I had first supposed, but was water. The next day I crossed a canon leading from the place where the phenomenon had occurred. Water was still running in it, and there was evidence of a recent flood. Inquiring further, I consulted the Hon. William R. Harrison, a gentleman of scientific attainments who had spent several years in the Humboldt mountains. He told me that such phenomena were not of infrequent occurrence in the Humboldt mountains, and were called 'cloud-bursts.' He had witnessed several of them---had once been in the edge of one, and had once stood on the top of a mountain and witnessed the terrific scene in the canon beneath him. He says: 'The first sign of them is the sudden gathering of a small, dense, black cloud on the mountain side, about one-third of the way from the top, and generally at the head of a canon. Soon this cloud seems to dash itself to the earth, taking a circular motion. It appeared as if an inverted whirlwind was drawing from the cloud immense quantities of water, which is dashed in floods against the mountain side.'" (R4)

X8. June 14, 1878. Bath, England. "Shortly after five o'clock in the evening the inhabitants of the village of Weston, which lies between Kelston Hill and Bath, were startled by a volume of water advancing like a tidal wave along the Kelston Road; in a minute the water was upon them, flooding the houses and laying the main street four feet deep under water; with such force did it come that a stone weighing five hundred-weight was carried several yards, while smaller ones were taken a much greater distance. It was not known in the village from where the water had come, but it so happened that about five o'clock I was proceeding to Weston Station by the Midland Railway from Bristol to Bath, and when in sight of the Round Hill I was struck by the blackness and lowness of the clouds in its vicinity. Suddenly there was a flash of lightning, and immediately after the Hill was enveloped in what appeared to be a storm of rain of unusual density. On arriving home I was not altogether surprised to find the commotion in the village, and I at once attributed the source of the water to the cloud which I had seen; I therefore made my way in the direction of Kelston Hill. On arriving under the brow of the Hill it was very clear that something more than an ordinary storm had occurred. Near the end of a lane (Northbrook) leading to some fields, the hedge on the right for some yards was lying in the road, but the field beyond this point presented only the appearance of an ordinary storm, while the lane itself was like the bed of a river. To the left was a field of standing grass; for about twelve feet from the hedge the grass remained intact, then for about the same distance it was as though it had been mown down. This torrent, for such it might have been compared to, came to almost a sudden termination a little above the end of the lane, but it extended down the Hill till it was joined by two others, one of which had carried a hedge away bodily....I gather from spectators at Kelston Hill that it began to be cloudy at half-past four in the afternoon; at five there was a rattling clap of thunder, followed by a downpour of rain---in 'bucket-fulls,' as one expressed it; but all seemed to agree that the greater portion of the water fell under the brow of the hill, where it came down in several columns." (R5)

X9. October 21, 1881. Little Haldon, England. A fall of water in the shape of a waterspout. Intense rain in a localized area. (R6)

X10. August 2, 1883. The Ochils, Scotland. A waterspout burst against the Ochils. Much property damage. (R7)

X11. June 9, 1888. Langtoft, England. See description in X12. (R8, R12)

X12. July 3, 1892. Langtoft, England. "At a place named 'Round Hill,' on Saturday, June 9th, 1888, about noon, a waterspout had torn its way into a slight hollow or combe on the hillside taking a northeasterly course, and formed three large holes in the chalky rubble scattering the stones all around, producing a flood which inundated the village lower down the valley. These holes, which are roughly circular and connected by a deep trench.... measured from one end to the other about 70 yards, and were from 8 to 9 feet deep in their deepest portions. Several tons of soil, boulders, and gravel were thrown out and carried down the valley by the flood, and the village streets were covered with a mixture of these substances. The damage done by that flood of 1888 was, however, insignificant when compared with the one now under discussion. Not more than 20 yards from the site of the former cloudburst, or waterspout, and a little further to the south, three gutters or trenches have been scooped out of the solid rock, nearly parallel to each other and at right angles to the valley bottom; the direction taken being slightly more easterly than that on the former occasion. From the appearance of the trenches it is highly probable that there were three waterspouts moving abreast simultaneously. Two of the trenches or ravines are 68 yards in length and of great size and depth, and as the hillside here somewhat differs from the adjoining portion, where it consists of loose chalk mixed with soil and is composed of strata of solid rock slightly inclined to the vertical, beneath a thin layer of earth, the force exerted in removing the ponderous mass of material, about 180 yards in circumference, must have been very great indeed. The smaller trench, 15 yards to the left and much shallower, is rather over 50 yards long, but this is discontinued before the summit of the hill is reached, as the gyratory power of the tornado had evidently become weaker and the spout was presumably drawn up again into the cloud....The probable causes that bring about the formation of these waterspouts or cloudbursts in this particular spot may lie in the peculiar character and configuration of the surrounding valleys, which all converge to a point south of this place, and have only one outlet to the east, while the north-easterly side upon which the waterspouts impinge is strongly fortified by steep declivities which appear to impede the storms in their path. Here, possibly, the overcharged undercurrent of warm air, supplemented by the warm air of the valley (for the afternoon sun had been bright and hot), was suddenly broken into and disturbed by the cool rain and air descending from above, and a series of whirls were formed, which, after developing into waterspouts and conforming to the laws of tornado motion, moved away in a northeasterly track, and hence came in contact with the steep hillside, where, finding their paths impeded, they tore huge holes in the hillside." (R8, R18)

X13. July 2, 1893. Cheviots, England. "A hill in the Cheviots, known as Bloody Bush Edge, was visited by a waterspout or cloudburst. The day was oppressive and about 10 A. M. heavy clouds gathered. These broke about 1 P. M. and 'the whole hill and parts of the adjoining hills were covered with a sheet of water'. The peat which forms the surface of the hill was ploughed up to a depth of about five feet, and the rocks beneath laid bare over a space of 30-40 acres. The River Breamish rose forty feet in sudden flood, swept away its bridges and destroyed long stretches of roadway." (R14)

X14. 1898. No place given. "As a boy I saw a small hailfall of about ten to fifteen meters width across a road. We boys ran from the dry side through the hail to the other dry side and back." (R10)

X15. June 18, 1907. Blanchland, England. A waterspout burst, flooding the countryside, breaking up stone walls, and doing much damage. (R13)

X16. April 26, 1922. Semur, France. A couple driving along a road encountered two "walls" of intense precipitation. (R9)

X17. August 1, 1932. London, England. "It began to rain---heavily at first and then softly. Suddenly torrential rain fell only one hundred yards from where I was standing. The nearest trees in Kensington Gardens were almost hidden behind a milky mist of heavy rain. The rain-drops rebounding off the street created a layer of spray as high as the tops of the wheels of the taxis standing in the street. Where I was sheltering, hardly a drop of rain was falling. The contrast was so striking that I called the attention of an unknown bystander (as though I could not believe my eyes). Then the spray on the ground came nearer like a wave, and receded. Suddenly it vanished completely, and the trees behind in Kensington Gardens stood out black against the sky. It was over." (R15)

X18. August 2, 1966. Greenfield, New Hampshire. "Rain began to fall about 1900 EST, or about an hour before the outbreak of more generalized showers in the region. It soon became a downpour, continuing until about 2300 EST, at which time Mr. Stanley went to bed. It was then still raining, but had slackened noticeably. The rain may have stopped by midnight. A remarkable nonvariability of the intense rain was noted by Mr. Stanley. There was very little slackening, even for brief intervals, during the period of heaviest fall, which was from about 1945 to 2215 EST. There was practically no wind. Neither thunder nor lightning was observed. The noise on the roof was terrific, like that of a continuous waterfall. A plastic bird feeder mounted on the side of the house was broken by the impact of sheets of water from the eaves. Looking out the window, Mr. Stanley could see stones and gravel from the roadway, south of the house, being washed away by torrents of water. Upon rising in the morning, Mr. Stanley noted that the weather had cleared, with a brisk westerly wind. After finding the 5.75 in. of rain in the gage, he inquired from a neighbor 0.3 mi to the east. He found that the neighbor had but 0.50 in. in his gage. He thereupon examined the countryside for visible effects. The road washout extended only a few hundred feet. Upon going one-half mile in either direction, no evidence of rain erosion of sand or gravel could be found. South of the house, beginning at the gage which was mounted on a pole, well distant from structures or trees, there stretches a 10-acre field. The knee-high grass therein was beaten down flat. By afternoon it began to revive. By the following noon it was erect. To the west of the house, a dry-wash brook running bankful at dawn was empty by 0800 EST. Drawing a line around the traces of erosion, one obtains an oval area about a mile north-south and about three fourths of a mile east-west. Within this area, rain varied from the order of 1 in. on the limits to almost 6 in. in the center. Outside this limit, rain is believed to have fallen off sharply to less than one-fourth of an inch, generally within a few thousand feet." (R19)

X19. No date given. Chatham, England. Heavy rain fell in a strip 30 feet wide and three miles long. (R16)

X20. September 2, 1961. The Pennines, United Kingdom. A waterspout "fell," washing away an area of ground 180 yards long by 15-20 yards wide. This caused an avalanche of peat, boulders. and other debris. (R21)

X21. July 17, 1983. Upper Teesdale, United Kingdom. A point rainfall of 104.8 millimeters (over 3 feet) occurred in a 24-hour period resulting in several peat landslides. (R21, R22)

X22. September 15, 2001. Williamson Valley, AZ. A remarkable point hailfall accompanied by 2-4 inches of rain. The hailfall was extremely localized. Its area estimated to be only about the size of a football field. Residents a mile away saw no hail at all. The hour-long storm swept the hail into piles as high as 8 feet. When graders opened up the affected road, they heaped up piles 10 feet high. These took a week to melt, even in the usual 90°F daytime heat. (R23)

X23. May 30-31, 1935. Eastern Colorado. An exceptional cloudburst dumped up to 24 inches of rain in 6 hours, based upon readings from three remote rain gauges. The area inundated was actually fairly extensive and hardly point rainfall. However, the intensity of the rainfall was nearly a world record and highly unusual outside of the tropics. (R24)

X24. July 18, 1942. Southport, PA. "Perhaps the most extraordinary rainfall ever measured in the world occurred in the unlikely location of McKean County, Pennsylvania, in and around the town of Southport...All told, 34.50 inches fell in an 18-hour period of which 34.30 inches fell in 12 hours and 30.70 inches in just 6 hours." (R24)

As of 2004, such intense rainfall has never been recorded elsewhere in the world. (R24)

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GWP13 Surplus Ice Crystals in Clouds

Description. The presence in clouds of from 1,000 to 10,000 times more ice crystals than can be accounted for by the number of active ice nuclei. The ice nuclei are needed to initiate the crystallization of supercooled cloud water.

Data Evaluation. The great discrepancy between ice crystals and ice nuclei is confirmed by actual counts at high altitudes, according to the single discussion of the subject found so far in the literature. Rating: 2.

Anomaly Evaluation. Modern cloud physics requires that each ice crystal form on an ice nucleus. At present, there seems to be no acceptable theory explaining how all the ice crystals form without corresponding numbers of ice nuclei. Rating: 2.

Possible Explanation. Supercooled water droplets may be carried to high altitudes where adequate populations of nuclei exist by convection. Existing ice crystals may splinter and multiply the number of ice nuclei present.

Similar and Related Phenomena. None.

Examples of Surplus Ice Crystals in Clouds

X1. General observations. Counts of ice crystals in clouds are from 1,000 to 10,000 times greater than ice nuclei. (R1)

References

R1. "Where Do All the Extra Ice Crystals Come From?" New Scientist, 64:316, 1974. (X1)

GWP14 Decrease of Rainfall with Increasing Altitude

Description. The observation that the quantity of rain collected in rain gauges usually diminishes markedly as the height of the gauge above the ground is increased. Apparently, additional rain condenses rather close to the ground.

Background. This intriguing observation comes from a very old report, but nothing further has been discovered on the subject in later journals and texts. Quite possibly, this phenomenon is well recognized and explained but has not yet been encountered in our literature searches.

Data Evaluation. Only a single report from 1868 wherein the phenomenon is represented as well-accepted. Rating: 3.

Anomaly Evaluation. According to R1, the condensation of water vapor on cold, falling raindrops cannot explain the facts, but small droplets, invisible to the eye, may be present in sufficient quantity to account for the increased rainfall closer to the ground. If this is true, no anomaly exists. Until such confirmation is found, this phenomenon will be recorded and given a low anomaly rating. Rating: 4.

Possible Explanation. The "sweeping out" of small, invisible droplets of water by falling raindrops.

Similar and Related Phenomena. Precipitation from a cloudless sky (GWP1) may originate in the same population of water droplets that is substantial but nevertheless not visible in cloud form.

Examples of Decrease of Rain with Increasing Altitude

X1. General observations. "One of the most remarkable results of observations made upon rain, has been the discovery that the amount of fall at any place diminishes largely as the rain gauge is raised above the level of the ground. It is not very easy to explain this remarkable fact. The explanation offered by Kamtz is, that a falling drop carries with it the temperature of the upper regions of air, and condenses on its surface the aqueous vapour present throughout the lower strata of the atmosphere, as a decanter of cold water does when brought into a room. And of this explanation Professor Nichol remarks, that 'it is not an hypothesis but a rigorous deduction, giving an account of all the facts as yet ascertained in connection with this subject.' But unfortunately, the explanation, though it undoubtedly presents a vera causa, will not bear the test of 'quantitative analysis.' Sir John Herschel has gone through the simple calculation required to overthrow the theory, and points out, that if we allow the cause the full value it can possibly have (a value far exceeding that which can probably be attributed to it) we obtain an effect only one-seventeenth part of what is wanted to account for the phenomenon," The author next suggests a connection between the phenomenon and the well-known fact of precipitation from a clear sky. There are, he says, considerable numbers of small water droplets in the atmosphere, even when the sky seems clear. (R1)

References

R1. Proctor, R. A.; "Rain," English Mechanic, 6:357, 1868. (X1)

GWP15 Rain Gushes Associated with Lightning

Description. Sudden gushes of rain or hail that are closely associated in time and space with lightning flashes.

Data Evaluation. Rain gushes have been linked to lightning flashes for over a century. Radar observations of thunderstorms suggest that lightning flashes are followed by the intensification of radar echoes and ground observation of gushes of precipitation. Some older observations, however, insist that the rain gushes precede the lightning. Rating: 2.

Anomaly Evaluation. There is currently considerable debate as to whether the strong electric fields existing within thunderstorms have any effect on precipitation. Theory seems to say that no connection exists, which is contrary to observation. Rating: 3.

Possible Explanations. Electrostatic fields may help stimulate the condensation of water vapor in the storm clouds. The thunder, too, may affect condensation of raindrops.

Similar and Related Phenomena. Large hydrometeors (GWF1) and the so-called "thunderstones" (GWF2), both of which are linked to lightning. Hot-air blasts after lightning (GLL12).

Examples of Rain Gushes Associated with Lightning

X1. July 25-26, 1849. England. Observations made during severe thunderstorms. "On this occasion his attention was more particularly directed to the connexion between the electric discharge and the sudden gush of rain that more or less accompanies it, with a view to illustrate the question occurring in the Report of the Committee of Physics approved by the President and Council of the Royal Society, p. 46, 'Is this rain a cause or consequence of the electric discharge?' On the previous day, the 25th, about 3h 50m P. M., during a thunderstorm a sudden gush of heavy rain occurred, which within two seconds, by estimation, was succeeded by a vivid flash of lightning: the thunder occurred at a further interval of some seconds. From this it would appear, provided the heavy rain fell over the entire space between the place of observation and that of the electric discharge, that it was not a consequence of that discharge, the gush occurring at a sensible interval previous thereto. The setting in of the storm of the 26th, about 1h 45m P. M., again called the attention of the writer to this point; and several flashes occurred between 1h 45m P. M. and 2h 3m P. M. without being preceded by a gush, although heavy rain more or less accompanied the discharges, in one or two instances al- simultaneously or immediately afterwards. At length, about 2h 4m P. M., a most violent and very remarkable gush of rain occurred, which was followed within one minute by a most vivid flash of lightning, the thunder succeeding almost instantaneously..... Within a minute or two after this discharge a partial cessation of the heavy rain took place, but sudden gushes occurred at short intervals within the next six or seven minutes; they were, however, unaccompanied by lightning. ....Within ten minutes, however, the storm again burst forth; the lightnings played, the thunder roared, and heavy rain, mingled with hail so thickly that comparatively near objects could scarcely be distinguished, fell in torrents, and the writer observed during the remainder of the storm four or five sudden gushes that were quickly succeeded by lightning. On all these occasions he is quite certain that the sudden gush of rain preceded the electric discharge." (R1) The order of events here is the reverse of those in the following reports. (WRC)

X2. General observations. "Abstract. Observations of thunderstorms in New Mexico were made with a vertically-scanning, 3-cm radar on a mountain top. Prior to a cloud-to-ground lightning discharge nearby, the radar echo overhead was usually quite weak, indicating low intensities of precipitation there. Following the lightning it was observed sometimes that in the region of the cloud where the discharge occurred the radar echo intensity rapidly increased, and shortly thereafter a gush of rain or hail fell nearby. These studies confirm earlier radar observations, made by the authors at Grand Bahama Island, B. W. I., in which it was found that lightning is often followed by a rapidly intensifying echo and then by a gush of rain at the ground. The increases in radar reflectivity in small of the cloud following lightning suggest that the electric discharge is influencing the size of the particles in the cloud. An analysis indicates that within 30 seconds after a lightning discharge, the mass of some droplets may increase as much as 100-fold as a result of an electrostatic precipitation effect." (R2) However, see the following item.

X3. General observation. Calculations suggest that electrostatic forces, such as those in thunderstorms, are not necessary to explain rainfall. (R4)

X4. General observations. "In his book, The Flight of Thunderbolts, Dr. Schonland states, 'It is a familiar experience to all who live in thundery regions that rain does not usually fall from a thundercloud until at least one lightning flash has taken place.' From observations of many isolated, air-mass thunderstorms over the mountains of New Mexico, we support Dr. Schonland's conclusion." (R3)

X5. General observations. The following result comes from laboratory studies. "In general, at temperatures colder than -20°C, hail becomes negatively charged, but at warmer temperatures it becomes positively charged. The formation of the lower positive charge center in thunderstorms and the initiation of a lightning flash which precedes the commonly observed gush of rain on the ground may be explained in terms of this charging process." (R5)

The precipitation (rain or hail) transports this accumulation of positive charge to the ground, producing an electric-field excursion plus a gush or rain (or hail).

References

R1. Birt, William Radcliff; "On the Production of Lightning by Rain," Philosophical Magazine, 3:35:161, 1849. (X1)

R2. Moore, C. B., et al; "Gushes of Rain and Hail after Lightning," Journal of the Atmospheric Sciences, 21:646, 1964. (X2)
R3. Moore, C. B.; "Lightning Discharge and Precipitation," Royal Meteorological Society, Quarterly Journal, 91:368, 1965.(X4)
R4. Brazier-Smith, P.R., et al; "Increased Rates of Rainfall Production in Electrified Clouds," Royal Meteorological Society, Quarterly Journal, 99:776, 1973. (X3)
R5. Jayaratne, E.R., and Saunders, C.P.R.; "The 'Rain Gush', Lightning, and the Lower Positive Charge Center in Thunderstorms," Journal of Geophysical Research, 89:11816, 1984. (X5)

GWP16 High Frequency of Wet Weekends along the North American East Coast

Description. Along North America's east coast weekends tend to be wetter than weekdays.

Data Evaluation. Popular belief is supported by satellite-based precipitation estimates. We have, however, only one scientific paper dealing with this phenomenon. Rating: 2.

Anomaly Evaluation. The observed wet weekends have been correlated with a weekly cycle in air pollutants along the eastern Atlantic coast. It therefore seems that a reasonable explanation for the phenomenon exists. Rating: 4.

Similar and Related Phenomena. Rainfall correlated with meteor showers (GWS4).

Entry

X1. General observations. A long-time popular belief of residents of the east coast of North America is that weekends are more likely to be wet than the days of the work week. An examination of rainfall data has proven that, indeed, Saturdays received 22% more rain than Mondays. The likely cause: the build-up of atmospheric pollution along the northwestern Atlantic coast during the work week. (R2)

The scientific analysis was carried out at Arizona State University by R.S. Cerveny and R.C. Balling, Jr. Reporting in Nature, their abstract reads in part: "Three atmospheric monitoring stations record minimum concentrations of ozone and carbon monoxide early in the week, while highest concentrations are observed later in the week. The air-pollution cycle corresponds to observed weekly variability in regional rainfall and tropical cyclones. Specifically, satellite-based precipitation estimates indicate that near-coastal ocean areas receive significantly more precipitation at weekends than on weekdays. (R1)

Not only is the U.S. east coast highly industrialized but the predominate westerly wind flow tends to sweep inland air-pollutants toward the Atlantic coast.

References

R1. Cerveny, Randall S., and Balling, Robert C., Jr.; "Weekly Cycles of Air Pollutants, Precipitation and Tropical Cyclones in the Coastal NW Atlantic Region," Nature, 394:561, 1998. (X1)
R2. Cohen, Philip; "Rain, Rain, Go Away...," New Scientist, p. 22, August 8, 1998. (X1)

GWP17 Future Rainfall Correlated with Soil Temperature

Description. The prediction of future rainfall from current deep soil temperatures.

Data Evaluation. A Chinese claim published in an American popular science magazine. No scientific studies found as yet. Rating: 3.

Anomaly Evaluation. No cause-and-effect link seems to tie future rainfall to present deep-soil temperatures. Rating: 2.

Possible Explanation. Precipitation and deep-soil temperatures may be causally connected but out-of-phase.

Entry

X1. General observations, According to Chinese scientists, if you dig a hole about 40 inches deep and take the soil temperature at that depth, you can predict future wet and dry periods months ahead of time. To illustrate, warm spring soils are usually followed by rainy summers; cold soils precede dry summers most of the time.

At first, American scientists doubted this Chinese discovery, but their research soon proved that the correlation is even stronger in the United States. The best explanation so far is that soil temperatures affect atmospheric convection and modify weather patterns locally. (R1)

Reference

R1. Anonymous; "Digging for a Forecast," Science Digest, 91:30, September 1983. (X1)

GWR TEMPERATURE ANOMALIES

Key to Phenomena

GWR0 Introduction

Meteorological records often quote high and low temperature extremes but say little about rapid rates of temperature change, which some term "temperature flashes." To the anomalist these temperature flashes are much more interesting than mere highs and lows, for they signify violent weather. Although the familiar Chinook winds and thunderstorm activity seem to accompany most temperature flashes, there are some that have no ready explanation.

GWR1 Temperature Flashes

Description. Large, rapid temperature fluctuations, often amounting to tens of degrees in a few minutes. Temperature flashes are often associated with Chinook-type winds in the United States and with their analogs elsewhere. Other temperature flashes sometimes accompany thunderstorms.

Data Evaluation. Several excellent instrumented observations. Rating: 1.

Anomaly Evaluation. The hot, dry Chinook winds are fairly well understood, but the temperature flashes associated with nighttime thunderstorms remain to be elucidated. Other temperature flashes, viz. X2, have no known causatative agent. Rating: 3.

Possible Explanations. Passing over the well-known Chinook winds, one can surmise that thunderstorms are the products of instability and must therefore consist of regions with strong temperature variations; in other words, the temperature flashes are the consequence of unmixed volumes of hot daytime air. Electrical heating of air by thunderstorm activity is also a possibility, but no evidence has been discovered for this.

Similar and Related Phenomena. Hot air blasts subsequent to lightning strokes. (GLL12)

Examples of Temperature Flashes

X1. September 20, 1911. Kimberley, South Africa. "It may interest you to know that at 9 p.m., on the 20th September, a thunder cloud approached from the west, bringing with it a squall of wind that caused the temperature to rise in a few minutes to 110°F. By 9.45 p.m. it had fallen again to 67°, which I expect was about the temperature before the squall. I do not think my thermometer responded quick enough to register the highest point, but it is safe to say it rose 40° in five minutes." (R3)

X2. November 4, 1911. Teneriffe, Canary Islands, Spain. A curious heat wave. "At 12:45 A.M. the thermometer at the municipal meteorological observatory registered 63 deg. F.; it then suddenly rose within two minutes to 79 deg. F., and after remaining at the latter temperature for a few minutes fell back suddenly to 63 deg. F. During this time the barograph showed marked oscillations of pressure. No satisfactory explanation of this occurrence has been offered." (R2)

X3. January 13, 1913. Rapid City, South Dakota. During the onset of a Chinook wind. The 8 A.M. temperature was -17° F; at 10 P.M., it was 47° F; an increase of 64° in 14 hours. (R4)

X4. June 30, 1921. Killarney, Manitoba, Canada. During a thunderstorm, at midnight, the temperature rose to 93° F. (R5)

X5. January 22, 1943. Rapid City, South Dakota. Chinook wind. Beginning at 7:32 A.M. the temperature rose 49° in two minutes---from -4° to 45° F. Frost appeared almost instantaneously on car windshields. (R4)

X6. June 20-21, 1960. Gretna, Manitoba, Canada. Thunderstorms along an advancing squall line. "After midnight had passed there occurred two sudden and most pronounced temperature rises at Gretna. The situation was described thus by the observer on duty:'We had two blasts of hot air from the south of approximately 15 minutes duration each; the first from 0025 to 0040 and the second from 0200 to 0215. The first reached a high of 96° and the second 97°. The wind changed direction several times before and after these periods and at times was calm.' There is no thermograph at Gretna station hence a pictorial record of the temperature variations is not available. The first temperature flash was a rise of 16 degrees---the temperature equalling the previous afternoon's maximum. The extent to which the temperature dropped between flashes is not known. The second flash exceeded the previous afternoon's maximum by one degree. The temperature then dropped sharply although again the amount of the sudden drop is unknown." (R5)

X7. No dates given. Georgia and Kansas. "Several currents of intensely hot air have been experienced which appear to be similar to those which are common in Egypt, Persia, and some portions of India. A hot wind extending about 100 yards in width, lately passed through middle Georgia, and scorched up the cotton crops on a number of plantations. A hot wind also passed through a section of Kansas; it burned up the vegetation in its track and several persons fell victims to its poisonous blast. It lasted for a very short period, during which the thermometer stood at 120°---far above blood heat." (R1)

X8. July 11, 1909. Near Cherokee, Oklahoma. At 3 A.M. a heat burst reached 136°F. A small area of crops in the center of the burst were desiccated instantly. (R6)

X9. June 15, 1960. Northwest of Waco, Texas. Right after midnight, a blast of hot wind pushed the temperature from 70° to 140°F. The wind blast was estimated to be 80-100 miles/hour. "Cotton fields were reported to have been carbonized, leaving only burnt stalks standing." (R6)

References

R1. "Hot Weather and Burning Winds," Scientific American, 3:106, 1860. (X7)

R2. "A Strange Heat Wave," Scientific American, 104:54, 1911. (X2)

R3. Parkinson, F. B.; "Great Heat in a Thunder Squall," Symons's Meteorological Magazine, 46:201, 1911. (X1)

R4. Hamenn, Roland R.; "The Remarkable Temperature Fluctuations in the Black Hills Region, January 1943," Monthly Weather Review, 71:29, 1943. (X3, X5)

R5. Lowe, A. B.; "Temperature Flashes at Gretna, Manitoba," Weatherwise, 16:172, 1963. (X4, X5)

R6. Burt, Christopher C,; Ext eme Weather, New York, 2004, p. 36, 37. (X7-X8)

GWS WEATHER AND ASTRONOMY

Key to Phenomena

GWS0 Introduction

Folklore is emphatic that the moon affects rainfall, and a few scientists have long suspected a solar influence on terrestrial weather. Neither effect is overwhelming, whatever the mechanisms may be, assuming the phenomena really do exist. In fact, the effects are so small that most scientists have pooh-poohed both solar and lunar weather influences for many years. Nevertheless, an immense literature (merely sampled here) definitely favors some statistical relationship between weather and astronomy.

Recently, with spacecraft and rocket measurements, it has become apparent that solar activity can indeed affect the earth's atmosphere through sun-emitted streams of plasma. It is possible that these atmospheric changes may manifest themselves as weather modifications. This new creditability of sun-weather relationships removes some of them from the category of anomalies and thus outside the purview of this Catalog.

The moon's influence on weather, however, remains controversial. Favorable and unfavorable data abound. Three kinds of effects are recognized, each with a proposed physical mechanism:

(1) Lunar modulation of rainfall through atmospheric tides;
(2) Lunar modulation of rainfall through gravitational or electrostatic modification of the influx of meteoric dust that serves as precipitation nuclei; and
(3) Lunar influence on thunderstorm and lightning incidence through the moon's interaction with the earth's magnetic tail that, in turn, modifies the the number of charged particles entering the atmosphere and affecting the planet's electrical balance,

Solar and lunar effects on the weather are so muted that other astronomical bodies would be expected to be completely ineffectual. But to be thorough in the search for anomalies, we must ask whether the planets may not modify the weather, too. This effect may be indirect, for planetary position has frequently (and controversially) been correlated with solar activity, which itself may influence the earth's weather. Meteors and even comets must also come under scrutiny, for it is conceivable that sudden influxes of meteoric dust could trigger storms that would otherwise have never formed. In short, whatever orthodox science may say today, we should not close our minds to potential extraterrestrial modulation of our weather. Only a century ago, the foremost scientists declared with great certainty that the influence of the sun on terrestrial weather was nil and that all who thought otherwise were fools!

It would also be incorrect to be too generous with respect to those statistical correlations of phenomena that seem to have no obvious cause-and-effect relationships. As ESP proponents have found to their dismay, poor statistical techniques may suggest influences that simply do not exist. Similarly, improper statistical methods have long dogged the correlation of astronomy and terrestrial weather. So often the data employed are insufficient in quantity and quality. The mere comparison of graphs may be misleading if the data are not handled properly. Before science accepts astronomical influences on weather, the correlations must have high statistical significance. The existence of a recognized physical mechanism also makes scientific acceptance easier, although mechanisms and theories should not veto good data.

GWS1 The Correlation of Lunar Phase and Terrestrial Weather

Description. The statistical correlation of lunar phase with various terrestrial weather phenomena, such as precipitation, drought, hurricane occurrences, the amount of sunshine, etc. In particular, the relationship of lunar phase and precipitation has received considerable attention in both folklore and the literature of science down the centuries.

Background. Weather lore has long insisted that rainfall is heavier around the time of the new moon. Science has both ridiculed and embraced this contention, presenting data pro and con. Generally, in the past, scientists have rejected a lunar connections because they could not perceive any physical mechanism whereby the moon could significantly affect the earth's weather. In recent times, though, some analyses of rainfall and the timing of the formation of tropical depressions have strongly supported a connection with lunar phase---at least in some parts of the globe. In addition, some possible physical mechanisms have now been identified by which the moon can indeed influence earth's weather. Chief among these are lunar tides in the atmosphere. Even so, the statistical picture is often complex and sometimes inconsistent.

In passing, it should be recognized that science-in-general has a natural antipathy for theories wherein terrestrial phenomena are affected by the movement of astronomical bodies---doubtless a prejudice derived from an age-old abhorence of astrology.

Data Evaluation. Numerous, each seemingly sound, moon-weather correlations exist, but they are not all consistent. In addition, lunar correlations are always mixed with the sun's influences on terrestrial weather. Separating the two is sometimes difficult. The moon-linked terrestrial variables are also diverse and possibly arise from different lunar-produced physical effects. We see the complexity of the analytical situation in the following list of "dependent variables" that appear in the cited studies (X1-X41):

- Rainfall
- Wind conditions
- Hurricane onset
- Sediment-layer thickness
- Weather-in-general!
- Drought
- Amount of sunshine
- Tree-ring width
- Winter severity

All of these have, at one time or another, been used to demonstrate a lunar connection. Obviously, the scientific picture can be quite confusing. Rating: 2.

Anomaly Evaluation. Taking all the data collectively, there is little doubt that the phase of the moon is involved in some aspects of terrestrial weather. The 18.6-year lunar cycle shows up often and emphatically, but so too do other cycles. There is still much to be learned about the moon's impact on the earth's weather. Rating: 2.

Possible Explanations. The lunar tide in the earth's atmosphere somehow affects the above-mentioned dependent variables. The exact mechanisms involved have not been fully worked out. The moon may gravitationally modulate the flux of incoming meteoric debris and thus the amount and distribution of condensation nuclei.

Similar and Related Phenomena. The alleged lunar dispersal of clouds (GWC11); thunderstorm frequency (GWS2); the alleged correlation of planetary configurations and weather phenomena (GWS8); the lunar temperature effect (GWS7); lunar phase correlated with atmospheric ozone (GWS6); correlation of auroras with lunar phase (GLA18 in Remarkable Luminous Phenomena in Nature).

