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A REVISED ANALYSIS OF SOLAR-CONSTANT VALUES

BY
C. G. ABBOT
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(PUBLICATION 3902)

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In volume 6, Annals of the Smithsonian Astrophysical Observatory, revised 10-day and monthly mean values of the solar constant of radiation, August 1920 to September 1939, were given in table 27. From these data 14 regular periodic variations of the sun's output of radiation were discovered as stated on page 181. These periodic variations are set down in table 32, as they progressed from 1920 to 1939. They were synthesized to give the curve marked B in figure 14. This synthetic curve was produced forward, through 1945, as a prophecy. There was satisfactory verification until late in 1944. Great interest was taken in the march of the prophetic curve in the years 1944 and 1945, for it indicated a considerable depression, somewhat like that observed in 1922 and 1923, as shown in greater detail in figure 12 of the Annals.

L. B. Aldrich, Director of the Observatory, having now kindly given me the solar-constant observations up to the end of 1945 in final form, I wished to see if the great depression occurred in 1945 as expected, and whether the prophecy was generally fulfilled within experimental error.

It is to be regretted that the long series of solar-constant values, 1920 to 1945, has several less satisfactory intervals. First, as stated on page 168 of the Annals, volume 6, was the critical interval 1921 and 1922. At Montezuma (our best station), as may be seen by referring to volume 5 of the Annals, pages 195 to 199, on the average only 3.4 days per decade were observed there from December 21, 1920, to February 28, 1923.

The excellent station on Mount Saint Katherine, in Egypt, where observations were made from January 1934 to November 1937, had to be abandoned because of wars. Hence no support to Montezuma work came from there from 1938 to 1945.

The station at Tyrone, in New Mexico, from which observations came after February 1939, fell more and more behind our hopes as time went on. One disturbing factor was variable smoke arising from increased mining and smelting operations in the surrounding region. The station was closed in 1946. In table 1, which follows, only Table Mountain and Montezuma values are given, omitting Tyrone.

The Montezuma values are weaker than usual in 1939 and throughout 1940. Meteorological conditions at Table Mountain are inferior to those at Montezuma, especially in the months March to June, inclusive, as shown by figure 7, Annals, volume 5, so that intervals of weakness at Montezuma cannot be fully corrected by Table Mountain results.

With these explanations I now give in table 1 the 10-day and monthly mean values of the solar constant of radiation from October 1939 to December 1945. The individual days' results were thoroughly gone over by Messrs. Aldrich and Hoover and Mrs. Bond, of the Observatory staff, and all the individual observations were scrutinized with all the care that long experience suggests. All the statistical evidences as to accuracy and the methods of checking and correction, as described in volume 6 of the Annals, were employed, except that the spectroscopic method of getting "improved preferred" values, as described at pages 166 and 167 of volume 6 of the Annals was not used. In table 1 are given the year and month in the first column; in the second and third columns the mean decade and monthly values from Table Mountain (T) and Montezuma (M). For each month the monthly means follow the three decade means. In the fourth column are given the preferred mean values for decades and for months. To save printing, only the last two figures are given, so that all values are to be understood as prefixed by 1.9. For example, for October 1939, 43 means 1.943 in calories per square centimeter per minute, at mean solar distance, outside the earth's atmosphere. I do not give here the number of days of observation for individual decades at the two stations. However, in computing "preferred mean" values these data, and also the grade of the observations at the two stations, were considered.

It was immediately apparent that though there is fair agreement between prophecy and observation up to near the end of 1944, the large depression of solar-constant values, prophesied from 1939 to occur in 1945, did not occur. I thought it might be because the master period of 273 months was incomplete in 1939. I therefore used the additional values 1939 to 1945 with those preceding, as given in table 27, Annals, volume 6, to make an entirely new analysis, after the manner described in pages 178 to 182 of Annals, volume 6. After tabulating the values for each periodicity in several successive groups, covering respectively successive intervals of time in order to test the

TABLE 1.—*Ten-day and monthly means, 1939 to 1945, from Table Mountain and Montezuma, and preferred values*

