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MOUNT ST. KATHERINE, AN EXCELLENT SOLAR-RADIATION STATION

(With Two Plates)

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MOUNT ST. KATHERINE,
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For many years the Smithsonian Astrophysical Observatory has been engaged in measuring solar radiation on mountain peaks in desert lands, and computing therefrom the solar constant of radiation. By that we mean the intensity of the sun's radiation as it would be found by an observer with a perfect instrument, constantly stationed in free space, outside the earth's atmosphere, at the earth's mean distance from the sun. Our object in this work is to determine to what degree the sun's output of radiation is variable, and what effects its variations produce on weather.

In his "Report of the Mount Whitney Expedition", Langley speaks strongly of the difficulty of measuring solar radiation *anywhere* as *"formidable"*, and that of correcting such measurements for *atmospheric losses* as *"perhaps insuperable"*. But over 50 years have passed since Langley made this statement, and new apparatus and new methods have been devised.

About one million dollars has been spent in making solar measurements at the most favorable stations to be found on the earth. The most earnest efforts have been made to conquer the difficulties so forcibly stated by Langley. Many discussions of the sources of error and the degree of their elimination have been published. Tests and tested inferences which indicate very high present accuracy have been disclosed. We have not, indeed, claimed to determine the exact intensity of that ultraviolet part of the solar radiation which never reaches the earth because it is cut off completely in the upper atmosphere by ozone. This is, however, but a very small fraction of the solar constant. This region of the solar spectrum is probably the most variable. Because its rays are lost at high altitudes, its variations do not perceptibly affect the variation of the sun as an agency to be taken account of in weather.

Meteorologists have, I feel, somewhat neglected our proofs of the accuracy of our work, and have been, I think, somewhat misled by certain criticisms which have appeared in the literature.

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Hence it is with unusual satisfaction that I am able to report the close agreement between the results obtained at Mount St. Katherine, our new station in Egypt, and those obtained on the same days at Montezuma in Chile. For since these totally independent stations are in opposite hemispheres, winter at the one coincides with summer at the other. If the contrasting atmospheric and geometric conditions of winter and summer do not bring about appreciable discordance, we may, it would seem, now admit that Langley's two obstacles are sensibly overcome, and the work which has gone on at Montezuma for some years may be accepted with still greater confidence than heretofore.

In the year 1931 I published, under the title " Weather Dominated by Solar Changes ", evidence that the short-interval changes in the intensity of the sun's radiation are of considerable influence in governing the ordinary fluctuations of weather. The solar-radiation values used in that paper were exclusively from the Smithsonian station at Montezuma, Chile. The results seemed to indicate that solar fluctuations of less than 0.5 percent are associated with notable weather changes. But it was impossible from the observations at one station, subject to accidental errors of the instruments and observers and to the difficulty of evaluating the losses in our atmosphere, to be sure of distinguishing solar changes of less than 0.5 percent from errors of observation, except when numerous apparently favorable cases were averaged.

Our station at Table Mountain, Calif., did not then and does not now yield results as accurate as those of Montezuma. The difficulty at Table Mountain lies not in the inadequacy of the apparatus or the observers, but in some obscure invisible changes of atmospheric conditions, whose effects we have hitherto been unable to eliminate completely. New efforts to improve Table Mountain results are now on foot.

With the generous support of the National Geographic Society, an attempt was made about 10 years ago to find and equip a supporting station in the Eastern Hemisphere equal to Montezuma. After a journey to Algeria, Egypt, Baluchistan, and South Africa, I fixed on Mount Brukkaros in South-West Africa as most suitable. Five years of observing there demonstrated that owing to high winds, which carry dust over the mountain, this station was inferior both to Montezuma and to Table Mountain.