Examples of the Relation of the Moon to the Weather

X1. Statistical analysis. London and vicinity. The analysis of 100 lunar cycles showed that 47.60 inches of rain fell during days 3-7, but only 26.42 during days 17-22. These periods include the times during which the moon ascends and descends through the plane of the earth's orbit respectively. (R1)

X2. Statistical analysis. English wind data from 1840 to 1847. "...it seems that when the sun and the moon were in and near conjunction, the air was less frequently calm; the duration of the north wind with its east compounds was less frequent; the south wind with its west compounds was more frequent than when the sun and moon were in and near opposition. From this it would seem that the position of the moon in respect to the sun has exercised an influence on the direction of the wind in these years....The influence of the moon on the temperature, and therefore density, of our local atmosphere, seems to be exercised chiefly through the medium of the winds. It is a secondary effect of her varied attraction, which continually tends to change the bearings of the different currents in the great body of the atmosphere, and we are successively involved in all their modifications. Not but that there are seasons, such as dry years after wet, or vice versa, in which the predominant solar influence is exerted to a degree which renders these lunar changes of small consequence, and when, in spite of the various aspects of our attendant planet, we are drenched with rain or parched with drought for months together." (R2) This obviously primitive and simplistic view of the weather and its possible relationship to astronomy is included here as a period piece.

X3. Statistical analyses. Two quotes from a cogent survey of several studies of the possible influence of the moon upon weather. "In examining a question of this kind, preconceived opinions are very liable to influence the results obtained, except where absolute measurements (such as height of barometer, depth of rain, &c.,)are employed; therefore, though we have lunar maxims and theories more than 2000 years old, we leave them unnoticed, for the present at any rate, and with them all but instrumented records, for an observer predisposed to a belief in the influence of lunar phases will consider himself warranted in classing as a change in weather a variation which one holding opposite views would consider far too trivial to constitute a 'change.'.....Thomas Forster, in his Atmospheric Phenomena, says, 'It is certain that the place of the moon has much influence on the weather. That changes of weather oftener take place about the full and new of the moon and about the quadratures than at other times, is really a fact founded on long observation, and is quite conformable to what we actually know, respecting the moon's influence on the tides.'" (R3) The latter statement is by a 'believer' in lunar influence and, in the literature of this period (1868) is literally overwhelmed by condescending comments by 'unbelievers.'

X4. Statistical analysis. "Although it seems certain that the meteorological influence of the moon's phases is very slight, I am prepared to prove---as the result of a long series of investigations---that the declination influence of our satellite is very great. One extremely important secret of lunar influence on the weather is in the principle of uniformity---uniform movements of the moon causing fine weather, and extremes of temperature both in summer and winter; while irregularity of lunar movements (a condition far more common than uniformity) appears to cause the unsettled weather that usually prevails in this climate. Another extremely important secret of lunar influence on the weather is the distance of the sun from our meridian, or the meridian of the antipodes at the time the moon crosses the equator; for the nearer the sun is to noon or midnight at the time of this lunar phenomenon, the greater the influence of the moon in raising or depressing our temperature according to the season of the year..... In conclusion, I may observe that until the year 1860 I entirely disbelieved in the moon's influence on the weather, and invariably ridiculed the theories of lunar meteorologists; but certain phenomena that occurred in that year induced me to examine the subject with some care, and a seven year's investigation of this branch of predictive meteorology has so far converted me, that I have become a lunarist in spite of my prejudices, and almost against my will." (R4) Such reluctant conversions are very common in anomaly research.

X5. Review of statistical studies. The lunar effect on weather is essentially nil. The "influence of the planets" is the sole cause of the weather and its variations. See GWS8 for more on this theory, which smacks even more of astrology. (R5)

X6. General observation. Lunar radiation and tidal pull are too small to affect terrestrial weather. (R6)

X7. A review of weather lore involving lunar phases. The author generally ridicules any suggestions that the moon has an effect on terrestrial weather because no known physical force is powerful enough to have an effect. It is akin to astrology and superstition. One example of lunar weather lore is the so-called "Saturday moon," which insists that when a new moon falls on a Saturday wet and unsettled weather invariably follows. (R7)

X8. Statistical analysis. Bethlehem, Pennsylvania. "The observations of rainfall, taken at Bethlehem, Pa., by Mr. F.E. Luckenbach, during 1881-1890, are selected as as the basis of a brief discussion, and they are believed to be free from the objections above noted. The amount of rainfall in each year was obtained for the day of new moon and for each of the three days preceding and following, and also for the other quarters. For each year a curve of rainfall throughout a lunar month of 28 days could then be drawn, and these curves were combined in various ways to endeavor to ascertain the features common to all of them. The following conclusions were derived: First, the new moon is liable to be followed by an increase in rainfall; second, the full moon is liable to be followed by a decrease in rainfall; third, the wettest period is generally at and preceding the full moon; and, fourth, the driest period is generally at and preceding the first quarter. These conclusions are, in general, most plainly marked in the years of least rainfall." This study was followed by one by Hazen, using Philadelphia data (not far from Bethlehem), in which it was concluded that there is little if any lunar effect on rainfall. (R8)

X9. Statistical analysis. East coast rainfall data. "While both New York and New Haven show an increase at the time of new moon, yet the figures at Boston show a very remarkable maximum at the day of new moon, and an equally remarkable minimum on the seventeenth day of the lunation, or two days after full moon. I do not set forth these figures as an absolute proof that the moon does influence rainfall in the neighborhood of Boston, but it looks as though there must be something in it." (R9) This study is by the same H. A. Hazen mentioned in X8, where he concluded no effect existed.

X10. Statistical analysis. Greenwich, England. Data on rainfall from 1889-1900 show maximum wetness near the time of the new moon with a minimum shortly before the last quarter. (R10, R11)

X11. General observation. Scientific men of the present day (1902) see no reason whatsoever for imputing to our satellite even the slightest change in the weather. It is all superstition. (R12)

X12. Statistical analysis. Barometer data from Greenwich (1889-1904) and Ben Nevis (1884-1892) tend to substantiate the notion from folklore that the full moon brings fine weather. Referring to his graphs of average values. "These two curves seem to tell much the same tale; few days of low barometer about (just after) full and new moon, many such days about (just after) the quarters. Thus, so far as the summer half in those twenty-one years is concerned, the popular belief would appear to be vindicated." (R13)

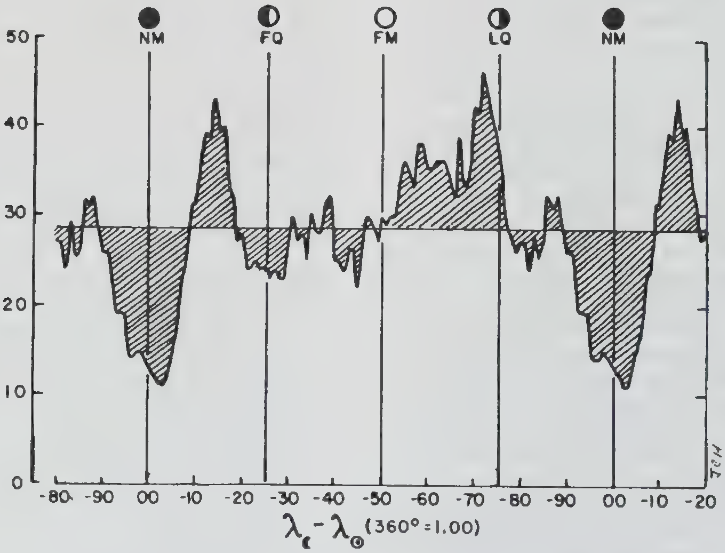
X13. Review of weather folklore. A typical condescending discussion of popular weather lore, which emphasizes the fact that the moon's heat and gravitational force cannot possibly affect terrestrial weather. All lunar weather lore is thus merely superstition. (R14)

X14. Statistical analysis. Glasgow Observatory's hourly barometric pressure reading from 1868-1912. A strong diurnal variation was shown to exist at Glasgow in contrast to other sites where the variation is semidiurnal. No satisfactory explanation exists for this anomaly. (R15)

X15. Statistical analysis. 41 lunar cycles from Shangugu, Ruanda. A 27-day cycle in precipitation was confirmed. (R16)

X16. Statistical analysis. United States. "Abstract. Precipitation activity over broad areas appears to be closely associated with the monthly lunisolar cycle. Indexes of precipitation in the continental United States over a continuous 50-year period, and 91-year daily histories of individual stations, reveal that heavy rains occur most frequently in the first and third weeks of the synodical month." (R17, R18, R20)

X17. Statistical analysis. New Zealand. "The influence of the moon in producing tides in the upper atmosphere and the appearance of a lunar component in daily temperature in certain parts of the world are comparatively well known, but the effects are extremely small and difficult to detect. The possibility of a large effect on rainfall first came to our notice in 1960 with the chance reading of a paper by Rodes. Rodes showed what appeared to be a connection between rainfall in the Spanish peninsula and both the declination and the position of apogee and perigee of lunar motion. An investigation was therefore made of the rainfall data in our possession, and it was apparent that it contained a strong lunar component. However, it was also clear that this was connected with the phase of the moon rather than with the parameters used by Rodes. At this point a decision was taken not to publish the data immediately, but to reserve it for a later date. The reason for doing so was that our work on singularities in rainfall was still being treated with disbelief in meteorological circles, and to suggest a lunar effect on rainfall would simply not have met with the right response. We were not sur-



Ten-unit moving totals of the heaviest falls of the month, for fifty New Zealand stations, 1901-1925 (X17) prised therefore when we received a communication from Bradley, Woodbury, and Brier indicating a pronounced lunar effect in U.S. rainfall. The effect is matched by similar effects in the southern hemisphere. A curve showing the heaviest falls of the month for 50 stations in New Zealand, plotted in the same way as the U.S. data are plotted, is given in Fig. 1. It shows variations of a magnitude comparable with those in the U.S. and closely related in phase." (R18, R20)

X18. General observation. In response to X16 and X17, widespread precipitation is frequently associated with hurricanes, which are in turn probably influenced by the moon's tidal action during their formative period. (R19)

X19. Statistical analysis. Indiana. "About 10 years ago I was working on weekly rainfall totals and their effect on corn yields for 15 counties in central Indiana. From folklore I had learned that precipitation was more likely to occur during the week following a new moon and the week following a full moon than at other times, so I proceeded to test this idea. To my amazement I found some agreement. After applying several statistical treatments to the data I produced a short manuscript as well as an outline suggesting some further investigations along this line. I need not relate here the review comments or the outcome of the proposed investigations. In short, the whole matter was dropped." (R21)

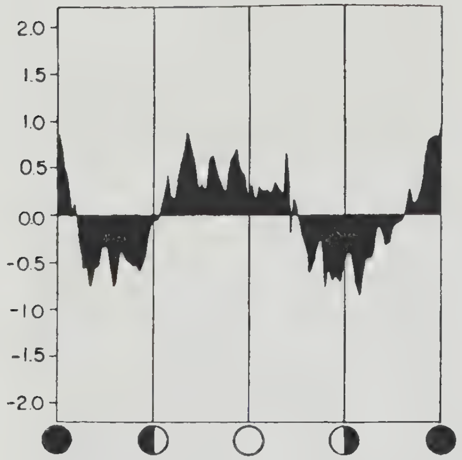
X20. Statistical analysis. After presenting a series of graphs showing ice nucleus concentrations in the southern hemisphere, E.K. Bigg observed: "The result is as surprising as the rainfall discoveries. In every case, there are two distinct maxima in the lunar month, about the first and third quarters of the Moon, and the total range is three or four to one, even with the smoothing used. There appears to be a slight shift with latitude, the peaks occurring later nearer the equator.... It is apparent, therefore, that, in addition to the effect on rainfall, the Moon has a large effect on the freezing nucleus count. It is well known that the effect of the Moon on other meteorological variables like barometric pressure, surface temperature, is extremely small; the implication is strong, therefore, that the effect on the freezing nucleus count does not originate in the lower atmosphere. However, a possible mechanism is that the Moon in some way controls the incoming meteor rate and so affects the number of freezing nuclei falling into the lower atmosphere." (R22, R23)

X21. Survey paper. A review of the data presented in R18, R19, and R22, plus a discussion of the theory that the moon and meteoric particles are electrically charged. The moon would thus deflect like-charged meteoric particles away from the earth during part of the lunar cycle, consequently affecting raintall. (R23)

X22. Statistical analysis. United States. "A cycle of 14.765 days, one-half of the lunar synodic month, can be demonstrated in the precipitation data for the United States for the period 1871-1961. Numerous rigorous statistical tests show that the association is real and an estimate is obtained of the magnitude of the lunar effect. Geographical, seasonal and other sources of variation in the effect are suggested by the data. No other periodicity with comparable amplitude was found by the statistical analysis, but there is evidence that the lunar synodic cycle interacts with the nodical cycle." (R24)

X23. Statistical analysis. Atlantic hurricanes. "An American research worker reports an apparent connection between the phases of the Moon and the genesis of hurricanes. Donald A. Bradley, of the College of Engineering, New York University, took the records of 269 Atlantic hurricanes between 1899 and 1958. He noted the positions of the Moon on dates when they 'matured', in other words, when they first developed winds of force 12 on the meteorologist's Beaufort scale. His figures show that 90 of the hurricanes matured within 46 hours of either New Moon or Full Moon. That is 20 or more than one would expect if there was no connection between the weather and the lunar cycle and is, in statisticians' terms, highly significant." (R25)

X24. Statistical analysis. United States. "Abstract. An analysis of daily observations of sunshine taken in the central and northeastern United States during the spring and summer indicates the presence of a lunar synodical period. Less than average sunshine is observed during the first and third weeks of the lunar month and more than average sunshine is observed during the second and fourth weeks. Although this lunar period is significant by most statistical tests, the possibility that its appearance is due to a combination of the smoothing procedure and the temporal and spatial correlation among the observations cannot be completely ignored." (R26) See GWC11 for data on the possible dispersal of clouds by the moon.

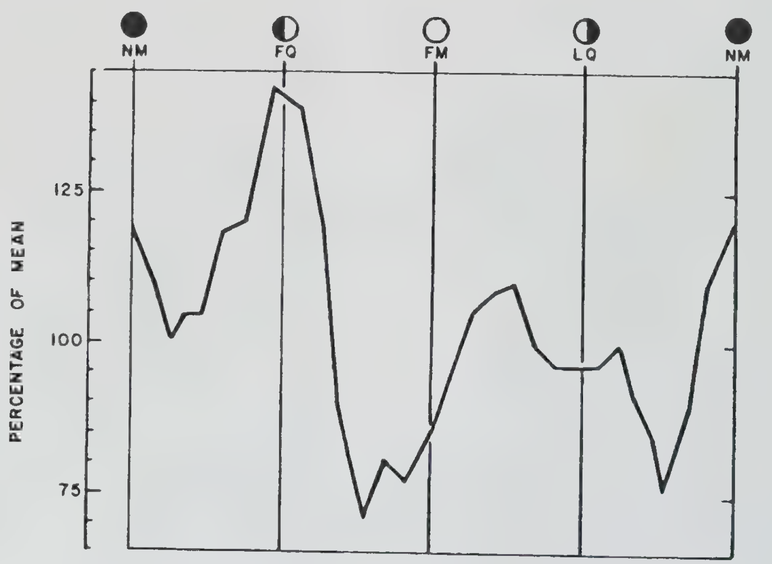


Sunshine trends versus lunar phase (X24)

X25. Statistical analysis. Sydney, Australia. 'Summary. Daily rainfalls of an inch or more for 100 years at one station have been classified according to the phase of the moon with which they occurred. An apparent significant correlation between two 50-year smoothed sub-series is found to have been induced by the filtering process of taking sums. When the effects of the ensuing serial dependence are eliminated, the results are not indicative of a significant overall relationship between the series of rainfall and moon phase." (R27)This seems to contradict other data from the southern hemisphere; viz., X17.

X26. Statistical analysis. South Africa. Abstract. "Rain and hail data from five meteorological stations on the plateau of South Africa have been examined for a dependence on lunar phase. Different distributions with respect to lunar phase were found for summer and winter data. Statistical analyses of the winter descriptions, which appeared to be more significant than those for the summer, suggested that winter rain is modulated by the moon in such a manner that there is one component with the same period as the luni-solar cycle which depends on station latitude and another having three peaks which is latitude independent. This three-peak component seems to operate throughout the year." (R28)

X27. Statistical analysis. Indian Ocean. "The data for this investigation were taken from a publication issued by the Indian Meteorologi-



Frequency of atmospheric depressions, 1877-1960, in the Bay of Bengal and Arabian Sea (X27) cal Department which catalogues depressions formed in the Indian Seas, and gives the date on which the depression stage was reached and its corresponding position. The phase of the Moon for each day is given in terms of synodic decimals (hundredths of a synodic month) in the ephemeris by Carpenter. The synodic decimal corresponding to each date was taken from that source and the frequency of formation of depressions corresponding to each synodic decimal was found. Successive ten-unit moving totals of the frequencies were then made, and of the hundred such totals thirty were chosen to correspond to the thirty days of the lunar month. For purposes of comparison the frequencies were expressed as percentages of the mean. Fig. 1 shows the curve, prepared in this manner, of depressions which formed in the latitude band 19°N - 22°N in the Bay of Bengal and Arabian Sea during the period 1877-1960.... There is a strong indication that the heavy falls (of rain) were associated with the depressions. The tidal influence on the formation of depressions is also indicated, as in both curves the 14.765 day wave accounts for 48.1 of the total variance and is the largest component." (R29)

X28. Statistical analysis. Worldwide study. "Abstract. To examine the hypothesis of a worldwide relation between some lunar periods and tropical disturbances, we collected first-formation dates for 1,013 hurricanes and typhoons and 2,418 tropical storms in both hemispheres. Using the superposed epoch method, we found a lunar synodic cycle (29.53 days) in North Atlantic hurricane and northwest Pacific typhoon formation dates. About 20 percent more hurricanes and typhoons formed near new and full moon than near the quarters during a 78-yr period, showing a stronger peak at new moon than at full moon. Statistically, the existence of an effect dependent on the lunar synodic cycle is supported by a significance level of 7 percent on unsmoothed data from an analysis of variance for categorical data. During the same 78 yr, North Atlantic tropical storms that did not later become hurricanes tended to form near the lunar quarters. Several other categories of tropical storms were not clearly related to the synodical month. Severe tropical storms in two portions of the Indian Ocean over 75 yr formed more often several days after syzygy and quadrature, but this and other severe tropical storm results lack definition, probably due to poor data. Theoretical calculations of the lunar-solar gravitational tide showed that the anomalistic lunar cycle affects only the amplitude and not the timing of extrema. No marked anomalistic or latitude components in hurricane formation were found." (R30)

X29. Statistical analysis. New South Wales, Australia. "An examination of the weather of one hundred years of New South Wales has shown that certain features recur every nineteen years; we have seen that the droughts of history---the great and conspicuous droughts I mean---all drop into this same cycle; both those that happened before the birth of Christ, and those that have occurred in our era; for instance, Elija's drought happened in B.C. 908, that is, 2736 before our great drought in 1828, and the interval is 19 x 144. Great hurricanes, the great frosts of history, all the red rains, and all the droughts that history records, with a very few exceptions, likewise are included in this cycle, and the level of great lakes in Palestine, South America, and New South Wales are subject to the same mysterious influence that controls our weather.

As my investigation proceeded, the weight of evidence gradually converged upon the moon as the exciting cause. I have never had any sympathy with the theory of lunar influence upon weather, and received, rather against my will, the evidence that presented itself; still the logic of facts left no alternative but to accept the moon as prime motor. There has not been time to complete this investigation, and when finished it must form another paper. Meantime I may say that, so far, the comparison of the moon's position in relation to the sun and earth and droughts shows that when the eclipses congregate about the equinoxes, that is, in March and September, they do so in the years which give us great droughts. Further, that when the eclipses accumulate in February and March, that is, at the vernal equinox and the month before it, and September, the autumnal equinox, and the month before it, August, we have the more intense and relatively shorter droughts of the second series, with heat, gales, and hurricanes; on the other hand, when they accumulate about March and April, that is, the month of equinox, and the one following, and about September, the month of equinox, and October following it, we have droughts of the first series that are less severe, but much longer than the droughts of the second series. I have spoken chiefly of droughts; though, so far as our own history is concerned, it would have served the purpose just as well if I had taken up the periodicity of wet years, but outside Australia it would have been very difficult to get the necessary data, for history has much more to say about the horrors of drought than the abundance of wet seasons." (R31)

X30. General observations. The "20-year" droughts of the American Midwest may actually be controlled by the lunar 18-year cycle, for the data fit the 18-19 year cycle just as well as they do the 21-22 year double sunspot cycle. (R32) "It now looks very much as if western US droughts over the past four centuries have been modulated at periods of 22 and 18.6 years---corresponding to dominant solar and lunar cycles. This explanation of why the solar and drought cycles do not always march in step greatly strengthens the case for some solar variability influences on western US droughts." (R33)

X31. Summary of pertinent studies from 1983. (1) Analyses of tree-ring data from the western United States by R.G. Currie (X33, X35), and (2) Beijing precipitation records by S. Hameed et al (X32). Both studies suggest that rainfall/drought exhibit a strong 18.6-year lunar signal. (R34) See X32, X33, X35 for details.

[Currie's] "explanation for the phenomenon links the extreme movement of the Moon north or south of the equator (which follows the 18.6-year cycle) with shifts in the prevailing weather moving from west to east around the Rockies, either to the north or south." (R34)

The modern view is that lunar tides in the earth's atmosphere affect the distribution of precipitation.

X32. Hameed's historical study of Beijing rainfall records. Using the dryness/wetness index for Beijing 1470-1974, S. Hameed et al found a "significant signal at 18.7 years." This is a component of the tide-generating force. The team also found a significant 80-year signal. However, the expected 11-year and 22-year solar cycles were weak or nonexistent. (R35)

X33. Analysis of tree-ring data from western North America. "Analysis of 102 recent tree-ring chronologies confirms earlier evidence for 18.6-year drought/flood induction and led to discovery of 11-year solar cycle induced drought/flood for western North America." (R36)

X34. Overview of solar/lunar effects on rainfall/drought. R.A. Kerr introduced this Science article by emphasizing the historical inconclusiveness of such investigations of astronomical effects on terrestrial weather and climate. Kerr wrote:

"Cyclicity is the bugaboo of climate studies. Many cycles are reported, few are confirmed. The dubious reputation of most cyclicity studies makes the recent discovery of the moon's periodic influences on weather all the more startling. Although it is a subtle effect, the lunar cycle that influences droughts in the American Great Plains, in combination with a previously reported solar influence, may on rare occasions wreak such widespread havoc as the Dust Bowl of the 1930's."

Kerr related how early studies of tree-ring data seemed to indicate a 22-year drought cycle in the American Great Plains. This 22-year signal was small but nevertheless had gained widespread support circa 1980. Then, R. Currie (R36 and R38), to everyone's surprise, claimed an 18.6-year lunar signal in the rainfall/drought record for western North America, but at the same time Currie denied the presence of a 22-year solar signal. However, Currie did see an 11-year sunspot signal in his tree-ring data. Thus, in 1984, the effects of the sun and moon on terrestrial rainfall were unclear. However, the reality of an 18.6-year lunar cycle in precipitation was finally generally acknowledged. (R37)

X35. More evidence for a lunar effect. An additional study by Currie.

"Analysis of 38 tree-ring chronologies yields evidence for enhanced drought conditions every 18.6 years in the North American interior for the past millennium." (R38)

X36. Tree-ring data from the Corn Belt. A 1985 paper by D.M. Meko et al in Science further muddied the waters when they shifted tree-ring studies farther east into the Corn Belt (Iowa, Illinois, etc.). They wrote:

"Recently collected tree-ring data from the U.S. Corn Belt for the years 1680 to 1980 were examined for evidence of either these cycles [18.6-and 22-year] on a regional scale. Spectral analysis indicated no periodicity in the eastern part of the Corn Belt, but a significant

18.33-year period in the western part. The period length changed from 17.60 to 20.95 years between the first 150 years and the last 151." (R39)

Why the puzzling shift in period length? Why different results for the eastern and western sections of the Corn Belt?

X37. Inconclusivity reigned in 1985. Science News remarked that Meko's 18.33-year periodicity (X36) could not be ascribed to either the moon or sun.

Because severe droughts tended to occur 2 years after alternate alternate lows in the sunspot cycle, Meko opined that the solar influence probably outweighed that of the moon. (R40)

If droughts skipped every other sunspot low, a 22-year cycle is implied.

X38. A lunar effect on Nile floods. R. Currie extended his studies of the moon's influence on rainfall to Africa. He employed the long series of records of summer and winter flooding in the Nile region that began in 622 A.D. and ended in 1490. The 18.6-year lunar cycle showed up strongly. The evidence for a 10-to-11 year solar-activity cycle was present, too, but weak. (R41)

X39. Astronomical influences on ancient sediment layers ("varves"). The geological evidence is seen in the sediment layers of the 60-million-year-old Elatina formation in South Australia. The thickness of each varve is taken as a measure of annual rainfall. Solar and lunar cycles of 10.8- and 20.3 years were easily discerned. The timing of the lunar signal was different from that of today because the moon was closer to the earth 60 million years ago.

Interestingly, the fact that the lunar cycle was almost double that of the sun created a strong "beat" effect. Quite obvious in the data, the beat period is 28.4 sunspot cycles long. (R42)

X40. Unexpected rainfall cycles. Using rainfall records from 234 British weather stations, covering the period 1881-1986, B.R. May and T.J. Hitch picked out two previously unrecognized cycles from these records.

"The meteorologists found four significant patterns of variation [of rainfall] which follow closely sine waves of period 7, 11, 20, and 50 years. The 20-year cycle, say May and Hitch, may match a well-known variation in the strength of tides raised in the atmosphere (and the oceans) by the Moon, a rhythm which repeats every 18.7 years.

"The 11-year cycle is even more clearly tied to the cycle of activity of the Sun, with the heaviest burst occurring when the Sun's activity is near its peak. As yet, Hitch and May have no explanation for the cycles 7 and 50 years long." (R43)

Note that the length of the record used is only 105 years long!

X41. Timing of lunar phase related to severe winters. J.N. Graham speculated as follows in a 1991 issue of Weather.

"In 1985 I put forward the idea that that the timing of the lunar synodical cycle [29.531 days] in preceding months might influence the development of winter circulation patterns affecting England and the rest of western Europe. It appeared that severe winters only followed when spring tides fell on specific calendar days. There have since been two winters within the first quintile of severity in central England, 1984/85 and 1985/86, the former being exceptionally severe in other parts of western Europe. Both winters followed the lunar model previously indicated." (R44)

Since winter serverity usually includes snowfall as well and low temperatures, we catalog this curious and hard-to-explain astronomical effect here.

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GWS2 The Correlation of Thunderstorms with Lunar Phase

Description. The supposed tendency of thunderstorms to be more frequent around the time of the new moon. This phenomenon is not clear-cut and is, of course, embedded in the lunar rainfall effect (GWS1).

Data Evaluation. As with GWS1, the statistical analyses of available data are in conflict, even though based upon many years of observations. Different geographical areas seem to encounter different moon-thunderstorm relationships, suggesting a complex relationship or perhaps none at all. Rating: 3.

Anomaly Evaluation. The magnitude of the anomaly here depends upon whether current scientific theories of thunderstorm development can countenance a lunar effect. Since thunderstorm frequency seems to be related to solar activity (GWS3) and the state of the terrestrial-atmospheric electrical circuit, any lunar disturbance of these relationships might carry through and affect thunderstorm frequency. The moon does, in fact, pass through the earth's magnetic tail and neutral sheet, providing a mechanism that could explain any positive correlation between lunar phase and thunderstorm frequency. Rating: 3.

Possible Explanations. The moon's passage through the terrestrial magnetosphere may modulate the number of charged particles reaching the earth from the sun, thus disturbing the terrestrial-atmospheric electrical current and thunderstorm formation.

Similar and Related Phenomena. The correlation of thunderstorm frequency with solar activity (GWS3); the relationship between thunderstorms and cosmic rays (GLL16).

Examples of Thunderstorms Correlated with Lunar Phase

X1. Statistical analysis. Greenwich, England. Thunderstorm frequency is maximum near the new moon and minimum between the full moon and the last quarter. (R1)

X2. Statistical analysis. Providence, Rhode Island. Comparing American data with that of X1, thunderstorm frequency is maximum between new moon and the first quarter, minimum from the first quarter to full moon. The Providence data were so different from those from Greenwich that the author ventured that the effect must be quite different at Greenwich or that the moon really has nothing to do with thunderstorm frequency. (R2)

X3. Statistical analysis. Bridport, England. More thunderstorms were recorded near the full moon than the new moon, in contradiction of X1 (Greenwich) observations. (R3)

X4. Statistical analysis. Germany. "To most of us who have been brought up to consider that it is rank heresy to suggest that the Moon has any influence on the weather, it is a little startling to look up the amount and quality of the data that have been collected upon this subject, especially in Germany. The point which seems to have been particularly investigated is the relation of the phases of the Moon to thunderstorms." A large table of German data is omitted here. "The number of observations here collected seems to be large enough to enable us to draw definite conclusions, without fear that further records will revise or neutralize them. From these observations we conclude that there really is a greater number of thunderstorms during the first half of the lunar month than during the last half, also that the liability to storms is greatest between new moon and the first quarter, and least between full moon and last quarter. Also we may add that while theoretically very interesting, the difference is not large enough to be of any practical consequence. Thus it would seem that besides the tides and certain magnetic disturbances, there is a third influence that we must in future attribute to the Moon." (R4, R5) Note that W. H. Pickering, the author of this article, held many unconventional views with regard to the moon.

X5. Statistical analysis. Northern Italy. A review of the studies of Schiaparelli, using 1827-1864 data, arrives at a conclusion exactly the reverse of Pickering (X4). (R6)

X6. Statistical analysis. United States. "Abstract. Using the superposed-epoch method, we statistically analyzed thunderstorm frequencies for 108 stations in eastern and central United States in relation to lunar positions for the years 1930-1933 and 1942-1965. The results are as follows. With full moon as key day, a peak in thunderstorm frequency occurs for 1953-1963 two days after full moon, the mean being 2.7σ above average level. This mean frequency is 4.8σ above the mean when computed only for the full moons as key days that have a declination of 17° north or more. We suggest that these increases near full moon may be related to the earth's magnetic tail and the neutral sheet." (R7)

X7. General observation. "Many facts relative to the cause of storms are still unknown; no reason can be given for the fact that on the shores of the North Sea, of the Gulf of Bengal, and many other regions bordering the ocean, thunder-storms almost always commence at the hour of high tide." (R8) This is the only allusion we have found to this remarkable phenomenon.

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GWS3 Thunderstorms Correlated with Solar Activity

Description. The increase of thunderstorm frequency and/or lightning incidence during short-term solar flares and long-term, more general increases of solar activity. This relationship can be seen in the historical analysis of thunderstorm and lightning incidence and also in direct measurements of the electrical properties of the atmosphere, such as electrical conductivity.

Background. It is well-established that aurora frequency increases with solar activity. A few investigators have maintained that a reciprocal relation holds between auroras and thunderstorms, both being in effect competing mechanisms for carrying electrical currents in the upper atmosphere. In other words, when auroras wax, thunderstorms wane.

Data Evaluation. Modern measurements of atmospheric electrical properties via balloon and rocket are quite convincing. However, the statistical analyses of thunderstorm/lightning incidence versus solar activity are sometimes conflicting and may include a confusing latitude effect. Rating: 3.

Anomaly Evaluation. A reasonable physical mechanism involving solar cosmic rays describes how increased solar activity can increase the initiation of lightning and, therefore, thunderstorm frequency. The postulated essential role of cosmic rays is recent and is not yet universally accepted. Rating: 3.

Possible Explanations. Ionizing radiation from the sun and cosmos change the electrical properties of the atmosphere and thereby foster the initiation of lightning discharges.

Similar and Related Phenomena. Solar activity affecting terrestrial weather (GWS5); lunar phase related to thunderstorms (GWS2); cosmic rays correlated with the incidence of lightning (GLL16); the apparent reciprocal relationship between auroras and lightning (GLA9). The last two references are to be found in the catalog Remarkable Luminous Phenomena in Nature.

Examples of Thunderstorms Correlated with Solar Activity

X1. Statistical analysis. Kremsmunster, Germany. Thunderstorm observations made between 1764 and 1869. "In years when the temperature is high and the sun's surface relatively free from spots, thunderstorms are abundant. Since, moreover, the maxima of the sun-spots coincide with the greatest intensity of auroral displays, it follows that both groups of phenomena, thunderstorms and auroras, to a certain extent supplement each other so that years of frequent storms correspond to those auroras, and vice versa. He (W. von Bezold) observes that such a connection between sun-spots and storms does not by any means sanction the supposition of a direct electrical interaction between the earth and sun, but may be simply a consequence of a degree of insolation dependent upon the sun-spots." (R1, R2) Today, space experiments do find a direct electrical connection between earth and sun---the solar wind.