1939	T	M	Pfd. mean	1941	T	M	Pfd. mean	1942	T	M	Pfd. mean	1943	T	M	Pfd. mean	1944	T	M	Pfd. mean
Oct.	..	43	43	Jan.	38	51	45	Apr.	—	42	42	July	49	48	48	Oct.	44	47	46
	51	41	46		39	52	46		53	46	49		43	46	45		34	43	39
	54	37	45		36	..	(40)		61	42	51		50	50	50		49	36	42
	52	40	45		38	51	44		57	44	47		47	48	48		41	42	42
Nov.	54	38	46	Feb.	38	52	45	May	43	42	42	Aug.	48	47	47	Nov.	44	47	46
	54	39	46		..	..	(49)		58	49	53		46	48	47		..	45	45
	48	40	44		45	61	53		61	48	54		53	53	53		44	46	45
	53	39	45		39	56	49		50	47	50		50	49	49		44	46	45
Dec.	52	38	45	Mar.	..	55	(50)	June	53	48	50	Sept.	43	47	45	Dec.	45	42	43
	55	46	49		38	54	50		53	48	50		52	50	51		..	41	41
	52	44	48		47	54	51		54	46	50		50	47	48		39	45	42
	54	43	47		41	54	50		53	47	50		47	48	48		42	43	42
1940 Jan.	..	46	46	Apr.	36	50	43	July	48	49	49	Oct.	39	45	42	1945 Jan.	46	..	46
	48	42	45		46	55	51		56	49	52		52	46	49		30	43	37
	..	47	47		23	52	(49)		42	46	44		48	44	47		..	44	44
	48	46	46		37	52	48		48	48	48		49	45	46		33	44	42
Feb.	42	44	43	May	38	56	47	Aug.	41	45	43	Nov.	42	49	46	Feb.	34	48	41
	44	43	43		46	..	(46)		48	46	47		45	39	42		50	45	47
	52	41	46		56	60	58		42	44	43		37	41	39		37	48	43
	46	43	44		43	58	50		44	45	44		41	46	42		40	46	44
Mar.	46	47	47	June	44	59	52	Sept.	46	45	45	Dec.	44	45	45	Mar.	19	46	46
	54	37	45		43	58	51		34	44	39		42	42	42		..	46	46
	36	40	38		52	50	51		46	48	47		46	52	49		..	41	41
	44	41	43		47	56	51		41	46	44		44	49	45		19	45	45
Apr.	..	44	44	July	42	62	52	Oct.	42	47	45	1944 Jan.	54	44	49	Apr.	..	45	45
	42	47	45		48	56	52		46	44	45		48	..	48		..	49	49
	45	55	50		52	55	54		49	46	47		47	44	45		..	49	49
	42	50	46		47	57	53		46	45	46		51	44	47		..	48	48
May	38	51	45	Aug.	50	57	54	Nov.	48	44	46	Feb.	55	46	50	May	..	47	47
	40	49	45		44	55	50		50	48	49		54	36	45		42	45	44
	47	51	49		47	47	47		47	53	50		56	..	(56)		44	48	46
	42	50	46		46	53	50		49	48	49		55	41	50		44	47	46
June	44	50	47	Sept.	53	54	54	Dec.	47	47	47	Mar.	52	38	45	June	36	47	42
	41	49	45		50	51	51		38	41	40		58	38	48		41	44	43
	41	54	48		41	51	46		39	45	42		55	37	46		15	42	42
	42	51	47		48	53	50		40	45	43		55	37	46		37	44	42
July	43	52	48	Oct.	50	54	52	1943 Jan.	39	42	41	Apr.	48	39	43	July	..	50	50
	44	55	50		..	46	46		36	43	40		54	43	48		36	47	42
	45	51	48		45	51	48		..	44	44		48	43	45		29	48	48
	44	53	49		50	50	49		37	43	42		49	42	45		35	48	47
Aug.	46	51	49	Nov.	52	55	54	Feb.	46	..	(46)	May	46	46	46	Aug.	37	50	44
	39	48	44		53	47	50		43	49	46		56	44	50		41	42	42
	43	50	47		55	49	52		41	43	42		..	44	44		..	30	(40)
	42	49	47		53	50	52		43	47	45		48	45	47		40	41	42
Sept.	47	55	51	Dec.	51	53	52	Mar.	40	45	43	June	49	44	46	Sept.	..	40	40
	49	55	52		56	49	52		43	52	48		46	43	44		36	43	40
	39	47	43		..	55	55		46	44	45		42	44	43		47	42	44
	46	52	49		53	53	53		43	46	45		45	44	44		44	41	41
Oct.	46	45	45	1942 Jan.	48	58	53	Apr.	30	43	37	July	49	40	44	Oct.	50	44	47
	37	47	42		43	54	49		41	44	43		44	44	44		42	39	40
	48	49	49		54	51	52		50	46	48		48	41	44		53	32	42
	43	48	45		47	55	51		45	44	43		48	42	44		48	39	43
Nov.	50	45	47	Feb.	49	50	50	May	46	46	46	Aug.	52	46	49	Nov.	51	49	50
	..	45	45		50	50	50		30	47	47		44	39	41		54	41	47
	41	42	42		44	46	45		..	46	46		52	32	42		52	46	49
	45	44	45		47	49	48		38	47	46		51	40	44		51	45	49
Dec.	45	45	45	Mar.	44	41	42	June	43	48	46	Sept.	35	39	37	Dec.	49	40	43
	..	50	50		52	41	46		50	50	50		52	33	42		54	41	44
	44	45	45		46	48	47		55	50	52		40	34	37		55	39	44
	45	47	47		47	43	45		50	49	49		42	37	39		52	40	44

