FLUCTUATIONS OF LONG-PERIOD ACCUMULATIONS OF DAILY RAINFALL AMOUNTS*

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Introduction

In a recent communication, Bowen (1953) notes the tendency for heavy falls of rain at stations widely scattered over the southern hemisphere to occur on certain dates rather than on others. Surprisingly enough, records for the British Isles show maxima of frequency of heavy rain on the dates, or close to the dates, of peaks for the southern hemisphere stations concerned. As for the

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latter stations no evidence is found for progressive displacement in the timing of peaks with geographical location, and as the data for the British Isles indicate that some of the peaks occur on dates identical, or nearly identical, with those for the southern hemisphere stations, Bowen suggests that an extraterrestrial factor must be operative resulting in increased precipitation on certain dates. In particular, he suggests that fine meteoritic dust provides rain-forming nuclei when it falls into the cloud tops of the lower atmosphere. The meteoritic dust is believed to originate from meteor streams in the solar system through which the Earth passes about one month prior to the dates of the daily rainfall peaks. For further details of this hypothesis, reference is made to the original paper.

Problem of the Present Paper

On reading Bowen's paper, an examination of local rainfall data appeared to be worth while. In the archives of the Climatological Division of the Israel Meteorological Service, records of daily rainfall amounts have been readily available for a number of stations in the area of the former British Mandatory Palestine. For dates between January 1 and February 5,* peaks exceeding the mean by 50 per cent. appear on the dates cited in Table 1.

TABLE 1

DATES OF PEAKS OF ACCUMULATED DAILY RAINFALL FOR SOME STATIONS IN THE AREA OF THE FORMER PALESTINE

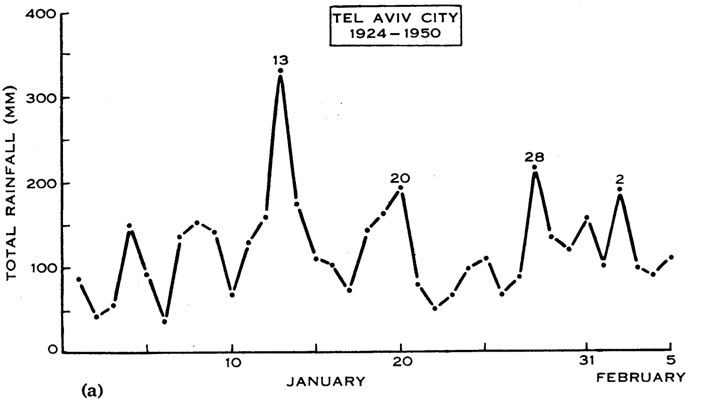
Station	Geographical Coordinates N.	Geographical Coordinates E.	Years	Dates
Haifa	32° 49′	34° 59′	1880–1939	Jan. 10, 14, 21
Jenin	32° 28′	35° 18′	1921–1939	Jan. 8, 12–13, 30–31; Feb. 3–4
Tel Aviv City	32° 04′	34° 46′	1924–1950	Jan. 13, 20, 28; Feb. 2
Jerusalem, American Colony	31° 48′	35° 14′	1898–1939	Jan. 13–14, 19–20
Jericho	31° 51′	35° 27′	1922–1939	Jan. 11–13, 15, 31; Feb. 1–4
Hebron	31° 32′	35° 04′	1895–1914	Jan. 7, 10, 18–19, 22, 27
Beersheba	31° 14′	34° 47′	1921–1939	Jan. 15, 19–20, 29–30; Feb. 2, 4–5
Gaza	31° 31′	34° 27′	1919–1939	Jan. 9, 12, 14, 18, 29, 31

Some of the dates in Table 1 are surprisingly close to the dates in Bowen's (1953, p. 492) Table 1. Particularly good is the timing of the peaks for Tel Aviv and Sydney. The daily rainfall amounts for Tel Aviv between the dates January 1 and February 5, in the years 1924–1950, are shown in Figure 1 (*a*).

The question arises whether the coincidence, or near-coincidence, of peaks at stations widely scattered in the two hemispheres is due to a physical factor exerting its influence the world over, as suggested by Bowen, or is, perhaps, the outcome of random fluctuations. The latter possibility should not be ignored

* Most of Bowen's data refer to this period.

ab initio despite the simultaneity of some of the peaks at different places. In a somewhat restricted sense, the problem is whether for any of the stations, the peaks can or cannot be the result of *random accumulations* of rainfall on the dates concerned. It is this restricted problem which will be considered below.



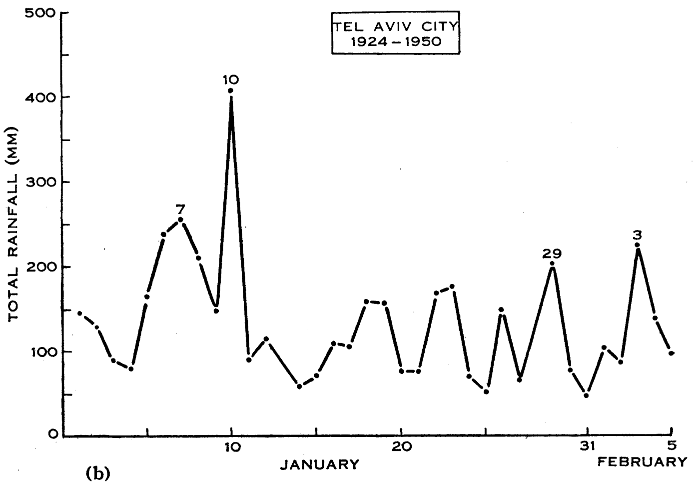


Fig. 1 (*a*).—Accumulated daily rainfall amounts for Tel Aviv City—original (true) data.