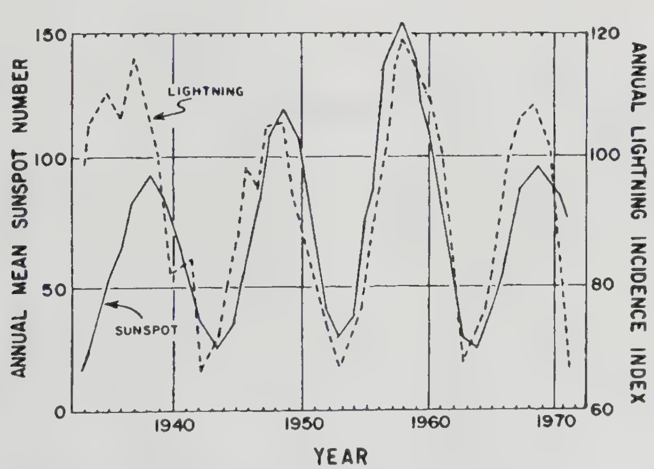
X2. General observations. Conclusions from a long study. "As a result of the extended series of observations described, it has been found in general that whenever groups of faculae, with or without dark spots, are appearing by rotation or are bursting forth upon the eastward side of the sun there is an immediate increase in thunderstorms in the lower latitudes, and probably of auroras in the higher latitudes. If, however, the aurora becomes visible nearer the equator at such times, there is an immediate, though perhaps temporary, decrease in thunder-storms, as though the aurora had taken their place. In short, the aurora and thunder-storms appear to have a common origin, and in certain localities, at least, a reciprocal relation to each other. Instances have been noted also in which an aurora in the United States has been coincident with unusual electrical storms in Europe, and vice versa." (R3, R16)

X3. Statistical analysis. Geneva, Switzerland, and Berlin, Germany. Data from 1850-1891. The maximum in thunderstorm frequency occurs when sunspots are fewest. (R4)

X4. Statistical analysis. Siberia, Russia. Data from 1888-1924. Thunderstorm frequency peaks when sunspot number peaks. (R5) This is, of course, just the opposite of X3. Does it indicate that the correlation is dependent upon geography?

X5. Statistical analysis. England. Lightning incidence records from 1930-1973. "There is a clear-cut cyclic variation in the thunderstorm incidence which varies with an 11-year cycle, in phase with the solar activity, and with an amplitude of ±30 per cent of the mean---a real enough effect indeed!" (R6, R7)

X6. General observations. Correlative evidence accumulating since 1926 suggests that there must be some physical coupling mechanism between solar activity and thunderstorm occurrence in middle to high latitudes. Such a link can be provided by alteration of



Lightning incidence compared with the sunspot number (X5) atmospheric electric parameters through the combined influence of high-energy solar protons and decreased cosmic ray intensities, both of which are associated with active solar events. The protons produce excess ionization near and above 20 km, while the Forbush decrease causes a lowered conductivity and enhanced fair-weather atmospheric electric field below that altitude. Consequent effects ultimately lead to a charge distribution similar to that found in thunderclouds, and then other cloud physics processes take over to generate the intense electric fields required for lightning discharge." (R8, R9)

X7. General observations. Thunderstorm frequency in some regions is positively correlated with sunspot number. The triggering mechanisms proposed are essentially those of X6. (R10)

X8. General observations. A detailed scenario in which cosmic rays initiate and control the development of lightning. (R11)

X9. August 1972. Worldwide phenomenon. "A direct observation of solar flare modification of thunderstorm driven electric fields is presented. During the August 1972 solar flares the vertical atmospheric electric field in the stratosphere decreased by at least an order of magnitude. The electric field decrease can be explained by a model in which the electrical conductivity is enhanced by ionization due to the solar protons. A global index of VLF whistlers shows a large increase at the time of the solar proton maximum, thereby indicating a possible worldwide high latitude enhancement in thunderstorm activity. Models of thunderstorm triggering mechanisms which are supported by these data will be discussed." (R12, R13)

X10. November 1979. Antarctica. "Last November, a sequence of balloons was launched at the same time as a major solar flare. At first, no changes in the weak air-to-ground currents were recorded but subsequent balloons showed a major rise over a period of two days, eventually saturating the electrosondes between 25 and 30 km height. This implies an increase in current of more than 70 per cent. The surge was followed by a gradual return to a normal weak current---clearly bursts of energetic particles from the flare enhanced the weak current. This could raise the frequency of lightning flashes in thunderstorms and increase their rain-producing activity. The Sun could be an external driving force on the severity of the 1500 or so thunderstorms which are active on Earth at any one time. The global circuit theory must now be modified to accommodate solar as well as thunderstorm effects." (R14)

X11. General observation. Electrification of the terrestrial atmosphere is strongly affected by cosmic rays. There also seems to be a thundercloud electrical mechanism that is sensitive to atmospheric electrification, so that thunderstorms (and lightning) are influenced by cosmic rays. (R15) Solar activity produces some of the cosmic rays incident upon the earth.

X12. Weather-station survey. For the years 1954-1976 in the eastern two-thirds of the U.S., the number of stations reporting a thunderstorm is correlated with solar activity in several ways. During the five days when a solar active region having a sufficiently high level of activity is near central meridian (CM) on the solar disk, the number of stations reporting a thunderstorm is abnormally large. The minimum number in this report occurs when the plage is 10-14 days past CM. The threshold of activity required to produce this effect is higher during solar maximum than during minimum. (R17)

X13. Measurements of electrical currents in the atmosphere. Data collected from electrosondes (balloons measuring atmospheric electrical currents) over the Antarctic ice caps infer that solar flares stimulate large surges in the flow of electrical charge from the upper atmosphere to the earth's surface. Because this unidirectional flow of fair-weather electricity must ultimately be balanced by thunderstorms somewhere on the planet, it follows that the frequency and severity of terrestrial thunderstorms are dictated, at least on the average, by solar activity. Formerly, global circuit theory had it that the thunderstorms themselves were the driving force behind the fair-weather current flow. Now it seems that the sun calls the tune and that thunderstorms do not arise at random. (R18)

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R3. Veeder, M. A.; "Coincidence of Sun Spots with Thunder-Storms and Auroras," Monthly Weather Review, 15:206, 1887. (X2)
R4. "Thunderstorms and Sunspots," Nature, 46:488, 1892. (X3)
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R14. "Solar Activity and Terrestrial Thunderstorms," New Scientist, 81:256, 1979. (X10)
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R17. Olson, Roger H., and Roberts, Walter O.; "On the Apparent Modulation of Thunderstorms by Solar Plages," in International Symposium on Solar-Terrestrial Influences on Weather and Climate, Boulder, 1982, (X12)
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GWS4 The Effects of Meteors on the Weather

Description. The correlation of weather phenomena with meteor showers, especially the apparent peaking of rainfall approximately 30 days after prominent meteor showers.

Data Evaluation. Several analyses of rainfall data indicate strong positive correlations with well-known meteor showers, but the correlation of rainfall with visual meteor rates is weak. Rating: 2.

Anomaly Evaluation. Although meteoric particles are acceptable nucleating agents and could enhance rainfall, the rainfall peaks should theoretically be spread out in time, but instead they are sharp. This puzzling detail is probably well within the explanatory capabilities of current theories. Rating: 3.

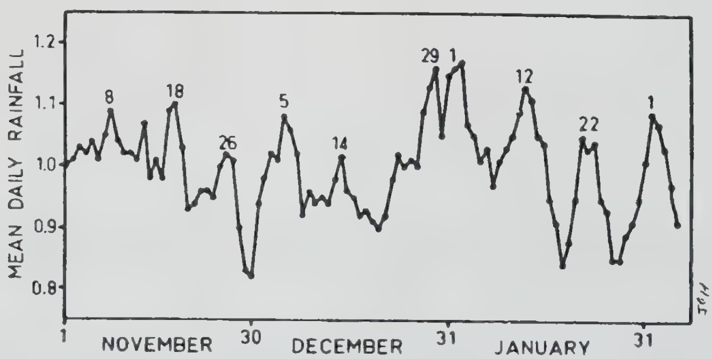
Possible Explanations. Meteoric particles serve as precipitation nuclei.

Similar and Related Phenomena. The correlation of lunar phase with terrestrial weather (GWS1), which may depend upon lunar modulation of meteor flux.

Examples of the Effects of Meteors on the Weather

X1. General observations. After a discussion of Erman's theory that the so-called "cold days" occurring in February, April, and May are due to the partial screens of the earth by meteor streams. "I have been in the habit of regarding Erman's theory as probably erroneous altogether, though noting that it would have to be accepted if any evidence were obtained showing the whole Earth, and not Europe only, to undergo these periodical refrigerations. Mr. Russell, Government Observer at Sydney, has recently published evidence which seems to go a great way towards proving that this really is the case. In Australia and in America, it would seem, the average temperature of the cold days is lower than it should be if the seasonal rise from January to July were steadily maintained. He also quotes evidence obtained in Galileo's time, which shows that the same peculiarity was recognized in Europe more than two centuries and a half ago. That sometimes the fall of temperature must have been very marked is shown by the existence of popular proverbial expressions, doggerel verses, and so forth, in reference to these cold spells." (R1) Little credence is given to this theory today.

X2. Statistical analysis. "Examination of rainfall figures for a large number of stations shows that there is a tendency for more rain to fall on certain calendar dates than on others. There is a close correspondence between the dates of the rainfall maxima in both the northern and southern hemispheres, and this is difficult to explain on a climatological basis. The effect might, however, be due to an extraterrestrial influence. The rainfall peaks occur approximately 30 days after prominent meteor showers, and it is suggested that they are due to the nucleating effect of meteoric dust falling into cloud systems in the lower atmosphere, the time difference being accounted for by the rate of fall of the material through the atmosphere. The hypothesis is tested for a particular meteor stream, the Bielids, which is known to have a 6.5-year period. The rainfall 30 days after the meteor shower is found to have a similar period. Furthermore, the phase of the rainfall periodicity is almost identical with that of the meteor shower. The data examined are confined to the month of January, and it



World rainfall as affected by meteor showers (the numbers above the peaks indicate specific meteor showers) (X2) is proposed to extend the investigation to other months in future papers." (R2)

X3. General review of the meteor hypothesis put forward in X2. Studies subsequent to X2 have established fairly firmly the reality of world-wide, annually recurring singularities in rainfall, which seem to require an extraterrestrial mechanism. The striking feature of the meteor hypothesis is the 30-day delay between the meteor shower and the rainfall peak. The peak is explained in terms of the time of fall of the meteoric particles; but the different rates of fall of the different sized particles should smear out the rainfall peak. On the contrary, the rainfall peaks remain sharp. (R3)

X4. Statistical analysis. "Abstract. Recently published data on the average hourly rates of visual meteors for each night of the year have been compared with the average daily precipitation of a number of stations for a 50-year period. No significant relation was found between meteor showers and precipitation although there was a very slight suggestion of a maximum in precipitation around 30 days after peak meteor activity.: (R4)

References.

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R4. Brier, Glenn W.; "Visual Meteoric Activity and Rainfall Singularities," Journal of the Atmospheric Sciences, 19:56, 1962. (X4)

GWS5 Correlations between Solar Activity and Weather

Description. The correlation in time of various weather-related phenomena (rainfall, temperature, droughts, tree-ring thickness, etc.) with solar activity as usually measured by sunspot number. In addition to the possible short-term direct influences of solar-flare ionizing radiation on weather, the literature abounds with a wide variety of lomger-term correlations of terrestrial weather with the 11-year sunspot cycle and the 22-year double-sunspot cycle. The major cyclic periods claimed in the literature are: 27 days, 11 years, 20 years, and 22 years. Most of these claimed correlations are weak and have been hotly debated. Often they have been rejected as statistical flukes.

The physical mechanisms underpinnning the several proposed correlations are usually unspecified. Sunspottery, as it used to be called, is mainly a statistical game of sorts. To make matters worse, some of the statistical methods employed sometimes introduce false periodicities. Beat frequencies have also been proposed.

Background. Ever since the sunspot cycle was discovered, it has been correlated with various natural phenomena including human activities. Wide extremes of opinion have been expressed from blind-faith in a sun-weather connection to outright ridicule and strong declarations that no physical mechanisms exist that could possibly connect the solar activity to terrestrial weather. Not surprisingly, the pertinent literature is extensive, and it is only sampled here.

Even after about 150 years of statistical study, most meteorologists remain unconvinced that there is a significant solar-activity effect on the earth's weather.

Data Evaluation. Century-long stretches of sunspot counts and abundant data on various terrestrial phenomena are buried in the archives of science. Statisticians have much to chew on. Actually, their sun-weather correlations can be rather impressive for very specific, usually short, time periods and limited geographical areas. But the correlations are often clouded by high noise levels, the superposition of several periodicities, including lunar modulation, and the improper use of statistics. Rating: 3.

Anomaly Evaluation. Scientists have proposed a few physical mechanisms that might link solar activity to terrestrial weather (see below), but their efficacies have not been demonstrated convincingly. The repeated appearance of a 20-year cycle---rather than 22-years---in some terrestrial weather phenomena might be solar-induced but there do not seem to be any robust solar phenomena exhibiting a 20-year cycle. In view of science's emphatic and usually justified dismissal of the mountains of published correlations, the actual appearance of any strong sun-weather correlation, backed by a reasonable physical mechanism, would be an important anomaly. In other words, the ruling paradigm is no significant sun-weather effect. Rating: 2.

Possible Explanations. Solar-wind periodicity, cyclic variations in solar heating of the earth, solar tides in the earth's atmosphere.

Similar and Related Phenomena. Weather correlated with lunar phase (GWS1); weather correlated with planetary configuration (GWS8); solar activity correlated with thunderstorm frequency (GWS3); solar cosmic rays correlated with lightning (GLL16 in Remarkable Luminous Phenomena...).

Examples of Correlations between Solar Activity and Weather

X1. 1859. Worldwide phenomenon. "M. Rudolph Wolf of Berne has shown that those years remarkable for abundance of solar spots have also been more than commonly rich in aurorae boreales. The greal auroral display at the commencement of September 1859, occurring about the time for the return of sun-spot maximum, and which seems to have been visible over the greater portion of both hemispheres, appears to have been the precursor of a great meteorological disturbance: in England and Northern Europe more than an average amount of cold, wind, and rain have prevailed ever since; in North America and India more than an average amount of drought and heat. The opinions of philosophers differ respecting the influence of a paucity or an abundance of solar spots upon the temperature and seasons of the earth; the probability is, there is simply a general disturbance, arising from increase of (solar) magnetic influence, which may produce greater heat and dryness in one part of the globe, and more cold and rain in other parts." (R1) These general thoughts about the sun-weather effect can hardly be made much more specific today, even after well over a century of correlations and more sophisticated research. See the recent skeptical opinions expressed in later entries.

X2. Statistical analysis. A presentation of tables of rainfall data from 18 stations at various localities around the world for different spans of time. "The above Table comprises the results of all the rainfall-tables I can find containing a maximum- and a minimum-period. Now we see that, in the maximum-sunspot periods of three years each, the rainfall at the eighteen stations was 395.85 inches greater than in the minimum-sunspot periods of three years each, and, which is still more striking, that the excess is on the side of the maximum-periods at fifteen out of the eighteen stations." (R2) At this point in history worldwide weather data were almost nonexistent, and the studies were necessarily crude by modern standards. (WRC)

X3. General observation. Comments on an article in the London Times linking the Indian famines (droughts) with the sunspot cycle. In essence, the whole idea is "absurd and ridiculous." (R3) Similar disdain is still expressed today.

X4. Statistical analysis. Worldwide data. "The idea that years of maximum sunspots are also years of abundant harvests, originally suggested by Sir William Herschel, has lately been brought into prominence through the labours of Mr. Meldrum, of the Mauritius, whose latest paper on the subject, published in the monthly notices of the

Mauritius Meteorological Society, gives figures based on the rainfall statistics of a large number of stations in different parts of the world. These seem to show that the average rainfall of the globe is subject to a regular fluctuation through periods of about 11 years, and that at its maximum, which occurs about a year later than the epoch of maximum sunspots, the mean fall is about 15 per cent. greater than at its minimum, which precedes that of minimum sunspots by one or two years." (R4, R5) Meldrum's careful analysis was an early benchmark in sun-weather analysis. (WRC)

X5. Historical review. Sir William Herschel's 1801 papers on a possible connection between the solar cycle and our weather are resurrected. Long quotations from Herschel's papers reveal that he proposed that variations in the quantity of solar heat reaching the earth might contribute to the cyclic variations in weather. (R5)

X6. General observations. A rambling dissertation on how the sunspot cycle might affect both terrestrial weather and human activities. Written in memory of Stanley Jevons, an early and prolific proponent of "sunspottery." The only pertinent data are the following observations, which are fairly typical of 1883: "Of late years the rainfall of the British Islands has become an object of special study and investigation, with amateurs as well as paid officials. Mr. J. J. Symons, of the Meteorological Society, who has recently published statistics gathered from numerous quarters, takes occasion to refer to the existing caprice of heaping ridicule on the astronomical precedent of referring the phenomena of Nature to fixed and pre-determinate laws. He calls attention to the circumstance that the wettest years in England of late prove to have been 1836, 1841, 1848, 1852, and 1860, and that the first, third, and fifth of these years fall into a twelve-year period. He further calls attention to the circumstance that the driest years in England of late prove to have been 1826, 1834, 1844, 1854-5, 1858, and 1864, and that the second, third, fourth, and seventh of these fall into a ten-year period. Now it is at once manifest that the twelve-year period of wet years he here indicates coincides with the solar cycles, and that the dates only differ by two years on the whole from the epochs of most sun-spots assigned by Prof. Wolf. The ten-year period of dry years, which alternates with these wet years, which then consequently correspond to the minima years of solar spots, from which in three of the instances they differ but one year." (R6)

X7. Statistical analyses. Following a short history of sunspot-weather correlations, a statement by Arthur Schuster, "There can be no longer any doubt that during about four sun-spot periods (1810 to 1860) a most remarkable similarity (existed) between the curves representing sun-spot frequency and the curves of nearly every meteorological element which is related to temperature. This is not, in my opinion, a matter open to discussion: it is a fact. But it is equally certain that during the thirty or forty years previously to that time so such relationship existed, and that since 1860 the connection has again in some instances become less distinct." "In so far as regards the temperature of the globe, these conclusions are almost identical with those enunciated by Prof. Koppen, in a paper published in the April-May Heft of the Austrian Meteorological Zeitschrift for 1881, and indeed the apparent discrepancy of the temperature and sun-spot curves after 1858 had been indicated by him in his former paper, published eight years earlier. But this discrepancy did not set in simultaneously in different parts of the globe, nor has it been such as to obliterate all trace of the sun-spot cycle in the temperature curves. During about four cycles previous to 1858, the temperature of the tropical zone rose and fell with somewhat striking regularity inversely as the spotted surface increased or diminished, so that the highest temperatures approximately coincided with the sun-spot minima, and the lowest with their maxima." (R7) Almost a century ago the complexity of the sun-weather relationship was appreciated, as correlations waxed and waned. (WRC)

X8. Statistical analysis. Scotland. An unbroken series of rainfall data from 1800 shows good correlation with the sunspot cycle. (R8)

X9. Statistical analysis. Jamaican rainfall data from 1870-1910. "Excepting the rainfall minimum in 1875 the minima for rainfall follow solar maximum and minimum by one and a half or two years. The rainfall maximum between the minimum are more irregular." (R9) Spelling is as in the original article.

X10. Statistical analyses. Christiania, Norway, and Greenwich, England. Mean temperatures for both locations show strong correlation with the sunspot cycle. (R10)

X11. 1911. Opinion ventured that the unusual diminution ot ultraviolet radiation from the sun caused an extremely dry summer in Europe and a very wet winter in South America. Fewer condensation nuclei thought to be the underlying reason. (R11)

X12. Statistical analysis. Montezuma, Chile, and Washington, DC. "Regular observations of the sun's radiation are made from a station at Mount Montezume, Chile, a mountain 9,000 feet high in the Atacama desert, and these show that the sun does not always radiate the same amount of heat. Instead, it varies from day to day, even after allowances are made for the effect of the earth's atmosphere. In a study of these variations since January, 1924, Dr. (C.G.) Abbot has found 98 cases of rapid increase of the radiation of heat and 91 of decrease, in each case the change taking about four or five days. Dr. Abbot has studied the temperature variations at Washington at the times of each of these increases and decreases. Taking the temperature just before the beginning of the solar change as normal, he finds that as the solar radiation varies, the temperature also changes, and that the change in temperature continues until at least four days after the maximum or minimum of radiation. A change in the radiation of eight-tenths of a per cent is accompanied by a temperature change of about five degrees. At times when increase of radiation is accompanied by an increase in temperature, a decrease of radiation is generally accompanied by a decrease in temperature. This is taken by Dr. Abbot as rather conclusive proof that the changes are not mere coincidences. A curious feature of the results is that an increase of radiation is not always accompanied by an increase in temperature, or vice versa." (R12)

X13. Statistical analysis. Egypt. Flood and low stages of the Nile. "A remarkable series of yearly records of high and low levels of the Nile at the Roda gage, Cairo, from 622 A.D. to 1470 has been published by Prince Omar Toussoun. The original records are in cubits and dated in Mohammedan years. One list from 640 to 1451 was published in 1923. Another list from 622 to 1470 in metric equivalents and corrected to the modern calendar was published in 1925. These two lists differ slightly and after careful examination of the graphs of both lists it was decided to use the first one, making a few corrections to readings, evidently misprints, by comparison with the later list and supplying a number of missing years. Five-year means have been computed for both flood and low stages. The 11-year period. The influence of the 11-year solar period on the flood stages is shown by an excessive predominance in the 5-year means of the two intervals. over the normal frequency for random numbers, 50 percent vs. 40 percent. As for the minima there is a relative excess of the four- and five-intervals, indicating a 20- to 25-year period." Longer periods evident in the analysis are 37, 83, and 300 years. (R13)

X14. Statistical analysis. Severe winters in Europe. "Records of unusual meteorological events are abundant in European literature. The occurrence of severe winters has been very consistently recorded, and Bruckner, by means of this material, was enabled to extend his 35-year cycle, deduced from modern instrumental records, back to the year 1000..... To extend the series backward, I have used Hennig's catalog which is very complete. Easton's list was also consulted. Employing the method used by Bruckner, the total number of severe winters in the 20-year interval centered on every fifth year were counted and the numbers from 340 to 1030 together with his numbers from 1030 to 1775 are shown graphically.... The 37-year period. Maxima and minima are quite definitely apparent except in a few instances where data are lacking." There are indications of 83- and 300-year periods, too. (R13)

X15. Statistical analysis. Wheat prices in England. "In a paper published after his "Klimaschwankungen", Bruckner concluded from an examination of wheat prices in western Europe for 200 years that high prices occur during or shortly after periods of maximum rainfall. Beveridge computed yearly index numbers of wheat prices in England from 1500 to 1870 by expressing them as a percentage of 35-year moving averages. His periodogram of wheat prices shows a period of considerable amplitude at 35.5 years." (R13)

X16. Statistical analysis. Tree growth in Arizona and California. Measurements of tree growth rings in California (sequoias) and Arizona (yellow pine) demonstrated the existence of climatic periods of 37, 83, and 300 years. (R13)

X17. Statistical analysis. Levels of the Great African Lakes, 1900-1930. "In 'The Hydrology of Lake Tanganyika'.... C. Gillman gives us for the first time a picture of the fluctuations in level of Lake Tanganyika. To it he adds C.E.P. Brooks's curves of

Victoria and Albert and F. Dixey's of Nyasa, brought up to date, and the curve of sunspot numbers. Excepting the abnormality in Nyasa dating from the closing of the Shire outlet (1924), the trends of the lake fluctuations are similar and the correlation with the sunspot curve close. Mr. Gillman, however, cautions against too facile an interpretation. He points out that in 1929 when Victoria, Albert, and Tanganyika were at a distinct low, sunspot numbers soared, and when in 1930-1931 the numbers declined, there was a rise in lake level. Before 1902 also Victoria seems to have 'reacted incorrectly.' While we are still far from a solution of the problem, much is to be hoped from simultaneous study of all four lakes, with their broad regional similarity and their individual differences." (R14)

X18. Statistical analysis. Greenwich, England. The sunspot cycle is barely seen in 100 years (1764-1863) of mean temperature data from Greenwich. (R15)

X19. Study of post-Pleistocene climates. Abstract. "The most conspicuous climatic aberration of the past two millennia was the temperature decline and glacial advance of the A.D. 1550 to 1900 period. This temperature decline has been correlated with an interval of lower solar activity and there is evidence from both the post-Pleistocene glacial record and from oxygen-18 analysis that such an interval has recurred at cyclic periods of around 2400 to 2600 years." (R16)

X20. Statistical analysis. "...two investigators, Walter Orr Roberts, president of the University Corporation for Atmospheric Research, and Roger H. Olson, an Environmental Data Service research meteorologist with NOAA, appear to have confirmed a statistical relationship between the behavior of certain atmospheric features over the Gulf of Alaska and geomagnetic storms. Apparently, low-pressure troughs found at the 300-millibar level tend to intensify or deepen, in response to storms in the geomagnetic field, which are marked by displays of auroras. Trough development in that geographic area has an important influence on North America's weather. About one-third of the Gulf of Alaska'a low pressure systems eventually move into the central United States. Those preceded by northern lights penetrate about 200 miles farther south, and bring cooler weather with them. Although not all large troughs are triggered by northern lights and not all auroras are followed by trough development, the probability of the trough's intensifying seems to be approximately doubled by the occurrence of a magnetic storm.....Still, the results of the entire study are perplexing to the scientists because there is no proven physical explanation for them. Regarding mechanisms to explain the findings, they speculate that the geomagnetic control may come about through trapping of the black-body radiation normally lost to space over the relatively warm Pacific during these winter months. This could be the result of cirrus cloud formation by phenomena associated with the geomagnetic disturbance. Other alternative explanations may involve changes in ozone content, and possibly increased thunderstorm activity." (R17)

X21. Statistical analysis. Tree ring data from the western United States from 1700 to date. "No evidence was found for any influence of the 11-year cycle, but there is a very strong match between periods of drought and the 22-year double sunspot cycle (the Hale magnetic cycle). The area covered by drought tended to reach a maximum about 3 years after every other minimum in the 11-year cycle, with the most recent well-documented drought being that of the mid-1950s, correlating with the sunspot minimum of 1954. (The drought of the 1970s seems to be correlating with the sunspot minimum of 1976.) The time between droughts averaged 20.4 years, whereas the average double sunspot cycle is 22 years. The reason for this apparent discrepancy is that the best coherence between drought area and sunspots comes during times when the sunspot maxima are high. It is during such periods that the time between successive maxima and minima tends to be smaller. When the sunspot numbers are small, the period of the cycle increases, and the correlation with drought area becomes weak." (R18) These data hardly support those of X16. (WRC)

X22. Review paper. Several studies now confirm a solar influence on atmospheric circulation at the 300 millibar level and below. The passage of solar-sector boundaries seem to affect the vorticity of the atmosphere. (R19)

X23. Review of a lecture by J. W. King of the Appleton Laboratory. "...the new work from the Appleton Laboratory concentrates instead on much shorter term influences, associated with the roughly 27.5 d rotation period of the Sun. The 'signature' of this rotation shows up clearly in such meteorological parameters as the height of the 500 mbar pressure level in the atmosphere, as well as influencing ionospheric properties. In some danger of numbing his audience with overkill at times, King hammered home the reality of these links with a wealth of data, the most intriguing of which showed clear geographical variations of the magnitude and even sign of the atmospheric changes produced by the Sun. Small wonder, then, that global averages over long periods show much less indication of any solar influence on weather!....The Appleton team have now found that not only does a solar flare produce a disturbance of the atmosphere, commencing some four days after the flare, as shown by the work of Olson and others, but that the atmospheric disturbance is repeated at 32 and 60 days as well, one and two solar rotations later. In at least one case, an effect on the atmosphere is also found at -24 d, that is one solar rotation before the flare became apparent. So a specific region of the Sun which is involved in some disturbance can affect specific regions of the Earth's atmosphere over a period of 2-3 months---and, equally, the effects of solar activity which are disturbing the atmosphere today must be the integrated effects of several such past disturbances, which suggests that we should not find any simple relation between what the Sun is doing today and what the atmosphere does tomorrow." (R20) But see the following entry. (WRC)

X24. Summary of the Ohio State University Sun-Weather Conference, July 24-28, 1978. Many of the presentations were skeptical of the reality of any sun-weather effects, as typified by the following: "The chief skeptic by far, was A. B. Pittock, temporarily of the University of Arizona. He cast strong doubts on many published reports of correlations between weather and the various solar cycles (such as 27 days, 11 years and 27 years). The 27-day cycle was also attacked by others, who pointed out that it is difficult to distinguish between 27-day solar and lunar effects." (R21)

X25. Review paper. Abstract. "During the past century over 1,000 articles have been published claiming or refuting a correlation between some aspect of solar activity and some feature of terrestrial weather or climate. Nevertheless, the sense of progress that should attend such an outpouring of 'results' has been absent for most of this period. The problem all along has been to separate a suspected Sun-weather signal from the characteristically noisy background of both systems. The present decade may be witnessing the first evidence of progress in this field. Three independent investigations have revealed what seem to be well resolved Sun-weather signals, although it is still too early to have unreserved confidence in all cases. The three correlations are between terrestrial climate and Maunder Minimum-type solar activity variations, a regional drought cycle and the 22-yr solar magnetic cycle, and winter hemisphere atmospheric circulation and passages by the Earth of solar sector boundaries in the solar wind. The apparent emergence of clear Sun-weather signals stimulated numerous searches for underlying causal links." (R22)

X26. General observations. "There is a general consensus among meteorologists and climatologists that for reasons unknown to them, quiet Sun produces severe winters whereas the appearance of colder sunspots on the solar disk produces warmer winters on Earth. Severe winters appear to correlate well with the solar cycle. There is also evidence of enhanced cloud cover and thunderstorm activity, and anomalous rainfall patterns which follow solar flare and auroral activities. To explain some of the features, physical mechanisms based on changes in the character of solar particulate and electromagnetic radiation and their interactions with the Earth's atmospheric, hydrospheric and magnetic environment were proposed in an earlier paper. This hypothesis is further advanced to explain the anomalous rainfall pattern, i.e. increased rainfall at 55°N and reduced rainfall at 35°N latitudes following solar flare activity. The explanation involves interaction between descending streams of charged particles with global circulations in the presence of Earth's magnetic dipolar field whose axis does not coincide with Earth's North-South geographic axis." (R23)

X27. Statistical analysis. "In a recent paper, Nastrom and Belmont have found an interesting correlation between the 11-year sunspot cycle and the upper troposphere and lower stratosphere. They have thoroughly and carefully analysed data from the Northern Hemisphere for a period covering 1949 to 1973, i.e., just over two solar cycles. Their results indicate that during the winters of this period, the average position and, to a lesser extent, the strength of the jet stream and the intensity of features such as the Siberian upper level trough, have a strong correlation with solar activity. It is not so much the statistical significance of the results which is surprising, but rather that in certain areas of the hemisphere 50% of the interannual variance is explained." (R24)

X28. General observation. "Despite almost 180 years of study, we have little evidence to support the hypothesis that solar activity significantly affects the troposphere. There is a plethora of statistical correlations, but many of these have been produced by over-filtering and selecting the data and the remainder have nearly all failed where the data sets have been extended in time." (R24) This comment of course applies to correlations with lunar phase.

X29. Statistical analysis. After noting that climatic oscillations with a period of about 20 years have been detected in U.S. midwest drought records, dendrochronological data, and sea surface temperature anomalies, the authors present their studies of Greenland ice core records. "To gain more insight into such 20-yr oscillations, we have examined characteristic oscillations in Greenland ice core oxygen isotope records. The results show that the strongest spectral peak occurs at a period of 20 ± 0.5 yr with a statistically significant amplitude. This period is essentially the same as that found in eastern North American winter temperatures. Moreover this 20-yr oscillation is found to be coherent in phase with the dominant variation in the Sun's motion about the centre of mass of the Solar System. This motion has been hypothesised to be closely linked with sunspots. On the basis of these observations we speculate here that a 20-yr oscillation may be a more fundamental solar and/or climatic oscillation than the nominal 22-yr cycle often mentioned." (R25)

X30. Statistical analysis. Abstract. "July Palmer Drought Severity Indices (PDSI) have been reconstructed for the Hudson Valley region of New York State from the annual ring-width variations of local old trees. Using additional, subsequently developed tree-ring chronologies, we have developed a new July drought reconstruction that extends back to 1694. Variance spectra of the new PDSI series reveal statistically significant quasi-periodicities of 11.4 and 26 yr." (R26) The 11.4-year period is, of course, close to that of the sunspot cycle, while the 26-year period correlates with the soli-lunar tidal period.

