Visual Meteoritic Activity and Rainfall Singularities[1]

GLENN W. BRIER

U. S. Weather Bureau

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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.

1. Introduction

The meteoritic dust hypothesis has been advanced by Bowen (1953) to explain singularities in world rainfall amounts. The suggestion has resulted in considerable controversy, not only as to whether singularities in weather actually exist but also regarding the possible physical role that meteoritic particles might play in atmospheric phenomena. Regarding weather events that tend to occur on or near fixed calendar dates, Wahl (1952) suggested that these "singularities" are related to features of the general circulation and are much more than local phenomena. Although there was some question regarding the statistical significance of his results, subsequent studies indicate the reality of singularities. Kline and Brier (1958) found highly significant singularities in ice nuclei from measurements in a number of places over the world during several months of January. Brier (1961) found a highly significant association between daily precipitation values for the United States for the period 1952–58 and the world rainfall data for the period 1880–1950 analyzed by Bowen.

Although these and other studies may indicate that weather and circulation singularities are real phenomena of the atmosphere, they say little or nothing about what the physical causes might be. An attempt to link these singularities directly with meteoritic dust seems impossible at the present because of the lack of the necessary physical measurements and accompanying physical theory of cloud and weather processes. Likewise, an indirect or statistical approach is handicapped by lack of quantitative data, expecially with respect to meteors and meteoritic dust. However, Olivier (1960) has published a summary of visual meteors for each night of the year, based on data for a 58-yr period. It appeared to this writer that these data, in spite of their limitations, might be used for an initial study of the relationship between meteor showers and world rainfall. This paper presents the results of such an investigation.

2. The material

The data published by Olivier (1960) give the average hourly rates of visual meteors for each night of the year, beginning at 0601 local astronomical time and ending at 1700. For this study, these hourly values were summed for each day to get daily totals. Three-day moving averages were then obtained in order to reduce high frequency "noise" and to make the data more comparable with the world rainfall series to be discussed later. The resulting values are shown in graphical form in Fig. 1. The pronounced peaks in August and December are associated with the well known Perseids and Geminids, respectively. A number of other showers that are recognized by meteor authorities show up on this curve but there are some exceptions. For example, the Giacobinids (or Draconids) usually listed for 9–10 October do not appear. However, it is known that this shower shows appreciable displays only about once in twelve years and in his catalogue Olivier states, "The table omits all observations of the great Draconid shower of 1946, 9 and 10 October. Inclusion of these meteors would have resulted in completely misleading averages for those dates." On the other hand, the curve gives some evidence of peak meteor activity around 18 March, for example, but this is not usually considered as a date for meteor showers even though a similarly high peak for 20 April can be identified as the well known Lyrids. In considering the limitations of these data for representing the influx of meteoritic material into the atmosphere, it should be kept in mind that there are many day-time showers whose rates can only be determined by radio astronomy (or satellite) methods.

The curve of Fig. 1 indicates an annual cycle in the visual meteor rates. Since the annual cycle is of no concern in this investigation, its effect was removed by expressing the values in Fig. 1 as departures from a 90-day moving average. From these resulting values the dates of the twenty highest peaks and twenty lowest troughs were selected. A peak was defined as a day with meteor rates higher than the adjacent days and a trough was defined as a day with lower meteor rates than the

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adjacent days. These 20 peak days, as well as the days preceding and following were assigned a code number 1. A trough day and the adjacent days were assigned the value −1 and all other days were classified as 0. The results of this classification are presented in Table 1.

The rainfall data used here are those supplied by E. G. Bowen and previously used in the study of rainfall singularities by Brier (1961). These data consist of three-day moving averages of total precipitation for a world network of approximately 300 stations for the period 1880 to 1950. As described in the previous reference (Brier, 1961), the 20 highest peaks and 20 lowest troughs were chosen so that each day of the year was classified as a peak day (1), trough day (−1) or neutral day (0).

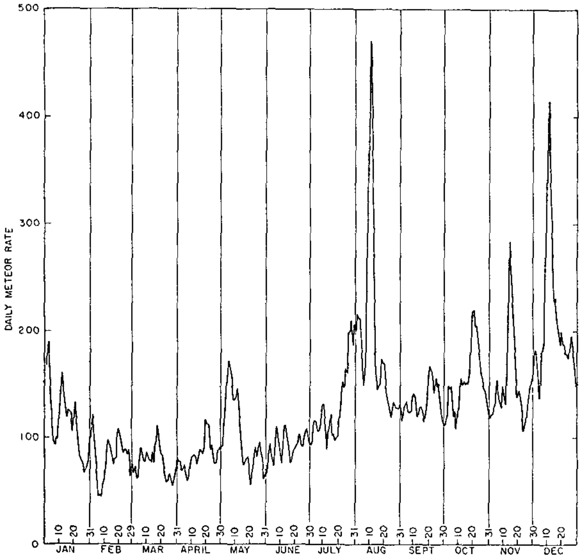

FIG. 1. Three day moving averages of visual meteor rates from data published by Oliver.