Thereupon, with generous support from Mr. John A. Roebling, Mr. and Mrs. A. F. Moore made a second journey of exploration occupying about 20 months. They were equipped with portable in-

SOLAR OBSERVING STATION ON MOUNT ST. KATHERINE, SINAI PENINSULA

VIEW SHOWING THE WEST AND NORTH SIDES OF THE OBSERVATORY AND THE DWELLING, MOUNT ST. KATHERINE struments, almost, indeed, adequate to observe the solar constant of radiation, and they spent weeks and even months in observing at some of the more promising stations. In this way they visited the Cape Verde Islands, many peaks in South-West Africa, and finally Mount St. Katherine, about 10 miles from Mount Sinai in Egypt, having an altitude of about 8,500 feet. No station visited proved as promising as the last mentioned. Mr. and Mrs. Moore observed there on about 100 days during the months of March, April, May, June, and July, 1932. As a result I was convinced that Mount St. Katherine had a fair chance of proving to be nearly as satisfactory as Montezuma in Chile for solar-constant observations.

With further support from Mr. Roebling, and with the generous gift from the National Geographic Society of the apparatus which had formerly been installed at Mount Brukkaros, Mount St. Katherine was occupied in the summer of 1933, and regular observations of the solar constant of radiation were begun there in December 1933.

It is a pleasure to acknowledge the great aid received and the cordial relations which have prevailed at all times with His Eminence Porphyrios III, Archbishop of Mount Sinai, and with the monks of St. Katherine's Monastery, under his direction, on Mount Sinai. During Mr. and Mrs. Moore's reconnaissance, the monks placed an existing structure on Mount St. Katherine at the disposal of these observers and brought them supplies. When a permanent occupation was undertaken, the authorities of the Monastery built the observatory and living quarters of stone on Gebel Zebir, a spur of Mount St. Katherine, built trails, and developed water. They still continue to transport supplies to the station from the Red Sea, and are helpful in uncounted ways.

The station was built, equipped, and occupied under the supervision of Harlan H. Zodtner, our field director, assisted by Frederick A. Greeley. Mrs. Zodtner and their two children accompany Mr. Zodtner, and she makes a home for the expedition.

Plates 1 and 2 show the inhospitable mountain site, and the buildings erected by the authorities of the Monastery for the instruments and observers.

Records of the observations made from December 1933 to April 1935 have now been reduced under the direction of my colleague, L. B. Aldrich. A short method similar to those in use at our stations Montezuma and Table Mountain was developed by him for St. Katherine. Also some improvement based on additional observations has recently been made by him in the reduction tables for Montezuma, and more correct new values, differing by a few thousandths of a calorie from those first computed, have been substituted for the broadcasted Montezuma observations of the solar constant of radiation for the past few years.

Our first care was to reduce the St. Katherine results to the same average scale as Montezuma. The scale depends on the adopted constants of the pyrheliometers, and no favorable weather for determining these was available in Washington before the departure of the Egyptian expedition. The scale correction was obtained by computing the average difference for 180 individual days of good quality at both stations. The resulting mean difference, 0.034 calorie, was subtracted from all St. Katherine daily values.

Next the average mean difference of the daily results of good quality common to the two stations was computed for each month without regard for sign, as shown in table 1, together with the number of days represented in each mean. The values given are in thousandths of a calorie.

TABLE 1.—*Monthly Averages of Daily Differences, Montezuma Minus St. Katherine*

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1933	Mean Value	..	..	..	..	..	..	..	..	..	..	..	7
	Number days	..	..	..	..	..	..	..	..	..	..	..	4
1934	Mean Value	4	8	7	14	12	9	5	7	7	11	7	8
	Number days	4	7	10	13	5	11	19	19	26	14	11	8
1935	Mean Value	13	12	8	12	..	..	..	..	..	..	..	..
	Number days	9	4	7	11	..	..	..	..	..	..	..	..

General mean, 182 days, 0.0086 calorie.

Thus the general mean of all the daily differences, numbering 182 in all and covering a period of 17 months, is approximately 0.45 percent of the solar constant, taken as 1.940 calories. Omitting 6 aberrant values, it is 0.0079 calorie, or approximately 0.40 percent. Dividing by $\sqrt{2}$, we find the average daily accidental error of a single station is 0.30 percent.

It was particularly important to determine whether the daily differences, Montezuma minus St. Katherine, show a yearly period. Accordingly mean values of them were computed monthly having regard to sign. The results are given in table 2. They are expressed in thousandths of a calorie.