X31. Statistical analysis. Leona M. Libby and colleagues at the University of California at Los Angeles have found periods of 10.4 and 6.7 years in sequoia tree rings dating from 2,000 years ago, using isotopic measurements as indicators of temperature. There was, however, no trace of the 21-year solar magnetic cycle. (R27)

X32. Statistical analysis. Studies of North American temperature records by Robert Currie, Goddard Space Flight Center, reveal the 11-year sunspot cycle to be present in temperature data east of the Rockies and north of about 35°N. The winds in this region are part of the circumpolar vortex that helps determine the climate of the earth. (R27)

X33. Statistical analysis. "In 1980, Minze Stuiver of the University of Washington compared ten different records of climate from around the world with the varying carbon-14 content of tree rings over the last 1000 years; carbon-14 is an indirect measure of changing solar activity. Stuiver failed to find a significant correlation between solar activity and any of the climate records." (R28) Obviously, conflicting results, such as this and X30-31, make for a muddled picture and undermine confidence in the reality of solar influence. (WRC)

X34. Statistical analysis. Records of drought from the American west, added to newly obtained data from the Great Plains, show the 22-year solar magnetic cycle very strongly---at a high level of significance. (R28)

X35. Statistical analyses. Examination of drought records from the American west (X34) seem to show that in addition to the the 22-year solar magnetic cycle there exists a 18.6-year effect of lunar tidal action. These cycles are superimposed on one another, making a most confusing situation. (R29)

X36. Statistical analysis. 1784-1869. A positive correlation was found between the sunspot number are: March-April rainfall in France; arrivals of birds in France; thickness of annual growth rings in sequoias; commodity prices in Great Britain and Ireland; and auroral frequency. (R30)

X37. Statistical analysis. A review of studies of tree-ring growth cycles. Concluding statements. "In a general way it is safe to say that the sunspot cycle and its double and triple value are very general. The double value has persisted in Arizona for five hundred years and in some north European localities for the century and a half covered by our tree groups. The triple period, essentially Bruckner's cycle, has operated in Arizona for the last two hundred years and in Norway for four hundred at least. A hundred-year cycle is very prominent throughout the three thousand years of sequoia records and also in the five hundred years of yellow pine. It is still uncertain whether the eleven-year cycle can be judged by the variations in its double value, which, from the absences of certain interfering periods, is more easily traced through long periods. But a very incomplete review of the sequoia record suggests that from 1300 B. C. to well after 1000 B. C. the eleven-year cycle was well developed; then it slowly decreased. From 300 B. C. on it was increasing and was very conspicuous during the first two centuries of our era. Then it decreased, and from 400 to 650 A. D. was only occasionally evident. From 650 to 850 or 900 it seems fairly continuous. Then it appears only occasionally until about 1250, when it again becomes fairly continuous, except for the changes in the seventeenth century above noted." (R31)

X38. Statistical analysis, 1871-1973. New York, New York. The January mean temperatures show a strong 20-year cycle. (R32)

X39. Compilation of statistical coefficients. During the 1920s and 1930s, H.H. Clayton collected a large body of statistical evidence for the existence of causal links between solar activity and various terrestrial weather phenomena. In this paper (62 pp. long), he presented a summary table of 20 such correlation coefficients between solar activity and a rather disparate group of weather data collected from many weather stations.

For example, the first six table entries presented coefficients "Between monthly mean temperature 0 to 4 months succeeding high and low months of solar radiation of the years 1905 to 1925 from stations at Nome, Juneau, Edmonton, St. Johns, Hatteras, and Key West." The table continued with similar rather obscure relationships.

Clayton justified this sort of narrowly focussed statistical approach with:

"As it has seemed to me that heretofore critics have been apt to overlook many of the evidences favorable to solar variation and its influence on weather, perhaps because these were too numerous and extensive to be mentally digested."

Remember that a significant sun-weather relationship was generally denied by meteorologists at this time, and Clayton was fighting an uphill battle. In truth, though, Clayton's 20 sun-weather "connections" are too fragmented to be very convincing.

See X41 for another similar paper in this long series of studies by Clayton.

X40. A 1933 summary of sun-weather connections. In 1933, C.G. Abbot was secretary of the Smithsonian. He was also deeply immersed in attempts to correlate solar activity and terrestrial weather. Abbot also supported Clayton's studies described in X39 and X41.

In the present paper, Abbot presents four major conclusions he had arrived at during his personal studies of the sun-weather connection. The first two of these conclusions are recognized as potential, probably minor, contributors to terrestrial weather by today's meteorologists, but they weren't in Abbot's day.

"1. The principal departures from normal climates which comprise 'weather' are due primarily to a group of periodic variation's of the sun's radiation rather than to terrestrial complexities as has been generally supposed.

"2. Sunspots are associated with important modifications of weather not hitherto recognized.

"3. Important periodicities in solar variation have their least common multiple of 23 years. As a consequence, weather repeats itself in all parts of the world with 23-year intervals...

"4. At many stations this cycle in weather enables us to forecast general conditions of temperature and precipitation for many years in advance..."

Conclusions #3 and #4 are not accepted today, especially #4.

X41. Overview of world weather and solar activity. In the sixth of a series papers supported by the Smithsonian, H.H. Clayton stressed three general observations.

"1. The world-wide correlations of atmospheric changes, as indicated by a similarity in these changes in both the Northern and Southern Hemispheres and in widely separated continents and oceans. In some cases the changes are directly similar, and in others the changes are directly opposite---that it, when one increases the other decreases.

"2. A relationship is found between atmospheric changes and sunspot activity, and an even closer relationship with changes in solar radiation.

"3. Centers of action in the atmosphere are found to shift position uner the influence of changes in the intensity of solar activity..." (R37)

Modern meteorologists probably see much that is naive in the above assertions!

X42. Statistical analysis. Circa 1945, C.G. Abbot, in a 44-page paper, set down 18 key observations supporting his hypothesis that terrestrial temperatures depended upon variations in solar radiation. For a sample, we quote from his number 5.

"Main results : Solar changes affect weather for about 20 days; produce major effects on temperature which are generally opposite for rising and falling solar activity; and may alter temperatures by 10° to 15° F. as much as 10 days after the zeroth day, depending on whether the solar radiation has increased or decreased." (R38)

X43. Sunspots and Canadian weather. In 1936, A. Thomson downplayed the usefulness of sunspots in weather forcasting.

"Variations in the period and amplitude of sunspot fluctuations are so great that that the number of sunspots present a year or so in advance cannot be accurately forecast. Hence seasonal weather forecasts based on sunspot numbers are unreliable." (R39)

An obvious blow to believers in a strong sun-weather connection and the usefulneess of sunspots in predicting weather..

X44. Statistical analysis. Sunspots and Canadian weather. Thunderstorm frequency and temperature at Toronto are inverse to the sunspot cycle. In general, however, correlations of sunspots with Canadian weather are not straightforward.

Again, only a highly focussed correlation had been found amidst confusing data from elsewhere.

The author of the referenced paper, R.E. De Lury, made an interesting comment regarding precipitation and Canadian geography.

"Investigation of the sunspot influence on precipitation has led us to what is considered to be a fundamental concept, namely, that there are two ideal responses to the sunspot cycle, the one an oceanic or aquene response, the other an inland or terrene response, the former in direct phase with the sunspot cycle and the latter in inverse phase." (R40)

Why these two effects exist was an unanswered in 1938. In fact, we never see the words aquene and terrene in the modern literature.

Interest and research in "sunspottery" and weather declined during World War II. Our files are empty from 1938-1976!

X45. Statistical analysis. Eastern North American temperature records. Roughly four decades after the Smithsonian and Canadian studies, statistical correlations again became fashionable. S.J. Mock and W.D. Hibler examined the temperature records from 19 stations in eastern North America from their beginning up to 1974/1975. Many of the records are over a century long. They reported the following.

"It has been argued that there is little or no reliable evidence for 11- or 22-yr cycles in meterological time series, and that even if a spectral peak exists, the identified cycle may not maintain its phase and amplitude sufficiently to allow prediction. To investigate this we have examined January temperature records for 19 stations in eastern North America. Our results show that: first, a pervasive 20-yr peak exists in the spectra of January temperatures in eastern Canada and the United States; secondly, the 20-yr oscillation was largely in phase over this region until approximately 1960; and thirdly, the predictability of this oscillation is, at best, only marginal." (R41)

Two points of interest here are: (1) the cycle is 20 years long, far short of the double-sunspot cycle; and (2) the implied loss of phase after 1960. What happened then?

X46. Sun-weather cycles and autosuggestion. A.B. Pittock, in a 1978 symposium presented a rather unflattering review of past studies of the frequently claimed influences of sunspots on the earth's weather.

"It is concluded that despite the great number of papers on the subject, little convincing evidence has been produced for real correlations between sunspot cycles and weather or climate, although evidence of correlations between weather and solar events on time scales of days appears to exist. The conclusions tend to support Monin's impression of successful experiments in autosuggestion and Gould's recent suggestion that unconscious manipulation of data may be a scientific norm." (R42)

In essence, Pittock opined that many sun-weather researchers were seeing only what they wanted to see in their data!

X47. Solar electrifcation of the earth's atmosphere and weather. R. Markson suggested in a 1978 issue of Nature (273:103) that variations in solar radiation might modify the electrical structure of the earth's atmosphere in ways that could account for some of the many published sun-weather correlations.

Finally, someone was proposing a physical mechanism that might explain some of the correlations---an element sadly lacking in the sun-weather studies.

L.C. Hale, however, asserted that available evidence did not support Markson's suggestion, especially in the matters of ionization levels and the 1979 models of the atmosphere's electrical structure. (R43)

In a companion letter in Nature, Markson answered Hale's objections, adding:

"An attempt to explain solar-weather relationships as due to ionospheric and magnetospheric electrical processes is understandable, however, these do not seem applicable to the problem. Upper atmospheric currents and particles would introduce energy into the atmosphere orders of magnitude too small to affect weather processes." (R43)

In other words, correlations of terrestrial weather with solar activity probably cannot be explained by the impact of the sun's particulate radiation on atmospheric electricity!

X48. Statistical analysis. See: GWS1-X33.

X49. The sun and global warming. In 1984, Arctic and Antarctic temperatures warmed in step---a strong sign of global warming. Some scientists saw these observations to be the consequence of "the internal complexities of the global climate system;" that is a purely terrestrial phenomenon. It was, nevertheless, admitted that changes in solar activity might be involved. (R45)

X50. Statistical analysis. North American Corn Belt. See results in GWS1-X36. (R46)

X51. Statistical Analysis. North American Corn Belt. See reults in GWS1-X37. (R47)

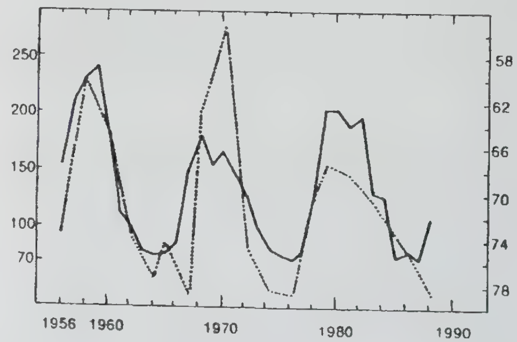
X52. Statistical analysis. In the middle 1980s, meteorologists in general had concluded that the many proposed links between solar activity and terrestrial weather---such as cataloged here in X1-X51---were unconvincing and revealed no significant cause-and-effect relationship.

But in 1987, K. Labitzke at Berlin's Free University was struck with the idea that perhaps the oft-proclaimed but widely doubted solar-weather connection might show up clearly only under special conditions.

The special condition chosen for analysis by Labitzke was the QBO (Quasi-Biennial Oscillation). The QBO is a period that occurs every 2 or 3 years when the wind in the equatorial stratosphere reverses its direction. [We do not know her reasons for selecting this obscure phenomenon.]

"It suddenly occurred to her to plot on one graph the wintertime temperature at about 23 kilometers over the North Pole during west equatorial against sunspot number....When Labitzke plotted only pole temperatures from the QBO's west phase, a strong correlation became clear."

Labitzke's correlation was so strong that many long-time doubters of such sun-weather correlations were impressed. However, a physical mechanism for the correlation was not apparent. How could the weak solar-cycle variations, which were observable mostly in the ultraviolet and affected only the earth's thin stratosphere, trickle down and perturb the much more massive troposphere. (R48)



Example of a claimed strong correlation in time between a measure of solar activity (left ordinate, dotted line, solar 10.7-cm flux) and the temperature in the North Pole stratosphere (right ordinate, solid line, in °C). (X52)

X53. Statistical analysis. A 1987 Science News story covered Labitzke's discovery and supporting work by H. van Loon. Even though Labitzke's correlation was strong, meteorologists still had reservations. Some of these reservations were doubtless based upon the "disreputable" past history of sun-weather correlations. Van Loon himself remarked: "This is purely statistics, and we don't understand the physical mechanism. Until we understand it, we should not use statistics to form predictions." (R49)

X54. Statistical analysis. In the September 8, 1988, issue of New Scientist, van Loon and Labitzke collaborated in writing a popular account of their work mentioned in X52 and X53. Their article ended with another warning.

"Our analyses are nothing more than statistics. We can only be sure that we are right if someone can explain how such a large influence on the atmosphere can be produced by comparatively small changes in the energy output of the Sun during the solar cycle." (R50)

X55. Overview of the reception of the Labitzke correlation. Toward the end of 1988, the sunspot-weather connection proposed by Labitzke was still holding up but still unexplained physically. Its long survival surprised the many skeptics who were sure that it was just a fluke and would soon go away! (R51)

X56. Statistical analysis. Labitzke's work was supported in 1988 by some data published by B.A. Tinsley. He showed that the storm tracks in the North Atlantic Ocean were anticorrelated with the solar cycle only when the QBO (Quasi-Biennial Oscillation) was in its west phase. (R52)

The Sourcebook's sweep of the literature is fairly broad, but we have found no further discussion---positive or negative---of the Labitzke correlation. It must be noted, though, that this correlation, if it is sustained, is very narrow in its scope. The sun's impact on terrestrial weather, if it really exists, is slim and spotty.

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GWS6 The Influence of Lunar Phase on Atmospheric Ozone

Description. The apparent increase in the amount of atmospheric ozone at the vernal equinox about the first and third lunar quarters, with a corresponding descrease at the same phases at the autumnal equinox.

Data Evaluation. A single study with data from only two stations. Rating: 3.

Anomaly Evaluation. The mechanism by which the moon's position could influence the production of atmospheric ozone is a mystery, and there are few obvious candidates considering our present knowledge of geophysics and astronomy. Rating: 2.

Possible Explanations. Since the lunar effect appears when the earth crosses the plane of the ecliptic, one suspects a lunar shielding of the earth from some ozone-producing mechanism confined to that plane.

Similar and Related Phenomena. Lunar phase correlated with thunderstorms (GWS2); lunar phase correlated with rainfall (GWS1).

Examples of the Influence of Lunar Phase on Atmospheric Ozone

X1. Statistical analysis. "Abstract. Evidence is presented for a lunar effect on the amount of atmospheric ozone at Arosa in Switzerland and Canberra in Australia. The amount of ozone increases at the vernal equinox about the first and third lunar quarters and decreases at the same lunar phases at the autumnal equinox. There is no effect at midwinter or midsummer. The explanation of this lunar effect is unknown, and further investigation is needed." (R1)

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GWS7 The Lunar Temperature Effect

Description. Near the time of the full moon, the increase in polar air temperatures over those prevailing at the time of the new moon. At mid-latitudes, the effect is reversed, while in the tropics the effect is negligible.

Data Evaluation. The older literature provides some striking examples of the lunar effect at several, but not all, mid-latitude stations. Modern satellite instruments reveal a full-moon, polar-air warming and also confirm the mid-latitude depression of temperature minima. Rating: 2.

Anomaly Evaluation. The lunar tidal action on the earth's atmosphere and the earth's closer approach to the sun at the full moon are possible warming mechanisms, but they would not not account for the mid-latitude cooling at full moons. Rating: 2.

Possible Explanations. See above.

Similar and Related Phenomena. The moon's effect on the weather (GWS1); on thunderstorms (GWS2); on atmospheric ozone (GWS6), and on cloud cover (GWC11).

Entries

X0. Introduction. Given the moon's small size, great distance from earth, and cold surface, one would not expect it to have any influence at all on the earth's temperature. But our file on this subject reveals an "old" series and a "new" series of terrestrial temperature observations that belie our expectations and perplex scientists.

The "old" series began in 1857 and was still under discussion as late as 1953. Our file indicates that the "new" series did not begin until 1995---42 years later. Curiously, the "new" series never mentions or references the "old" series!

The full moon is the "force," rather the indicator of some unperceived influence or mechanism, in both series. In the "old" studies, this full-moon "force" usually depressed average minimum temperatures at various mid-latitude ground stations; while the full-moon influence in the "new" studies, as measured by satellites, correlated with a slight elevation of average maximum polar temperatures! The satellites also confirmed a dip in mid-latitude temperature minima seen in the "old" series ground-based data.

When reading the eleven referenced papers, it is apparent that the lunar effect on earthly temperatures is complex. It varies geographically and is not always punctual when the full moon rises! (X5) At some weather stations, the effect is completely absent in the "old" series. (X5, X6)

Below: "old" studies: X1-X8; "new" studies: X9-X10.

X1. Statistical analysis. A period piece. "The author commenced by saying that, although the question of lunar influence on the atmosphere of our planet was very generally considered as set at rest by the investigations of M. Arago, yet he felt very confident that he was in a position to prove the law he was now about to announce without fear of contradiction. He had reduced and thrown into the form of tables and of curves 280 lunations, with the corresponding mean temperatures; and the laws at which he had arrived were, first, between the first and second octant the temperature immediately after the first quarter, both on the average, and also, with rare exceptions, in each individual lunation is higher than the temperature shortly before the first quarter; secondly, and more particularly, the mean temperature of the annual means of the second day after the first quarter (or the tenth day of the moon's age) is always higher than that of the third day before the first quarter (or the fifth day of the lunation). The tables and curves accompanied the essay, which illustrated these laws at great length." (R1, R2) R1 is a summary of R2, which is more difficult to comprehend, if that is possible!

X2. Statistical analysis. North Wales, 1947-1951. Daily records of mimimum temperatures have been kept during many years by observatories and meteorological stations, but such records have appeared in the form of long columns of numbers, among which an abnormality might remain unnoticed, unless special search were made for it. In a previous publication from similar lists of minimum night temperatures taken in North Wales, monthly graphs were drawn, with temperatures as ordinates and days of the month as abscissae, for each of the years 1947, 1948, and 1949. When temperature curves were drawn, there appeared a regular fall in the minimum night temperature at or near the date of full moon at each lunation during the three years.... The temperature fall was sometimes gradual, its incidence being as much as a week before and its lowest point occurring on the date of full moon, or generally within 48 hr of it. Mostly, however, the curve of the fall was more sudden, being limited to 2 or 3 days." The author also acquired temperature records from other stations around the globe, which confirmed the lunar effect detected in the data from Wales. (R3) In a second paper, the author noted that the fall of minimum temperature near the full moon was less in the summer than in winter; a phenomenon paralleling oceanic low tides. He then postulated that the temperature effect, too, was tidally induced and due, perhaps, to the adiabatic expansion of the atmosphere under lunar influence. (R4)

X3. Statistical analysis. Syracuse, New York. Data from 1931-1946. "The results were striking. During the summer period there is a gradual increase in temperature from just prior to the new moon until a week after the full moon, followed by a rapid fall of 4^{o} within the next week. The lowest point is reached two days prior to the new moon. The situation during the winter period is not quite as clear-cut. From just prior to the new moon until the first quarter, an irregular but marked rise in temperature takes place, over a range of approximately 4^{o}. Between the first quarter and the full moon, a slump occurs, with a fairly distinctive high ending it immediately following the full moon. This slump is a crude inverse of the rise during the same interval of the summer period. Another marked slump follows, between the full moon high and the new moon, reaching its lowest point two days prior to the new moon. The slump is essentially the inverse of the rise that occurs during the summer period following the full moon." (R5)

X4. Statistical analysis. Yakima, Washington, 1949-1952. Daily minimum temperatures for 45 lunations. "In each case, counting in the occasions when two equal falls occurred, one at full moon and one at some other time, the greatest fall came at full moon on only 20 occasions out of 45. Although this is more than would be expected, since the 6-day period around full moon is only about one fifth of the total time, it is far from being the rule. Of the 14 occasions of greatest fall at full moon during the past 3 1/2 years, 3 came in 1949, 8 in 1950, 3 in 1951, and none so far in 1952. Thus the distribution is erratic." (R5)

X5. Statistical analysis. Riverside, California; data from 1942-1951. The analysis showed no significant different in minimum temperature fall between the full-moon interval and any other interval. (R5)

X6. Statistical analysis. Ottawa, Regina, and Edmonton, Canada. Minimum temperature data from 1950 and 1951 . "On the basis of the data analyzed here there is no indication of any tendency for the greatest consecutive fall of minimum temperatures within 48 hr of the full moon to be significantly greater than falls for any other phase of the moon." (R5)

X7. Statistical analyses. Several Canadian weather stations; data from 1947. This study suggested that the fall of temperature near a full moon is greater than at other times but not overwhelmingly so. (R5)

X8. Statistical analysis. Boston, Massachusetts. Temperature records for 78 years. No significant relationship between minimum temperatures and lunar phase found. But the critiques of other attempts to establish this phenomenon are more pertinent than the Boston results. "Unfortunately the data and methods employed by Henstock (X2) appear to invalidate his findings from the start. The acceptance of his results even as a working hypothesis for further research is not warranted. His data, at most 5 years at one station and single years at others, are absolutely insufficient in any attempt to evaluate such effects as lunar influences. It should be pointed out that, for example, the establishment of the magnitude of the lunar tide in the atmospheric pressure---which can be shown to exist theoretically---necessitated the use of about 350,000 observations even in tropical latitudes, where the other random effects upon the pressure are small! When dealing with minimum temperatures we must contend with large random effects introduced by air mass changes, variations of insolation, and other factors, which result in a large standard deviation of such temperature values." The author goes on to note that the lunar period is almost the same as that of solar rotation as well as one of the possible, stable, free oscillations of the atmosphere. (R5) The above criticisms should be applied to all GWS phenomena, including some of the analyses presented above that show <u>no</u> lunar effects on minimum temperatures.

X9. Statistical analyses: 1995-1997. Abroad at night, one feels no warmth from the full moon. Well, one shouldn't, except perhaps for psychological effects. However, satellite instruments tell us that Arctic and Antarctic temperatures in the lower troposhpere (lowest 6 kilometers) definitely average about 0.55°C higher at full moon compared to the new moon temperatures. Not much, it would seem; but this full-moon polar warming is 25 times that of the global average! More than enough to perplex meteorologists. Even more puzzling is that contrary dip in mid-latitude minima first seen in the "old" series.

The major scientific puzzles are:

(1) Why is there any effect at all given that moonlight is merely greatly weakened, reflected sunlight?

(2) Why is there a "latitude effect" in which the polar regions are warmed while the mid-latitudes are cooled, and the tropics affected not at all? Obviously, the effect is not due to direct lunar radiation, which is least at the poles and highest in the tropics.

In contrast to the "old" measurments (X1-X8), which were mostly from single observing stations, the "new" data come mainly from satellite observations. They cover much of the globe. From these spacecraft data, we see that the lunar

temperature effect is global in nature.
Explanations of these unexpected temperature correlations with lunar phase (positive and negative) include satellite-instrument artefacts, the lunar tide in the atmosphere, and the earth being closer to the sun at full moon (4,700 kilometers closer than its average distance). (R6-R11)

References

R1. Harrison, J. P.; "On a Law of Temperature Depending upon Lunar Influence," Franklin Institute, Journal, 64:414, 1857. (X1)
R2. Harrison, J. Park; "Evidences of Lunar Influence on Temperature," Report of the British Association, 1857, part 1, p. 248. (X1)
R3. Henstock, Herbert; "Minimum Night Temperatures at or near Full Moon," Science, 116:257, 1952. (X2)
R4. Henstock, Herbert; "Fall in Minimum Night Temperature at or near Full Moon: Part II," Science, 117:302, 1953. (X2)
R5. Edwards, Robert L., et al; "Night Temperature and the Moon," Science, 117:305, 1953. (X3-X8)
R6. Balling, Robert C., Jr., and Cerveny, Randall S.; "Influence of Lunar Phase on Daily Global Temperatures," Science, 267:1481, 1995. (X9)
R7. Gribbin, John; "A Mysterious Monthly Temperature Cycle," New Scientist, p. 18, January 28, 1995. (X9)
R8. Szpir, Michael; "Lunar Phases and Climatic Puzzles," American Scientist, 84:119, 1996. (X9)
R9. Dyre, Jeppe C., et al; "Lunar Phase Influence on Global Temperatures," Science, 269:1284, 1995. (X9)
R10. Monastersky, R.; "Earth's Poles Feel Warmth of the Full Moon," Science News, 151:22, 1997. (X9)
R11. Pearce, Fred; "A Full Moon Warms Icy Wastes," New Scientist, p. 15, January 11, 1997. (X9)

GWS8 The Purported Effects of the Planets on the Weather

Description. The statistical correlation of any of the various terrestrial weather phenomena, such as mean temperatures and rainfall, with the planets, particularly the positions of the major planets.

Background. While scientists can now hypothesize some physical mechanisms by which the sun can directly affect the earth's weather, the slowly wandering planets have no known physical ties of significant magnitude with the earth. In addition, planetary influences are redolent of astrology---science's ancient enemy. Astrological trappings are to be avoided at all costs. Still, solar activity has been correlated with planetary position in respectable journals (ASO). Planetary position, therefore, may correlate with terrestrial weather as a secondary effect. Of course, the means by which the planets modulate solar activity, if they do, is unknown, for gravitational tides seem far too weak.

Data Evaluation. Few scientists have dared to investigate this possible anomaly; so the data are sparse and of poor quality. Rating: 3.

Anomaly Evaluation. Modulation of the earth's weather by the planets, even if indirectly accomplished via solar activity, would be an anomaly of the first rank, because none of the recognized forces involved; viz., gravity; is strong enough. Rating: 1.

Possible Explanations. Terrestrial weather modification by the planets could be an indirect result of their effect on solar activity; but this is just an appeal to another anomaly.

Similar and Related Phenomena. The correlation of solar activity (sunspot number) with planetary positions (ASO9 in The Sun and Solar System Debris), terrestrial radio propagation affected by planetary positions (GER11 in Rare Halos, Mirages, etc.; all of astrology---a subject not included in this catalog.

Examples of the Purported Effects of the Planets upon the Weather

X1. Unsystematic observations. A curious theory with strong astrological overtones. The author believes that the positions of the planets affect terrestrial temperatures and provides numerous examples from various localities to substantiate his claim. Of more value here is his own statement of philosophy. "You will thus see, Mr. Editor, that by the aid of the planetary philosophy I have enunciated that I am not only able to show a remarkable similarity of phenomena, but to trace each occurrence up through the several years, solving the difficulty of their occurrence at times varying with the motion of the planets in the zodiac, and thus demonstrating them to be caused by planetary attraction, and not by solar influence, the same phenomena marking ten other positions, in which the planets are totally independent of solar combination. (R1, R2, R5) We do not record the author's supposed examples of success because, with the world's varied weather at any given moment, one can always find a temperature change that will "prove" the influence of any planet. (WRC)

X2. Unsystematic observations. "To the many popular and scientific opinions as to the cause of rain I would beg to add one that I have not yet seen described in any book---viz., the influence of the moon when passing Venus, Jupiter, and other planets. It may only be a peculiarity of this 'station', but I have noticed over and over again that rain falls when the moon at night is two or three degrees to the west of Venus or Jupiter, when these planets are in the west, or when the moon in the morning is two or three degrees to the east of a planet situated in the east." (R3)

X3. General observation and speculations about the possible influence of the planets on the sun and consequent solar effects on terrestrial weather. "While it is true that a conjunction of the great planets produces no marked disturbance, it is believed by high authority that sun events have slight influence on the Sun through media and in ways, not yet understood. When either Jupiter, Venus or Mercury passes nearest the Sun in their respective orbits, the solar surface seems to show greater activity than usual, though no marked changes have been observed, nor could they be naturally expected from such a cause. On the other hand, it is well established that intense solar activity produces magnetic storms in the earth's atmosphere, some of which have been singularly powerful in recent years. Whatever influence the perihelion passage of certain planets may have in agitating the solar surface, it is plain that the earth must share in the results. If these be very small, or too delicate to measure by known methods, it should not be forgotten that they may be constant and extend over considerable period of time, and that conjunctions, or near groupings, of the major planets are favorable times for the exercise of these unknown cosmic forces, whatever they may be in kind or extent.... Recent interesting coincidences invite astronomers to this study. The year 1883, very probably marks the maximum of a passing sun-spot period. In some locations, certainly, last year will be long remembered for its cyclones and tornadoes. In a group of nine Western States, the Signal Service reports the occurrence of over forty of these dreadful storms within the space of four months." (R4)

X4. Statistical analysis. "The nineteenth century discarded horoscopy of the weather with the other appurtenances of astrology. Dr. Z. Kamerling would have us reverse this verdict and employ the motions of the planets as the basis of long-range forecasting. His thesis is that widespread periodicities must have a cosmic origin, and sunspots having failed, there remain only the planets. Accordingly he investigates periodicities of the length of the 'synodic rotations,' that is, the intervals between the dates at which the various planets are nearest to the earth. (It appears that the theoretical basis of this planetary connexion has been given in a previous paper; one wonders what it can possibly be.) These give him in years: Venus 1.60, Mars 2.13, Jupiter 1.09, Saturn 1.035, Uranus 1.018. As material he has forty years of average monthly rainfall over east Java and over west Java, twenty years' rainfall at Pernambuco, and temperatures at Winnipeg, Konigsberg, and Zwanenburg. The method is to write down the monthly data in sets corresponding with the 'synodic year,' so that, for example, all the months of perigee come in the same vertical column, and to plot the smoothed means of these columns. From his graphs, Dr. Kamerling concludes that there are real periodicities corresponding with the synodic periods of each planet, giving maxima generally near perigee and secondary maxima near apogee.

Such a result would be of considerable importance if substantiated, as explaining the origin of a number of periodicities of a little more than a year which have been suggested from time to time, but unfortunately the author has not done all he might to prove his case. He does not express his periodicities as Fourier series, nor does he attempt to determine their exact length. The original data are given only for the east Java rainfall, and here inspection shows that the annual variation has not been completely eliminated. They show, in fact, a residual mean annual variation with a range of 16 mm., which is of the same order as the ranges of the planetary periods. The normal used apparently covers the first thirty-three years, so that the error is entirely concentrated in the last seven years, and falsifies any apparent periods up to 1.1 year. The supposed period for Uranus (1 year 4 days), with a range of 18 mm. is almost entirely due to this residual annual variation. The author does not give the standard deviations of the data which he uses, so that no test of reality can be made. The Venus period in east Java, which has by far the largest range of any, may be taken as a test case. The amplitude of the corresponding Fourier series is found to be 9 mm., and the standard deviation of the original 480 values is 63 mm. The amplitude is therefore 4.5 times the expectancy on a chance basis, and the period seems to be real. Its exact length, however, turns out to be 1.58 year, while the 'synodic year' of Venus is 1.60 year; this means that the maximum phase shifts by about 120° in forty calendar years, which seems too great, and the interpretation suggested is that there is a periodicity in the east Java rainfall which happens nearly, but not quite, to coincide with the Venus synodic year." (R6)

X5. Statistical analysis. "If sunspots influence the course of the weather on the earth (and presumably also on other planets) the planets in their turn influence the formation of sunspots, and thus indirectly their own weather events. A statistical study of correlations between the positions of the three planets nearest the sun---Mercury, Venus, and earth---and the numbers and positions of sunspots has been made by Dr. Fernando Sanford of Palo Alto. Dr. Sanford has reported his results through the Smithsonian Institution, whose secretary, Dr. Charles G. Abbot, has been a leading investigator into the question of a possible connection between sunspots and weather." (R7)

X6. Statistical analysis. "A 1980 paper, 'The Effect of Planet Movement on Changes in Climate,' by Ren Zhenqiu of the Peking Meteorological Institute and Liu Zhilin of the astronomy department of the Chinese Science Institute, has just arrived in the U.S. Through charts and graphs, it tracks 19 past planetary alignments and finds (according to a translation privately commissioned by this newspaper) that 'for the past 3,000 years, China's temperatures have changed in accordance with the seasons of the planetary alignments.'

Most alignments came at intervals of 178.7 years, some more frequently. The most recent was Jan. 24, 1844. Eight alignments came in the summer half of the year, and 'all of those eight periods were relatively warm ones,' the paper says. Nine alignments came in the winter half with the planets close enough to be inside an arc of 70 degrees (as they will be this year), and in each case temperatures were below normal except for one in 631 A.D., when weather data in China was unavailable. Two other alignments came in winter, but with wide arcs of 84 and 100 degrees; temperatures were mixed but on the warm side. Two previous alignments, in 1415 B.C. and 1595 B.C. were in summer and accompanied by warm periods.

Messrs. Ren and Liu found that the narrower the arc (the closer the planets), the more extreme the temperatures. 'During 1665, when the angle of convergence was smallest---only 43 degrees---this corresponded to... when China and the Northern Hemisphere had the coldest temperatures of the past 3,000 years,' they said. They calculated that during alignments 'the radius of the earth's orbit around the mass center of the solar system' is 1% longer than normal, extending one or another season according to formulas they provide. They also studied Greenland's weather during the past five alignments, and found it 'consistent with the trend.'" (R8) These planetary alignments gained recent fame under the guise of the Jupiter Effect. Another summary of the Chinese study by John Gribbin, one of the authors of the book The Jupiter Effect, is found in R9.

