SPECIAL OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING AUGUST, 1919.

By HERBERT H. KIMBALL, Professor of Meteorology, in Charge.

[Dated: Solar Radiation Investigations Section, Washington, Sept. 29, 1919.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1919, **47**:4.

The monthly means and departures from normal in Table 1 show that radiation measurements averaged close to August normal values at Washington and above normal at Madison and Lincoln. But few measurements were obtained at Santa Fe on account of clouds the first of the month and smoke from forest fires during the last decade of the month. At Madison a noon reading of 1.41 cal. per square centimeter per minute measured on the 31st is the highest intensity ever measured at that station in August.

Table 3 shows an excess of 12 per cent for Madison and 5 per cent for Lincoln in the total radiation for the month as compared with the normal amounts for August. The total for Washington is close to normal.

The skylight polarization measurements made at Washington on seven days give a mean of 50 per cent, with a maximum of 65 per cent on the 2d. At Madison, measurements made on 18 days give a mean of 61 per cent, with a maximum of 71 per cent on the 25th. These are average values for August.

TABLE 1.—*Solar radiation intensities during August, 1919.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Aug. 2	1.36	1.28	1.20	1.12	1.04	0.98	0.93	0.87	0.81	.....
11	1.14	0.89	0.71	0.62	0.53	0.41	.....	.....	.....	.....
14	.....	0.95	0.75	0.64	.....	.....	.....	.....	.....	.....
15	.....	0.93	0.75	0.50	.....	.....	.....	.....	.....	.....
16	.....	.....	0.82	0.70	0.60	0.55	0.51	.....	.....	.....
19	.....	1.06	0.93	0.82	0.72	0.64	0.58	0.52	0.47	.....
20	1.20	1.09	0.98	0.89	0.80	0.72	0.65	0.56	.....	.....
22	1.24	1.05	.....	.....	.....	.....	.....	.....	.....	.....
23	1.25	0.90	0.74	0.64	0.57	.....	.....	.....	.....	.....
26	.....	1.21	1.04	0.91	0.80	0.70	.....	.....	.....	.....
27	.....	1.13	.....	.....	.....	.....	.....	.....	.....	.....
Monthly means	**1.24**	**1.05**	**0.88**	**0.76**	**0.72**	**0.67**	**0.67**	**0.65**	**(0.64)**	.....
Departure from 11-year normal	±0.00	−0.01	−0.02	−0.05	−0.02	+0.02	−0.01	+0.06	+0.06	.....
P. M.										
Aug. 9	.....	1.29	1.20	1.12	1.04	.....	.....	.....	.....	.....
14	.....	.....	0.72	0.62	.....	.....	.....	.....	.....	.....
22	.....	.....	1.05	.....	.....	.....	.....	.....	.....	.....
26	.....	0.88	.....	.....	.....	.....	.....	.....	.....	.....
Monthly means	.....	**(1.08)**	**0.99**	**(0.87)**	**(1.04)**	.....	.....	.....	.....	.....
Departure from 11-year normal	.....	**−0.01**	**+0.02**	**+0.01**	**+0.25**	.....	.....	.....	.....	.....

Madison, Wis.

Date.	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
A. M.										
Aug. 1	1.36	1.22	1.06	0.98	0.94	0.88	0.84	0.80	.....	.....
2	1.33	1.24	1.16	1.08	1.00	0.94	0.89	0.85	.....	.....
7	.....	1.28	1.19	1.10	.....	.....	.....	.....	.....	.....
8	1.42	1.32	1.23	1.13	1.06	0.99	0.94	0.91	.....	.....
9	1.40	1.26	1.14	1.04	0.98	0.92	0.87	0.82	0.78	.....
13	1.41	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	1.09	0.96	.....	.....	.....	.....	.....	.....	.....

TABLE 1.—*Solar radiation intensities during August, 1919*—Contd.