TABLE 2.—*Monthly Averages of Daily Differences, Montezuma Minus St. Katherine Taken with Regard to Sign*

Year	Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1933	Mean	..	..	..	..	..	..	..	..	..	..	..	+1
1934	Mean	+3	−4	0	+14	+12	−4	+1	+2	−3	−9	+4	+2
1935	Mean	+13	−1	−6	−6	..	..	..	..	..	..	..	..

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1933	Mean Value	..	..	..	..	..	..	..	..	..	..	..	7
	Number days	..	..	..	..	..	..	..	..	..	..	..	4
1934	Mean Value	4	8	7	14	12	9	5	7	7	11	7	8
	Number days	4	7	10	13	5	11	19	19	26	14	11	8
1935	Mean Value	13	12	8	12	..	..	..	..	..	..	..	..
	Number days	9	4	7	11	..	..	..	..	..	..	..	..

General mean, 182 days, 0.0086 calorie.

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1933	Mean	..	..	..	..	..	..	..	..	..	..	..	+1
1934	Mean	+3	−4	0	+14	+12	−4	+1	+2	−3	−9	+4	+2
1935	Mean	+13	−1	−6	−6	..	..	..	..	..	..	..	..

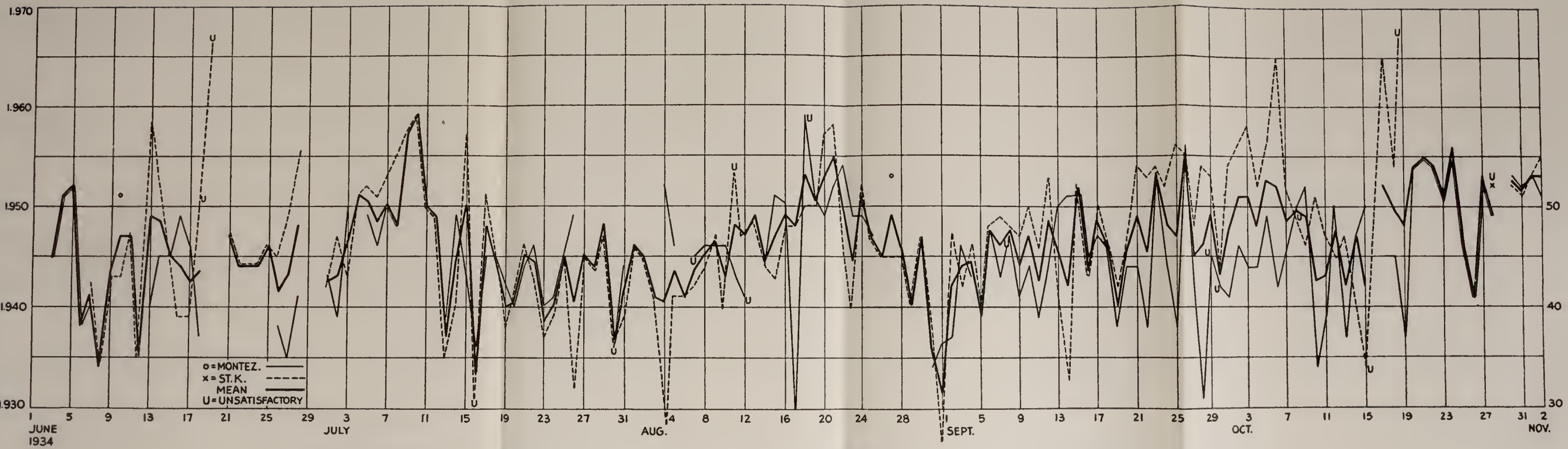

Fig. 1.—Comparison of solar-constant values from two stations 7,000 miles apart on opposite sides of the Equator. One percent equals four vertical divisions.