X7. Critique of the Chinese hypothesis described in X6. W. Roder, a geology professor at the University of Cincinnati, agrees that the planetary alignments selected by Zhenqiu and Zhisen do indeed agree with Chinese historical data. They do not, however, fit well with the climatic curve derived from studies of the Greenland ice cores. The fit is even poorer for Iceland records. He asserts:

"Clearly, these inferred records of past climates do not agree sufficiently with each other to pin a cold period on any short-term astronomical event." In this manner, Roder rejects the Chinese hypothesis and regrets that it was turned into "quasi-astrological hype." (R10)

References

R1. Pratt, Frederic; "Extraordinary Temperatures," English Mechanic, 7:387, 1868. (X1)

R2. Pratt, Frederic; "Lunar Influences and the Weather," English Mechanic, 13:89, 1871. (X1)

R3. Carruthers, G. P.; "Planetary Rain," English Mechanic, 27:264, 1878. (X2)

R4. Payne, Wm. W.; "The Planets and Cyclones," Sidereal Messenger, 3:164, 1884. (X3)

R5. Pratt, F.; "The Riddle of the Weather---Opposition of Uranus and Neptune," English Mechanic, 83:107, 1906. (X1)

R6. "Planets and Periodicities," Nature, 119:298, 1927. (X4)

R7. "Planets Help Make Weather by Influence on Sunspots," Science News Letter, 30:9, 1936. (X5)

R8. Kwitny, Jonathan; "A Controversial Theory of the Weather," Wall Street Journal, March 9, 1982. (X6)

R9. Gribbin, John; "Stand by for Bad Winters," New Scientist, 96:220, 1982. (X6)

R10. Roder, Wolf; "The Gribbin Effect," Skeptical Inquirer, 8:252, 1984. (X7)

GWS9 Comets and the Weather

Description. The dependence of terrestrial weather on the passage of comets through the inner solar system, particularly those that pass close to the earth's orbit.

Background. Comets have long inspired fear in humanity and been regarded as harbingers of change---usually change for the worse. Not surprisingly, the onset of bad weather was frequently blamed on comets in our unscientific past.

Data Evaluation. No data even remotely approaching satisfactory quality exist. Only one scientist (Arago) is known to have dared to touch this subject. Rating: 4.

Anomaly Evaluation. Comets being much less massive than the planets should exert even less influence on the earth, either directly or through their effects on solar activity. One would thus be tempted to classify comet-induced weather as even more anomalous than planetary modulation (GWS8). This might be incorrect because the passage of comets could affect the earth's weather in a straightforward cause-and-effect manner, as described below. Rating: 2.

Possible Explanations. The passage of a comet may leave a huge wake of dust and gases, which if encountered by the earth might result in the influx of precipitation nuclei. These in turn might lead to cloudiness, precipitation, and lower temperatures.

Similar and Related Phenomena. Meteors correlated with weather (GWS4), auroras correlated with meteors (GLA11).

Examples of the Purported Effects of Comets on the Weather

X1. Review paper. Mankind's curious preoccupation with the baleful influences of comets is discussed as well as some comet-weather folklore. Only in a very few instances have scientists deigned to examine this subject. "Yet, though the wide-spread and long continued belief in the influences of comets upon the weather has even survived the belief in their direct baleful influence upon the fortunes of humanity, we must, nevertheless, place it in the same category as the supposed lunar influence. In the words of the late Professor Young, we may say that 'there is no observable change of temperature or of any meteorological condition, nor any effect upon vegetable or animal life produced by a comet, even of the largest size.' Arago, more than half a century ago, made some attempts to deal statistically with the question. He took the mean temperature at Paris for the years 1735 to 1853, placing side by side the number of comets observed in each year, and thus showed that years fruitful in comets, such as 1808 and 1846, were marked by temperatures lower or hardly equal to those of years in which few or no comets were seen. Sixty-nine years with comets gave a mean annual temperature of 51.46 F, twenty-seven years in which no comets were seen gave a mean of 50.94. He considered this slight difference as explained by the fact that years without comets were most frequently more cloudy than the others, the prevalence of clouds concealing comets from observation." (R1)

References

R1. Henkel, F. W.; "Comets and the Weather," Symons's Meteorological Magazine, 45:128. 1910. (X1)

GWS10 The Eclipse Wind

Description. During solar eclipses, slight gusts of wind preceding and following totality. A train of weak pressure waves has also be observed to follow the moon's shadow.

Data Evaluation. The eclipse wind observations are far from robust. Many reports, pro and con, have appeared in the science literature. In sum, some weak positive evidence for the phenomenon exists. Only one observation of the trailing train of pressure waves is in our files. Rating: 3.

Anomaly Evaluation. Wind disturbances during total solar eclipses can be explained by cyclonic disturbances attributable to the sudden loss of solar heating. The significant anomaly here is the unexplained train of pressure waves that are reported to follow the moon's shadow. Rating: 3.

Similar and Related Phenomena. Wind perturbations accompanying sunrise and sunset, as in the "cry of Memnon" at Egyptian desert sunrises (GSM-006 in our Sourcebook Strange Phenomena, vol. G2).

Entries

X1. General observations. During the solar eclipses of the 1800s, many observers reported small changes of wind velocity and direction during the passage of the moon's shadow. Was there such a phenomenon as an "eclipse wind"?

A.L. Rotch, of the Blue Hill Meteorological Observatory near Boston, ruminated as follows:

"Theoretically, the passage of the moon's shadow, by suddenly chilling the atmosphere, ought to increase the barometric pressure along its path and so cause an outflow of air in all directions. Investigations to determine the amount of this change of pressure were made by Professor Upton and the writer during the eclipses previously mentioned with the result that the changes which could be attributed to the eclipses were found to be too small to measure directly." (R1)

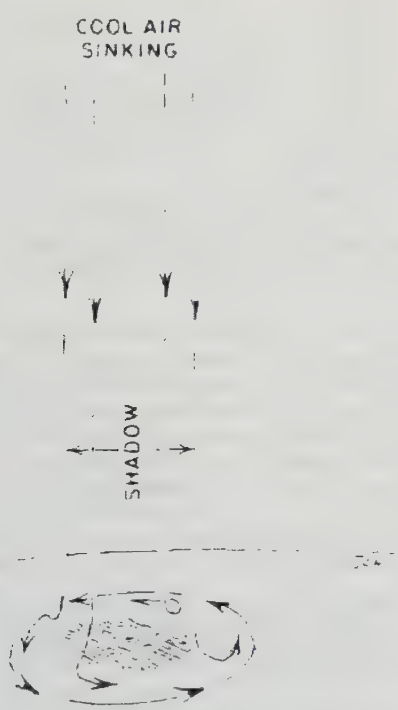
X2. June 18, 1918. United States. The eclipse on this date was cited by J. Anderson, in 1999, as the eclipse that convinced many astronomers that the eclipse wind was a mere "urban legend."

"One source of the eclipse-wind legend may result from studies done at the turn of the century by meteorologists with the US Weather Bureau. Kimball and Fergusson (1919) present a dissection of wind changes during the eclipse of 8 June 1918 across the USA. They describe a weak component blowing toward the shadow axis from stations as much as 1000 km from the path. Their evidence is weak and subject to considerable subjective interpretation, appearing in some eclipses and missing in others" (R2)

From R2, it is obvious that, in 1999, just about all scientists were convinced that eclipse observers in or near the path of totality were over-reacting---perhaps subjectively--- to minor vicissitudes of local winds that were in the main unconnected to the major astronomical event then under way.

X3. August 11, 1999. Despite the prevalent negatism of 1999 [X2], a solar eclipse occurring that very year seemed to rescue the eclipse wind from the urban-myth dead-file and also add a new twist to the phenomenon.

Physicist K. Alpin and meteorologist G. Harrison were not content with the trashing of the eclipse wind. They recalled that the American meteorologist A. Clayton had shown back in 1901 how the moon's shadow should be trailed by a cold-core cyclone that would easily explain the sudden, slight wind gusts that many observers in the paths of totality experienced just before and just after totality.



Alpin and Harrison, probably in the face of much ridicule, set up instrumentation for the August 11, 1999, eclipse in the UK, at Reading, where the eclipse was partial, and in Cornwall, where it was total.

"They now [2002] report that at both sites, there was a slight gust at the beginning of totality and another at the end in the opposite direction, just as Clayton had suggested in 1901. At Reading, they also picked up small changes in atmospheric pressure. These peaked every 35 minutes and peristed for hours after the eclipse. Such pressure waves are probably set up by the cold eclipse shadow racing across the sky at supersonic speeds." (R3)

In conclusion, weak gusts of eclipse wind are not mythical, and there are also a following, unexplained, pattern of small pressure waves.

In theory, a cold-core cyclone follows the moon's shadow across the landscape. Ground-level wind gusts should occur as shown. (R3)

References

R1. Rotch, A. Lawrence; "Physical Observations during the Total Solar Eclipse," Science, 11:752, 1900. (X1)

R2. Anderson, Jay; "Meteorological Changes during a Solar Eclipse," Weather, 59:207, 1999. (X2)

R3, Muir, Hazel; "Moon's Shadow Stirs Up Eclipse Wind," New Scientist, p. 17, November 30, 2002. (X3)

GWT THE IDIOSYNCRACIES OF TORNADOS AND WATERSPOUTS

Key to Phenomena

GWT0 Introduction

Ostensibly, tornados and waterspouts are the same species of rotary storm. The passage of a tornado from land to water converts it automatically into a waterspout, or so the prevailing theory goes.

A controversial theory that unites the two phenomena is that of their purported electrical origin. Both tornados and waterspouts are usually accompanied by severe lightning, but the hypothesis of electrical origin requires powerful cloud-earth currents to keep the storm's motor running. The effects of this large-scale flow of electricity should be observable. The "tornado lights" cataloged under GLD10 may be considered evidence of electrical action of some kind. Other confirmatory phenomena are: large terrestrial current flow in the neighborhood of the funnel, the smell of ozone or sulphur, and burning and dehydrating effects noticed along the path of the tornado. The latter effects, however, are also attributed to the aerodynamic heat created by the tornado. Whatever the truth may be, the auxiliary phenomena accompanying tornados are most curious.

The theory of the waterspout is not as completely worked out as some meteorologists would like. They find that the hollow-tube geometry of the waterspout is different from what some theories imply. Along this vein, conventional wisdom also has trouble dealing with forked waterspouts, waterspouts between clouds, and multiwalled waterspouts.

Both tornados and waterspouts can be dangerous phenomena; the former generally being the more violent. One must also ask whether there is a continuous gradation in size and violence from the small mischievous dust devil to the town-levelling tornado a mile wide. Do all of these rotary phenomena have the same cause? Meteorologists, in fact, do not understand completely the genesis of atmospheric vortices. Something seems to trigger these atmospheric maelstroms; perhaps electricity or natural surface features or even automobile traffic!

GWT1 The Tornado as an Electrical Machine

Description. Electrical attributes of tornados above and beyond the intense lightning normally expected during a severe storm. Collectively, these phenomena imply that tornados may owe their origins and maintenance to electricity. Pertinent phenomena are: (1) Tornado lights, which are dealt with at length in GLD10; (2) Anomalous heat generation and the dehydration of vegetation, as described in GWT2; (3) The smell of ozone or sulfur; (4) Buzzing or other sounds typical of electrical discharges; (5) Radio noise (sferics); (6) Strong earth currents in the neighborhood of tornado funnels; and (7) The apparent impossibility of generating tornado force winds by means of any conceivable temperature differences attainable in the atmosphere.

Background. Today's meteorologists doubt that electricity plays any significant role in tornado genesis and maintenance. A century ago, however, the major importance of electrical forces was widely accepted.

Data Evaluation. Tornados are attended by many electrical phenomena; this fact is widely acknowledged. It is a question of whether electricity is essential to the birth and maintenance of the tornado. If electricity is important, electrical phenomena in and around all tornados should be strong. This does not seem to be the case. Rating: 2.

Anomaly Evaluation. The current scientific consensus denies a major role to electricity in generating and sustaining tornados. Rating: 2.

Possible Explanations. Powerful electrical discharges between clouds and the earth (not lightning but something more akin to a glow discharge) may contribute to the formation and maintenance of tornados. The mechanism by which electrical energy is converted into vortex energy is not well-understood.

Similar and Related Phenomena. Electrical properties of whirlwinds (GWW4); tornado lights (GLD10); earthquake lights (GLD8). The latter two references are in Remarkable Luminous Phenomena.

Examples of the Tornado as an Electrical Machine

X0. Cross reference. Luminous phenomena, probably of electrical origin, have been observed around many tornados. These anomalies have been collected under the category GLD10 in another volume of this Catalog.

X1. June 3, 1860. American Midwest. A tornado leaves a strong sulphurous odor in many places. (R2, R3)

X2. April 10, 1885. North Atlantic Ocean. When a ship encountered a waterspout, much St. Elmo's Fire was observed around the ship. (R4)

X3. May 27, 1962. Tulsa, Oklahoma. Earth current measurements near a large tornado.

Abstract. "Measurements of the magnetic field and earth current in the vicinity of a tornado show large step-like deflections coincident with the touching down of the funnel. Calculations with a simple current model indicate that a minimum current of several hundred amperes must be postulated to account for the observed deflection in magnetic field. The existence of a steady current of 225 amperes for a period of about 10 minutes provides joule heat at the rate of approximately 10^{10} joules per second, and involves a total charge transfer of 135,000 coulombs. The calculations imply that a tornado is electrically equivalent to several hundred isolated thunderstorm cells active simultaneously." (R7)

X4. March 24, 1975. Atlanta, Georgia. Sferics associated with a tornado. Abstract. "Joint observations by radio and high-frequency sferics detectors at Georgia Institute of Technology provided unique data on the Atlanta tornado of 24 March 1975. The classic hook echo was detected by radar at a range of about 26 km, 15 min before the tornado touched down. While the tornado was on the ground the sferics burst rate was very low, despite very high values recorded immediately before and after this interval. This observation, together with visual reports of a strong cloud-to-ground discharge at the time of tornado touchdown, suggests an interaction of the tornado with the electric field of the storm." (R9)

X5. General observations. "Water-spouts often leave behind a sulphureous (sic) smell, and there are examples of a disagreeable smell remaining along the whole tract traversed by them. One individual, however, who became involved in a water-spout perceived no odor. We seldom read accounts of water-spouts without finding also that electrical phenomena were noticed at the same time. Lightning is almost never wanting; thunder is likewise often connected with them, and it has been remarked that the loud noise which follows water-spouts easily prevents feeble peals of thunder from being heard. Now and then, a more widely dispersed light has been seen; so that people imagined that the corn in the fields was on fire, but afterwards to their joyful astonishment found it uninjured. It has been reported of one water-spout that fire balls proceeded from it, one of which was accompanied by a report like that of a musket." (R1)

X6. Summary of field observations. Abstract. "Eighteen close range tornado observations reveal that electrical activity near or within the funnel is far too infrequent to lend credence to electrical theories of tornado genesis and maintenance." (R8)

X7. Laboratory experiments made to check the possibility that electricity might play an important role in a tornado's life cycle indicated that a continuous electrical discharge in the center of a vigorous vortex actually inhibited vortex circulation. (R6)

X8. Theoretical arguments. The remarkable feature of the tornado is not its energy but rather its energy density. "Some idea of the extraordinary energy concentration in the tornado can be obtained by estimating the temperature differences that would have to exist in the atmosphere to cause its winds. We can compute an absolute minimum temperature difference that would be required by considering the atmosphere as a perfect heat engine in which all processes are reversible and in which dissipative processes such as turbulence, entrainment, and friction do not occur..... From the foregoing considerations it can be seen that in order to cause the winds of near sonic velocity that appear to exist in the tornado, temperature contrasts must occur between air masses that are well in excess of the theoretical minimum of 70°C, and probably of the order of several hundred degrees centigrade. The puzzling fact is that none of the soundings made during conditions that cause tornadoes shows the possibility of such temperature contrasts. Even the most unstable atmospheric conditions..... are capable of giving rise to thermal contrasts of only 25°C between air masses. This is well below the theoretical minimum that would be required to produce tornado velocities..... The clue that may provide the answer to the riddle of the tornado is the very intense electrical display that is commonly observed to accompany these storms. According to modern thinking, this unusual electrical activity does not play a significant role in tornado dynamics. McEachron and Jones suggested that perhaps the tornado itself somehow causes electrification. This appears unlikely, however, for both Jones and the Air Weather Service sferics observers at Tinker Field, Oklahoma, have shown that very intense electrical activity both precedes and follows the appearance of the funnel. If the tornado does produce the lightning that is observed to accompany it, then its energy is even more remarkable, for it will be shown that the power required for the lightning display is commensurate with the power required to produce the tornado winds themselves. It appears to the author that the ancient idea that electricity is a cause, rather than a result, of tornadoes may afford a better explanation of the facts. The vivid electrical displays observed, particularly with nocturnal tornadoes, are so striking that the obvious deduction that tornadoes might be caused by electricity is old indeed." (R5)

X9. Laboratory experiments. Abstract. "Laboratory experiments showed that under certain conditions of vorticity the electrical heating produced by a high-voltage discharge at atmospheric pressure can cause the formation of a miniature tornado-like vortex. Once it forms, this vortex stabilizes the electrical discharge along its axis and changes its character from that of a spark to a high-pressure variety of glow discharge. Electrical and dynamic parameters were measured. By relating observations and measurements made in these experiments to previous work and to analogous situations in nature, it is concluded that the heating produced by electrical discharges in a large storm may play a significant role in forming and maintaining natural tornadoes." (R10)

X10. May 25, 1955. Udall, Kansas. R. Gunn, U.S. Weather Bureau, took electric-field measurements at eight locations during this very active tornado. He reported: "There is little evidence suggesting that the electrical effects near the funnel differ basically from ordinary thunderstorm electrification." (R11)

X11. January 10, 1994. Farnham, Surrey, United Kingdom. At 0448 GMT, following a sudden cessation of rainfall, M.D. Smith became aware of an orange glow outside his window. Accompanying it was a roar like that of a military jet. The phenomenon occurred a total of four times; the second of which is the most interesting and now follows.

"A second illumination was observed twenty seconds later, but this time it reappeared away from the tree so a clear view was possible. The illumination was in the form of a narrow column and of the classic gentle 'S' tornado shape in the 'roping out' stage; it was silvery in colour towards the top and golden-orange lower down. Additionally, Mr. Smith saw the illumination move from the sky towards the ground, but at a speed slower than lightning. The sound of rushing wind was heard again, while this illumination lasted five to six seconds." (R12)

The slowly descending luminous region is thought to have been an anomalous electrical-discharge phenomenon.

Although ordinary lightning accompanies many tornados, glowing columns suggestive of other types of electrical discharge are not part of prevailing tornado theory. Nevertheless, observations of glowing discharges within the funnels of nighttime tornados---making them look like neon lights---have been observed and even photographed. (GLD10 in Remarkable Luminous Phenomena)

X12. January 21, 1992. Cripple Creek, Colorado. Shortly after 2 PM, while fishing at Skagway Reservoir, D. McGown spotted an ominous cloud formation developing in the west. A horizontal, black cloud rolled toward him. Suddenly, it lifted to reveal a huge, twisting funnel advancing directly at him. He threw himself to the ground, but got a good look up into the interior of the funnel.

"The outside of the tornado was spinning so fast my eye couldn't follow it, but the inside was rotating almost lazily. I could see a thousand feet up inside it. Tiny fingers of lightning lined the hollow tube." (R13)

Passing over him, the funnel bounced across the lake, ripped up some trees, and was gone.

X13. August 28, 1990. Plainfield, Illinois. The electrical effects of this tornado---one of eight examples, listed by W.P. Winn et al, is called a "striking example of electrical behavior associated with a tornado." Winn described it thusly.

"During the 20 min of tornado formation and intensification of the Plainfield, Illinous, tornado of August 28, 1990, the cloud-to-ground (CG) lightning activity was much reduced. Furthermore, the dominant CG flash polarity changed from positive to negative over the entire thunderstorm area at the time of the tornado. (R14)

It is surmised that some of the flow of CG electricity was transferred from the lightning to the tornado funnel. The polarity change, too, was remarkable.

References

R1. Oersted, Hans C.; "On Water-Spouts," American Journal of Science, 1:37:250, 1839. (X5)

R2. Howig, Frank A.; "The Great Tornado in the Far West," Scientific American, 3:19, 1860. (X1)

R3. "Phenomena of Storms," Scientific American, 22:302, 1870. (X1)

R4. Science, 5:391, 1885. (X2)

R5. Vonnegut, Bernard; "Electrical Theory of Tornadoes," Journal of Geophysical Research, 65:203, 1960. (X8)

R6. Wilkins, E. M.; "The Role of Electrical Phenomena Associated with Tornadoes," Journal of Geophysical Research, 69: 2435, 1964. (X7)

R7. Brook, Marx; "Electric Currents Accompanying Tornado Activity," Science, 157:1434, 1967. (X3)

R8. Davies-Jones, R. P., and Golden, J. H.: "On the Relation of Electrical Activity to Tornadoes," Journal of Geophysical Research, 80:1614, 1975. (X6)

R9. Greneker, E. F., et al; "The Atlanta Tornado of 1975," Monthly Weather Review, 104:1052, 1976. (X4)

R10. Ryan, R. T., and Vonnegut, B.; "Miniature Whirlwinds Produced in the Laboratory by High Voltage Electric Discharges," Science. 168:1349. 1970. (X9)

R11. Gunn, Ross; "Electric Field Intensity at the Ground under Active Thunderstorms and Tornadoes." Journal of Meteorology, 13:269, 1956. (X10)

R12. Reynolds, David J.; "Nocturnal Tornado Illuminated by an Electrical Discharge at Farnham, Surrey, 10, January 1994," Journal of Meteorology (U.K.), 20:381, 1995. (X11)

R13, McGown, Dennis; "Letters," Time, 147:8, June 10, 1996. (X12)

R14. Winn, W.P., et al; "Electric Field at the Ground in a Large Tornado," Journal of Geophysical Research, 105:20145, 2000. (X13)

GWT2 Burning and Dehydration during Tornados

Description. The observation of the effects of intense heat along the track of a tornado, such as evidence of fusion, charred bodies, and vegetation that has been scorched, dehydrated and/or exploded. The smell of sulphur, possibly indicative of electrical action (GWT1) is also frequently present. Curiously, a disproportinate number of examples come from France, where tornados are much less frequent than in the United States.

Data Evaluation. Although this pheomenon is sometimes described as if it were well-supported by observations (R10), high quality examples are scarce in the literature. Rating: 2.

Anomaly Evaluation. Burning and dehydration along a tornado track suggests extremely hot winds and/or intense electrical discharges. Neither are accepted characteristics of tornados. Rating: 2.

Possible Explanations. Powerful electrical currents generated by the tornado (GWT1). An oscillating ring current around the funnel (R10). Aerodynamic heating of the tornado core is a possibility, although the temperatures required for the observed effects are probably several hundred degrees. However, if tornados can drive straws into trees (GWT7), aerodynamic heating may not be unreasonable.

Similar and Related Phenomena. Tornado electrical characteristics (GWT1); tornado pranks (GWT7); whirlwinds of fire and smoke (GLD11) tornado lights (GLD10). The latter two references are in Remarkable Luminous Phenomena.

Examples of the Drying and Burning Effects of Tornados

X1. June 1839. Chatenay, France. An account of an especially violent tornado. "In this hasty account I have, with the intention of returning to this portion of the subject, omitted to speak particularly of its effect upon trees. All those which came within influence of the tornado, presented the same aspect; their sap was vaporized, and their igneous fibres had become dry as if kept for forty-eight hours in a furnace heated to ninety degrees above the boiling point. Evidently there was a great mass of vapor instantaneously formed, which could only make its escape by bursting the tree in every direction; and as wood has less cohesion in a transverse direction, these trees were all, throughout one portion of their trunk, cloven into laths. Many trees attest, by their condition, that they served as conductors to continual discharge of electricity, and that the high temperature produced by this passage of the electric fluid, instantly vaporized all the moisture which they contained, and that this instantaneous vaporization burst all the trees open in the direction of their length, until the wood, dried up and split, had become unable to resist the force of the wind which accompanied the tornado. In contemplating the rise and progress of this phenomenon, we see the conversion of an ordinary thunder gust into a tornado; we behold two masses of clouds opposed to each other, of which the upper one, in consequence of the repulsion of the similar electricities with which both are charged, repelling the lower towards the ground, the clouds of the other descending and communicating with the earth by clouds of dust and by the trees. This communication once formed, the thunder immediately ceases, and the discharges of electricity take place by means of the clouds, which have thus descended, and the trees." (R1, R3, R10)

X2. August 19, 1845. Rouen, France. The famous tornado of Monville. "The trees in the vicinity were flung down in every direction, riven and dried up for a length of from six to twenty feet and more. While clearing away the ruins, in the attempt to rescue the unfortunate people buried beneath them, it was noticed that the bricks were burning hot. Planks were found completely charred, and cotton burned and scorched, and many pieces of iron and steel were magnetized. Some of the corpses showed traces of burning, and others had no visible cuts or contusions, but seem to have been killed by lightning. Workmen who were hurled into the surrounding fields, all agreed in saying that they had seen vivid flashes and had noticed a strong smell of sulphur. Persons who happened to be on the adjacent heights, alleged that they saw the factories wrapped in flames and smoke as the cloud enveloped it." (R2, R4)

X3. 1860. Iowa. A tornado left a sulphurous odor and blackened bodies of victims. (R5)

X4. Circa 1880. No place given. "The tornado was preceded by a dark cloud from which there was considerable thunder and lightning, but there was very little, if any, near the tornado. After the storm had passed, the air was saturated with ozone to such a degree that even the small children noticed it, who compared it to the odor of burning brimstone or burning matches. Unfortunately, I once stood a few rods from a tree when it was struck by lightning, and I distinctly remember the peculiar odor which I attributed to ozone which had been formed by the passage of lightning through the air. As the odor which followed or accompanied the tornado was similar, I concluded there must have been electricity with it. I followed the path of destruction, which was not over ten rods wide, for a couple of miles, and at different places saw small hickory and white oak trees, from one to two inches in diameter, ruptured or burst open, with crevices on all sides as though they had been exploded with some explosive; the fine splinters standing out, brush-fashion, on all sides. These small trees grew on ground which had once been farmed, and were of slow growth and the toughest which grow. There was such a marked difference between these, and those which had been twisted by the wind, that I had no difficulty in distinguishing one from the other. They were ruptured by electricity. At other places I saw small roots which had been laid bare, split open without any other marks about them, and I believe them to have been split by electricity. Had they been split by any visible or hard object, it must have left some other marks upon them. This, again, must have been the work of electricity." (R6)

X5. August 18, 1890. Domagne, France. Ozone smell and scorched vegetation left behind by tornado. (R7)

X6. August 18, 1891. Dreux, France. After the passage of a tornado, traces of melting were found in poorly conducting bodies. (R8)

X7. May 24, 1948. Mauritius. "In the middle of the afternoon a whirlwind touched down to earth over a hard tennis court, causing considerable damage to its hard compact surface. A trench running in a north-south direction, 60 feet long and 1 to 2 1/2 feet wide, was cut in the bare surface of the court to a depth varying from 1 to 4 inches. The material lifted from the trench was all thrown to the west to a distance of 50 feet; pieces weighing about one pound were thrown as far as 30 feet. The surface material was slightly blackened as if by heating, and a crackling like that of a sugar-cane fire was heard for two or three minutes. The court was made of a ferruginous clay, which packs down to a surface more smooth than that of the hard tennis courts usually made in Great Britain. Unfortunately, there were no very reliable witnesses of the phenomenon. The impressions gained by two servants of the tennis club who saw the incident differed considerably on important details. One claims to have seen a ball of fire about two feet in diameter which crossed from a football pitch to the tennis court through a wire-netting fence without leaving any evidence of its passage until it bounced along the court, making the trench in the surface before disappearing completely." (R9) This might very well be an example of ball lightning rather than tornado burning. (WRC)

X8. Theoretical explanation. Abstract. "The explanation generally offered for the observed dehydration, heating and burning effects associated with tornadoes is based on either of two mechanisms. The first involves a hot wind while the second involves corona discharges sometimes called St. Elmos fire, while the smell of 'brimstone' often often appears to be overlooked. An alternate explanation which could deal with both phenomena is obtained by assuming that a pulsed oscillatory 'ring current' exists within the tornado cloud whose radiation field at large distances can be associated with the observed and measured tornado sferics and at close distances could be responsible for the observed heating effect along with the smell of burning 'sulfur.'" (R10)

X9. June 1960. Kopperl, Texas. Thunderclouds and lightning gave way to winds in excess of 75 mph, with temperatures of up to 140°F. Surveying the storm damage later, townspeople found ample evidence of the storm's intense heat.

"Aside from the expected remains of a severe wind storm---uprooted trees, snapped telephone poles, roof damage and banged-up boats docked lakeside---the area had the ironic appearance of having been stung by a June freeze. Tree leaves, shrubs, hanging plants and crops were curled and wilted, as if frostbitten. Uncut Johnson grass was dried and ready to bale, although the hay normally required two or three days of drying time after being cut. Perhaps the most startling remains of the storm was in what had been the cotton patch at Pete and Inez Burns' farm. The cotton was about knee high and a 'lucious crop' the day before, according to the couple. The next morning all that was left were carbonized stalks peeping out of the ground. The corn fared little better." (R11)

X10. August 16, 1985. Annesley Woodhouse, United Kingdom. Here is an example of a so-called "scorching" tornado.

"What was interesting about the storm was not only the damage it caused, but also the type of damage. After touching down the tornado uprooted a large oak tree, 15 metres high, in Lawn Road (luckily the residents of the house were away on a holiday). The tornado proceeded to rip tiles off several roofs, demolished completely several greenhouses, and next scorched a 4-metre section of gable on the south side of a house in Forest Street (number 9). The gable section was scorched so badly that the gable had already been repainted when I called, although the evidence could still be seen." (R11)

References

R1. Peltier, M.; "Account of a Whirlwind, Accompanied by Immense Electrical Discharges....," Franklin Institute, Journal, 31:62, 1841. (X1)

R2. "Whirlwind near Rouen, August 19th, 1845," Franklin Institute, Journal, 40: 420, 1845. (X2)

R3. Hare, R.; "On Tornados as an Electrical Storm," Franklin Institute, Journal, 54: 28, 1852. (X1)

R4. Zurcher, Frederic; "The Tornado of Monville," Meteors, Aerolites, Storms, and Atmospheric Phenomena, New York, 1876, p. 154. (X2)

R5. Howig, Frank A.; "Remarkable Tornado," Scientific American, 47:17, 1882. (X3)

R6. Moore, H. D.; "Electricity and Tornadoes," American Meteorological Journal, 2:517, 1886. (X4)

R7. Hazen, H. A.; "Electric Storms and Tornadoes in France on Aug. 18 and 19, 1890," Science, 17:304, 1891. (X5)

R8. Nature, 44:112, 1891. (X6)

R9. Davy, E.S.; "Unusual Damage by a Tornado," Weather, 4:156, 1949. (X7)

R10. Silberg, P.A.; "Dehydration and Burning Produced by the Tornado," Journal of the Atmospheric Sciences, 23:202, 1966. (X1, X8)

R11. Glaze, Dean; "Kopperl's Close Encounter with Satan's Storm," Meridian (TN) Tribune, May 12, 1983. (X9)

R12. Matthews, Peter; "Lightning inside a Tornado," Journal of Meteorology U.K., 10:375, 1985. (X10)

GWT3 Tornados and Waterspouts with Horizontal Funnels

Description. Tornado and waterspout funnels that extend horizontally from the parent cloud for long distances, often terminating in midair. Some tornados display long sinuous funnels that deviate from the vertical but not to the degree described below.

Data Evaluation. Horizontal funnel clouds, while rather rare, have been reliably reported and photographed. Rating: 1.

Anomaly Evaluation. Theory does not require that funnel clouds be vertical. In fact, one theory of waterspout formation has the funnel forming inside the parent cloud in a horizontal position and arching down toward the water only at its terminus. We must classify this phenomenon as simply a curiosity. Rating: 3.

Possible Explanations. Funnel cloud orientation is determined more by meteorological forces than by gravity.

Similar and Related Phenomena. Horizontal roll clouds (GWC12).