continuity of a supposed periodicity, I found it seemed indicated that some changes should be made from the schedule of periodicities given at page 181 of Annals, volume 6. For comparison I repeat here in table 2, table 31 from that source, with two additional lines to show the modifications found to be desirable. The amplitudes given in the lowest line of table 2 relate to the second of two analyses which I made of the data, as about to be described.

Two complete analyses of the data were computed, of which I give here only the second. The first started with August 1920. In making it, two curves were drawn at the end. In one the sums of the effects of 14 periodicities were used. In the other curve the best representation that I could make of Aldrich's determination [1] of the effect of sunspots on the solar constant was added to them. Neither of these curves fitted the solar-constant results of 1945. The great depression showed by the synthetic curves did not occur in the observations.

It may very well be that the great depression in the observed values, shown in figure 14, Annals, volume 6, in the years 1922 and 1923, is real, and is a fortuitous phenomenon, not included in the sun's ordinary course of variation as represented by the periodicities related to the 273-month master period; or it may be due to a long periodicity like $45\frac{1}{2}$ or 91 years. Possibly, on the other hand, the defective observations at Montezuma, and unsatisfactory sky conditions at Harqua Hala may have been the cause of the great observed depression. In short, possibly it was erroneous, though it is difficult to accept this view as appears from the Annals, volume 6, page 176.

I made a second analysis. Omitting the questionable interval, I started in the middle of the year 1923, and ended with December 1945. Before giving the results of this second analysis I shall give illustrative examples. First I show my method. Then I shall show that individual periodicities continue throughout the entire period. Finally I shall show why certain periodicities found in the earlier 1939 analysis are now omitted, and others substituted.

Figure 1 gives a facsimile reproduction of the computation of the periodicity of $11\frac{1}{4}$ months for the interval May 1923 to September 1945. Although not quite identical, the three sections of the computation agree in supporting the continuing reality of this period of $11\frac{1}{4}$ months.

The reason for introducing the periodicity of 16 months is that I had found it in the residual curve C of figure 14, Annals, volume 6.[2] It is not an important periodicity, but I think a real one.