Madison, Wis.—Continued.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Aug. 16	1.37	1.26	1.17	.....	.....	0.92	.....	0.79	.....	.....
18	.....	1.06	0.88	0.71	0.61	0.59	.....	.....	.....	.....
19	1.38	1.27	1.17	1.08	1.00	0.95	0.90	0.87	.....	.....
21	1.42	1.28	1.17	1.07	1.00	0.90	0.87	0.82	.....	0.71
22	1.41	1.29	1.17	1.07	1.00	0.93	0.86	0.78	.....	.....
23	.....	0.81	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	1.34	1.26	1.18	.....	.....	.....	.....	.....	.....
26	.....	1.25	.....	1.03	0.95	.....	.....	.....	.....	.....
27	.....	1.31	1.21	1.11	1.04	0.98	0.92	0.88	.....	.....
28	.....	1.28	1.19	.....	.....	.....	.....	.....	.....	.....
30	.....	1.25	1.17	1.01	0.91	0.83	0.75	0.67	.....	.....
31	1.46	1.35	1.25	.....	.....	0.93	0.84	0.77	.....	.....
Monthly means	**1.40**	**1.23**	**1.15**	**1.05**	**0.95**	**0.90**	**0.87**	**0.81**	**(0.78)**	**(0.71)**
Departure from 10-year normal	**+0.08**	**+0.03**	**+0.05**	**+0.03**	**+0.03**	**+0.02**	**+0.04**	**+0.01**	**+0.05**	.....
P. M.										
Aug. 1	.....	1.25	1.14	.....	.....	.....	.....	.....	.....	.....
7	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	1.25	1.10	1.02	0.93	0.84	.....	.....	.....	.....
19	.....	1.22	1.06	.....	.....	.....	.....	.....	.....	.....
21	.....	1.32	1.20	1.10	1.02	0.94	.....	.....	.....	.....
22	.....	0.95	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	1.33	1.23	1.14	.....	.....	.....	.....	.....	.....
26	.....	1.12	.....	.....	.....	.....	.....	.....	.....	.....
27	.....	1.30	1.20	1.09	0.97	.....	.....	.....	.....	.....
28	.....	1.29	1.18	.....	.....	.....	.....	.....	.....	.....
Monthly means	.....	**1.23**	**1.16**	**1.09**	**0.97**	**(0.89)**	.....	.....	.....	.....
Departure from 10-year normal	.....	**+0.07**	**+0.11**	**+0.11**	**+0.10**	**+0.08**	.....	.....	.....	.....

Lincoln, Nebr.

Date.	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
A. M.										
Aug. 13	.....	1.34	1.21	1.11	0.99	0.93	0.88	0.84	.....	.....
14	.....	.....	.....	0.97	0.90	0.83	.....	.....	.....	.....
16	(1.36[1])	1.21	1.11	0.99	0.91	0.84	.....	.....	.....	.....
18	.....	1.28	1.16	1.10	1.03	0.96	.....	.....	.....	.....
Monthly means	.....	**1.28**	**1.16**	**1.04**	**0.96**	**0.89**	**(0.88)**	**(0.84)**	.....	.....
Departure from 5-year normal	.....	**+0.08**	**+0.08**	**+0.04**	**+0.06**	**+0.03**	**+0.07**	**+0.09**	.....	.....
P. M.										
Aug. 3	(1.40[1])	1.22	1.09	0.99	0.91	0.83	0.75	0.69	.....	.....
11	.....	.....	.....	0.90	.....	.....	.....	.....	.....	.....
12	.....	.....	.....	0.84	.....	.....	.....	.....	.....	.....
13	.....	1.24	1.14	1.08	0.97	0.88	0.81	0.77	0.68	0.61
14	.....	1.14	0.99	0.84	.....	.....	.....	.....	.....	0.43
16	(1.39[1])	1.26	1.16	1.08	1.00	0.95	0.89	0.84	.....	.....
18	(1.44[1])	1.31	1.20	1.11	1.04	0.97	0.91	0.86	0.82	0.78
Monthly means	.....	**1.23**	**1.12**	**0.98**	**0.98**	**0.91**	**0.84**	**0.79**	**(0.75)**	**0.61**
Departure from 5-year normal	.....	**+0.02**	**+0.01**	**−0.03**	**+0.05**	**+0.05**	**+0.06**	**+0.04**	**+0.03**	**−0.07**

[1] Extrapolated, and reduced to mean solar distance.