Examples of Horizontal Funnel Clouds

X1. May 24, 1909. Dijon, France. A tornado with a horizontal, serpent-like funnel that terminated in mid-air. (R1)

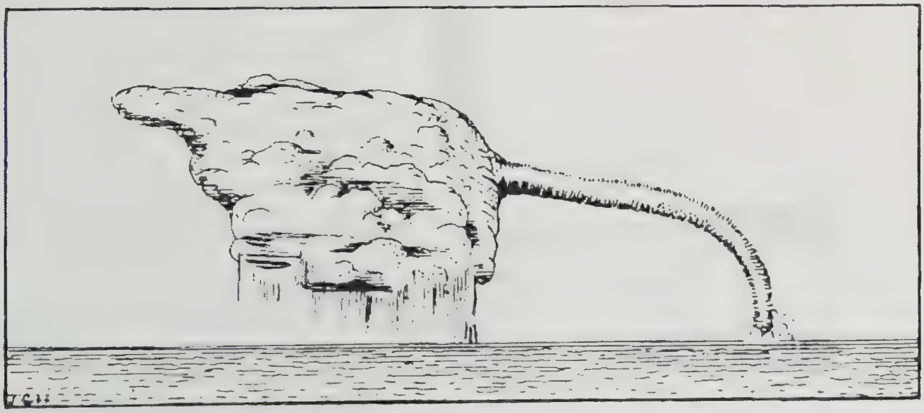
X2. May 28, 1956. North Atlantic Ocean. "A most unusual waterspout was observed bearing due E. from the ship. It originated from a large Cb with rain falling, and stretched diagonally towards the horizon, as illustrated.....The waterspout lasted about 3 min before dissolving." (R2)

X3. June 29, 1976. Near Shawnee, Oklahoma. (R4)

X4. July 9, 1977. Waco, Texas. A horizontal funnel cloud was photographed near the top of a line of light thunderstorms. (R3)

References

R1. Loisier, M. l'abbe L.; "Meteorologie," L'Astronomie, 23:316, 1909. (X1) (Cr. L. Gearhart)
R2. McCrone, J.; "Waterspout," Marine Observer, 27:80, 1957. (X2)
R3. McCauley, Gerald W.; "Horizontal Funnel Cloud," American Meteorological Society, Bulletin, 59:291, 1978. (X4)
R4. Pielke, Roger A.; "Another Horizontal Funnel Cloud," American Meteorological Society, Bulletin, 59:1168, 1978. (X3)



Waterspout with a long horizontal section (X2)

GWT4 Multiwalled Waterspouts

Description. Waterspouts consisting of two or more hollow concentric tubes, which may rotate at different angular velocities. One tube is the rule but several double-walled and one triple-walled spout have been recorded.

Data Evaluation. Several detailed, seemingly reliable field observations of multiwalled waterspouts have been found. Further, the double-wall structure has been verified by laser probes. Rating; 1.

Anomaly Evaluation. Conventional waterspout theory deals fairly well with single-walled spouts but does not accomodate multiwalled spouts with concentric walls rotating at various velocities. Rating: 2.

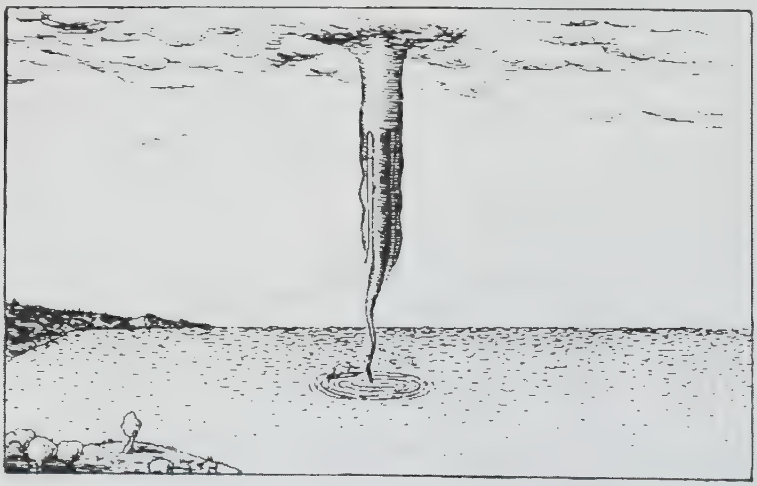
Possible Explanations. None.

Similar and Related Phenomena. None.

Examples of Multiwalled Waterspouts

X1. June 30, 1922. Lake Victoria, Uganda. A waterspout passed 100 yards offshore. "The pedicle arose from a well-marked circular area on the water, which was otherwise only faintly rippled by the preliminary puff of wind before the approaching storm. This circular area was evidently very violently disturbed as a cloud of vapour, greatly agitated, rose from it for a little distance. The pedicle was extremely narrow at its lower end, and not quite straight, being sinuous in outline. It broadened out gradually into a column which went up into the low cloud; the core of this column was much less dense than the periphery, and the violent upward spiral ascent of the water could be clearly seen. So far I have described nothing unusual, but the following was quite new to me and seemed of great interest.

Surrounding the central core, but separated from it by a clear narrow space, was a sheath, the lower end of which faded away some distance above the water. The profile of this sheath was undulating, it being thicker in some places than others. A curious point is that this sheath seemed to pulsate rhythmically, but I could not say whether the appearance of pulsation might not have been an illusion caused by waves travelling up its outer surface. This pulsation gave an uncanny suggestion of a live thing, which was aided by the violent spiral movement upwards in the central core, the clouds of vapour boiling round its base, and the movement of the whole across the water---indeed, we watched



Double-walled waterspout over Lake Victoria (X1) it spellbound until the pedicle dissolved away at the bottom, and the ascent of the part above brought the phenomenon to an end." (R1, R2)

X2. February 22, 1923. North Atlantic Ocean. A report from the American steamship Warwick. "The spout was seen late in the afternoon of February 22 and was described as 'close aboard' so that with glasses its peculiar structure could easily be observed. The inner spout was apparently darker than the outer and at times it would be withdrawn into the heavy globular appearing cloud above, leaving the outer spout still 'drawing water.' The compound spout was something of the shape of an S, extending in a nearly horizontal direction to near the horizon, where it descending vertically to the water. After about fifteen minutes the inner spout was suddenly withdrawn and ten minutes later the whole mass moved eastward and a heavy rain set in." (R3)

X3. May 27, 1951. South China Sea. A three-walled waterspout. "It began as a faint tube of cloud particles emerging from a cumulus bank estimated to be slightly above 2,000 ft. Directly underneath, the sea was disturbed and throwing up spray to about 100 ft. in a circular area 300 ft. wide. In the second stage the tube, which appeared to be hollow, extended downwards to meet the surface spray. In its third stage, the tube which was about 30 ft. in diameter, apparently formed a second hollow cloud tube inside the first tube for about the middle third of its length. In the fourth stage, a thick cloud sleeve about 400 ft. long and 150 ft. wide grew downwards from the cloud base, concealing the original spout and a similar sleeve or annulus grew from the sea at the same time. The spray from the sea surface remained visible outside the sleeve. The reverse processes now took place, and when the spout had reached the second stage again a shower spread from the north, enveloped it and hastened its decay, although it was possible to discern foam on the sea surface five minutes after the spout was no longer visible. No rotation was visible at any time, except in the spray which appeared to drift slowly in a clockwise direction." (R4)

X4. Laser probes of waterspouts off the Florida Keys, 1976. "With the laser device it was possible to measure windspeeds and identify the dynamic difference---the difference in velocity within the spout that indicates two cylinders rotating about a common axis. Preliminary analysis of the data suggests that the two vortices of a double spout are in fact two separate, concentric funnels which rotate in the same direction, but at different speeds." (R5)

References

R1. Carpenter, G. D. Hale, and Brunt, D.; "Waterspouts," Nature, 110:414, 1922. (X1)

R2. "Some Observations of Waterspouts and Allied Phenomena," Meteorological Magazine, 57:248, 1922. (X1)

R3. Science, 57:sup xvi, April 6, 1923. (X2)

R4. Phillips, P. E.; "Triple-Walled Waterspout," Meteorological Magazine, 81:88, 1952. (X3)

R5. "NOAA, University Scientists Probe Double Waterspouts," Mariners Weather Log, 21:387, 1977. (X4)

GWT5 Anomalous Historical Incidence of Tornados

Description. The apparent four-fold increase in the incidence of U.S. tornados during the period 1950-1973 and, on a weekly time frame, a dramatic reduction in tornado incidence on Saturdays compared with the rest of the week.

Data Evaluation. Little has been found to date in the literature on this purported anomaly. The authors of the single study available admit possible problems with nonuniform reporting down the years but claim to have this factor under control Rating: 2.

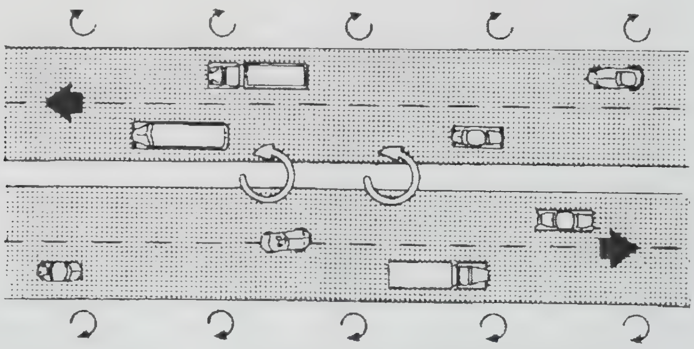
Anomaly Evaluation. No known natural forces account for this strange distribution of tornados in time. Manmade sources of atmospheric vorticity, as mentioned below, have not been accepted as yet. Rating: 2.

Possible Explanations. Automobile traffic may add vorticity to the atmosphere and account for both the general historical increase in tornados and the Saturday phenomenon.

Similar and Related Phenomena. None.

Examples of Anomalous Historical Incidence of Tornados

X1. Statistical analysis. "We have obtained the detailed record of all US tornadoes (15,234) reported between 1950 and 1973 in the 48 contiguous states. The annual incidence shows an increase over the period of a factor of four. Changes in observation and reporting are undoubtedly serious and we have applied tests that are relatively independent of secular changes in reporting. .....The data display a strong weekly periodicity. Over the entire record the reported number of tornadoes on Saturdays is less than the daily average by more than 7.1 standard deviations (1,868 on Saturdays as against a daily average of 2,176). The statistical probability of this record occurring by chance from a random sample is $P<10^{-9}$. This hebdomadal event dominates in 18 of the 24 yr and in most states. (Thirty-seven of the forty-eight states show a Saturday incidence below the average.) Nineteen states show Saturday's incidence to be a minimum." (R1) The "Saturday Effect" was suggested to be a consequence of vag-



How motor vehicle traffic creates atmospheric vorticity (X1) aries in reporting by letters to Nature commenting on R1. Several letter writers believed that auto traffic, which occurs on a small scale when compared to cloud dimensions, could contribute no net vorticity to the atmosphere. (R2)

J.D. Isaacs added the following observation to his foregoing statistical correlation of U.S. tornados and traffic.

"Another statistic that intrigues Dr. Isaacs and his colleagues is that a third of northern tornadoes spun clockwise before the rise of highway usage. Today, these wrong-way tornadoes are rare, a phenomenon he believes may be due to right-hand driving in the area of tornado activity may be the reason for the increase in more tornadoes." (R3)

References

R1. Isaacs, John D., et al; "Effect of Vorticity Pollution by Motor Vehicles on Tornadoes," Nature, 253:254, 1975. (X1)

R2. Kessler, Edwin, et al; "Tornado Forum," Nature, 260:457, 1976. (X1)

R3. Anonymous; "Tornado Traffic," Science Digest, 77:28, May 1975. (X1)

GWT6 Reversal of Rotation in Waterspouts

Description. The apparent reversal of the direction of rotation in some waterspouts.

Data Evaluation. A single observation. Rating: 3.

Anomaly Evaluation. The only known way for a waterspout to reverse its direction of rotation and still obey the laws of physics is to slow down, die out, and reform on the same spot rotating in the opposite sense. This is unlikely and did not occur in the example below. If waterspouts actually do reverse rotation suddenly and spontaneously, theory cannot account for it. Rating: 2.

Possible Explanations. The supposed change of direction is merely an optical illusion.

Similar and Related Phenomena. The apparent direction of rotation of phosphorescent wheels may be either clockwise or anticlockwise. When multiple wheels are present, both directions of rotation may be seen (GLW4 in Remarkable Luminous Phenomena).

Examples of Reversal of Rotation in Waterspouts

X1. August 18, 1951. North Pacific Ocean. "A waterspout formed to the NE at a distance of about one mile and moved westwards at 10 to 15 kt. It appeared to rotate rapidly, first clockwise, then anti-clockwise, continually changing the direction of rotation. At no time did it reach cloud level. Just before it disappeared at 2039 it ceased rotating and dispersed temporarily. It finally disappeared veering WNW, leaving a cloud of spray." (R1)

X2. September 28, 1991. Western Mediterranean. Aboard the m.v. Staffordshire enroute to Port Said. Of the several waterspouts observed by the crew, one exhibited anomalous rotation:

"At 0722 [UTC] the two spouts furthest forward and the one on the beam dissipated leaving one which was of quite a large diameter, about 20 m as seen at a range of about 300 m. The direction of rotation of the water in the spout was clearly seen. Although the observers were aware that the direction of rotation should be anticlockwise in this case, they decided (with great surprise) that the direction of this particular one was clockwise. The only other spout that passed closer, within 15 m, was very weak, but the direction of rotation at the surface was clearly anticlockwise." (R2)

We have no high quality records of tornados rotating in the "wrong" direction, except for the general comment of J.D. Isaacs in GWT5-X1, which we have not been able to verify.

References

R1. Hutchinson, W.; "Waterspout," Marine Observer, 22:123, 1952. (X1)

R2. Edwards, R.A.F.; "Waterspouts," Marine Observer, 62:113, 1992. (X2)

GWT7 Pranks of the Tornado

Description. The propensity of the tornado to carry out curious, improbable, and sometimes seemingly impossible actions; such as, defeathering chickens, driving boards through thick trees, and carrying people long distances without hurting them.

Background. Tornados, in common with lightning and whirlwinds, do the unlikely. At least these "pranks' and "freaks" seem improbable to us. The chief variety of tornado prank might be termed "surgical violence" because incredibly strong forces are exerted over curiously delimited regions while adjacent areas are untouched. One should remember in this context that tornados do not normally carry people 100 yards and set them down unhurt; they usually kill and mangle people. Our statistics are thrown off because we tend to remember the unusual rather than the usual.

Data Evaluation. Tornado tales are legion. Only a sampling from the science-oriented literature is recorded here. Tornado pranks are well-accepted phenomena. Rating: 1.

Anomaly Evaluation. Most of the peculiar actions of tornados could probably be explained if we could divine the detailed structure of the tornado. That is, if we knew wind velocities throughout the storm, present physical laws could give us a cause-and-effect accounting of each and every prank. Rating: 3.

Possible Explanations. Extremely high, localized winds probably account for almost all of the so-called tornado pranks.

Similar and Related Phenomena. Falls (GWF); whirlwind pranks (GWW2); pranks of lightning (GLL1); "bizarre" ball lightning (GLB21). The latter two are cataloged in Remarkable Luminous Phenomena.

Examples of Tornado Pranks

X1. June 3, 1860. American Midwest. A tornado crossed Iowa, Illinois, and Michigan, a total distance of 560 miles. "When the spout reached the Iowa river, the spray was seen to come out of its apex, making a picture even more impressive than Niagra Falls. The evidences of the amazing power of the wind were innumerable. In one instance a joist was driven directly through a tree. At the time of the passing of the spout an odor of sulphur was noticed by many persons, and one of the most curious of the phenomena attending the storm was that many fowls were entirely stripped of their feathers, while the fowls themselves remained uninjured." (R1)

X2. May 18, 1883. Sangamon County, Illinois. A tornado attended by the odor of sulphur and fireballs. "The family of Mr. T, who had also sought shelter in a cellar from the same storm, were covered with a gummy substance, which would not wash off! This substance might have been formed from the sap of trees and juice of leaves, combined with the moist heated atmosphere. . . . . A thrifty young maple-tree, twelve inches in diameter, stood apart from other trees, near the edge of the storm's track. About six feet from the ground the bark was peeled entirely off for a distance of two feet. No broken limb, or other missile, lay near the tree, and its top was uninjured! . . . . . A flock of geese were plucked of their feathers, which were deposited in a hedge-fence, giving it a complete coating." (R2)

X3. 1890. Louisville, Kentucky. A tornado tore the roof off a house and pulled a child from its mother's arms, depositing it safely at another house six blocks away. (R5)

X4. May 11, 1892. Novska, Slavonia. During a powerful tornado, a young girl was transported more than 90 meters without receiving any injury. (R3)

X5. May 27, 1896. Saint Louis, Missouri. "Willis L. Moore, then chief of the Weather Bureau, who visited St. Louis, Missouri, the day following the great tornado of May 27, 1896, reported seeing a two-by-four pine scantling which had been blown through solid iron five-eighths of an inch thick on the Eads Bridge, the end of the scantling protruding several feet through the hole it had gouged in the iron. He also reported seeing a six by nine timber driven four feet almost straight down into hard, compact soil, a gardner's spade shot six inches into the limb of a tree, and wheat straws forced into the trunk of a tree to a depth of more than an inch. . . . . a man driving a team to a heavily loaded wagon suddenly found the team missing, blown away, but the wagon and himself uninjured, except, of course, for the tongue of the wagon." (R8)

X6. Circa 1905. Oklahoma. "In the Associated Press dispatches concerning the recent tornado in Oklahoma, mention is made of the occurrence of some remarkable phenomena which cannot be explained by our accepted physical laws. Among these is a statement that 'all the corpses in the track of the storm were found without shoes.' 'In some instances the hair was taken from the head without injuring the scalp beneath.' Similar storms have been reported with like curious phenomena, such as the removal of the feathers from one-half a chicken, leaving the bird otherwise uninjured; driving a piece of straw several inches into the trunk of a tree without breaking the straw, etc." (R4)

X7. March 18, 1925. The Tri-State tornado. ". . . . . a large plank, several feet long, was found driven horizontally into a tree trunk so firmly that the far end of the plank was capable of supporting the weight of a man without loosening it from the tree." (R8)

X8. June 3, 1927. Topeka, Kansas. ". . . . a rafter, badly weathered and charred with old age, was blown from an old barn through the siding and two-inch sill of a nearby comparatively new house, pointed end first, and left sticking in the hole it punched. The most incredible part was that the charred, tapered end of the old rafter showed no battering effect whatever. The speed of its impact must have been tremendous." (R8)

X9. March 14, 1933. Nashville, Tennessee. The following were observed by the official in charge of the local weather station. "A cornstalk was found driven endwise through a piece of weather boarding. A 2 x 4 inch timber plunged through a panel door without causing the slighest splitting or splintering. The timber exactly fitted the opening. A 1 x 6 inch plank was forced through the trunk of a sturdy young tree, splitting the latter in half." (R7)

X10. June 1, 1943. Lansing, Michigan. ". . . . . thirty chickens, stripped entirely of their feathers, were found after the storm sitting in the poultry house, stiffly at attention. All were dead." (R8)

X11. June 23, 1944. West Virginia. "When the destructive tornado of June 23, 1944, passed over West Fork River, West Virginia, the water was actually sucked up and the river left dry, momentarily, at the place where the storm crossed it." (R8)

X12. April 9, 1947. Higgins, Texas. "According to the account, two Texans, Al and Bill, last names not given, were visiting in Al's home near Higgins, Texas, when the tornado that later struck Woodward passed over them. Al, hearing the roar, stepped to the door and opened it to see what was happening. It was torn from his grasp and disappeared. He was carried away, over the tree tops. Bill went to the door to investigate the disappearance of his friend and found himself, also, sailing through the Texas atmosphere, but in a slightly different direction from the course his friend was taking. Both landed about two hundred feet from the house with only minor injuries. Al started back and found Bill uncomfortably wrapped in wire. He unwound his friend and both headed for Al's house, crawling because the wind was too strong to walk against. They reached the site of the house only to find that all the house except the floor, had disappeared. The almost incredible part of the story is that Al's wife and two children were huddled on a divan, uninjured. The only other piece of furniture left on the floor was a lamp." (R8)

X13. April 29, 1947. Worth, Missouri. "Mr. Ferguson arrived on the scene of devastation shortly after the tornado struck and observed not only dead, deplumed fowls, but also others deplumed and dazed which expired in a short period of time." (R10)

X14. May 30, 1951. Scottsbluff, Nebraska. "After the passage of a tornado at Scottsbluff, Nebraska, on May 30, 1961, a bean was found embedded one inch deep in an egg without having cracked the shell." (R8) One assumes that a hole was made without cracking around its edges, as in X9. (WRC)

X15. June 8, 1953. Flint, Michigan. "Also, in our files, is a rather aged and yellow supplement to the Flint (MI) Journal showing a picture of a deplumed chicken, 'pecking around a truck twisted like a steel pretzel' in the aftermath of the famous Flint Tornado of 8 June 1953. While it is not the mission of the National Severe Storms Forecast Center (NSSFC) to record tornadoes which deplumed fowls, enough events of this phenomenon have been documented over the past one hundred and forty years to warrant its acceptance." (R10)

X16. No date or place given. "No account of tornadoes is complete without the recital of some of the many 'freaks' which such storms are wont to perform. The removal of feathers from chickens, the complete destruction of houses, the clean sweeping through deep forests, and the carrying of objects great distances, are examples frequently recounted..... Here are some excerpts from the numerous accounts.... An automobile locked in a garage was undamaged, although the garage was blown to splinters. Half a dozen glass jars of fruit were carried 100 yards by the winds and not damaged." (R6)

X17. No date given. Texas. From a study of survivors in a small Texas town that was struck by two tornados a year apart. "But the tornadoes did leave their mark. After the first one, Moore says, 73 percent of the people admitted some member of their family suffered from emotional problems, apparently induced by the tornado. The second tornado was milder, and resulted in more than half of the people with this complaint. Sample emotional ills: One woman developed a limp although her doctor could find no physical cause. Another reported blindness for several days after the storm. A third experienced temporary amnesia. Several other persons reported unexplained weakness, insomnia, nightmares, and general depression. More than a year after a tornado, one survivor still could not use her home air-conditioner because of the sound of air being pulled through it." (R9)

X18. September 2, 1945. Khumotovo, U.S.S.R. In Chapter GWF, we cataloged many falls-from-the-sky of fish, frogs, hay, and other creatures and materials. Usually, the contents of such falls are assumed to have been sucked up by vortex-type storms, carried some distance, and then scattered widely over the ground, often at the feet of amazed onlookers. At least, we would expect that active wind vortices would be good scatterers of their contents.

D.V. Nalivkin, however, has collected evidence that in at least some cases the levitated objects and materials are transported through the atmosphere in small, compact masses, relatively intact, just as they were sucked up. They are then dropped in an area roughly the size of that where they originated. This defies common sense.

Nalivkin gives several specific anecdotal examples, We choose two for inclusion here: stacked hay (below) and the contents of a small pond (X19).

"On September 2, 1945, to the north of Moscow, in the village of Khumotovo, a stack of hay was lifted up by a tornado. After some time the compact mass of hay dropped from the cloud 3 km to the side of the track of the tornado, whose width was not more than 300 m."

The dense stack of hay was transpoted a total of 5 km and dropped to the ground as a compact, undispersed mass. (R11)

X19. 1927. Serpukhov, U.S.S.R. "In 1927, not far from Serpukhov, a tornado sucked up a small pool with its entire population. After a few kilometers, on the outskirts of the city, the pond with all the fish and frogs was dropped from the cloud, over quite a small area. The pool was transported in the form of a compact unit." (R11)

The "compact-mass" theory of transportation is at odds with many of the falls reported in Chapter GWF, where most falls consist only of one species of animal and no other naturally associated animals, vegetation, or inanimate debris.

References

R1. "Phenomena of Storms," Scientific American, 22:302, 1870. (X1)
R2. Smith, George Clinton; "Cyclones and Tornadoes," Popular Science Monthly, 23:748, 1883. (X2)
R3. "Trombe," Ciel et Terre, 14:144, 1893. (X4) (Cr. L. Gearhart)
R4. Lewis, F. Park; "Freaks of the Tornado," Scientific American, 92:423, 1905. (X6)
R5. Walsh, George E.; "Freaks of the Tornado," Harper's Weekly, 57:25, May 17, 1913. (X3)
R6. Meisinger, C. LeRoy; "Tornadoes," Science, 52:293, 1920. (X16)
R7. "Tornado Freaks," American Meteorological Society, Bulletin, 14:118, 1933. (X9)
R8. Flora, Snowden D.; "Freaks of the Storm," Tornadoes of the United States, Norman, Oklahoma, 1953, p. 13, 78. (X5, X7, X8, X10, X11, X12, X14)
R9. "Finds Mental Ills Are Aftermath of Tornadoes," Science Digest, 43:20, May 1958. (X17)
R10. Galway, Joseph G., and Schaefer, Joseph T.; "Fowl Play," Weatherwise, 32:116, 1979. (X13, X15)
R11. Nalivkin, D.V.; Hurricanes, Storms and Tornadoes. New Delhi, 1982, pp. 432-435. (X18, X19)

GWT8 Tornado Incidence Correlated with Magnetic Variation

Description. The tendency of tornados to be more frequent along lines of 8-10° magnetic variation, at least in Missouri, where a study was made.

Data Evaluation. One old analysis from a limited geographical area. Rating: 3.

Anomaly Evaluation. Any cause-and-effect relationship between the variation of the earth's magnetic field and tornado frequency would be startling in terms of present meteorological theory. Rating: 2.

Possible Explanations. Trends in magnetic variation may be related to geology and topology, which in turn might affect tornado development.

Similar and Related Phenomena. Geography strongly influences weather, as exemplified by "Tornado Alley" in the American midwest.

Examples of a Relationship between Tornados and Magnetic Variation

X1. Statistical analysis. "The following may be of interest as to the possible relation between tornadoes and whatever causes variation of compass. The variation in Missouri was determined by a magnetic survey made by Prof. F.E. Nipher. The number of tornadoes was obtained from Signal Service publications, Missouri Weather Reports, newspapers and individuals. None but genuine twisters were listed. The greatest variation is in the extreme N.W. part of the state, the least in the S.W.

On the line of:

11° variation	3 counties had	7 tornadoes
10	5	15
9	20	22
8.3	18	13
8	14	7

7.3	23	8	
7	11	5	
6.3	8	4	
6	4	1	(R1)

References

R1. Llewellyn, J. F.; "Relation between Tornadoes and Variations of the Compass," American Meteorological Journal, 4:135, 1887. (X1)

GWT9 Landspouts or Dustspouts

Description. The formation of the waterspout's typical hollow tube from dust and sand rather than water and mist. In contrast to dust devils and whirlwinds, a parent cloud is present. On the other hand, except for its marked tubular structure, the dustspout is very tornado-like and may, in fact, be just an unusual subspecies of this phenomenon.

Data Evaluation. A single but well-observed example. Rating: 3.

Anomaly Evaluation. The dustspout is curious for its hollow-tube structure, which is much more obvious than in a normal tornado. Otherwise, it seems no more mysterious than the ordinary tornado. Rating: 3.

Possible Explanations. Dustspouts are probably just weak tornados.

Similar and Related Phenomena. All tornados, waterspouts, dust devils, and whirlwinds. (GWW).

Examples of Dustspouts

X1. December 27, 1915. Persia. Description of a "waterspout" formed of dust 150 miles from the nearest sea. "Its distance from myself as observer was about two miles, and it was viewed through a pair of Zeiss glasses with a magnification of eight. As the pendant gradually dropped from the cloud, a hollow column of dust from the plain rose to meet it. The pendant and column eventually joined, the whole swaying about in a particularly beautiful manner. The height of the column from the plain to the cloud was about 2,000 feet, and the motion of the column about fifteen miles per hour but very irregular. I have no note on the direction of rotation of the column. The whole phenomenon lasted about fifteen minutes, and the pendant portion withdrew into the cloud first, leaving the lower portion rotating at the bottom. At the base of the column there was a fountain of large fragments thrown out, stones, sticks and anything that was loose. The whole column appeared like a translucent glass tube, but flexible, that is, there was a dark edge and a brighter middle.....A solid column of mist would have given an exactly opposite effect, namely, a dark middle and a bright edge. There is no doubt in my mind at any rate that the column was hollow, and that the lower part of it was composed of dust, which was of a browner colour than the cloud above it. Such a 'landspout' is, of course, not to be confused with the ordinary dust devil, which is quite common in any desert on a bright day." (R1) Dust devils (GWW) do not have parent clouds. (WRC)

References

R1. Busk, H. G.; "Land Waterspouts," Meteorological Magazine, 61:289, 1927. (X1)

GWT10 Waterspouts between Clouds

Description. The formation of waterspouts between two clouds rather than from cloud to water.

Data Evaluation. Only two observations have been uncovered in the meteorological literature. The observations are difficult because it is often impossible to determine whether the funnel-like structures are composed of water or are simply clouds. Rating: 3.

Anomaly Evaluation. Waterspouts or funnel clouds between clouds can be classified as unusual but there seems to be no theoretical reason why vortexes cannot form between clouds, even to the point of one drawing vapor from another. Rating: 3.

Possible Explanations. The chance connection of two clouds by a funnel or vortex, perhaps encouraged by different meteorological conditions existing at two cloud levels.

Similar and Related Phenomena. Horizontal funnel clouds (GWT3), which sometimes end in mid-air; cloud arches (GWC2), which connect widely separated clouds.

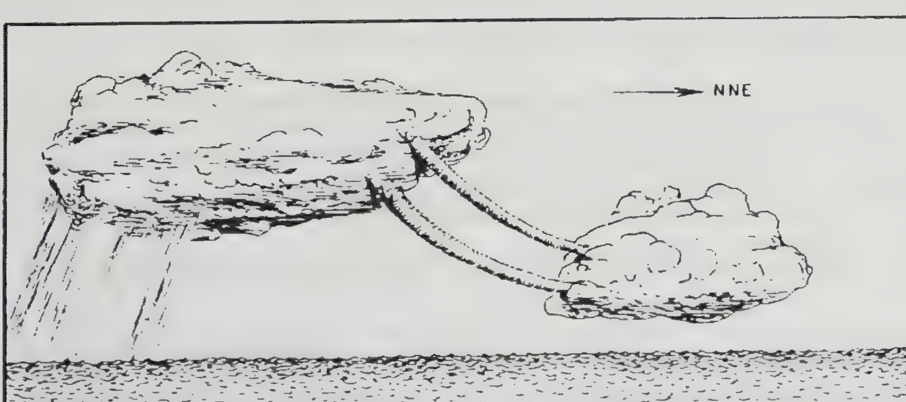
Examples of Waterspouts between Clouds

X1. May 10, 1928. South China Sea. "Sky three parts clouded with heavy Cumulus. Rain squalls around the horizon. Observed peculiar cloud formation to Eastward. Altitude about 3500'. It appeared as if a heavy rainfall was taking place from one cloud to another. It was quite apparent that no rain was falling into the sea. This rain was 'funnel—shaped, and it is considered that a small waterspout had formed in the sky and was sucking rain from a heavy cumulus cloud to another cloud (small, fluffy and whitish) above it." (R1)

X2. June 14, 1928. North Atlantic Ocean. "...at 1.55 p.m., a nimbus cloud bearing W.N.W. and moving in a N.N.E.'ly direction was observed to be connected to a bank of cumulus cloud by two waterspouts, which did not reach sea, but merely stretched between the two cloud-banks." (R2)

References

R1. Haselfoot, F.E.B.; "Cloud Phenomenon," Marine Observer, 6:102, 1929. (X1)
R2. Major, T.W.; "Waterspouts between Cloud," Marine Observer, 6:127, 1929. (X2)



Two waterspouts linking two clouds over the North Atlantic (X2)

GWT11 Forked Waterspouts

Description. A single waterspout funnel that splits into two diverging branches.

Data Evaluation. A solitary example has been found, which is weakened by the possibility that a closer spout may conceal the upper portion of a second, more distant spout, making it seem as if the first spout possesses two lower branches. Rating: 3.

Anomaly Evaluation. Forked waterspouts, if a fact, present serious problems in explanation, because at the fork there would seem to be two vortex walls rotating in opposite directions. Rating: 2.

Possible Explanations. Forked waterspouts may be simply illusions due to perspective and bad seeing.

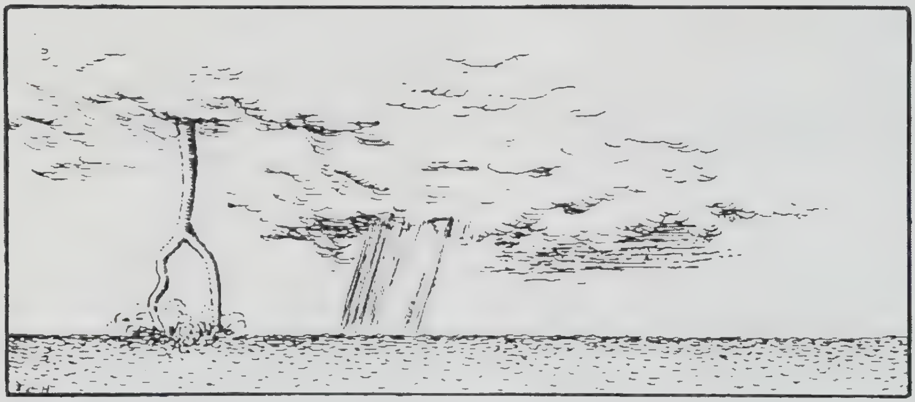
Similar and Related Phenomena. None.

