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PRECIPITATION

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G. G. ABBOT
Secretary, Smithsonian Institution



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CITY OF WASHINGTON
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A 27-DAY PERIOD IN WASHINGTON PRECIPITATION

By C. G. ABBOT

Secretary, Smithsonian Institution

On March 17, 1943, I wrote (in part) to the Chief of the United States Weather Bureau:

You will perhaps recall that I showed you a plot indicating a 27-day period in Washington precipitation since 1924. I have thought it interesting to take from it the dates in 1943 when (prevailingly) precipitation is to be anticipated. Of course that does not mean that all rain will fall on these dates. These are given in the enclosed table.

In what follows I shall show that this prediction was gratifyingly verified by the event.

In volume 6 of the *Annals of the Smithsonian Astrophysical Observatory*, we indicated that the solar constant of radiation displays small variations in correlation with the period of 27 days, which is the effective resultant of the rotation periods of the sun. It is well known that the period of solar rotation increases from the sun's equator toward its poles, but for the major part of its surfaces a period of 27 days is the approximate mean. In the year 1942 I made a statistical study to determine whether this period of 27 days also exists in the precipitation at Washington, and whether, if so, it is relatively permanent.

For this purpose I tabulated the daily precipitation at Washington with reference to a 27-day period from 1924 through 1941, in 2-year intervals, keeping the phase of the 27-day period unchanged throughout, as of January 1-27, 1924. Each 2-year tabulation included 27 complete periods, with 1 or 2 days over, depending on leap years, I took mean values for each 2-year table of 27 lines. I was at once struck by the fact that on the 11th or 12th day of the 27-day cycle Washington precipitation was high as indicated by the mean in every one of the 9 tables, each of which, as stated, contained 27 lines of 27 days per line. It proved also that the highest precipitation occurred on the 11th day in the earlier years, and on the 12th day in the later years. Thus the true period exceeds 27 days slightly, and appears to be $27\frac{27}{10 \times 365}$, or 27.0074 days approximately.

In the accompanying illustration, curves 1, 2, 3, 4 give, respectively: (1) The mean form of the 27.0074-day cycle for the total period of 243 repetitions; (2) the mean form for 54 dry-year cycles; (3) the mean form for 108 cycles which occurred in years of medium precipitation; and (4) the mean form for 81 cycles which occurred in wet years. It will be seen that the 12th day of these four mean cycle forms shows always from two to three times as much precipitation as the 6th and 7th days.

I now come to the test of my prophecy, which I made for Dr. Reichelderfer almost a year in advance, as stated above. In the year 1943 the initial days of the 27-day cycles (neglecting the small correction determined above) occurred on the following dates, to correspond in phase with the cycle beginning January 1, 1924.

No. of cycles	1	2	3	4
Date	1942, Dec. 31	1943, Jan. 27	Feb. 23	Mar. 22
No. of cycles	5	6	7	8
Date	Apr. 18	May 15	June 11	July 8
No. of cycles	10	11	12	13
Date	Aug. 31	Sept. 27	Oct. 24	Nov. 20
				Dec. 17

The 273-month master period¹ which we discovered in solar radiation and terrestrial weather enabled me to anticipate that the year 1943 would be one of intermediate total precipitation at Washington.² I therefore referred to curve 3 and expected that days 1, 2, 3, 4, 5, 12, 17, 22, 23, 24, 25, 26, 27 of the cycles would afford a decidedly larger average precipitation than the others.

I tabulated the selected dates for all cycles of 1943, from December 31, 1942, to December 31, 1943, 366 days. The observed precipitations at Washington were obtained from United States Weather Bureau publications form 1030, using the column of total precipitation, midnight to midnight. The results found are as follows:

	Total numbers	Measurably rainy	Trace of rain	Total No. wet	Percent wet	Total precip., inches	Ppt.* per day, inches
Preferred days	175	67	21	88	50.3	20.12	0.115
Other days ..	191	49	34	83	43.4	13.99	0.073

* Total precipitation divided by total number.

From these figures we see that in the year 1943 the observed precipitation at Washington agreed well on the whole with the average

¹ See Smithsonian Misc. Coll., vol. 101, No. 1, p. 27, 1941.

² It turned out to be a low intermediate, or high low-precipitation year.