Except for the large positive values found sporadically in January 1935, and April and May 1934. there seems to be no evidence of appreciable yearly periodicity. For the differences are no larger than would be expected as the result of unbalanced experimental errors. During the months just excepted somewhat unsatisfactory conditions prevailed at one or both stations. This general conclusion is highly satisfactory. It means that on good days the differences of exposure of instruments caused by unequal altitudes of the sun and the differences of procedure and magnitudes in allowing for atmospheric losses at two independent stations in opposite hemispheres, separated by nearly a third the circumference of the earth, produce no differential periodicity in excess of two or three tenths of 1 percent of the solar constant of radiation. Accordingly the yearly range of systematic error for one station, being half as great as the combined ranges of two stations, is surely negligible. Summer with its increased heat, haziness, and humidity, opposed by winter with its greater cold, clearness, and dryness, and besides these the observation of the sun at different angles above the horizon at the constrasted stations, have altogether failed to produce differences in the results which indicate that systematic errors are certainly appreciable.

Finally, the individual daily values at the two stations during the five best months, June to October, 1934, have been tabulated in table 3, and plotted in figure 1. In computing the mean values and deviations in the table, I have included a few fairly good values marked " unsatisfactory " which were excluded in tables 1 and 2.

A heavy line in the figure gives the best value of the march of the solar constant of radiation.[1] The independent results of the two stations are indicated by a lighter line for Montezuma and a dotted line for St. Katherine. The close accord shown by these two remote and contrasting stations cannot but encourage the belief that the observations of the variability of the sun hitherto reported from Montezuma are very close to the truth.

Every day but six within this interval of 152 days from June to October 1934 is covered by good observations at one station or both. The two stations obviously support each other in displaying in common many variations of the intensity of solar radiation. The most conspicuous variation of long period shown has a periodicity of a little more than 40 days, perhaps even 45 days, and has an amplitude of about $\frac{3}{4}$ of 1 percent. This effect is doubtless to be associated with that solar periodicity of about 45 days to which I once drew attention

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[1] The table and diagram were prepared independently and may differ slightly.

TABLE 3.—*Comparative Solar-Constant Results at Montezuma and St. Katherine*

The values given are thousandths of a calorie, and in columns 2, 4, 6 are to be understood as added to 1.900 calories

1934	Montezuma		St. Katherine		S. C. Mean	Stations used [a]	Montezuma minus St. Katherine
	S. C.	Gr.	S. C.	Gr.			
June 1	..	..	..	..	..	..	..
2	..	..	..	..	..	..	..
3	45	S—	..	..	45	M	..
4	51	S—	106	U	51	M	..
5	52	U	..	..	52	M	..
6	38	S—	102	U?	38	M	..
7	40	S	42	S—	41	B	— 2
8	..	..	34	S—	34	K	..
9	..	..	43	S—	43	K	..
10	51	S—	43	S—	47	B	+ 8
11	..	..	47	S—	47	K	..
12	..	..	35	S—	35	K	..
13	40	S—	58	S—	49	B	—18
14	45	S—	52	S—	48	B	— 7
15	45	S	..	..	45	M	..
16	49	S—	39	S	44	B	+10
17	46	S	39	S—	42	B	+ 7
18	37	S—	50	U	43	B	—13
19	..	..	66	U	..	..	..
20	..	..	91	U	..	..	..
21	39	S—	47	S	43	B	— 8
22	..	..	44	S—	44	K	..
23	45	S—	44	S	44	B	+ 1
24	..	..	44	S—	44	K	..
25	..	..	46	S—	46	K	..
26	38	S—	45	S—	42	B	— 7
27	35	S	49	S	42	B	—14
28	41	S—	55	S—	48	B	—14
29	..	..	..	..	..	..	..
30	..	..	..	..	..	..	..
July 1	43	S—	42	S—	42	B	+ 1
2	39	S—	47	S—	43	B	— 8
3	50	S—	43	S—	46	B	+ 7
4	..	..	51	S—	51	K	..
5	49	S	52	S—	50	B	— 3
6	46	S—	51	S—	48	B	— 5
7	50	S	..	..	50	M	..
8	48	S—	..	..	48	M	..
9	..	..	57	S—	57	K	..
10	..	..	59	S	59	K	..
11	..	..	50	S	50	K	..
12	..	..	49	S—	49	K	..
13	39	S	35	S—	37	B	+ 4
14	49	S	40	S—	44	B	+ 9
15	43	S	57	S—	50	B	—14
16	36	S—	31	U	34	B	+ 5
17	45	S	51	S—	48	B	— 6
18	45	S	45	S—	45	B	0
19	42	S	38	S	40	B	+ 4
20	38	S—	41	S	40	B	— 3
21	44	S	46	S	45	B	— 2
22	46	S—	43	S	44	B	+ 3
23	40	S	37	S—	38	B	+ 3
24	41	S—	39	S	40	B	+ 2
25	45	S	45	S	45	B	0
26	49	S	32	S—	40	B	+17
27	..	..	45	S—	45	K	..
28	..	..	44	S—	44	K	..
29	..	..	48	S—	48	K	..
30	36	U	47	S—	42	B	—11
31	44	S	39	S—	42	B	+ 5