Examples of Forked Waterspouts

X1. May 19, 1967. South China Sea. "A waterspout which divided into two branches about half-way between the cloud base and the sea, as shown in the sketch, was seen at 0715 LMT about 10 miles off. The two parts joined together about 10 min later to form a single column, at the base of which great turbulence was observed." (R1)

References

R1. Rippon, R.G.; "Forked Waterspout," Marine Observer, 38:62, 1968. (X1)



A forked waterspout observed in the South China Sea (X1)

GWT12 Abnormally Thin Waterspouts

Description. Waterspouts with very thin funnels (less than 1 foot in diameter) or very low diameter-to-height ratios (less than 0.01).

Data Evaluation. A few accounts of rather poor quality have been found. One difficulty here is that the visible dimensions of a waterspout, as defined by the spray and vapor, may not mark the true bounds of the atmospheric vortex. Rating: 3.

Anomaly Evaluation. Atmospheric vortexes can be almost any diameter---there seem to be no physical restrictions---but it is remarkable to find stable waterspouts a hundred times their diameters in height, at least from the standpoint of stability. Rating: 3.

Possible Explanations. It may be that our physical expectations are faulty here and natural vortexes are much more stable at very low diameter-to-height ratios than we predict from intuition. Another possibility is the presence of an unappreciated stabilizing factor, such as an electrical discharge.

Similar and Related Phenomena. Other atmospheric vortexes may also display low diameter-to-height ratios (indeed, we would expect them to based on the similarity of the phenomena), but so far we have found no such records.

Examples of Abnormally Thin Waterspouts

X1. May 16, 1898. Eden, Australia. "The longest recorded waterspout occurred off Eden, Australia, on May 16, 1898. Pilot Newton described it as being 'straight as a shaft' and 'thirty times as high as a clipper ship.' Theodolite measurements verified its actual height at 5,014 feet---nearly a full mile above sea level. Central funnel diameter, however, was a mere ten feet."(R1)

X2. December 18, 1917. Rabat, Morocco. Spout 1000 feet high, but only 3 inches in diameter. (R1)

References

R1. Mooney, Michael J.; "Sea Squirts," Oceans, 6:42, May 1973. (X1, X2)

GWT13 Waterspout Funnel-Knots

Description. The appearance of knots or bulges at irregular intervals along an otherwise uniform waterspout funnel.

Data Evaluation. A single report casually mentions the existence of this phenomenon. Rating: 3.

Anomaly Evaluation. Waterspout theory does not predict funnel bulges, but said theory is based upon uniform atmospheric conditions. It is conceivable that waterspout diameters may expand as atmospheric parameters change at various altitudes. Rating: 3.

Possible Explanations. Varying atmospheric conditions (temperature, pressure, humidity, wind velocity, etc.) along the spout's funnel may dictate different funnel diameters.

Similar and Related Phenomena.

Examples of Waterspout Funnel-Knots

X1. General observations. "Other strange aberrations have produced 'funnel-knots' at irregular intervals, a great bulge in the upper funnel, and a classic 'hourglass' shape." (R1)

References

R1. Mooney, Michael J.; "Sea Squirts," Oceans, 6:42, May 1973. (X1)

GWT14 Bull's-Eye Squalls or White Squalls

Description. Strong vortices or squalls that descend vertically, sometimes from a clear sky. Some are presaged by the appearance of a bright region overhead.

Data Evaluation. Several reports in science magazines of strong downbursts and ground-level damage in different parts of the planet. Rating: 2.

Anomaly Evaluation. Vortices and strong turbulence invisible to the naked eye are well known to atmospheric scientists and to aircraft pilots; e.g., CAT or "clear-air turbulence." However, strong downbursts capable of leveling large areas of forest are phenomena not fully explained. Rating: 3.

Similar and Related Phenomena. Clear-air turbulence; the explosive onset of whirlwinds (GWW1). Some devastated forest areas, particularly in South America, have been attributed to meteor impacts. They could, however, be due to strong downbursts. (See p. 177 in Science Frontiers II.)

Examples of Bull's-Eye Squalls

X1. General observations. "Undoubtedly the most dangerous spout of all is the dreaded 'Bull's-Eye Squall' or 'White Squall.' Slater Brown explains that: 'On rare occasions, when the air is too dry to produce water in a spout, though all the other conditions are present, there occurs what is known as a white or Bull's Eye Squall....The Portugese describe a Bull's-Eye Squall as first appearing like a bright white spot at or near the zenith, in a perfectly clear sky and fine weather, and which, rapidly descending, brings with it a furious white squall or tornado. They generally occur off the west coast of Africa." (R1)

X2. August 1, 1984. Andrews Air Force Base, Maryland. Called a "microburst", the following phenomenon resembles the bull's-eye squalls.

"...a strong downdraft that causes winds to spread out in a ring-like pattern as they reach the ground....occurred last August 1. [T.T. Fujita's] study reveals the strongest microburst ever recorded happened only six minutes after Air Force One landed at Andrews Air Force Base near Washington. The winds measured near the end of the runway exceeded 130 knots, or about 149 miles per hour." (R2)

X3. Occasional occurrence. Brazil. "Scientists studying weather patterns in the Amazon Basin have detected extremely powerful, sudden bursts of wind over the rainforest. The winds, which appear to be associated with thunderstorms in the northwest part of Brazil, blow downward with tremendous force. Satellite photos indicate that a single episode demolished 10 square miles of jungle in only 20 minutes." (R3)

References

R1. Mooney, Michael J.; "Sea Squirts," Oceans, 6:42, May 1973. (X1)

R2. Simon, C.; "Record-Breaking Microburst near Air Force 1," Science News, 125:36, 1984. (X2)

R3. Anonymous; "Puzzling Winds," INFO Journal, #74:39, 1996. (X3)

GWT15 Tornado Onset Correlated with Intracloud Lightning

Description. The appearance of tornados during or immediately following high ratios of intracloud lightning discharges to cloud-to-ground lightning discharges.

Data Evaluation. As of 1995, only one report of the phenomenon in a popular science magazine. Rating: 3.

Anomaly Evaluation. The subject correlation is unexplained. Is it just an acausal correlation or does the intense intracloud lightning actually initiate the formation of a tornado? Rating: 3.

Similar and Related Phenomena. The apparent reduction of cloud-to-ground lightning near tornados (GWT1-X13).

Entry

X1. April 17, 1995. Oklahoma. On this date, the Optical Transient Detector satellite passed over an Oklahoma thunderstorm. The satellite recorded that there were 20 times more cloud-to-cloud lightning discharges than cloud-to-ground strikes. Normally, the ratio is 3:1 or 4:1, according to ground observers, who of course have a more limited view of storms than satellites.

About a minute after the satellite had passed over the storm, a tornado emerged from the cloud.

"The new satellite results suggest that a thundercloud is likely to spawn a tornado when an unusually high proportion of its lightning flashes do not hit the ground." (R1)

Reference

R1. Hecht, Jeff; "Tornado Watchers Get a Flash of Inspiration," New Scientist, p. 17, October 7, 1995. (X1)

GWT16 Anomalous Fallout of Debris from Tornados

Description. The long-distance transport of tornado debris and the preferred pattern of its deposition along the storm track.

Data Evaluation. A lengthy, comprehensive study published in a mainstream science journal. Rating: 1

Anomaly Evaluation. Meteorologists are uncertain as to: (1) How debris is transferred from the tornado proper to the mesospheric circulation; (2) Why tornado-carried debris tends to be deposited to the left of the storm track; and (3) Why a "preferred" band of debris deposition exists. Rating: 3.

Similar and Related Phenomena. The counterclockwise circulation of low-pressure cyclones in the Northern Hemisphere;

Entries

X0. Introduction. Tornados, like lightning and earthquakes, are examples of the extremely powerful forces Nature can raise on our planet's surface. When contemplating tornadic forces, science writers usually focus on the damage done along the storm's ground track: the demolished buildings, the number of deaths, and attention-grabbing phenomena, such as straws driven endwise into telephone poles.

A less-publicized phenomenon---one of more scientific importance---is the distant fallout of debris swept up by strong tornados. How far is debris carried? How heavy is it? What are the fallout patterns? Answers to such questions give us clues to tornado structure and its interactions with larger-scale atmospheric activity, such as mesospheric circulation.

X1. Tornado fallout studies. Comprehensive, far-ranging studies of tornado fallout are scarce. Anecdotal reports, in contrast, are common, such as shingles being dropped 5 miles away. This catalog entry is based upon a 1995 survey by J.T. Snow et al published by the American Meteorological Society. It is based upon data from over 10,000 North American tornados.

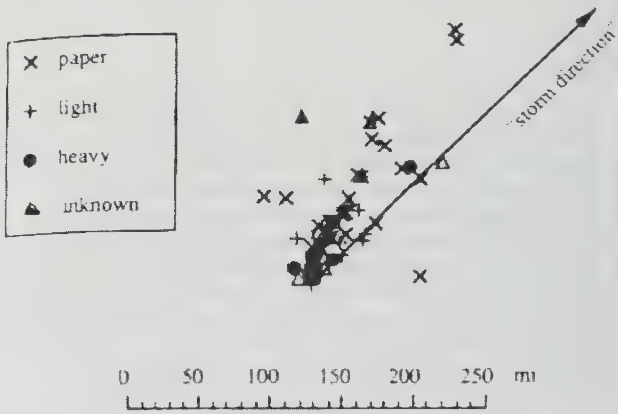
Snow et al first established three categories of fallout:

(1) Traceable paper (checks, letters, invoices, etc.)
(2) Traceable light objects weighing less than one pound (shingles, bank pouches, bundles of cancelled checks, etc.)
(3) Traceable heavy objects over one pound (pieces of plywood, aluminum siding, household items, etc.)

Their lengthy survey yielded three "conjectures" and a unique summary graph illustrating fallout patterns. (See accompanying figure.) We now quote from the first two conjectures.

(1) "Debris, sometimes large pieces, does fall from some tornadic storms well downstream from its source. While most lofted material falls out locally, we suspect a small amount of debris is carried upward in or around the tornado core and transferred into the circulation of the mesocyclone. The rising air in the mesocyclone apparently carries the material still higher into the parent storm. Exactly how high material is lofted and how the transfer occurs remains unclear."

(2) "Consistent with Anderson's findings, composited historical data contains hints that there is organization in how fallout occurs downstream. The large majority of historical accounts of long-distance transport of debris place the fallout to the left of the direction of storm movement. There is also a suggestion of a concentrated band of material within the overall fallout pattern..." (R1)



Composite pattern of 68 debris reports from 31 tornadic storms. Debris fallout items are plotted by distances from their sources and distances from the storm track. Note the leftward trend and the suggestion of a favored band. (R1)

X2. November 10, 1915, Great Bend, Kansas. This F4 tornado gives us a fascinating collection of long-range fallout anecdotes.

"Figure 4 (not reproduced) suggests that most heavy debris falls out within 50 miles (80 km) of its source, while most light debris falls out within 90 miles (145 km) of its source. Paper debris, on the other hand, can be deposited much farther. The farthest reported distance for any fallout is 210 miles (335 km); this was a cancelled check, found in Palmyra, Nebraska, transported by the thunderstorm that produced the 1915 Great Bend tornado. This tornadic thunderstorm also transported light and heavy objects farther than any other storm on record. Clothing, shingles, and fragments of books were found in Glasco, 87 miles (140 km) to the northeast of Great Bend. A sack of flour, categorized as heavy, was found 110 miles (175 km) to the northeast." (R1)

Reference

R1. Snow, John T., et al; "Fallout of Debris from Tornadic Thunderstorms: A Historical Perspective and Two Examples from VORTEX," American Meteorological Society, Bulletin, 76: 1777. 1995. (X0-X2)

GWT17 Tornados Correlated with Oil Deposits

Description. The correlation of tornado origins and areas where gas and oil deposits exist.

Data Evaluation. A newspaper account of a paper presented at a meeting of the American Geophysical Union. The claim is based only upon a correlation. No physical evidence was presented. Rating: 3.

Anomaly Evaluation. Mainstream science seems to have rejected this claim without further investigation. Since tornado genesis is deemed to be purely meteorological, the claim that subsurface geological phenomena may be involved is anomalous. Rating: 2.

Similar and Related Phenomena. The correlation between the locations of spontaneous wildfires, geological fault networks, and coronal mass ejections. (GWI2-X2)

Entry

X1. General observations. Sometimes obscure and unlikely correlations lead to new insights. In this context, we are obliged to mention a most improbable connection proposed by chemical engineer S. Mori in a paper presented at the Spring 2000 meeting of the American Geophysical Union. Mori suspects that oil and gas deposits are linked to the origin of tornados!

"In his paper, Mori said that positively charged oil deposits underground establish polarity with negatively charged oxygen ions at the surface. When a thunderstorm passes over the oil field, he thinks this subsurface polarity links up the with electric polarity established between clouds and ground, creating the vacuum that spawns the tornado.

"Over the years, Mori said he's built a data base of about 8,000 tornado hits in the United States for comparison with the location of known oil and gas deposits. He said that studies in Kansas, Pennsylvania and Texas found a high correlation." (R1)

Reference

R1. Lore, David; "Underground Oil One Twist in Tornado Theory," Charleston (WV) Dispatch, June 8, 2000. Cr. J. Dotson. (X1)

GWT18 Enigmatic Geyser-Topped "Waves"

Description. The appearance during heavy seas of wave-like structures topped by several thin geysers. This phenomenon is totally enigmatic.

Data Evaluation. Testimony of a seaman dating back to 1934. Obviously, caution must be used here. Rating: 3.

Anomaly Evaluation. The "family" of small geysers atop the giant wave-like structure has no known counterparts that we know of, and no explanation either! Rating: 2.

Similar and Related Phenomena. Families of whirlwinds and dust devils (GWW6).

Entry

X1. Spring 1934. North Pacific Ocean. Report from the freighter Cape Horn enroute to Singapore.

G. Craig was the helmsman on the Cape Horn during a powerful storm (winds of Force 9-10, seas running 8 meters high). Even at 4 A.M., the phosphorescence of the breaking sea made it seem like daylight.

At 4:30, Craig saw what he thought was a colossal wave forming. It was so large that the vessel seemed certain to capsize. He thought he was a goner. But, strangely, the "wave" closed with the vessel very slowly and seemed to move independently of the rest of the stormy sea. Craig recalled other strange features of the phenomenon.

"...what I had initially mistaken for wave crests were actually widely-spaced 'geysers', dancing on the upper surface and each rising to a height of about 20 feet, dropping to half of it, then rising again." [See Craig's accompanying sketch.]

Then, suddenly, when all seemed lost, the wind dropped from a full gale to an eerie calm. The "wave" passed---gently ---and then the storm resumed.

The Cape Horn was drenched, but there had been no shattering of glass nor rending of wood. There was some flooding but no more than usual in very heavy seas. Some of the lumber lashed to the deck had been lost, but, overall, damage was minimal. The seemingly catastropic "wave," topped by the peculiar geysers turned out to be only a hollow threat, and the "wave's" hollowness may be a clue to its true nature. (R1)

Indeed, hollowness is characteristic of waterspouts. They are fierce on the outside but calm inside. One senses an impending catastrophe but in the end there is only a gentle passage through the spout. The Cape Horn had apparently been hit dead on by a waterspout.

But the strange geysers atop the 'wave' or spout deserve an explanation that we cannot provide.

Reference

R1. Craig, Gavin; "Surviving a Giant Sea---Did the Ship Strike a Waterspout?" Journal of Meteorology (U.K.), 25:241, 2000. (X1)

G. Craig's sketch of the ominous "wave" topped by several "geysers." The passage through the phenomenon was surprisingly gentle.

GWW WHIRLWINDS AND DUST DEVILS

Key to Phenomena

GWW0 Introduction

Whirlwinds and dust devils are rotary disturbances of the atmosphere like tornados and waterspouts, but they are less energetic and often seem a different class of phenomena altogether. The playful vortex that spins up a cloud of leaves on a sun-warmed hillside or tosses a farmer's hay up on the telephone wires is certainly less fearful than the death-dealing tornado that can drive a straw into a telephone pole like a nail. Size and strength are the obvious differences between these classes of vortexes. Another salient feature of whirlwinds and dust devils is their fair-weather occurrence. Unlike tornados and waterspouts, they appear on sunny days without menacing clouds overhead. Their pranks are legend, but they are not entirely harmless either. The larger whirlwinds may be violent enough to rip off roofs; rarely they generate their own thunder and lightning. Even a small whirlwind a couple feet in diameter can upset lawn furniture and cause considerable mischief.

Whirlwinds and dust devils are set in motion by rising columns of warm air that are somehow invested with rotary motion. No one knows if electricity is important in starting these vortexes, but electrical phenomena are often present; viz., lightning and electric-field variations. On rare occasions, whirlwinds seem to be born violently with a sharp, explosive sound, the precise source of which is uncertain. Once in motion, they seem to have lives of their own and do not expire easily. Dust devils, those denizens of hot desert expanses, not only persist but may spawn progeny, or line up with other devils and march along in formation. Spiral dust-devil tracks are well known. But such amusing aspects of vortex behavior are not sufficiently anomalous to be included in this Catalog.

Finally, a special type of vortex called a "steam devil" makes its appearance in this chapter. Seen when the air temperature is much lower than water temperature, steam devils frequently reach hundreds of feet into the air to join clouds overhead---much like tornados and waterspouts. Despite the similarity, the steam devil is a mild-mannered vortex, possibly a hybrid between the whirlwind and the waterspout; and we include it in this section along with the other less energetic vortexes.

GWW1 The Explosive Onset of Whirlwinds

Description. The tendency of small but obviously energetic whirlwinds to begin suddenly, without warning, "out-of-the-blue," often with an explosive sound or a noise akin to distant thunder. Usually, the skies are fair and winds calm before the phenomenon begins.

Data Evaluation. Surprisingly, sudden and noisy debuts of whirlwinds have been recorded rather frequently. Rating: 1.

Anomaly Evaluation. The typical whirlwind is thought to originate when the warm sun causes convection currents, turbulence, and the subsequent formation of vortexes. All of the small lazy whirls of air seen in woods and fields are probably of this type. The explosive commencement of whirlwinds---especially accompanied by a detonation---is not in accord with this surface convection hypothesis. Something more seems required (see below), but it is not likely that current theory will have to be bent very far. Rating: 3.

Possible Explanation. Since the affected area is usually calm prior to the appearance of the whirlwind, it is possible that the vortexes may form aloft and descend suddenly to the surface, perhaps suddenly enough to generate considerable sound.

Similar and Related Phenomena. Bull's-eye squalls (GWT14).

Examples of the Explosive Onset of Whirlwinds

X1. June 2, 1779. Aberdeenshire, Scotland. "The 2nd of June (1779) sitting by the water we saw a pillar of water rise as high as the tallest tree, and fall down again, after which it rolled along for a considerable space in large rolls as if a cask had been under the water, (and out of those rolls sprung up small strings of water, rising pretty high, as out of the strup of a razor)---The noise it made was such as a firework of powder makes when first set off, but much louder. The day was clear, fine sunshine and not a breath of wind." (R10)

X2. June 29, 1842. Cupar, Scotland. "About half past 12 o'clock, whilst the sky was clear, and the air, as it had been throughout the morning, perfectly calm, a girl employed in tramping clothes in a tub in the piece of ground above the town called the common, heard a loud and sharp report overhead, succeeded by a gust of wind of most extraordinary vehemence, and only of a few moments duration. On looking round, she observed the whole of the clothes, sheets, &c, lying within a line of certain breadth, stretching across the green, several hundred yards distant; another portion of the articles, however, consisting of a quantity of curtains, and a number of smaller articles, were carried upwards to an immense height, so as to be almost lost to the eye, and gradually disappeared altogether from sight in a south-eastern direction and have not yet been heard of. At the moment of the report which preceeded the wind, the cattle in the neighboring meadow were observed running about in an affrighted state, and for some time afterwards they continued cowering together in evident terror. The violence of the wind was such that a woman, who at the time was holding a blanket, found herself unable to retain it in fear of being carried along with it." (R1)

X3. Circa 1879. Signy-le-Petit, France. "The weather was clear, there were no clouds, the air was cold, but still; there was not the least sign of wind. At Signy is an isolated house occupied by one named Chailloux-Binet. It is built of stone and roofed with slate. Suddenly a dull sound was heard, somewhat like the rumble of a carriage drawn by a horse at full gallop, then a whirlwind of irresistible force was formed, which suddenly and instantaneously carried off the roof of the house, and dispersed it in all directions. This whirlwind was neither preceeded nor followed by any rain. It is also extraordinary that this house alone was affected, and at ten metres distance no disturbance of any kind was experienced." (R2)

X4. September 3, 1879. Montgomery County, Maryland. A small but destructive whirlwind began its course with a roar. Several people heard sounds like explosions during its progress. (R4)

X5. Circa 1880. East Kent, Ontario, Canada. Two men were in a field "... when they heard a sudden loud report, like that of a cannon.

They turned just in time to see a cloud of stones flying upward from a spot in the field. Surprised beyond measure they examined the spot, which was circular and about 16 feet across, but there was no sign of an eruption nor anything to indicate the fall of a heavy body there. The ground was simply swept clean." (R3)

X6. August 27, 1886. Lough Neagh, Northern Ireland. "While standing with Mr. S. A. Stewart in a recently-mown meadow, near Portmore Lough, on the eastern side of Lough Neagh, our attention was attracted by a rumbling noise. The day was very fine and warm, and dead calm, not a leaf stirring, and a few very light clouds were in the sky. The noise was like a short distant peal of thunder, but sounded faint rather than distant. While we watched, a whirlwind suddenly appeared in the direction whence the sounds had come (the north), and at a distance of about a hundred yards from us. A quantity of loose hay was instantly whirled upward to a height of about 100 feet, and, after floating about in circles, slowly settled down. A haycock at the spot was much disturbed, and presented the appearance of having endured a gale of wind. The time between the rumbling sound (which closely resembled the distant report of a cannon) and the appearance of the whirlwind was about half a minute, and the whirlwind lasted somewhat over a minute." (R6)

X7. June 21, 1894. Reigate, England. A clear and brilliant day, no wind stirring. A violent whirlwind appeared without warning within a few yards of the observer, carrying hay to great heights." (R5)

X8. 1918. Launceston, England. A small localized whirlwind attracted the attention of observers because it made a noise like distant thunder. (R7)

X9. October 20, 1949. Shoeburyness, England. "Mr. Whitaker, who happened to be outside his office at the time, said that while watching what appeared to be a frontal cloud he heard a muffled sound like distant thunder or an explosion, and on turning to the south-west saw that at a distance of about 1,000 yd. the air was filled to a considerable height with leaves, twigs and similar light debris swirling violently as though after a large but smokeless explosion. He called out two other observers, who saw the subsequent events with him. Almost at once the wind increased to gale force, torrential rain began to fall, and the debris, now quite dense and only a few hundred yards away, was travelling towards them from a south-westerly direction and was observed to be rotating from left to right, i.e. counter-clockwise. The disturbance very quickly arrived where they were standing. Tall trees in leaf were bent over and thrashed about wildly, and one or two broke. These trees had trunks about 1 ft. in diameter and were about 30 ft. high in a row across the path of the disturbance.....The disturbance was all over in about a minute and the heavy rain ceased almost at the same time. The damage was confined to a narrow track about 100 yd. wide or less." (R8)

X10. September 3, 1955. Pilsden Pen, England. During a picnic. "Suddenly at about 1305 BST a sound was heard from the west like sand being loaded into a truck. But only a level stretch of coarse grass was to be seen. Some of the grass in the direction of the sound was then observed to be moving and becoming flattened, while bits of paper were seen whirling in the air, though the wind was light where the party was. In a few seconds the miniature whirlwind was upon the picnickers. It removed a small paper bag, and lifted up an umbrella which had been left open on the ground. This was moved in an anticlockwise manner away north-eastwards over the earthen rampart of the prehistoric fort and about twenty feet up into the air." (R9)

X11. June 16, 1988. Avebury, United Kingdom. Vapor vortices or vapor whirlwinds sometimes appear and dissipate suddenly. R. Lucas, a farmworker, apparently saw a phenomenon of this type in a wheatfield in the summer of 1988. Here is what he reported.

"Looking across the field of winter wheat to the east..., he suddenly noticed at a distance of 80 metres... what he took to be a large puff of white 'bonfire smoke' rising to 15 feet (5m) maximum height. The outer part of this 'smoke' column was scarcely rotating but the middle part, which was too thick to see through, was spinning rapidly. In a couple of seconds the effect had ended; the spinning central column had gone and the residual 'smoke' or cloud of fog drifted gently in the prevailing light north-east wind towards the south-west and dissolved after going several yards. He used the word smoke out of convenience but said that the effect was more likely caused by water vapour, cloud droplets or fog. He further emphasized the swiftness of the appearance and disappearance of the phenomenon. It had arrived suddenly like 'smoke from a distant cannon' or just as if 'a smoke-filled or fog-filled balloon had suddenly burst.' That is to say, it emerged as if from nowhere. He made the further point that the spinning column might have been very much longer than he could judge, for he realized that the only part he could see was the part rendered visible by the smoke or fog. The diameter of the cloud was about the same as its height, viz 4 or 5 metres."

The same phenomenon appeared again a few seconds later, and still again 5 minutes later. (R11)

References

R1. "Singular Phenomenon," London Times, July 5, 1842. (X2)
R2. English Mechanic, 29:262, 1879. (X3)
R3. "A Curious Phenomenon," Scientific American, 43:25, 1880. (X5)
R4. Farquhar, William Henry, and Hallowell, Henry C.; "A Miniature Cyclone," Popular Science Monthly, 18:264, 1880. (X4)
R5. "A Whirlwind in Surrey," Symons's Monthly Meteorological Magazine, 29: 90, 1894. (X7)
R6. Praeger, R. Lloyd; "Barisal Guns and Similar Sounds," Nature, 53:296, 1896. (X6)
R7. Rogers, R.B.; "Local Whirlwind," Symons's Meteorological Magazine, 53: 68, 1918. (X8)
R8. Hemens, L.G.; "Whirlwind at Shoeburyness," Meteorological Magazine, 79:256, 1950. (X9)
R9. Ward, Cyril G.; "A Whirlwind," Weather, 11:170, 1956. (X10)
R10. Meaden, G.T.; "A Meteorological Explanation for Some of the Mysterious Sightings on Loch Ness and Other Lakes and Rivers," Journal of Meteorology, U.K., 1:118, 1976. (X1)
R11. Meaden, G.T.; "The Vortices of Vapor Seen near Avebury, Wiltshire, above a Wheatfield on 16 June 1988," Journal of Meteorology (U.K.), 13: 305, 1988. (X11)

GWW2 Pranks of Whirlwinds and Dust Devils

Description. A catch-all category of curious observations connected with whirlwinds and dust devils, such as the propensity of these phenomena to lift up people and things and set them down in unusual places and, more remarkably, the dust devil's "inquisitive" behavior.

Data Evaluation. Only a few tales have been collected so far, but they seem authentic. Probably many stories never get into the scientific literature. Rating: 2.

Anomaly Evaluation. As in the cases of lightning and tornados, the pranks of these small vortexes can doubtless be handled by current theories of aerodynamics and physics. For example, the "inquisitve" behavior of dust devils is likely generated by the observer's modulation of wind patterns. Pranks are fascinating but hardly a challenge to basic scientific laws. Rating: 3.

Possible Explanations. See above.

Similar and Related Phenomena. Pranks of tornados (GWT7); the inquisitive nature of some ball lightnings (GLB1); ordinary lightning's pranks (GLL11). The latter two references are to be found in Remarkable Luminous Phenomena in Nature.

Examples of Pranks Played by Whirlwinds and Dust Devils

X1. February 25, 1911. Bradford, England. A letter to the editor called the report of a girl being killed by a gust of wind preposterous and asked for an investigation. The editor replied: "Acting on this suggestion, we communicated with Mr. H. Lander, the rainfall observer at Lister Park, Bradford, who kindly sent us a copy of the Yorkshire Observer for February 25th, in which there was a fairly full report of the inquest on the school-girl who was undoubtedly killed by a fall from a great height in an extremely exposed playground during very gusty weather. One witness saw the girl enter the playground from the school at 8.40 a.m., and saw her carried in three minutes later. Another witness saw the girl in the air parallel with the balcony of the school 20 feet above the ground, her arms extended, and her skirts blown out like a balloon. He saw her fall with a crash. The jury found a verdict, 'Died as the result of a fall caused by a sudden gust of wind.'" (R1)

X2. No date given. Egypt. While walking over the desert. "Hearing a swishing sound behind me, I turned and observed a large revolving ring of sand less than a foot high approaching me slowly. It stopped a few feet away and the ring, containing sand and small pieces of vegetable debris in a sheet less than one inch thick, revolved rapidly around a circle of about 12 ft. diameter while the axis remained stationary. It then moved slowly around me after remaining in one spot for at least thirty seconds, and slowly died down. It would be interesting to know if others acquainted with the desert have come across similar examples of a broad, flat eddy. The ancient superstition among desert tribes that these whirlwinds are spirits, called 'afrit' or 'ginni' (the 'ginni' of the 'Arabian Nights'), would seem to have a reasonable foundation in face of such an 'inquisitive' apparition," (R2)

X3. October 1990. Bristol, United Kingdom. The following account is suspect because it is based on the testimonies of two young children. Since it appeared in a science journal, we decided to include it anyway.

"Two ten-year-old girls were playing with a frisbee in a playing field adjacent to Downend sports centre, on the south-east outskirts of Bristol, in the County of Avon. While throwing the plastic dish, one little girl was surprised when it was suddenly flung back at her by 'some invisible force'. Next, the two children were enveloped in a 'yellow bubble'. This bubble apparently gave both girls a mild 'shock' and threw them to the ground. While lying on the grass, both children experienced difficulty in breathing. Eventually, the girls managed to 'break out' of the 'bubble' and run home, very frightened indeed." (R3)

Since vortices---tornados, whirlwinds---do exhibit electrical properties, we should at least allow for the possibility of a small whirlwind of yellow dust (the "bubble") producing electrical effects.

X4. 1869. Nashville, Tennessee. "In 1869, Harper's Weekly recounted the rather juvenile antics of a waterspout that formed on the Cumberland River near Nashville, Tennessee. According to the magazine, one hot summer day, a group of a dozen men and boys, who had wanted to cool off, had hung their clothes on trees and then began swimming in the river. Abruptly a waterspout that eventually reached a height of seven feet tall formed on the river.

"As the waterspout neared the swimmers, it shifted course, and moved on land and unceremoniously whisked away not only their clothes but also even the trees on which they had hung! Fortunately for the embarrassed swimmers, rescuers came in reponse to the loud calls of the men and boys and finally 'a sufficient number of articles of apparel were secured.'" (R4)

An amusing tale, to be sure, but it should be noted that newspapers and magazines in 1869 often printed exaggerations.

References

R1. Godden, William; "The Tale of---a Gust," Symons's Meteorological Magazine, 46:54, 1911. (X1)
R2. Capes, J. L.; "A Remarkable Whirlwind," Nature, 135:511, 1935. (X2)
R3. Rendall, P.D.; "Did an Electrically Charged Vortex Strike Two Girls in Bristol, Mid-October 1990?" Journal of Meteorology (U.K.), 15:403, 1990. (X3)
R4. Cerveny, Randy; Freaks of the Storm, New York, 2006, p. 265. (X4)

GWW3 Steam Devils

Description. Long fingers or columns of vapor rising from a water surface and swirling upward into the cloud deck. Large arrays of steam devils may form geometrical patterns. This phenomenon requires warm water and very cold air.

Background. Even the most casual observer has seen mist rising from water surfaces when the air is colder than the water. Sailors call it "sea smoke." Air currents form it into eerie swirls and eddies. Much more rarely analogs of whirlwinds and waterspouts form.

Data Evaluation. A handful of good observations plus some excellent photos. Rating: 1.

Anomaly Evaluation. Thermal convection obviously gives birth to steam devils, but why are they so stable, considering their thinness and height? Why do they sometimes form in geometrical patterns? Since tornados and waterspouts have comparable height-to-diameter ratios, the explanation of steam devil formation will probably evolve from present meteorological theory. Rating: 3.

Possible Explanations. The theory of atmospheric vortexes is probably adequate to account for the genesis and maturation of large steam devils. The geometrical patterns of devils may arise from the tendency of convection cells, in both air and water, to assume a hexagonal geometry.

Similar and Related Phenomena. Dust devils and spray devils may be spawned in groups and display some geometrical organization (GWW6); see Phenomena of the Hydrosphere (Chapter GHC in our catalog Earthquakes, Tides...)