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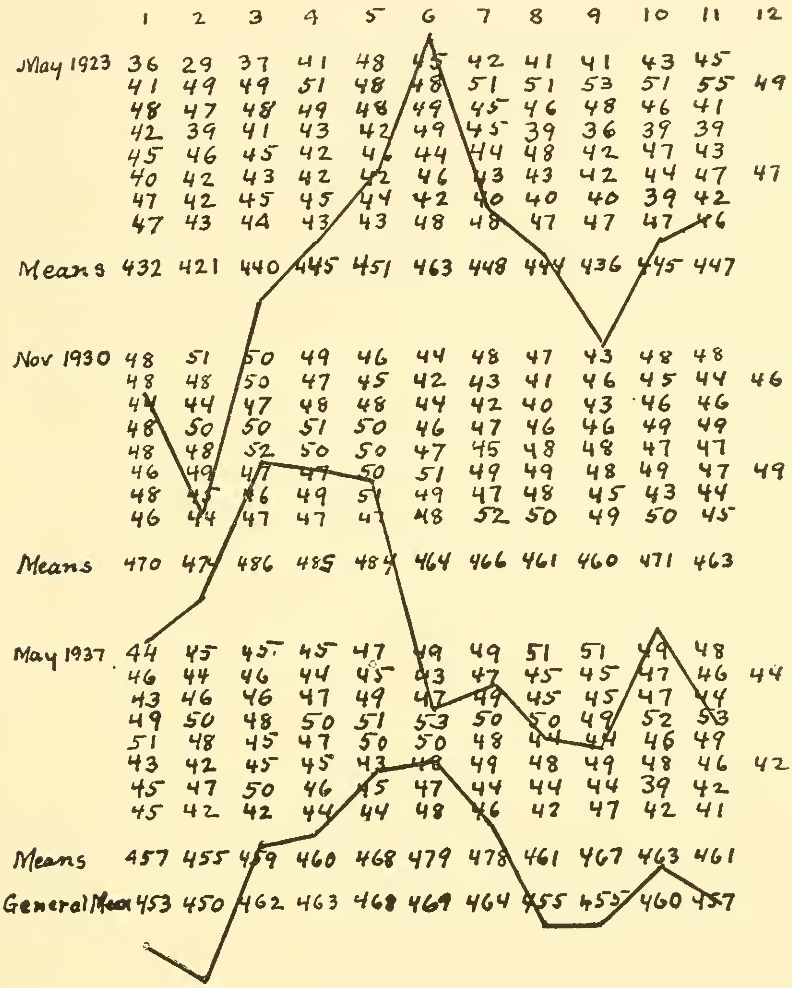
[1] Smithsonian Misc. Coll., vol. 104, No. 12, 1945.

[2] See Science, May 11, 1945, p. 483.

The reason for omitting periodicities of 21 and 25 months, and inserting one of $22\frac{1}{2}$ months, is that in the present analysis the periodicities of 21 and 25 months failed to persist without change of phase



	1	2	3	4	5	6	7	8	9	10	11	12
May 1923	36	29	37	41	48	45	42	41	41	43	45	
	41	49	49	51	48	48	51	51	53	51	55	49
	48	47	48	49	48	49	45	46	48	46	41	
	42	39	41	43	42	49	45	39	36	39	39	
	45	46	45	42	46	44	44	48	42	47	43	
	40	42	43	42	42	46	43	43	42	44	47	47
	47	42	45	45	44	42	40	40	40	39	42	
	47	43	44	43	43	48	48	47	47	47	46	
Means	432	421	440	445	451	463	448	444	436	445	447	
Nov 1930	48	51	50	49	46	44	48	47	43	48	48	
	48	48	50	47	45	42	43	41	46	45	44	46
	44	44	47	48	48	44	42	40	43	46	46	
	48	50	50	51	50	46	47	46	46	49	49	
	48	48	52	50	50	47	45	48	48	47	47	
	46	49	47	47	50	51	49	49	48	49	47	49
	48	45	46	49	51	49	47	48	45	43	44	
	46	44	47	47	47	48	52	50	49	50	45	
Means	470	474	486	485	484	464	466	461	460	471	463	
May 1937	44	45	45	45	47	49	49	51	51	49	48	
	46	44	46	44	45	43	47	45	45	47	46	44
	43	46	46	47	49	47	49	45	45	47	44	
	49	50	48	50	51	53	50	50	49	52	53	
	51	48	45	47	50	50	48	44	44	46	49	
	43	42	45	45	43	48	49	48	49	48	46	42
	45	47	50	46	45	47	44	44	44	39	42	
	45	42	42	44	44	48	46	42	47	42	41	
Means	457	455	459	460	468	479	478	461	467	463	461	
General Mean	453	450	462	463	468	469	464	455	455	460	457	

Fig. 1.—Computation of $11\frac{1}{4}$-month periodic variation of the solar constant, with graphs of three general means, 1923 to 1930, 1930 to 1937, and 1937 to 1945.

from 1923 to 1945, but that of $22\frac{1}{2}$ months did seem to persist throughout.