[a] M = Montezuma. K = St. Katherine. B = Both.

TABLE 3.—*Continued*

	Montezuma		St. Katherine		S. C. Mean	Stations used [a]	Montezuma minus St. Katherine
1934	S. C.	Gr.	S. C.	Gr.			
Aug. 1	..	..	46	S—	46	K	..
2	..	..	45	S—	45	K	..
3	..	..	41	S—	41	K	..
4	52	S—	28	S—	40	B	+24
5	46	S	41	S—	44	B	+ 5
6	..	..	41	S—	41	K	..
7	45	U	42	S—	43	B	+ 3
8	46	S	44	S—	45	B	+ 2
9	46	S—	47	S—	46	B	— 1
10	46	S—	40	S—	43	B	+ 6
11	43	S—	53	U	48	B	—10
12	41	U	47	U	44	B	— 6
13	..	..	49	S—	49	K	..
14	45	S—	44	S—	44	B	+ 1
15	51	S—	43	S—	47	B	+ 8
16	50	S—	48	S—	49	B	+ 2
17	30	S—	48	S	39	B	—18
18	59	U	50	S	54	B	+ 9
19	51	S	50	S	50	B	+ 1
20	49	S—	57	S—	53	B	— 8
21	52	S	38	S	45	B	+14
22	54	S	45	S	50	B	+ 9
23	49	S	40	S	44	B	+ 9
24	49	S	52	S	50	B	— 3
25	47	S—	47	S	47	B	0
26	..	..	45	S	45	K	..
27	53	S—	45	S—	49	B	+ 8
28	..	..	46	S—	46	K	..
29	..	..	40	S	40	K	..
30	..	..	47	S	47	K	..
31	34	S—	37	S	36	B	— 3
Sept. 1	36	S	26	S	31	B	+10
2	37	S—	47	S—	42	B	—10
3	46	S—	42	S—	44	B	+ 4
4	43	S—	46	S	44	B	— 3
5	..	..	39	S—	39	K	..
6	47	S—	48	S—	48	B	— 1
7	43	S	49	S—	46	B	— 6
8	47	U	48	S—	48	B	— 1
9	41	S	47	S—	44	B	— 6
10	44	S—	50	S	47	B	— 6
11	39	S—	46	S	42	B	— 7
12	44	S—	53	S	48	B	— 9
13	50	S—	41	S—	46	B	+ 9
14	51	S	33	S—	42	B	+18
15	51	S	52	S—	52	B	— 1
16	44	S	43	S—	44	B	+ 1
17	47	S—	50	S	48	B	— 3
18	46	S	46	S	46	B	0
19	38	S	42	S	40	B	— 4
20	44	S—	47	S—	46	B	— 3
21	44	S—	54	S—	49	B	—10
22	38	S—	53	S—	46	B	—15
23	53	S—	54	S—	54	B	— 1
24	44	S—	52	S—	48	B	— 8
25	38	S	56	S—	47	B	—18
26	56	S	55	S—	56	B	+ 1
27	42	S	48	S	45	B	— 6
28	31	S—	52	S	42	B	—21
29	45	U	53	S—	49	B	— 8
30	42	U	46	S—	44	B	— 4

[a] M = Montezuma. K = St. Katherine. B = Both.

