SMITHSONIAN MISCELLANEOUS COLLECTIONS
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C. G. ABBOT
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I published recently a paper entitled "The Sun's Short Regular Variation and Its Large Effect on Terrestrial Temperatures."[1] It showed a perfectly regular variation of the sun's output of radiation, with a period of 6.6456 days. Associated with this, but subject to occasional displacements of phase of 1, 2, or rarely 3 days, were temperature changes at Washington, St. Louis, and Helena, ranging from 2° to 20° Fahrenheit. I was unable to discover the causes of the displacements of phase and variations of amplitude in the terrestrial responses to the regular solar period, but averaged over many years the terrestrial effects showed the identical period found in the solar variation.

It occurred to me to test whether precipitation also responds to the 6.6456-day solar period. I did not expect much correlation, because precipitation in most regions is very irregular in amounts and intervals. However, a preliminary trial for Peoria, Ill., a station which previous studies showed to be largely dominated by solar variations, indicated that the 6.6456-day period is effective on precipitation there, but that phase changes similar to those noted above occur. I then undertook a statistical study of Washington precipitation, from 1924 to 1945, with reference to the 6.6456-day period.

As in the temperature studies, I made separate computations for each month of the year. It proved advisable to recognise the same phase shiftings that I had determined for temperatures. In order to see if the effect occurs at all times, I divided the data into three groups, 1924 to 1930, 1931 to 1937, and 1938 to 1945. All groups showed a considerable effect. To show the procedure, I now refer to figure 1, which is a facsimile of my computations for the middle group, 1931 to 1937, for March. I select a March group for illustration because table 3 of my paper (above cited) gives the phase shiftings for March in the temperature work, and I use in all months phase shift-

[1] Smithsonian Misc. Coll., vol. 107, No. 4, Apr. 4, 1947.

ings for the precipitation tables identical with those I used in collecting temperature effects.

Hence in figure 1 of the present paper the reader will find the date figures, which I have written small, not all in the column of zeroth day. They are found as follows: In the years 1931 and 1933 in column +2; in the years 1935 and 1936 in column +1; in the year 1937 in column −1; in the year 1932 in column −2; in the year 1934 in column −3. These shiftings are those idicated by tables 3 and 4 of my former paper. Without these phase shiftings the present results would be confused.

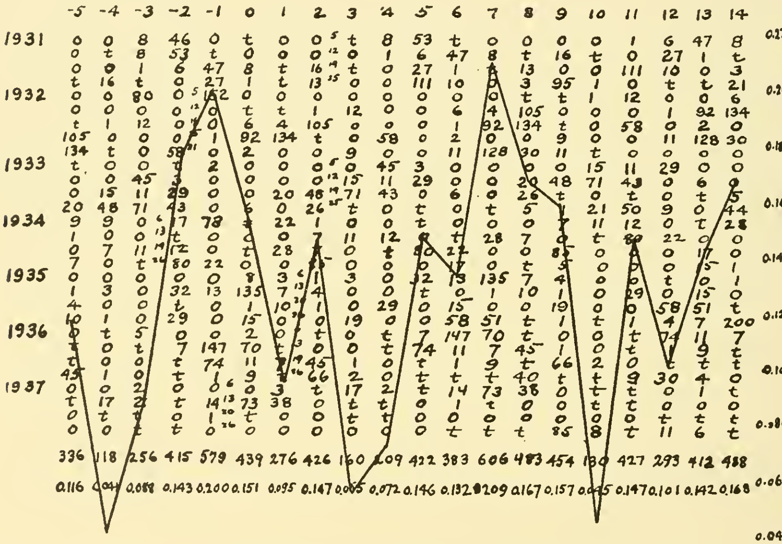

FIG. 1.—Computation of average effect, 1931 to 1937, of the 6.6456-day solar period on Washington precipitation for the month of March.

In figure 1 of the present paper, the top line indicates days from −5 to +14, with respect to zeroth day indicated basically in table 1 of my former paper. The next following 29 lines of figure 1 give for 20 days each the total precipitation, midnight to midnight, in hundredths of an inch, as published by the Weather Bureau for March 1931 to 1937. These data fix the form of the four or five returns of the 6.6456-day period which occurred in March of each year—thus in 1931 four, in 1932 five, et cetera. The next to last line of figure 1 gives the sums for each column, and the last line the average daily precipitation in inches for each of the 20 columns. At the right is a scale of inches, and in the body of the table a graph gives the results as written in the lowest line.

It will be noticed that the maxima are not exactly spaced at intervals of 6.6456 days, but they are approximately. The minima fall as closely to the correct intervals as could be, without dividing the days into hours. The range is from 0.040 to 0.204 inch, more than fivefold.

Having illustrated the procedure, I give in table 1 a summary of the places where the maxima were found in tabulations similar to figure 1, but covering, for each month of the year, all years from 1924 to 1945. This summary is entirely parallel to table 3 of my former paper. It was undertaken to correct for phase shiftings, before taking the general means of the effects. It seemed by no means to be assumed, without testing, that the lag of the effects of the solar change on precipitation would be identical for different seasons of the year.