3. Method of analysis

The relationship between the meteor series and the rainfall series was studied by matching the events in one series with those of the other. If on a particular day both series showed a peak (1) or both series showed a trough (−1), it was defined as a hit (*H*). If one series showed a peak (1) and the other series showed a trough (−1), it was defined as a miss (M). All the hits and misses were then counted and a score

$$S = H - M$$

was computed. Since the score expected by chance is zero when the two series are random with respect to each other, a positive score S represents a positive relationship between the series and a negative value of S indicates a negative correlation. By shifting one series relative to the other, it is possible to find out what time interval or lag must elapse between the series to produce the greatest positive correlation. A positive lag will be defined here when the precipitation series follows the meteor series. Since both series contain 365 days and can be considered as circular, it is possible to determine

TABLE 1. Classification of peak days (1), trough days (−1) and other days (0) for meteor data.

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Day 1	1	1	0	0	0	0	0	1	0	0	−1	0
2	1	1	0	0	0	0	0	1	−1	0	−1	0
3	1	1	0	0	0	0	0	1	−1	0	−1	0
4	0	0	0	0	0	0	0	0	−1	0	−1	0
5	0	−1	0	0	1	0	0	0	0	0	0	0
6	−1	−1	0	0	1	0	0	0	0	0	0	0
7	−1	−1	0	0	1	0	0	0	−1	0	0	0
8	−1	−1	0	0	0	0	0	0	−1	0	−1	0
9	0	−1	0	0	0	0	0	0	−1	0	−1	0
10	0	0	0	0	0	0	0	1	0	0	−1	0
11	1	0	0	0	1	0	−1	1	0	0	−1	1
12	1	0	0	0	1	0	−1	1	−1	0	−1	1
13	1	0	0	0	1	0	−1	0	−1	0	−1	1
14	0	0	0	0	0	0	0	0	−1	0	1	0
15	0	0	0	0	0	0	0	0	0	0	1	1
16	0	0	0	0	0	0	0	0	0	0	1	1
17	0	0	1	0	0	0	−1	0	−1	0	0	1
18	−1	0	1	0	0	0	−1	1	−1	0	0	0
19	−1	1	1	1	0	0	−1	1	−1	0	−1	1
20	−1	1	0	1	−1	0	0	1	0	1	−1	1
21	0	1	0	1	−1	0	0	0	0	1	−1	1
22	0	0	0	0	−1	0	0	0	0	1	0	0
23	0	0	0	0	0	0	0	0	0	1	−1	0
24	−1	0	0	0	0	0	1	0	0	1	−1	0
25	−1	0	0	0	0	0	1	0	0	0	−1	0
26	−1	0	0	0	0	0	1	0	0	0	0	1
27	−1	0	0	0	0	0	0	0	0	0	0	1
28	−1	0	0	0	0	0	0	0	0	0	0	1
29	0		0	0	−1	0	0	0	0	0	0	0
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31	0		0		−1		1	0		−1		0