Santa Fe, N. Mex.

Date.	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
A. M.										
Aug. 4	.....	.....	.....	.....	1.16	1.06	.....	.....	.....	.....
13	.....	.....	.....	.....	1.18	1.04	0.92	.....	.....	.....
18	1.43	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	1.32	.....	.....	.....	.....	.....	.....	.....	.....	.....
Monthly means	**(1.38)**	.....	.....	.....	**(1.17)**	**(1.05)**	**(0.92)**	.....	.....	.....
Departure from 7-year normal	**−0.03**	.....	.....	.....	**+0.09**	**+0.04**	**−0.02**	.....	.....	.....
P. M.										
Aug. 29	.....	1.28	1.17	1.08	.....	.....	.....	.....	.....	.....
Monthly means	.....	**(1.28)**	**(1.17)**	**(1.08)**	.....	.....	.....	.....	.....	.....
Departure from 2-year normal	.....	**−0.10**	**−0.07**	**−0.08**	.....	.....	.....	.....	.....	.....

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.
1919.	*mm.*	*mm.*	1919.	*mm.*	*mm.*	1919.	*mm.*	*mm.*	1919.	*mm.*	*mm.*
Aug. 2	9.14	11.38	Aug. 1	9.83	8.48	Aug. 3	17.37	13.13	Aug. 4	8.81	8.18
9	8.48	11.81	2	11.38	9.14	11	15.11	16.20	13	7.29	8.81
11	13.61	14.60	7	14.10	13.13	12	15.11	20.57	18	9.14	8.48
14	10.59	16.79	8	9.83	9.83	13	12.24	14.10	26	7.04	6.50
15	16.20	19.23	9	10.21	7.04	14	10.59	18.59	29	8.18	7.87
16	15.11	17.37	13	15.11	14.10	16	9.14	11.38	.....	.....	.....
19	15.65	17.96	14	14.60	14.60	18	9.83	9.83	.....	.....	.....
20	14.60	17.96	16	10.97	12.68	.....	.....	.....	.....	.....	.....
22	15.11	13.61	18	13.13	12.24	.....	.....	.....	.....	.....	.....
23	14.10	20.57	19	11.38	11.81	.....	.....	.....	.....	.....	.....
26	9.52	10.59	21	10.97	8.48	.....	.....	.....	.....	.....	.....
27	9.14	11.81	22	12.24	16.20	.....	.....	.....	.....	.....	.....
.....	.....	.....	23	16.20	16.79	.....	.....	.....	.....	.....	.....
.....	.....	.....	25	9.47	8.18	.....	.....	.....	.....	.....	.....
.....	.....	.....	26	8.48	8.81	.....	.....	.....	.....	.....	.....
.....	.....	.....	27	7.87	7.57	.....	.....	.....	.....	.....	.....
.....	.....	.....	28	7.04	7.87	.....	.....	.....	.....	.....	.....
.....	.....	.....	30	9.14	8.81	.....	.....	.....	.....	.....	.....
.....	.....	.....	31	8.18	9.14	.....	.....	.....	.....	.....	.....