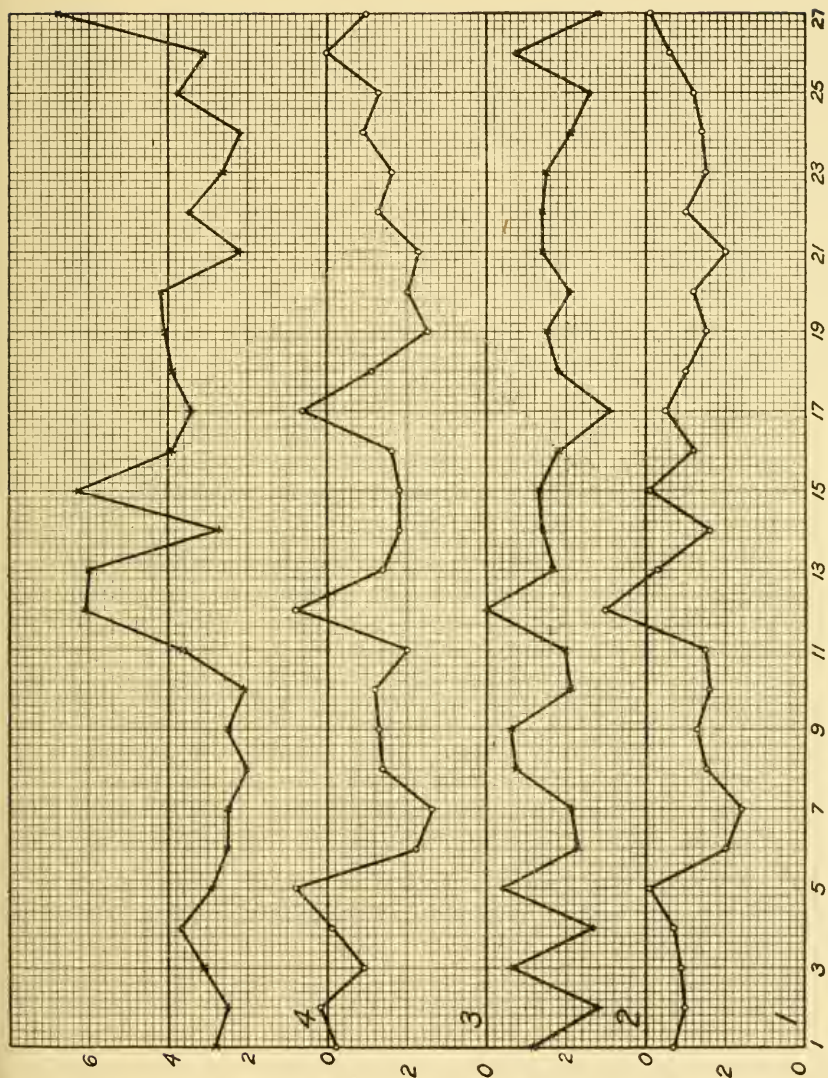


FIG. 1.—The 27-day cycle in Washington precipitation; arbitrary ordinates. Curve 1, mean of 243 cycles, 1924-1941; curve 2, mean of 81 cycles, dry years; curve 3, mean of 54 cycles, medium years; curve 4, mean of 108 cycles, wet years.

march of 27-day cycles which had occurred in 108 cycles in other years of intermediate precipitation from 1924 to 1941. The average observed precipitation per day in the expectedly wetter days of the cycles was actually 1.58 times as great as in the expectedly dryer days of the cycles. In curve 3 itself the corresponding ratio is 1.66. It seems to be probable that the 27-day cycle which has been followed so consistently at Washington without change of phase for at least 20 years is so firmly fixed that it will be followed also for many years hereafter.

Nevertheless it is surprising that in a purely gaseous body like the sun there should be fixed longitudinal distributions of the conditions which affect terrestrial precipitation. The unchanging phase of the effects is, to say the least, unexpected. One would be prepared from our previous studies for a 27-day periodicity in radiation which persisted in a given phase for two or three solar rotations, and then shifted to a new phase as new solar outbreaks occurred and the older ones died away. But this would not explain these new results. For the moment it seems most reasonable to suggest that the unchanged phase of the 27-day period in precipitation for 20 years is due to the immense diameter and mass of the sun. With such an immense body it may well be that 20 years is comparable to an hour or a day in the life of a man, and that no appreciable change of the solar conditions suitable to promote terrestrial precipitation ought to be expected in so brief a time.

It may be that the correlation of solar rotation with Washington precipitation is associated with sunspot influences through ionization bombardments. In this case it would be independent of the solar constant, for sunspots and the solar constant are not directly correlated, as shown in the *Annals*, volume 6, page 196. The constancy of phase for 20 years might then be related to the fundamental cause of sunspots, either planetary as many have supposed, or hydrodynamical, as suggested by Bjercknes, *Astrophysical Journal*, volume 64, page 93, 1926.