At this point I may say that since some periodicities are nearly integral multiples of others, and since, indeed, the longer periodicities may be obscured in the data, unless the shorter ones are first removed

TABLE 2.—*Long solar periodicities related approximately to 273 months*

		1	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/11	1/12	1/13	1/17	1/23	1/24	1/28	1/34	1/45
Integral ratio..........		1	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/11	1/12	1/13	1/17	1/23	1/24	1/28	1/34	1/45
Fraction of 273 months		273	91	68 1/4	54 3/5	45 1/2	39	34 1/8	30 1/3	24 9/11	22 3/4	21	16 1/17	11.87	11.36	9.75	8.03	6.07
Preferred length..	1939	273	91	68	54	45 1/4	39 1/2	34	30 1/3	25 1/3	....	21	....	11.87	11.29	9.79	8 1/8	.....
	1945	273	91	68	54 1/2	....	39 1/2	34	30 1/3	....	22 1/2	....	16	11 7/8	11 1/4	9 3/4	8 1/8	6 1/16
Amplitude	1939	90	52	66	55	69	82	56	38	44	....	48	....	34	31	13	18	.....
in (calories / 10,000)	1945	44	63	56	26	....	41	40	18	....	21	....	18	22	21	13	18	14

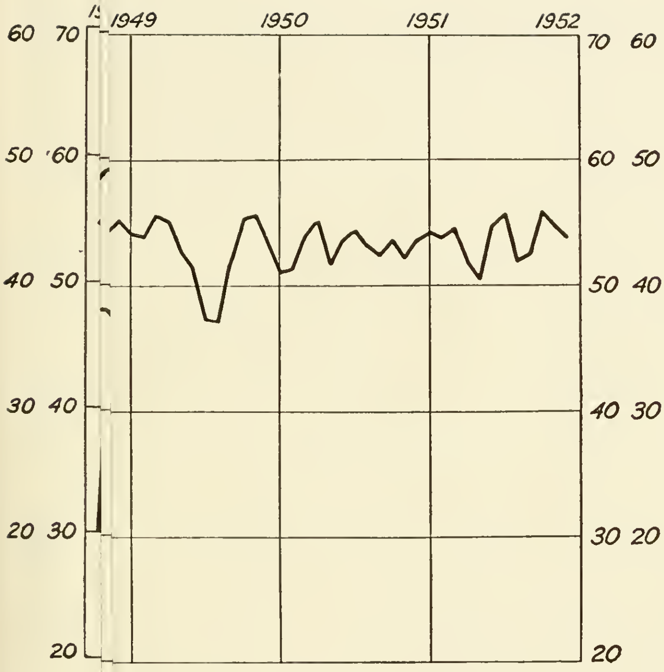
from the data, I proceeded in the following manner in the present analysis. Having computed the average characteristics of the periodicities of $8\frac{1}{8}$, $9\frac{3}{4}$, $11\frac{1}{4}$, and $11\frac{7}{8}$ months, I added their effects together for all months from 1923 to 1945, and subtracted the sums from the original data. I then used these revised residual data to compute for 16 months, 21 months, and $25\frac{1}{3}$ months. But as neither 21 nor $25\frac{1}{3}$ months proved satisfactory, I rejected them in favor of $22\frac{1}{2}$ months. Then I removed the joint effects of 16- and $22\frac{1}{2}$-month periodicities, to give a second type of residual data. From these residual data I computed for $30\frac{1}{3}$ months, removed its effects, and in each succeeding case used residual data from which the effects of all lesser periods had been removed. Arriving at $45\frac{1}{2}$ months, I found its range too small to be considered, and rejected it.

Arrived at 91 months, after computing this periodicity a very definite and persistent periodicity of about 6 months was for the first time disclosed as a sort of nuisance rider on the 91-month periodicity. I thought to remove it by computing such a period from the data as they stood before computing for 91 months. The effects of all periods up to and including 68 months had been removed. The result of this computation showed that a period of 6-1/16 months did in fact persist from 1923 to 1945, but its effect could not be fully removed. It had larger residual amplitudes in the latter part of the computed curve for 91 months. In other words the 6-1/16-month periodicity is of variable amplitude, and is really a subordinate feature of the 91-month periodicity. I had to content myself, unwillingly, with removing it in part as just stated and leaving it in, in part, as a feature of the 91-month periodicity. The part left in still appears as a nuisance rider in the 91-month periodicity, and makes that periodicity a very irregular thing. Instead of being represented by a fairly smoothly flowing curve like all the others, this periodicity has a succession of ups and downs. But I saw no way to avoid it. The period of 273 months is very smooth after the removal of 6-1/16- and 91-month effects.