TABLE 1.—*Phases of maxima in the 12 months, and phase corrections*

Days	Positions of maxima			Deviations from means			Average	Nearest integer
	I	II	III	I	II	III		
Jan.	1.5	4.5	11.5	+1.6	—1.5	—0.8	—0.2	0
Feb.	—1.0	6.0	12.5	—0.9	0.0	+0.2	—0.2	0
Mar. ...	—1.5	5.0	11.5	—1.4	—1.0	—0.8	—1.1	—1
Apr.	—0.5	6.0	13.0	—0.4	0.0	+0.7	+0.1	0
May ...	1.0	7.0	13.5	+1.1	+1.0	+1.2	+1.1	+1
June ...	1.0	7.0	13.0	+1.1	+1.0	+0.7	+0.9	+1
July ...	0.0	7.0	13.0	+0.1	+1.0	+0.7	+0.6	+1
Aug. ...	0.0	6.0	11.5	+0.1	0.0	—0.8	—0.2	0
Sept. ...	1.5	7.0	14.0	+1.6	+1.0	+1.7	+1.4	+1
Oct.	—1.0	6.0	12.0	—0.9	0.0	—0.3	—0.4	0
Nov. ...	—1.0	5.5	12.0	—0.9	—0.5	—0.3	—0.6	—1
Dec.	—1.0	5.0	10.0	—0.9	—1.0	—2.3	—1.4	—1
Sums ...	—1.0	72.0	147.5					
Means ..	—0.1	6.0	12.3					

Table 1, however, gives little ground to conclude that there are different lags in different seasons. The phase shiftings determined in the present table 1 do not exceed ±1 day. These might easily have resulted from the facts (a) that no account is made of hours in the records; (b) that tabulations, similar to table 3 of my former paper, include frequent cases where a computed phase shifting might have been altered 1 day by a difference in judgment as to the position of centers of features of graphs. In order to get the best determination of the amplitudes of precipitation effects, I used the phase shiftings indicated in the present table 1, when collecting the results of the 12 months of the year.

I give in table 2 the collected results of the precipitation in the

12 months, these being averages taken over 22 years from 1924 to 1945. The results are shown graphically in figure 2. There is a slight departure from exact intervals of 6.6456 days between maxima, but the intervals between minima are as close to the correct interval as

TABLE 2.—*Precipitation at Washington in the solar period 6.6456 days. Phases adjusted. Mean values in inches per day, the 12 months, 1924-1945. Prefix 0.0 or 0.*

Days	—5	—4	—3	—2	—1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Jan.	812	873	1055	1628	1476	605	953	797	709	1246	1367	1031	735	821	525	877	1744	1546	484	1093
Feb.	947	801	509	1152	1245	895	1044	842	587	820	1133	1019	1115	792	980	777	898	1563	1534	1176
Mar.	....	1034	995	728	1312	1346	1012	870	1105	1158	1018	1178	1001	1205	1177	851	1336	1143	1068	1226
Apr.	939	1294	929	1972	1236	1059	920	903	1321	1036	1000	1663	1216	1052	638	862	972	1149	1378	784
May	777	999	1182	687	1188	1484	1075	623	1073	1164	830	1571	1199	711	966	1127	695	1025	1285	....
June	899	670	1541	941	1181	2128	822	1009	1048	1392	1555	1196	1570	787	944	1654	1624	1135	1610	....
July	1061	691	1235	1246	1735	1183	1122	634	856	1110	1427	1977	980	748	485	1347	1378	1224	1314	....
Aug.	2136	1256	1555	1509	1390	1857	1826	1615	1094	1899	1234	2489	1665	1610	928	1464	1944	1779	1090	1662
Sept.	2007	1147	1035	1324	1619	1090	1316	1654	1159	923	1354	2167	379	1272	1262	665	1118	1397	1586	....
Oct.	555	1210	555	1301	1475	1325	620	671	869	1045	901	1079	1103	860	991	513	1322	834	1069	1068
Nov.	....	507	1054	675	821	1991	730	380	773	696	1026	1631	1230	634	646	845	938	940	1040	1470
Dec.	....	901	558	797	752	1089	680	927	774	1014	846	1104	907	647	802	1019	1168	1033	657	514
Means	1126	949	1017	1163	1286	1338	1010	910	947	1125	1141	1593	1092	928	862	1000	1261	1230	1177	1114

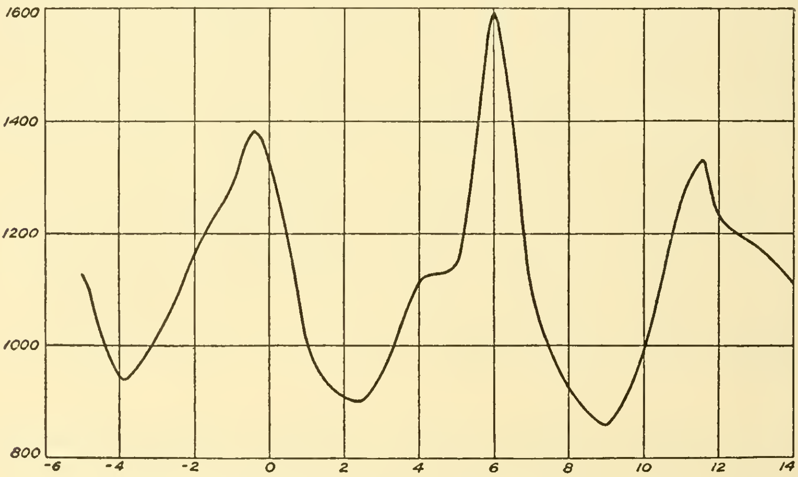

FIG. 2.—Graph of average effect, 1924 to 1945, all months, of the 6.6456-day solar period on Washington precipitation. Abscissae, days. Ordinates, inches/10,000.

can be shown without taking account of hours. The range of the effect is from 0.0862 to 0.1593 inch, a range of 85 percent.

It is indeed a pity that the shiftings of phase occurring with precipitation, as with temperature, are of unknown causation. If their causes could be found and the phase changes could be anticipated, here would be a valuable aid for forecasting. Perhaps it may have a valuable significance that the phase changes for precipitation are identical with those for temperature.