Table 3.—*Continued*

	Montezuma		St. Katherine				Montezuma minus
1934	S. C.	Gr.	S. C.	Gr.	S. C. Mean	Stations used [a]	St. Katherine
Oct. 1	41	S—	54	S—	48	B	—13
2	46	S—	56	S	51	B	—10
3	44	S	58	S	51	B	—14
4	44	S—	52	S	48	B	— 8
5	49	S—	56	S	52	B	— 7
6	42	S—	65	S—	54	B	—23
7	45	S—	52	S—	48	B	— 7
8	50	U	49	S	49	B	+ 1
9	52	S—	46	S—	49	B	+ 6
10	34	S—	51	S—	42	B	—17
11	39	S	47	S—	43	B	— 8
12	50	S—	45	S—	48	B	+ 5
13	37	S—	47	S—	42	B	—10
14	47	S	19	U	47	M	..
15	50	S	34	U	42	B	+16
16	..	..	43	S—	43	K	..
17	45	S—	65	S—	50	B[b]	—20
18	45	S—	54	S—	50	B	— 9
19	37	S—	67	U	37	M	..
20	54	S—	82	U?	54	M	..
21	55	S	92	U?	55	M	..
22	54	S	..	..	54	M	..
23	51	S	..	..	51	M	..
24	56	S	..	..	56	M	..
25	46	S	103	U?	46	M	..
26	41	S	..	..	41	M	..
27	53	S	..	..	53	M	..
28	49	S—	52	U	50	B	— 3
29	..	..	..	..	..	..	..
30	53	U	52	S—	52	B	+ 1
31	52	U	51	S—	51	B	+ 1
Nov. 1	53	S—	53	S	53	B	0
2	51	S—	55	S—	53	B	— 4
3	58	S—	56	S—	57	B	+ 2
4	..	..	67	U?	..	..	..
5	58	S	..	..	58	M	..
6	57	S—	47	S—	52	B	+10
7	42	S—	94	U	42	M	..
8	50	S	..	..	50	M	..
9	..	..	51	S—	51	K	..
10	63	S—	45	S—	54	B	+18
11	45	U	52	S—	49	B	— 7
12	..	..	58	U	..	..	..
13	..	..	..	..	..	..	..
14	50	S	..	..	50	M	..
15	59	S—	46	S	52	B	+13
16	..	..	50	S	50	K	..
17	..	..	58	S—	58	K	..
18	..	..	58	S—	58	K	..
19	53	S	52	S—	52	B	+ 1
20	53	S—	44	S—	48	B	+ 9
21	44	S	..	..	44	M	..
22	44	S—	..	..	44	M	..
23	55	S—	..	..	55	M	..
24	..	..	48	S—	48	K	..
25	52	S—	..	..	52	M	..
26	50	S	43	S—	46	B	+ 7
27	53	S—	54	S—	54	B	— 1
28	47	S	57	S	52	B	—10
29	43	U	66	S—	55	B	—23
30	..	..	54	S—	54	K	..

[a] M = Montezuma. K = St. Katherine. B = Both.

[b] Montezuma given greater weight in the mean.

as having occurred in the year 1924.[2] Many short interval fluctuations are also supported by both stations.

There is little to choose between the two stations as to the smoothness (*i. e.,* freedom from wild values) of their curves during this interval of 5 months. St. Katherine yields a few more days than Montezuma. As the average daily discrepancy between the stations during these 5 months is only 0.007 calorie, we infer that the average accidental error of a single station then was but 0.005 calorie, or ¼ of 1 percent.

A careful record of conditions at St. Katherine has been kept under Mr. Zodtner's direction. It is set forth in table 4.

On the whole it appears that Mount St. Katherine, except for a greater average wind velocity during the usual hours of observing, and greater haziness during the spring months, is equally as favorable a station for solar-constant observations as Montezuma. Moreover, the two drawbacks just mentioned do not seem to have lowered the quality of the daily St. Katherine observations below those of Montezuma. Thus far her numbers of days of good observing quality per year have slightly exceeded those of Montezuma, so that St. Katherine may be ranked quite as high on the whole as Montezuma.