All the periodic terms were tabulated and summed up after the manner of table 32, volume 6 of the Annals. The summation of them having been added in each month to a constant term 1.9462, there resulted a curve which could be compared with the original data, and which could be continued by way of prophecy backward from the middle of 1923 to August 1920, and forward from January 1946 to December 1951, as shown in figure 2. I give in table 3 the prophecy, 1946 to 1951, to show the forms and magnitudes of the several periodicities.

TABLE 3.—*Synthesis of periodicities, 1946 to 1951*

	$6\frac{1}{16}$	$8\frac{1}{8}$	$9\frac{3}{4}$	$11\frac{1}{4}$	$11\frac{7}{8}$	16	$22\frac{1}{2}$	$30\frac{1}{3}$	34	$39\frac{1}{2}$	$54\frac{1}{2}$	68	91	273	
1946-I	— 1	5	— 3	3	— 6	— 6	6	— 5	— 5	—16	— 6	—21	— 3	— 8	39.6
II	3	10	2	8	—10	— 5	3	— 6	—17	—20	— 9	—18	—33	— 8	36.2
III	7	— 8	7	12	—11	— 2	0	— 4	—17	—23	—13	—14	—20	— 8	36.8
IV	— 1	— 7	6	6	— 5	3	— 2	2	—12	—22	—14	—11	—10	— 9	38.6
V	— 7	— 5	0	— 2	0	8	— 4	7	— 8	—20	—13	— 8	7	— 9	40.8
VI	2	— 2	— 5	— 6	0	8	— 6	10	— 4	—16	—10	— 4	10	—10	42.9
VII	— 1	1	— 6	— 3	0	2	— 9	9	— 6	— 9	— 9	— 2	— 3	—11	41.5
VIII	3	2	— 6	— 4	2	— 5	—11	6	—11	— 6	— 9	0	—17	—11	39.5
IX	7	5	— 4	— 5	2	— 8	—10	3	—20	— 3	— 8	2	— 3	—12	40.8
X	— 1	10	— 2	— 9	6	— 6	3	0	—17	— 2	— 8	5	— 2	—13	42.6
XI	— 7	— 8	— 3	— 4	11	0	2	— 2	— 9	— 2	— 7	7	— 1	—12	39.1
XII	2	— 7	2	3	5	2	— 3	— 4	0	— 2	— 5	8	0	—13	45.0
1947-I	— 1	— 5	7	8	— 6	3	— 4	— 6	— 6	— 2	— 3	10	3	—13	44.7
II	3	— 2	6	12	—10	5	— 3	— 7	0	0	1	13	4	—13	47.1
III	7	1	0	6	—11	10	— 1	— 8	6	1	5	15	6	—13	48.6
IV	— 1	2	— 5	— 2	— 5	— 3	1	— 8	8	3	8	17	8	—14	47.1
V	— 7	5	— 6	— 6	0	— 6	3	— 7	12	6	9	20	10	—14	48.1
VI	2	10	— 6	— 3	0	— 5	6	— 5	7	8	7	22	11	—14	50.2
VII	— 1	— 8	— 4	— 4	0	— 2	8	— 3	12	10	5	24	12	—14	49.7
VIII	3	— 7	— 2	— 5	2	3	9	— 2	20	13	3	22	0	—14	50.7
IX	7	— 5	— 3	— 9	2	8	10	0	11	14	3	20	—10	—15	49.5
X	— 1	— 2	2	— 4	6	8	8	1	4	16	4	17	7	—15	51.3
XI	— 7	1	7	3	11	2	6	2	— 4	17	5	16	10	—15	51.6
XII	2	2	6	8	5	— 5	3	3	5	18	8	15	17	—16	53.3
1948-I	— 1	5	0	12	— 6	— 8	0	3	12	18	10	14	20	—16	52.5
II	3	10	— 5	6	—10	— 6	— 2	2	11	17	11	13	23	—16	51.9
III	7	— 8	— 6	— 2	—11	0	— 4	2	0	17	12	13	3	—17	46.8
IV	— 1	— 7	— 6	— 6	— 5	2	— 6	0	— 5	17	11	12	— 3	—17	44.8
V	— 7	— 5	— 4	— 3	0	3	— 9	— 1	— 4	16	8	12	—10	—17	44.1
VI	2	— 2	— 3	— 4	0	5	—11	— 2	4	16	6	12	— 7	—17	46.1