Fig. 1 (*b*).—" Accumulated daily rainfall amounts " for Tel Aviv City resulting from random shifting (in accordance with Table 2) of the original data.

Testing for Randomness

For examining the problem, a method devised by Bartels (1948) will in essence be followed. The idea underlying the method is as follows. Consider a time series the terms of which arise from accumulation of data and such that its peaks are believed to be produced by some physical factor becoming effective on certain dates. If now the basic data are reshuffled in some sort of random scheme, then in the series (accumulations) resulting from the reshuffling, the peaks should disappear. If, however, the new series be of a character similar to the original and, e.g., peaks of comparable magnitude appear on other dates, then the original peaks are likely to be the result of random accumulations.

In the present investigation, the time series is the series of accumulated daily rainfall amounts. The physical factor the effect of which is supposed to become effective on certain dates is meteoritic dust. The method will be applied

TABLE 2

INSTRUCTIONS FOR THE RANDOM SHIFTING OF DAILY RAINFALL DATA FOR THE TEL AVIV SERIES

Random numbers from a table published by Snedecor (1946, p. 12)

Year (from Snedecor's Rows)	Day (from Snedecor's Columns)	Column Marked "January 1"	
		For Year	Begins With
24	26	1924	Dec. 26, 1923
36	05	1936	Jan. 5, 1936
39	20	1939	Dec. 20, 1938
46	31	1946	Dec. 31, 1945
30	11	1930	Jan. 11, 1930
41	23	1941	Dec. 23, 1940
29	03	1929	Jan. 3, 1929
48	12	1948	Jan. 12, 1948
49	28	1949	Dec. 28, 1948
26	29	1926	Dec. 29, 1925
42	07	1942	Jan. 7, 1942
40	06	1940	Jan. 6, 1940
25	24	1925	Dec. 24, 1924
50	19	1950	Dec. 19, 1949
28	30	1928	Dec. 30, 1927
35	01	1935	Jan. 1, 1935
33	21	1933	Dec. 21, 1932
45	14	1945	Jan. 14, 1945
32	10	1932	Jan. 10, 1932
31	25	1931	Dec. 25, 1930
43	02	1943	Jan. 2, 1943
44	09	1944	Jan. 9, 1944
37	27	1937	Dec. 27, 1936
27	22	1927	Dec. 22, 1926
34	13	1934	Jan. 13, 1934
38	08	1938	Jan. 8, 1938
47	04	1947	Jan. 4, 1947

to the data for Tel Aviv. Although the rainfall series for Haifa and Jerusalem (Table 1) are longer, Tel Aviv's data were selected as the dates of its peaks show a better agreement with the corresponding data for Sydney considered by Bowen.

In computing the accumulated daily rainfall, one writes, of course, the rainfall amounts for each date in one column. The reshuffling mentioned above consists of shifting the rows for the different years by a varying number of days. Thus, for instance, for one of the years shifted the rainfall amount for January 9 may fall in the column headed "January 1"; for the same year, the figure for February 8 will appear in the column headed " January 31 ". As the Tel Aviv series comprises 27 years, dates between December 19 and January 14 inclusive were let appear once and only once in each case in the column marked " January 1 ". The years and dates were determined by reference to a table of randomly assorted digits published by Snedecor (1946, p. 12). In his table, two successive digits were thought to form a two-figured number. The tens and units of the figure representing the year (24–50) were obtained by reading Snedecor's rows from left to right; the days (19–31 and 01–14) were obtained by reading his columns downward, beginning with the left-hand column. For the years, it was sufficient to read the first nine rows; for the days, it was sufficient to read the first six (two-figured) columns. In this manner, a table of instructions, Table 2 above, for shifting the original data was derived, the two-figured numbers in Table 2 being quoted in the order as they appear for the first time in Snedecor's table.

The " accumulated daily rainfall amounts " resulting from shifting of the original data in accordance with Table 2 are shown in Figure 1 (*b*). It will be noted that the peaks of Figure 1 (*a*) for January 13, 20, 28, and February 2 have disappeared. New peaks have emerged for " January 7 ", " 10 ", " 29 ", and " February 3 ". Especially striking is the peak for " January 10 ". The " accumulated rainfall total " for this " date " exceeds by 20 per cent. the peak of Figure 1 (*a*) for January 13. In general, the character of the new fluctuation polygon is the same as that of the original.

Discussion of the Results

It is seen from the above that a random shifting of dates can lead to a polygon that simulates all essential characteristics of the original accumulated daily rainfall polygon. Although these results do not definitely disprove the hypothesis that the major peaks of Figure 1 (*a*) are produced by a genuine physical factor, they render such a hypothesis improbable. Indeed, they suggest that the peaks concerned have formed from a random accumulation of daily rainfall amounts. While this conclusion is primarily valid in respect of the Tel Aviv series, Bartels's (1948) work on the 97-year long rainfall series for Gütersloh, Westphalia, Germany, and the results of the present investigation would support the conjecture that the peaks for the stations considered by Bowen also are the results of random fluctuations.

A further shortcoming of Bowen's hypothesis is in that it only offers an explanation for the peaks but none for the " troughs ", i.e. low rainfall amount totals. Thus, e.g., the data for Sydney (see Bowen's Fig. 1) indicate rather low values of accumulated daily rainfall on or about January 8, 16, 24, and February 4 which remain unaccounted for. The hypothesis of random accumulations could account for both the peaks and the troughs.

References

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