In my paper " Weather Dominated by Solar Changes ", cited above, I indicated the dependence of weather on solar fluctuations of short interval. The results seemed to point to a possibility that at least at some stations and during some months of the year forecasts of weather for 10 days in advance might profitably be based on solar-radiation observations if these could be of sufficient accuracy and continuity. At that time it seemed doubtful if stations could be found whose combined results would yield on nearly every day in the year solar-constant values accurate to ¼ of 1 percent as regards accidental error, which seemed to be the minimum requirement for the purpose suggested. But not only do our two best stations now nearly reach that desired accuracy, but the impending substitution of Ångström type pyrheliometers at both stations as secondary instruments will probably increase this accuracy.

For nearly 20 years H. H. Clayton has worked assiduously on the problem of the correlation of solar variation with weather. In a recent paper[3] crammed with statistical results, he states: " In short, these extensive data, covering all parts of the world, prove that solar

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[2] See Smithsonian Misc. Coll., vol. 85, no. 1, fig. 3, 1931.

[3] Clayton, H. H., World weather and solar activity. Smithsonian Misc. Coll., vol. 89, no. 15, p. 24, 1934.

TABLE 4.—*Observing Conditions at St. Katherine*

Month and year	Number of days											Wind in m. p. h.		
				Observations possible:		Sky quality								
							Haze near sun:							
	Clear	Part Cloudy	Cloudy	Long method	Short method	None	Light	to	moderate	to	thick	Max. 24 h.	Min. 24 h.	Average for month
1933														
Oct.	17	14	0	23	31	4	6	6	12	3	0	30.7	3.6	13.3
Nov.	9	14	7	14	23	0	8	5	9	1	0	27.9	3.0	8.0
Dec.	7	5	19	8	12	8	2	0	1	1	0	46.4	5.1	16.2
1934														
Jan.	7	11	13	8	17	7	5	3	1	2	0	29.0	3.5	13.7^{+}
Feb.	15	6	7	16	21	6	7	2	2	2	2	41.4	1.9	14.3
Mar.	13	11	7	13	23	9	2	2	3	4	3	30.0	0.5	8.0^{+}
Apr.	15	11	4	20	26	4	5	3	7	3	4	32.2	1.8	9.8
May	5	12	14	9	17	0	4	4	3	0	6	25.0	0.8	8.1
June	13	12	5	19	25	2	6	2	4	1	10	13.5	0.7	5.3
July	16	13	2	27	29	8	5	5	8	2	0	11.0	0.2	3.6
Aug.	21	10	0	26	31	10	7	4	7	2	1	10.4	0.9	4.1
Sept.	23	7	0	30	30	8	10	3	7	0	2	18.6	1.2	5.5
Oct.	9	17	5	14	25	3	10	0	6	1	5	28.8	2.3	9.2^{+}
Nov.	3	19	8	10	22	11	8	1	2	0	0	18.4	0.9	8.2
Dec.	8	16	7	14	24	21	3	0	0	0	0	35.1	2.8	12.0
1935														
Jan.	5	16	10	11	18	13	2	2	0	1	0	...	..	19.0^{+++}
Feb.	10	12	6	12	20	14	1	0	0	2	3	...	..	16.5^{++}
Mar.	10	16	5	12	25	8	1	2	1	3	10	...	..	12.5^{++}
Apr.	14	12	4	21	26	9	4	1	3	0	9	...	..	11.6
May	8	15	8	18	23	1	1	4	5	3	9	...	..	8.5
June	14	16	0	23	30	4	6	2	7	1	10	...	..	6.8
July	19	11	1	22	30	2	15	6	4	0	3	...	..	8.2

$^{+}$ $^{++}$ $^{+++}$ One, two, and three days, respectively, lost owing to very high winds.

variation is an important weather factor, even the dominating one, as also appears from figures 13 and 14 and 23-26."

Our experience in selecting and operating solar-radiation stations has now placed us in a position where we might with relatively moderate additional financial support set up several additional solar-radiation stations competent to produce first-rate results. We could then furnish almost every day in the year solar-constant values with accidental errors not exceeding $\frac{1}{4}$ of 1 percent. The conclusions of Clayton and ourselves relative to the dependence of weather on solar variation seem to have reached such a stage of probability as to warrant this additional expense in the interest of producing a new tool of possible value for meteorology.