VII	— 1	1	2	— 5	0	10	—10	— 4	— 2	14	5	11	23	—17	48.9
VIII	3	2	7	— 9	2	— 3	3	— 5	— 3	12	3	11	27	—17	49.5
IX	7	5	6	— 4	2	— 6	2	— 6	— 5	9	2	11	7	—18	47.4
X	— 1	10	0	3	6	— 5	— 3	— 4	— 5	6	1	10	7	—18	46.9
XI	— 7	— 8	— 5	8	11	— 2	— 4	2	— 5	4	0	10	— 7	—18	44.1
XII	2	— 7	— 6	12	5	3	— 3	7	—17	2	— 2	11	0	—18	45.1
1949-I	— 1	— 5	— 4	6	— 6	8	— 1	10	—17	0	— 3	10	0	—18	44.1
II	3	— 2	— 2	— 2	—10	8	1	9	—12	— 2	— 4	8	0	—18	43.9
III	7	1	— 3	— 6	—11	2	3	6	— 8	— 6	— 6	6	27	—18	45.6
IV	— 1	2	2	— 3	— 5	— 5	6	3	— 4	—10	— 8	4	25	—18	45.1
V	— 7	5	7	— 4	0	— 8	8	0	— 6	—16	— 9	1	12	—18	42.7
VI	2	10	6	— 5	0	— 6	9	— 2	—11	—20	—10	— 1	0	—19	41.5
VII	— 1	— 8	0	— 9	0	0	10	— 4	—20	—23	—10	— 3	— 2	—19	37.3
VIII	3	— 7	— 5	— 4	2	2	8	— 6	—17	—22	— 9	— 4	—13	—19	37.1
IX	7	— 5	— 6	3	2	3	7	— 7	— 9	—20	— 9	— 5	13	—19	41.7
X	— 1	— 2	— 6	8	6	5	6	— 8	0	—16	— 6	— 7	30	—19	45.2
XI	— 7	1	— 4	12	11	10	3	— 8	— 6	— 9	— 3	— 8	20	—19	45.5
XII	2	2	— 2	6	5	— 3	0	— 7	0	— 6	1	—10	3	—20	43.3
1950-I	— 1	5	— 3	— 2	— 6	— 6	— 2	— 5	6	— 3	3	—12	— 7	—20	40.9
II	3	10	2	— 6	—11	— 5	— 4	— 3	8	— 2	4	—13	—13	—20	41.2
III	7	— 8	7	— 3	— 5	— 2	— 6	— 2	12	— 2	5	—14	7	—20	43.8
IV	— 1	— 7	6	— 4	0	3	— 9	0	7	— 2	5	—15	27	—20	45.2
V	— 7	— 5	0	— 5	0	8	—11	1	12	— 2	3	—15	— 5	—20	41.6
VI	2	— 2	— 5	— 9	0	8	—10	2	20	0	1	—14	0	—20	43.5
VII	— 1	1	— 6	— 4	2	2	3	3	11	1	— 2	—13	4	—20	44.3
VIII	3	2	— 6	— 5	2	— 5	2	3	4	3	— 6	—12	4	—20	43.1
IX	7	5	— 4	— 9	6	— 8	— 3	2	— 4	6	— 9	—12	5	—20	42.4
X	— 1	10	— 2	— 6	11	— 6	— 4	2	5	8	—13	—11	0	—20	43.5
XI	— 7	— 8	— 3	— 4	5	0	— 3	0	12	10	—14	—12	3	—20	42.1
XII	2	— 7	2	3	— 6	2	— 1	— 2	11	13	—13	—13	3	—20	43.6
1951-I	— 1	— 5	7	8	—10	3	1	— 4	0	14	—10	—15	12	—20	44.2
II	3	— 2	6	12	—11	5	3	— 4	— 5	16	— 9	—18	0	—20	43.8
III	7	1	0	6	— 5	10	6	— 5	— 4	17	— 9	—22	0	—19	44.5
IV	— 1	2	— 5	— 2	0	— 3	8	— 6	4	18	— 8	—25	— 5	—19	42.0
V	— 7	3	— 6	— 6	0	— 6	9	— 4	— 2	18	— 8	—29	0	—19	40.5
VI	2	5	— 6	— 3	0	— 5	10	2	— 3	18	— 7	—32	23	—19	44.7
VII	— 1	10	— 4	— 4	2	— 2	8	7	— 5	17	— 5	—29	20	—19	45.7
VIII	3	— 8	— 3	— 5	2	3	6	10	— 5	17	— 3	—25	—17	—18	41.9
IX	7	— 7	2	— 9	6	8	3	9	— 5	16	1	—21	—30	—18	42.4
X	— 1	— 5	7	— 4	11	8	0	6	—17	16	5	—18	7	—18	45.9
XI	— 7	— 2	6	3	5	2	— 2	3	—17	14	8	—14	3	—17	44.7
XII	2	1	0	8	— 6	— 5	— 4	0	—12	12	9	—11	0	—17	43.9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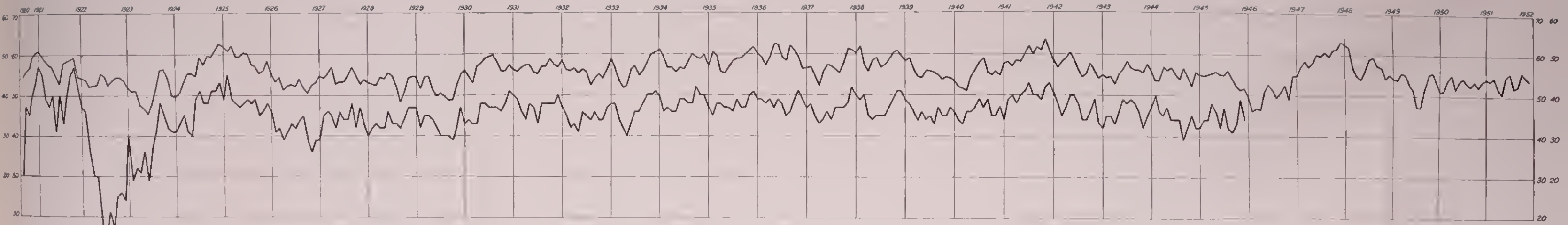