TABLE 3.—*Daily totals and departures of solar and sky radiation during August, 1919.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departure from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
1	405	679	170	− 73	202	−379	− 73	202	−379
2	616	611	488	139	137	− 59	66	339	−438
3	569	253	700	92	−218	155	158	121	−283
4	333	357	523	−143	−111	− 20	15	10	−303
5	225	351	609	−251	−114	68	−236	−104	−235
6	223	270	593	−251	−193	56	−487	−297	−179
7	462	620	684	− 9	159	152	−496	−138	− 27
8	500	639	584	31	179	56	−465	41	29
9	630	578	611	164	120	87	−301	161	116
10	579	574	518	115	117	− 2	−186	278	114
11	550	216	604	89	−239	89	− 97	39	203
12	458	518	345	0	64	−166	− 97	103	37
13	100	470	669	−355	18	163	−452	121	200
14	442	563	643	− 10	112	141	−462	233	341
15	486	475	480	37	26	− 18	−425	259	323
16	500	575	656	54	128	161	−371	387	484
17	378	384	686	− 64	− 60	195	−435	327	679
18	425	556	661	− 14	115	173	−449	442	852
19	473	540	230	37	102	−255	−412	544	597
20	550	271	567	118	−165	85	−294	379	682
Decade departure							−108	101	568
21	288	597	558	−141	164	80	−435	543	762
22	522	540	545	96	110	70	−339	653	832
23	498	512	539	76	85	67	−263	738	899
24	491	522	508	72	98	40	−191	836	939
25	328	592	495	− 88	171	− 60	−279	1,007	879
26	509	549	168	95	131	−295	−184	1,138	584
27	376	585	251	− 36	170	−209	−220	1,308	375
28	503	564	530	93	153	72	−127	1,461	447
29	478	332	463	70	− 76	7	− 57	1,385	454
30	158	465	612	−248	60	158	−305	1,445	612
31	433	539	620	28	138	168	−277	1,583	780
Decade departure							+ 17	+1,204	+ 98
Excess or deficiency since first of year. gr.-cal.							−4,697	−3,366	−1,938
Excess or deficiency since first of year. per cent							−5.0	−3.6	−1.8

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Director, Astrophysical Observatory.

[Dated: Smithsonian Institution, Washington, September, 1919.]

In continuation of the publications begun in February, 1919, I give herewith the values of the solar constant of radiation obtained at Calama, Chile, for the months of June and July, 1919.

I was present in Calama at the time that many of these observations were made, and in cooperation with the observers there worked out a new method of observing which has been employed for some of the days of observation included in the following tables, and which shall be briefly described as follows:

My colleagues, Mr. Fowle and Mr. Aldrich, as well as those in Calama, and myself have felt very keenly the desirability of devising some method of determining the solar constant of radiation which would be independent of changes in the transparency of the atmosphere during the period of observation. I had hoped that this might be done in some simple form by the aid of the pyranometer, that instrument which we devised several years ago for the purpose of measuring the brightness of the sky. It is well known that when the sky becomes more hazy the direct beam of the sun is reduced in intensity, but the scattered light of the sky is at the same time increased. Accordingly, it would seem that a pyranometer measurement of the brightness of a limited area of the sky near the sun would furnish an index of the state of the transparency of the atmosphere at the moment of observation, and this, combined with the usual observations of the solar intensity at the earth's surface by the pyrheliometer, and combined further with the determination of the quantity of the aqueous vapor between the observer and the sun (which is indicated by the state of the great infra-red absorption bands, ρ and ϕ) might give the means of estimating the solar radiation outside the atmosphere from observations made at a single instant of time.

When I reached Calama, after having observed the total eclipse of the sun at La Paz and having held a conference with Messrs. Wiggin and Clayton of the Argentine Weather Service at La Quiaca, Argentina, I found that Messrs. Moore and Abbot had prepared data giving the pyrheliometry, the transparency of the atmosphere for nearly 40 wave lengths, the function ρ/ρ_{sc}, and pyranometer values representing the intensity of the radiation of the sky in a zone 15° wide surrounding the sun. All these values were tabulated with solar constant values for 60 days of observation. They were taken for each day at the periods when the air masses were 2 and 3, respectively. I spent almost a week in working over these data, trying to find some method of combining them along the lines which I have suggested above, but without success. Mr. Moore, however, had once or twice suggested to me that if we knew the coefficient of atmospheric transmission for all of the individual wave lengths on a given day, and had observed with the spectrobolometer and pyrheliometer at air mass 2 or at air mass 3, we could determine the solar constant from these data