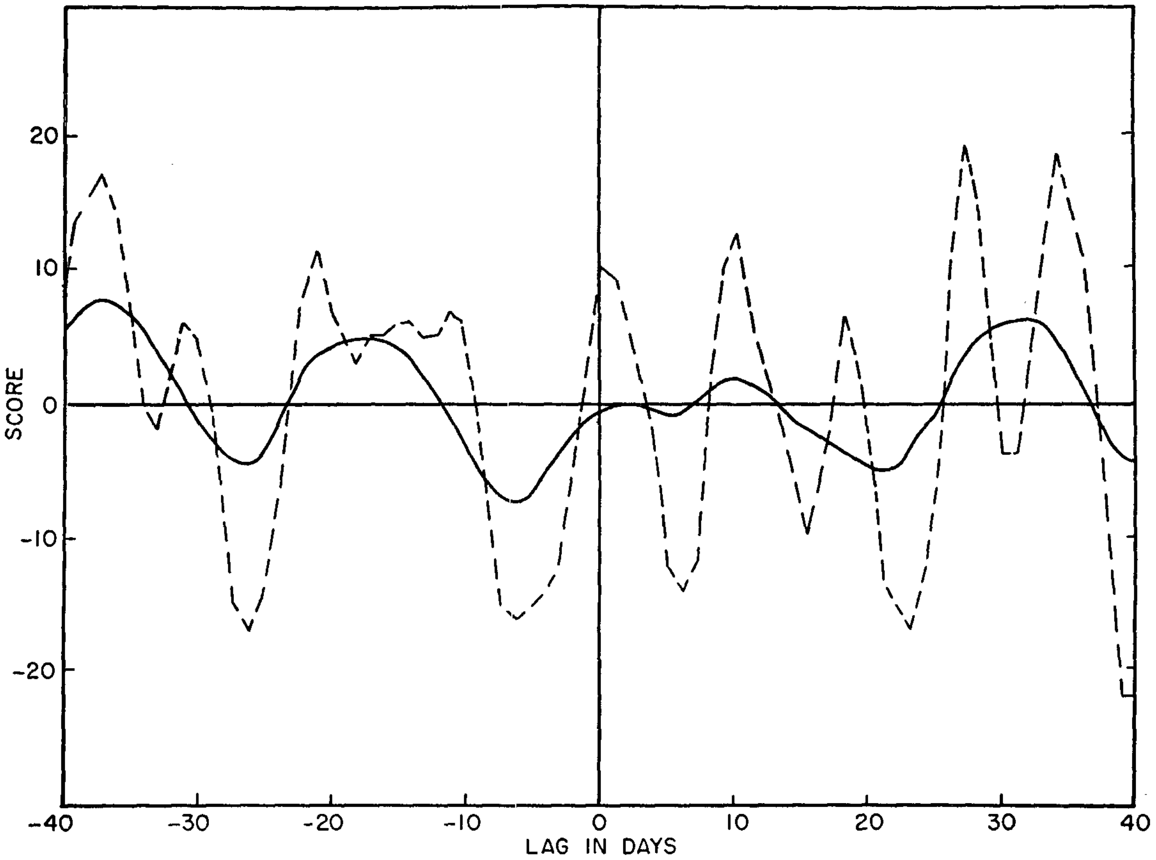

FIG. 2. Scores showing the relationship between daily world rainfall and visual meteor rates according to time lag in days. The dashed curve represents raw scores and the solid curve represents the scores after smoothing by a low pass filter.

the score S for lags ranging from -182 days to $+182$ days. The results for lags from -40 to $+40$ are shown in Fig. 2. The actual values of S are shown by the dashed curve while the solid curve was obtained by using a 21-term smoothing formula with the weights shown in Table 2. These weights were chosen to eliminate oscillations with periods shorter than approximately 10 days. The actual frequency response of this filter is shown in Fig. 3. For a more complete discussion of smoothing and filtering, the reader should refer to Holloway (1958).

The auto-correlation in the series can be studied by computing the score S when each series is compared with itself for different lags. Fig. 4 shows the results for lags up to 80 for the rainfall series. As before, the smoothed values are represented by the solid line. The correlation of the meteor series with itself according to various lags is shown in Fig. 5. Scores for additional lags up to 182 were computed but are not presented here since they show about the same type of variation as the first 80 lags.

4. Results and conclusions

Referring to Fig. 2, one may see that maximum scores are obtained at lags of 27 and 34 days. The smoothed score reaches a value of 6.4 at lag 31, which may suggest that rainfall peaks occur about 31 days after peak meteor activity. However, this cannot be considered as statistically significant since a smoothed value of the score of 7.9 also appears at lag -37 and 15 per cent of the 365 smoothed scores computed were greater than 6.4.

The tendency for the scores S represented in Fig. 2 to show oscillations of around 5 or 10 days is probably of no particular significance, being influenced by the distribution and number of rainfall and meteor peaks used. Somewhat similar oscillations are present in the curves for the individual series, Figs. 4 and 5. If the number of

TABLE 2. Weights used in 21 term smoothing formula, W_0 being the central weight.

W_{-10}	0.001	W_1	0.113
W_{-9}	0.003	W_2	0.099
W_{-8}	0.007	W_3	0.079
W_{-7}	0.013	W_4	0.058
W_{-6}	0.023	W_5	0.039
W_{-5}	0.039	W_6	0.023
W_{-4}	0.058	W_7	0.013
W_{-3}	0.079	W_8	0.007
W_{-2}	0.099	W_9	0.003
W_{-1}	0.113	W_{10}	0.001
W_0	0.119		

peaks chosen in each of the two series had been 30 instead of 20, for example, the characteristics of the curves would be different. The smoothed curves, which filter out these oscillations, should be more representative of the real state of affairs.