Fig. 2. Graphs of solar-constant monthly values 1920 to 1945. Lower curve as observed. Upper curve, synthesis of 14 periodicities. Predictions 1920 to 1923 and 1946 to 1951 in upper curve. Ordinates, calories per cm² per min when prefixed by 1.9. See footnote 3.

The average deviation between observed and synthetic curves, taken without regard to sign, from the middle of 1923 to the end of 1945, is 0.00177 calorie, or 0.081 percent of the solar constant.[3] This very surprisingly satisfactory fit between the observed and the synthetic curves seems to me to support my action with respect to the 91-month periodicity, as described above. For this period repeats three times. If the increasing importance of the unremoved part of the 6-1/16-month period toward the latter part of the 91-month periodicity was spurious, and caused by some large irregularity in a few years, then it would not be expected that to include these large ups and downs in the 91-month periodicity would so precisely satisfy the original observations, right through the entire interval 1923 to 1945. Following the prophetic curve back from 1923 to 1920, the great depression of the observed curve in 1922 is not found in the prophetic curve. But the principal features observed in 1920 and 1921 are well indicated in the prophetic curve. It will be of great interest to compare the observations, when they become available, with the prophetic curve from 1946 to 1951.

It is impossible at present to be certain whether the failure to follow the observations in 1922 is caused by defective observations, as already suggested, or by a deviation of the sun's output of radiation, at that time, from its normal course, which may represent a feature of a longer periodicity, such as $45\frac{1}{2}$ or 91 years.

The system of long-range solar periodicities that I now prefer is given in the lines marked "1945" of table 2. Like the curve of the sun-spot cycle of $11\frac{1}{3}$ years, the curves of these periodicities in the solar constant are not regular sine curves, but their forms are given by the tabulations, as in figure 1 and table 3. I see no advantage in forcing them to conform to Fourier's series procedures.

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[3] It will be noted that the curves of figure 2 come too close together at the end of 1945. As this paper was in press, work on the 1946 observations reached a stage which showed something wrong at Table Mountain. If Montezuma results Oct.–Dec., 1946, are used alone, the anomaly disappears.