Examples of Steam Devils

X1. January 4, 1910. Canandaigua Lake, New York. Bright sun, some low cumulus clouds, temperature 6°F. "The surface of the lake was covered by vapor caused by the difference in temperature between the cold air and the comparatively warm water. This vapor, white mist, gathered in spots in masses rising higher than the surrounding mist. As these masses of vapor reached a height of some twenty feet they appeared to take on a rotary motion and formed themselves into columns slowly rising until their apexes met the low-lying clouds, where they spread out in a funnel shape exactly as do water spouts. The columns varied from a foot to possibly ten feet in diameter; some of them ascending in a straight line and others bent into fantastic curves by the action of the wind. I saw a great number of these mist whirls during a drive of some two hours, covering a distance of ten miles along the lake shore, and as they formed and drifted slowly across the water, illuminated by the rays of the setting sun, they were a beautiful and to me a unique spectacle." (R1)

X2. Circa 1932. Grecian waters. "Prof. (Johannes) Walther tells of a recent voyage in Grecian waters, when a snowstorm was brewing and the waves were high. The cold air striking the warm water caused numerous columns of white vapor to rise over the foamy caps of the waves. They hovered momentarily, then were caught up whirling by the wind, and as they spun away through the air it did not require any violent stretch of the imagination to see them as feminine figures dancing in filmy draperies." The professor wondered if these steam devils might not be the origin of the tales of the Daughters of Nereus who danced on the waves and helped endangered mariners. (R2)

X3. January 30, 1971. Lake Michigan off Milwaukee, Wisconsin. "The period Jan. 30-31, 1971 was intensely cold in Milwaukee, the highest temperature reaching only -6°F with west-northwest winds frequently gusting to 40 mi/hr. Lake snow squalls were present in excelsis along the lee shores of all the Great Lakes. But most interesting was the view from the upwind shoreline. During both days, one could see the typical shallow, dense steam fog near the lake surface (water temperature 33°F) and the cumulus clouds building a few miles offshore. What was unusual were the numerous distinct fingers of columns of vapor swirling out of the steam fog layer directly into the overlying cumulus clouds. It is estimated that they were 50-200 m in diameter, traveled more or less with the wind, were nearly vertical, and showed a slow but distinct rotation (mostly cyclonic) of up to several revolutions per minute. The steam devils tended to be rather short lived, the longest surviving perhaps for 3 or 4 min. An even more interesting view of the same phenomena was taken from a commercial airliner on Jan. 30, 1971..... Visible are small cumulus (which were forming further offshore on this day), plus the steam devils and a highly patterned effect on the surface steam fog. It definitely appears that there were quasi-hexagonal cells elongated along the surface wind direction, the largest steam devils being present at the vertexes of the hexagons."(R3)

X4. December 25, 2000. Gulf of Finland. The Gulf waters were unusually warm, when, on Christmas Day, cold air (-8 to -10°C) moved in.

"Sea smoke developed as cold air was advected over the warm sea. From about 0800 to 1300 GMT, steam devils were observed to rise from the sea smoke. Some of the steam devils observed from Helsinki seemed to reach the height of the stratocumulus cloud base at 200-250 m. In Helsinki many of the tallest steam devils were observed in the lee of three small islands, Melkki, Katajaluoto, and Pihlajasaari. These islands are all about 1 km in their longest direction.

"Many steam devils formed one after another downwind of the islands. They seemed to move roughly with the mean wind and died 1 to 3 minutes after their formation." (R4)

References

R1. Lee, James S.; "A Curious Phenomenon," Scientific American, 102:103, 1910. (X1)

R2. "Pillars of Sea Mist May Be Foundation of Myth," Science News Letter, 22:84, 1932. (X2)

R3. Lyons, Walter A., and Pease, Steven R.; "'Steam Devils' over Lake Michigan during a January Arctic Outbreak," Monthly Weather Review, 100:235, 1972. (X3)

R4. Hyvonen, Reijo, and Bister, Marja; "Steam Devils over the Gulf of Finland," Weather, 57:51, 2002. (X4)

GWW4 Electrical Properties of Whirlwinds and Dust Devils

Description. Visual observation of electrical discharges associated with fair-weather dust devils and whirlwinds and instrumented measurements of their associated electric fields.

Data Evaluation. A few visual observations of overt electrical activity (lightning) complemented by data from electric-field meters. Rating: 1.

Anomaly Evaluation. Clouds of airborne particles (dust, snow, etc.) are normally electrically charged. It is therefore not surprising that dust devils and whirlwinds display some electrical properties. The unusual aspects of this phenomena are the actual production of thunder and lightning under clear skies and the difficult-to-model electric field profiles of passing dust devils. There are, however, no real challenges to prevailing meteorological theories. Rating: 3.

Possible Explanations. The electrical properties of whirlwinds and dust devils merely signify extreme cases of charge separation in dusty vortexes. Nevertheless, no ready explanation seems to exist for the curious electric-field profiles of dust devils.

Similar and Related Phenomena. Electrical phenomena accompanying snowstorms and duststorms (GLD5), electrical properties of tornados (GWT1).

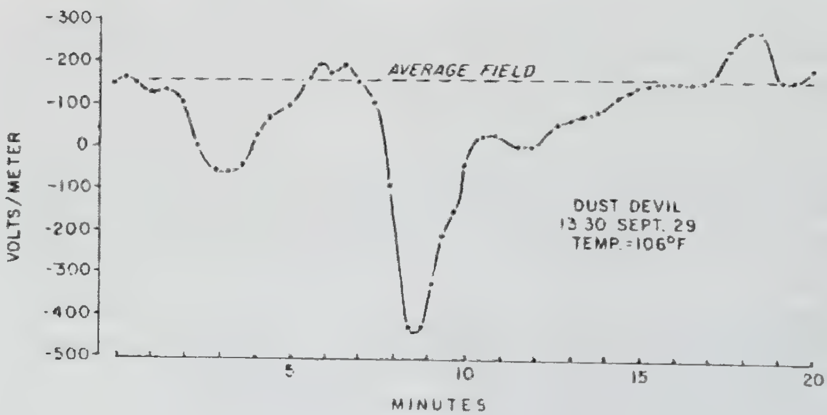
Examples of the Electrical Properties of Whirlwinds and Dust Devils

X1. 1902. Arizona. "I was on the White Mountain Apache reservation, in Arizona, on the day in question, when an ordinary desert whirlwind whirled into view from just around a southerly projecting point of land north of White River from the now abandoned Fort Apache. I had just crossed a flat area among the hills where an ancient lava flow once spread out, forming a 'lava lake,' an area probably six miles across from the afore-mentioned point to the mountainous hills to the northwestward, up which I was then ascending. In a moment it began to gain momentum on entering the level country and in a minute more it was a roaring funnel that was hurling immense quantities of dirt and sand skyward so that they formed an umbrella-like cloud around the apex of the whirling center. As the twister was coming in my direction, I shifted southward over a gulch to another ridge to escape its fury. On it came. It entered the canyon in which I had been only a minute before. Here as the canyon both wedged-in and ascended toward the mountains in the direction it was going, the rushing whirl became 'angry,' as it were. The day had been perfectly clear. Yet in a moment there were chain lightning and ripping thunder on every side, while at the same time the whirler uprooted trees and tore large-sized boulders from their places on the canyon walls, finally destroying itself in that canyon. From my observations I am inclined to believe that the electrical display that accompanied this whirl was due to the friction caused by the whirling debris." (R1)

X2. September 29, 1959. Sahara Desert. Experimental observations. "At the time of obtaining measurements on the earth's electric field during an eclipse of the sun in the Sahara Desert at Kidal, French West Africa, an interesting record was obtained on the electric field associated with a large dust devil. This record is shown in Figure 1, where positive values of the field imply positive charge above the earth. The dust devil was estimated to be between 100 and 200 meters high and about 8 meters in diameter, and its distance of closest approach to the electric field mill was about 30 meters. It was of sufficient strength to raise an army-type sleeping cot several meters into the air, and it was followed by truck for about 1 mile beforeit dissipated its energy. Its speed across country was about 4 m/sec.

The two negative excursions with a tendency to go positive between them suggests a sort of dipole structure for the dust devil with negative charge above (inverted thunderstorm)." (R3)

X3. August 21. 1962. Socorro, New Mexico. Experimental observations. Measurements of the electric field of a New Mexico dust devil revealed a structure qualitatively similar to that of X2. Little success was had in constructing a model that would account for the electric field structure determined in the field. (R4)



Electric field of a passing New Mexico dust devil (X3)

X4. General observations. "A piece of metal inserted into a dust devil a few feet above the ground becomes strongly charged with respect to ground, the amount of charge and its polarity being apparently a function of the nature of the dust particles." (R2)

References

R1. Reagan, Albert B.; "Sand-Storm Electricity," Science, 71:506, 1930. (X1)
R2. Ives, Ronald L.; "Behavior of Dust Devils," American Meteorological Society, Bulletin, 28:168, 1947. (X4)
R3. Freier, G. D.; "The Electric Field of a Large Dust Devil," Journal of Geophysical Research, 65:3504, 1960. (X2)
R4. Crozier, W. D.; "The Electric Field of a New Mexico Dust Devil," Journal of Geophysical Research, 69:5427, 1964. (X3)

GWW5 Energetic Miniature Vortexes

Description. Powerful vortexes measuring just a few feet in diameter and perhaps as tall as a person. Many dust devils, whirlwinds, and incipient waterspouts are only a foot or two in diameter and yet display surprising power.

Background. Anyone who spends much time outdoors sees small whirlwinds kicking up loose leaves and grass. The justification for this entry is the word "energetic," which is admittedly vague but allows leeway for including a wide variety of small yet unexpectedly powerful vortexes.

Data Evaluation. Scrutiny of hundreds of whirlwind accounts has yielded only a few examples of tiny but energetic vortexes. Rating: 3.

Anomaly Evaluation. It is a real puzzle how any accepted meteorological mechanism, particularly thermal convection, can concentrate so much energy in a small vortex. Rating: 2.

Possible Explanations. None.

Similar and Related Phenomena. All rotary disturbances (GWT and GWW).

Examples of Miniature vortexes

X1. April 16, 1872. St. Asaph, England. "On Saturday last, April 16, whilst fishing in the river Elwys at a point about two miles above the well-known Cefn caves, and five from St. Asaph by the river, I witnessed a very singular phenomenon. My attention was suddenly called up-stream by a remarkably strange, hissing, bubbling sound, such as might be produced by plunging a mass of heated metal into water. On turning I beheld what I may call a diminutive waterspout in the centre of the stream, some forty paces from where I was standing. Its base, as well as I could observe, was little more than two feet in diameter.' The water curled up from the river in an unbroken cylindrical form to a height of about fifteen inches, rotating rapidly, then diverged as from a number of jets, being thrown off with considerable force to an additional elevation of six or seven feet, the spray falling all round as from an elaborately arranged fountain, covering a large area. It remained apparently in the same position for about forty seconds, then moved slowly in the direction of the right bank of the river, and was again drawn towards the centre, where it remained stationary as before for a few seconds. As it moved in the former direction, gradually diminishing and losing force as it neared the bank, and finally collapsed in the shallow water. Strange to say, its course was perpendicular to the bank and not with the current." (R1)

X2. July 19, 1913. Hepple, England. "...a narrow strip of wind 1 1/2 ft. wide, drove through a hedge, lifting newly cut hay 60 yards high, proceeded through a tree with great violence, blowing off the leaves of a hedge and tree, and upset a haycock in an adjoining field. It lasted some 10 minutes and was accompanied by great noise." (R2)

X3. No date given. Egypt. "Dust-devils, or rotating columns of sand travelling rapidly across open spaces, are not uncommon objects to desert travellers. Their height and breadth is often very considerable and the evidence of the eddies causing them very great. The smallest of this type I have seen was only about 5 ft. high, that is, the visible column of sand, and less than a foot in diameter. It passed so close to me that it was easy to see its narrow cycloidal path marked on the sand, which was deposited and lifted as the eddy travelled on at not less than 15 miles an hour, although the wind was actually very light." (R3)

References

R1. Gray, J.; "A Waterspout," Nature, 5: 501, 1872. (X1)
R2. Clark, J. Edmund; "A Narrow Squall," Symons's Meteorological Magazine, 49: 52, 1914. (X2)
R3. Capes, J. L.; "A Remarkable Whirlwind," Nature, 135:511, 1935. (X3)

GWW6 Group Organization of Dust and Spray Devils

Description. The appearance of multiple atmospheric vortices in well-ordered circles or lines. The vortices in the circular formations, while spinning on their own axes, also usually rotate around the formation's center---a "wheels within wheels" situation. The observations on hand are not completely forthcoming on the directions of rotation of the individual vortices or the circular formations they belong to.

Data Evaluation. The observation of vortex "families" is mostly anecdotal, although their existence seems unquestionable. Data that might be useful to meteorologists (dimensions, directions of rotation, associated weather conditions, etc.) are skimpy. Rating: 3.

Anomaly Evaluation. We have seen no meteorological theory that explains why geometrically ordered families of vortices, moving as units, should form and persist. Rating: 3.

Similar and Related Phenomena. The organization of large thunderstorm systems (GQH3); tornado "outbreaks").

Entries

X1. Summer 1897. Medicine Lodge, Kansas. An observation submitted by O.C. Pepoon.

"In the summer of 1897, the exact date is forgottten, at about 3 P.M., I noticed a whirlwind moving from the northwest to the southeast. It was in every way similar to an ordinary whirlwind, including the straight wind which accompanied it, except that instead of one circular wind five small whirlwinds moved about a common center. Each whirlwind resembled an ordinary whirlwind in form and velocity. They whirled on their individual axes, also on their common axis, to the right. The whirlwinds were about 15 feet high. (R1)

Here, one should imagine a circle of small whirlwinds rotating about a common center.

X2. General observations. An overall look at Indian whirlwinds by P.F.H. Baddeley.

"Dust whirlwinds are common in all parts of India, especially during the dry season. Sometimes a slender lofty cylindrical pillar of dust is seen revolving on its axis of several such pillars moving on together in the same direction, or revolving in a circle, or as a dense cloud of dust sweeping over the country like a tornado, the cloud of dust occasionally presenting to the view a distinctly columnar structure. In northern India, the smaller whirlwinds appear in dry, windy weather. They occur with singular regularity during the middle of the day. Sometimes a slowly moving whirlwind, instead of appearing as a single column, is found to be composed of several distinct vortices, each one rotating on its axis as it revolves around in the whirling circle. Each separate vortex has attached to it a fan-shaped train of dust." (R1)

X3. General observations from Egypt. R.H. Swinn, formerly Chief Instructor for the Egyptian Gliding School, has had much practical experience with those fascinating little (sometimes not so little) swirls of hot air called "dust devils." Under the broiling Egyptian sun, dust devils launched themselves naturally every few minutes from a tented camp near the airfield where Swinn taught. Curiously, the devils often were born in pairs; a big one followed by a modest little chap following behind by 100-150 yards. The devils ranged from just a foot or so in diameter to 500 yards and more. The giants were majestic masses of swirling sand that moved along at leisurely paces. These appeared harmless enough, but stepping through the outer wall into the vortex sucked the air out of the lungs.

"Outside our hangar there is a large stretch of wind-sheltered concrete which becomes intensely hot. In this area, close to the foot of the hangar, one can start up one's own little devils on occasion by a quick sweep of a signalling bat (which is shaped like a large ping-pong bat) from shoulder level in circular and downwards direction to a point almost touching the ground; one must step rapidly back or the vortex that is set up is spoilt. Such a miniature thermal starts about a foot in diameter and quickly assumes a conical shape about two feet high, moving along the ground at a walking pace. Its rotation increases very rapidly, until one has the impression of a whirling snake in front of one. As it reaches the edge of the concrete a little sand is thrown up and the thermal dies away." (R2)

X4. January 30, 2004. Off the coast of Cyprus. When a tornado crosses a coastline and moves out over the water, it becomes a waterspout. But there is another class of weak rotary phenomena of the atmosphere that occurs over the sea. These are the "spray devils."

R. Sanderson spotted three groups of spray devils 1-2 kilometers apart off the coast of Cyprus in 2004. He watched one of these groups closely. He wrote to the journal Weather about this group.

"This group was observed to consist of a ring of spray devils about 200 m across, containing four or five devils roughly 100 m in height and a few tens of metres across. The individual devils, appearing as pirouetting dancers waving silk scarfs above their heads, were clearly observed to be moving in an anticlockwise rotation around the periphery of the ring with a pulsating motion both in its own spin and in its speed around the ring. The rotation within each devil could not be determined due to the spray." (R3)

The most interesting feature of this group was their coordinated motion. What larger, unseen, rotary phenomenon in the atmosphere was orchestrating this odd collective circular dance?

X5. 1851. Pakistan. P.F.H. Baddeley noticed a large whirlwind containing smaller whirlwinds within it.

"He observed that some dust devils, instead of appearing as a simple column, often are composed of several distinct vortices, each one rotating on its axis as it revolves round and round the whirling circle. The English scientist remarked: 'This remarkable sight gives the idea of a fairy dance around a ring, ---and the motions are, from all accounts, exactly imitated by the dancing Dervishes of Turkey.'" (R4)

X6. 1902. Statesville, North Carolina. A letter to the Monthly Weather Review described a multivortex dust devil the letter's author had observed.

"He wrote that the dust devil consisted of four separate whirlwinds, which followed each other around a circle about twelve feet in diameter, 'like horses going around a horsepower threshing machine.' The whole dust devil, he said, also seemed to be moving to the left around the center of an enlarging coil." (R4)

References

R1. Anonymous; "Dust Whirls and Fairy Dances," Scientific American Supplement, 48:19773, 1899. (X1, X2)
R2. Swinn, R.H.; "Recipe for Dust Devils," Journal of Meteorology (U.K.), 10:17, 1985. (X3)
R3. Sanderson, Ray; "'Spray Devils' near Paphos, Cyprus, 30 January, 2004," Weather, 59:168, 2004. (X4)
R4. Cerveny, Randy; Freaks of the Storm, New York, 2006, p. 206, (X5, X6)

GWW7 Sounds of Atmospheric Vortices

Description. The curious sounds created by various atmospheric vortices, described variously as screeching-howls, flapping, and "swirling" sounds.

Data Evaluation. All reports on file describing vortex sounds are anecdotal. There has, however, been much work done on the dangers aircraft trailing vortices to other aircraft in landing patterns. Some studies of ground damage are also available. Some of these may mention sound emissions. Rating: 3.

Anomaly Evaluation. That energetic atmospheric vortices might emit sounds of various sorts is not surprising. Tornados are well-known to roar like on-coming trains, why shouldn't much smaller vortices whir, screech, and flap? However, it must be admitted that we do not know exactly how such sounds are produced. We, therefore, catalog them as curiosities. Rating: 3.

Similar and Related Phenomena. Noisy clouds (GWC5); screeching of stratified typhoon waves (GHC3-X1 in Earthquakes, Tides...).

Entry

X1. August 20, 1950. Waldorf, Minnesota. A personal anecdote.

"It was perhaps around the 20th of August of 1950, and it was harvest time as my brother and I and our grandfather were busy unloading grain into the elevator pouring it into the granary bin. The day was clear, hot, and muggy, a typical late summer day in southern Minnesota where we farmed near the town of Walforf. Over the roar of the elevator and one-cylinder engine driving it, we suddenly heard a screeching howl coming from the southeast. Looking up from our work, we were startled to see a solid black, whirling column about 24" across and extending from the ground perhaps 200 feet, and straight as a power pole. When we first heard and saw it, it was coming across the hog pasture toward us in the farmyard across the country road separating the hog pasture from the main yard. We watched in fascination as it whipped up considerable straw from the straw-pile hog shed, moved across the gravel road and crossed the power lines, which whipped in agonized gyrations, then moved across the farmyard where it passed not more than 15' from where we were standing watching it in awesome fascination. It passed through the grove behind the house where it left a definite cleared area stripped of leaves. Outside of that whirling and roaring column, there was not a breeze stirring, and it passed not more than 15' away from us." (R1)

X2. General observations. Sounds and ground-effects of aircraft trailing vortices.

T. Surendonk has written to New Scientist how he and a friend would stop on Sepulveda Boulevard, at the edge of the Los Angeles airport, to watch the big jets come in directly overhead for a landing.

"While the huge planes were impressive enough, our attention was captured by an event that sometimes occurred between twenty and thirty seconds after a plane had flown over: a thin tube of misty air would zap past us at apparently high speed accompanied by a rather loud flapping sound.

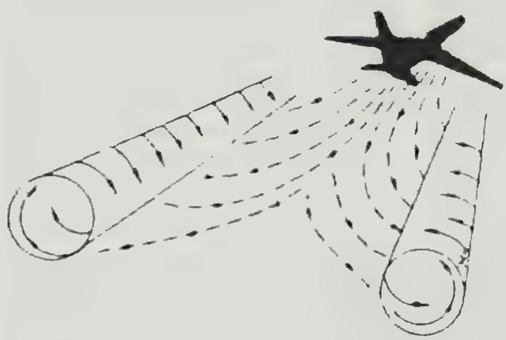
"Sometimes the "mist" would follow a straight path, but often it would follow a really contorted path that made the 'mist' look like a snake engaged in a rather violent path---rather captivating to watch." (R2)

Another letter on this subject was received by the New Scientist offices from T. Matthewson two years later.

"Having lived for many years on a hill overlooking Garwick Airport, three miles away as the plane flies, I became acccustomed to the sinister sounds of swirling air that would follow aircraft passing overhead---although visitors walking in the garden would frequently express alarm."

Matthewson also remarked upon how the trailing vortices young trees in his garden would sometimes be stripped of their upper branches. (R3)

Even ground-level cereal crops have been flattened in circles and other patterns by low-flying aircraft. (R4)



Trailing vortices created by an aircraft's wing tips. The vortices rotate in opposite senses. (R4)

References

R1. Becker, Richard; personal communication, February 6, 1983. (X1)

R2. Surendonk, Timothy; "Just Plane Weird," New Scientist, p. 58, March 5, 1994. (X2)

R3. Matthewson, Tom; "Sinister Swirling," New Scientist, p. 56, December 7, 1996. (X2)

R4. Meaden, G.T.; "A Study of the Effect of Aircraft Trailing Vortices upon a Cereal-Field near an Airport," Journal of Meteorology (U.K.), 14:9, 1989. (X2)

GWW8 Aerodynamic Phenomena as Creators of Simple Crop Circles

Description. Neatly flattened circular areas in cereal fields. Double circles and ringed circles are possible, as are a few other simple configurations. Sizes range from a few feet to many yards in extent.

This section does not include those elaborate, usually hoaxed, fantastic crop-circle designs that have fuelled the "crop-circle craze," which posits UFO and/or parapsychological interventions.

Data Evaluation. Simple crop-circle configurations are rarely mentioned in the scientific and fringe literature. Daytime-visual observations of simple crop-circle formation are even rarer. Mainstream scientific studies of the phenomenon, as limited by the above definition, are absent from our files. Rating: 3.

Anomaly Evaluation. While whirlwinds and whirlwind-family touchdowns are often blamed for simple crop circles, whirlwinds usually leave obvious trails of ground disturbances behind them, and these are usually missing in even the simple crop circles. Some other atmospheric phenomenon, such as microbursts, are also possible creators of simple crop circles. This entire subject lacks scientific attention and, if the simple crop circles are truly of natural origin, they are not well-explained. Rating: 3.

Similar and Related Phenomena. All whirlwind and dust-devil entries (GWW); microbursts (GWT14).

Entries

X0. Introduction. "Crop-circles" is now a general term applied to an amazingly large constellation of circles, other geometrical figures, and often-fantastic designs of flattened plants created in cereal fields---mostly by human hoaxers but, in a minority of cases, probably by atmospheric phenomena, such as whirlwinds.

In the beginning of the crop-circle phenomenon, the crop circles were really just simple circles of flattened grain a few feet to several yards in diameter. Sometimes there were paired circles or even ringed circles, but they were all "simple." These simple designs are the part of the crop-circle phenomenon that may have natural origins; these are the crop circles that are of interest in this part of our catalog.

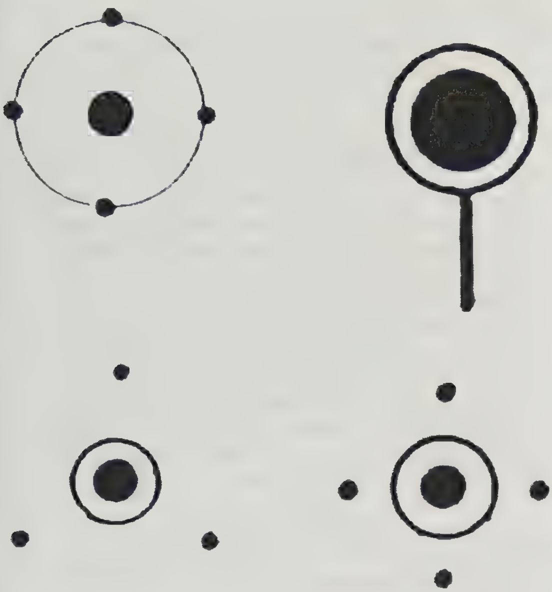
Such simple geometrical damage to farmers' fields and, indeed, to wild grasslands has probably been occurring for millennia.

The other part of the crop-circle phenomenon consists of those complex figures and designs hyped by newspapers and fringe publications. Always, it seems, they are engraved in bucolic fields in the dark of night. They have been associated with UFOs, extraterrestrials, and sundry esoteric forces. These are almost certainly the works of hoaxers. We relegate them and some similar science-associated hoaxes to a future volume of this catalog.

We now examine a handful of those "simple" crop circles that probably have natural origins.

X1. Late Summer 1981. Ross-on-Wye, United Kingdom. Early observations linking simple circles incised in cereal fields with whirlwinds, as reported by J. Lewis.

"I live on a ridge 450 feet (135 metres) above sea level, about 100 feet (30 metres) above the adjacent land; it is quite steep in parts on the north side and stretches for about 1½ miles (2.5 kilometres). One day, at about noon, I was inside my cottage when suddenly I heard a very loud roaring sound, not unlike an express train. I ran outside to see what it was, but saw nothing; the noise was something like the sound of a falling bomb. I thought no more of this until the following morning when taking



Some "simple" crop-circle patterns that are aerodynamically possible when whirlwinds and their satellite whirls touch down in cereal fields.

my dog for a walk. Then I saw two large circles, about 25 feet (7.6 metres) in diameter, of flattened barley in a nearby field. A neighbor who lives on the north side of the ridge had also heard the roaring noise but could find no cause for it. I wondered if we had heard some part of an aircraft or satellite, or even a small meteor, coming down and, with the local farmer, we investigated the circles, but found no debris at all---just flattened barley. The farmer said that sometimes growing conditions made barley collapse at its base, though he could not understand the almost perfect circle."

Further investigation turned up people who had seen a whirlwind in the area at the time. (R1) Also pertinent here is the fact that tornados are often preceded by a roaring sound. So, a strong whirlwind might produce the noise that was heard by Lewis and others.

Such circles in cereal fields appeared in large numbers in the 1970s and 1980s. They were widely publicized.

When alerted to this unusual phenomenon, UFO enthusiasts quickly attributed such circles of flattened crops to UFOs and extraterrestrials. But as long as the crop circles were simple, whirlwinds seemed to be adequate explanations for them. In other words, a good observational case was made that some of the crop circles might not be due to extraterrestrial activities of to hoaxes (which soon appeared in great numbers).

Incidentally, the noise and actions of the whirlwind reported above impel us to refer the reader to the explosive onset of some whirlwinds, as described in GWW1.

X2. Circa 1982. Westbury, United Kingdom. By this date, UFO enthusiasts had had a field-day speculating that nighttime landings of alien spacecraft had left behind the now-widely-publicized crop circles. However, we do have a good daytime description of the actual formation of a crop-circle sans UFO. The tale is, of course, anecdotal and therefore suspect. In truth, the "waves" described below are rather curious and suggest that whirlwinds may be aerodynamically more complex than we imagine.

The source is a letter to G.T. Meaden, Editor of the Journal of Meteorology (U.K.) from R.A. Barnes.

"I have been meaning to write to you for some time on the subject of corn circles. About six or seven years ago I was fortunate to see one of these form in a field at Westbury. It happened on a Saturday in early July just before six in the evening after a thunderstorm earlier that afternoon; in fact it was still raining slightly.

"My attention was first drawn to a 'wave' coming through the heads of the cereal crop in a straight line at steady speed; I have since worked this out to be about fifty miles per hour.

"The agency, though invisible, behaved like a solid object throughout and did not show any fluid tendencies; i.e., no variation in speed, line or strength. There was no visual aberration either in front, above, or below the advancing line.

"After crossing the field on a shallow arc the 'line' dropped to a position about 1 o'clock and radially described a circle 75 ft radius in about 4 seconds. The agency then disappeared." (R2)

The "wave" observed by Barnes sounds like something out of science fiction. He did not compare the "wave" to a whirlwind. All we have is a superficial description of what is probably an unusual atmospheric phenomenon of some sort---perhaps an unrecognized feature of downbursts (a recognized meteorological phenomenon). Considering the wave's mysterious motion, the precision of the circles it carved in the field, one would think meteorologists would be greatly interested.

Nevertheless, mainstream scientists relegate all crop circles to the hoax and pseudoscience files.

X3. General observations. On one hand, most mainstream scientists, when they deign to notice them at all, pronounce that all crop circles are the work of hoaxers, as is done in the article by J.W. Deardorff referenced below. (R3) On the other hand, several books and a flood of reports in fringe publications claim that the crop circles, particularly the complex ones, are evidence that extraterrestrial intelligences are attempting to communicate with us.

There is also a middle ground upon which stands G.T. Meaden, a physicist, and a few other scientists. Meaden has summarized this third position in the following paragraph using the editorial "we."

"...we believe that the formation of real crop circles is a rare phenomenon resulting from the motion of a spinning mass of air which Professor Tokio Kikuchi has modelled by computer simulation and calls a nanoburst. This disturbance could involve the breakdown of an up-spinning vortex of the eddy or whirlwind type. On this theoretical model such a process leads to plain circles and ringed circles ---types which are known from pre-hoax times in Britain and other countries, and are the only species which credible eye-witnesses have seen forming. All other so-called crop circles reported in the media news in recent years are likely to be the result of intelligent hoaxing, while the so-called paranormal events to which Deardorff alludes are nothing but the consequence of poor observation and/or exaggeration by susceptible mystics and vulnerable pseudoscientists. In the absence of hoaxing the subject would still be unknown to the general public because the average number of real-circle reports per annum is small (indeed in some years it may be zero). (R4)

In this way, Meaden splits the crop-circle universe in two (as we have): (1) Simple circles and configurations carved out by whirlwinds and other atmospheric phenomena; and (2) Hoax crop circles which appear in great abundance and with elaborate geometries. They are without any scientific value, except, perhaps, in psychology! Of course, if some events in this class are not hoaxes, we must reconsider everything.

One cannot escape the many parallels between this second crop-circle category and human psychological behavior when confronted with UFOlogy, pyramidology, remote viewing, sea monsters, famous assassinations, and the like. In each area, one finds a cadre of believers, regular publications, international meetings, and a corps of field researchers. Rarely, does mainstream science take notice of observations made by these non-professionals.

X4. General observations relevant to "how crop circles can be natural and, therefore, legitimate areas of scientific research!

Before today's prolific crops of bogus crop circles, there were rare instances where Nature neatly carved circles in fields of grain. These legitimate but ancient crop circles have been trashed by science along with the obvious hoaxes. These old observations are still ignored, even though they were reported by competent people and published in scientific journals.

A good example of the "real thing" was resurrected in the Journal of Meteorology (U.K.). The original source is: Nature (certainly no friend of pseudoscience) 22:290, 1880. J.R. Capron, a respected spectroscopist of the time, was the reporter.

"The storms about this part of Surrey have been lately local and violent, and the effects produced in some instances curious. Visiting a neighbour's farm on Wednesday evening (21st), we found a field of standing wheat considerably knocked about, not as an entirety, but in patches forming, as viewed from a distance, circular spots.

"Examined more closely, these all presented much the same character; viz., a few standing stalks as a centre, some prostrate stalks with their heads arranged pretty evenly in a direction forming a circle about the centre, and outside these a circular wall of stalks which had not suffered."

Capron thought the nearly perfect circles of crop damage bespoke cyclonic wind damage. (R5)

It seems that whirlwinds may have been carving out crop circles over a century ago. This old report is, of course, no proof of anything. All pseudosciences seem to be able to find ancient examples of their beguiling phenomena, such as those Biblical UFOs.

Much as mainstream science denies what they categorize today as pseudoscience, the historical record reveals that some of the most reviled scientific claims (e.g.; continental drift) may one day achieve scientific consensus! Perhaps, in the future, it will be admitted that a small proportion of the crop circles---the simpler ones---are natural phenomena.

References

R1. Anonymous; "Mystery Spirals in Cerealfields," Journal of Meteorology (U.K.), 8:216. 1983. (X1)

R2. Meaden, G.T.; "Circle Formation in a Wiltshire Cereal-Crop---an Eye-Witness Account....," Journal of Meteorology (U.K.), 14:265, 1989. (X2)

R3. Meaden, G. Terence; "Crop Circles: The Real and the Hoaxes," Weather, 47:368, 1992. (X3)

R4. Deardorff, J.W.; "Crop Circles: Someone Had to Say It," Weather, 47:142, 1992. (X3)

R5. Van Doorn, Peter; "A Case of Genuine Crop Circles Dating from July 1880 as Published in Nature in the Year 1880," Journal of Meteorology (U.K.), 25:20, 2000. (X4)

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