These results appear to be consistent with those reported by Krivsky and Letfus (1959), who found a similar maximum in rainfall on the 31st day after meteor showers but from all the evidence available were led to "regard the determination of the effect of meteoritic dust on precipitations from the published material . . . with an accuracy of days, as physically unsatisfactory, unrealistic and therefore as accidental." However, they did state that their statistical evidence indicated that the meteoritic dust might be able to affect the condensation or sublimation processes between the 23rd and 60th day after the shower.

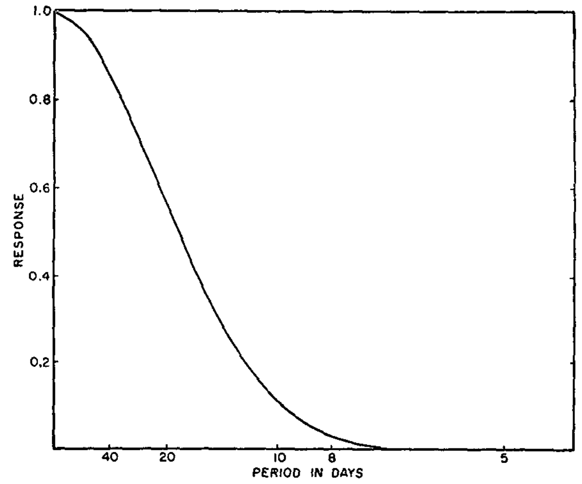

FIG. 3. Frequency response of smoothing formula used in Fig. 2.

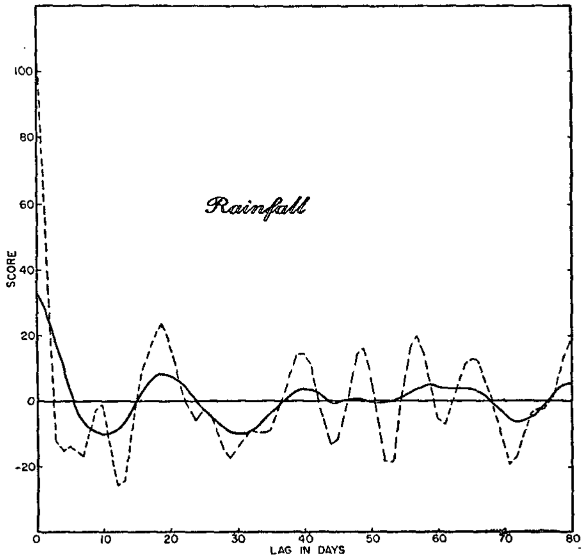

Fig. 4. Scores resulting from comparing the rainfall series with itself for various time lags. The smoothed values are represented by the solid curve.

Although the present studies have failed to establish a relationship between meteor showers and precipitation, the possibility is not ruled out and it might be desirable to perform a more definitive test using meteor data more meaningful than the visual observations which do not include the smaller and no doubt more numerous particles. Quantitative observations of both night-time and day-time meteor rates have been made over the past 15 yr by radar and more recently by satellites. These should eventually enable one to study the year to year variations in the relative intensity and exact time of meteor shower periods in relation to any subsequent changes in large scale precipitation.

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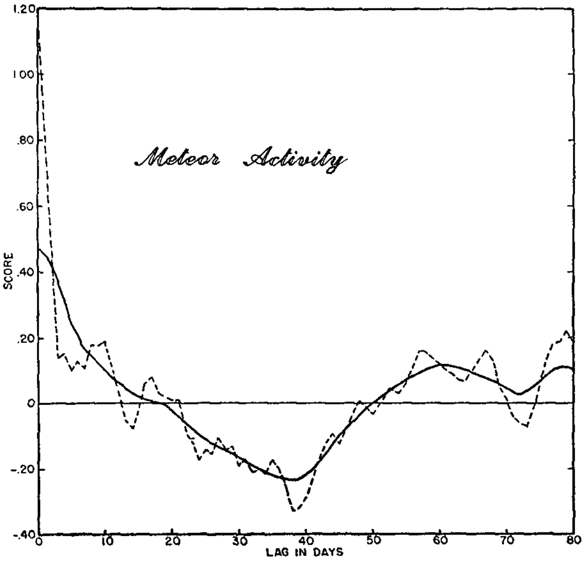

FIG. 5. Scores resulting from comparing the meteor series with itself for various time lags. The smoothed values are represented by the solid curve.