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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING JULY 1935

By IRVING F. HAND, *Assistant in Solar Radiation Investigations*

For a description of instruments employed and their exposures, the reader is referred to the January 1935 REVIEW, page 24.

Table 1 shows that solar radiation intensities averaged close to the July normals at Washington and Lincoln, and slightly above normal at Madison.

With the reopening of the pyrheliometric stations at Pittsburgh and La Jolla, the list of stations in table 2 is the largest in the history of the bureau. Owing to the relocation of the pyrheliometer at Pittsburgh from an urban to a suburban site, it has been deemed best to wait until new normals have been established before giving weekly departures of solar and sky radiation. New normals will also be necessary at La Jolla, for the reason that some doubt is held concerning the accuracy of the records obtained during the last few months with the old instrument which had absorbed some water-vapor. The Scripps Institution now has an hermetically-sealed thermoelectric pyrheliometer, and excellent records are to be expected from now on. Practically all stations in the central portion of the United States showed an excess in the total solar and sky radiation during the month. However, Washington, Chicago, Miami, New Orleans, and Riverside—all located near the seacoast or on the Great Lakes—showed a deficiency.

The red and the yellow glass filters used in turbidity measurements were tested during July by the National Bureau of Standards and found to have identically the same transmission coefficients that they had at the initial test.

Polarization measurements obtained on 4 days at Washington give a mean of 56 percent with a maximum of 61 percent on the 11th. At Madison observations taken on 8 days give a mean of 58 percent with a maximum of 66 percent on the 6th. All of these values are close to the July normals.

TABLE 1.—*Solar radiation intensities during July 1935*

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

WASHINGTON, D. C.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
July 3	11.81					1.16					9.14
July 11	19.23	0.61	0.68	0.86	1.02						16.79
July 12	20.57	.44	.57	.71	.88	1.04					17.96
July 15	18.59			.60							16.79
July 18	18.59	.63	.78								18.59
July 20	18.59				1.18						16.20
July 29	16.79			.51							14.10
July 30	10.97		.90	1.06	1.20	1.32					11.74
Means		.56	.73	.75	1.07	1.17					
Departures		−.02	+.05	−.03	+.15	−.04					

TABLE 1.—*Solar radiation intensities during July 1935*—Continued

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

MADISON, WIS.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
July 5	19.23			0.91							17.37
July 6	16.79		0.95	1.08	1.24	1.42					17.96
July 8	12.24	0.87	.96	1.07	1.23	1.40					14.60
July 10	16.20		.74								16.79
July 12	15.65				1.28	1.47					12.68
July 13	13.61			1.10	1.24	1.43					12.24
July 16	12.24					1.31					13.61
July 17	11.38			.99	1.17	1.36					14.10
July 19	16.79		.62	.77	.99	1.27					15.65
July 25	17.37				1.14	1.38					17.37
July 26	15.65				1.05						18.62
July 29	14.60		.87	.93		1.39					15.11
Means		(.87)	.83	.98	1.17	1.38					
Departures		+.17	+.03	+.05	+.10	+.07					

LINCOLN, NEBR.

July 1	18.59							0.65	0.43	0.34	21.28
July 2	19.89		0.53	0.71	0.94	1.24		.70	.57	.46	18.59
July 3	17.37		.83	.98	1.14	1.37					17.96
July 5	21.28					1.26	1.04	.88	.74	.61	20.57
July 8	18.74					1.30	1.04	.84	.67		17.37
July 10	21.28				1.10	1.29	.98	.75	.60	.50	16.20
July 12	16.79					1.33	1.13	.97	.83	.72	13.61
July 13	12.24	0.77	.88	.99	1.17	1.29					12.68
July 15	14.10		.91	1.02	1.21	1.42	1.18	1.00	.84	.72	10.97
July 16	14.10	.82	.93	1.06	1.23	1.39	1.15	.99	.87	.73	17.14
July 17	15.65		.79	.96	1.14	1.38			.77	.66	12.24
July 18	14.60		.79	.93	1.11	1.38					12.68
July 19	14.60	.45	.55	.70	.92	1.30					14.60
July 20	20.57	.50	.66	.84	1.06	1.35					15.11
Means		.64	.76	.91	1.10	1.33	1.09	.85	.70	.59	
Departures		−.03	−.02	−.01	+.02	+.02	+.07	+.02	.00	+.01	

BLUE HILL, MASS.

July 1	8.8				1.07	1.43					9.9
July 2	8.8				1.28	1.45					6.3
July 3	9.2					1.43	1.11	1.03			7.6
July 4	12.8				1.14	1.17					11.5
July 5	16.9				1.11	1.19					16.4
July 8	16.7				1.07	1.28					17.5
July 10	17.5				1.06	1.14	.99				14.7
July 11	17.5				.73	1.13					16.4
July 12	18.8				.80	1.04					16.4
July 17	16.9					1.10					15.8
July 18	18.2					1.28	.84				16.4
July 20	17.5					1.02	.84				14.7
July 23	20.1					1.11					18.8
July 26	9.9					1.41	1.15				8.8
July 27	11.9				1.18	1.35	1.11				9.2
July 28	10.3			1.03	1.20	1.42	1.21	1.07			9.6
July 30	11.5				1.23	1.38					9.6
Averages				1.03	1.08	1.25	1.04	1.05			

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	Mount Washington	Friday Harbor	Ithica	San Juan
	Gram calories per square centimeter																	
1935	*cal*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 2	456	497	622	412	556	769	592	596	563	665	478	394	622	558	.....	484	503	799
July 9	472	601	633	547	385	683	550	538	622	619	513	416	540	465	.....	567	537	771
July 16	469	570	604	544	424	726	594	380	610	574	460	263	584	460	.....	683	567	728
July 23	521	499	600	511	460	741	468	348	640	566	496	314	586	521	.....	497	472	803
	Departure from weekly normals																	
July 2	−83	−30	+40	+46	+112	+64	.....	+137	−40	.....	−41	+17	+10	.....	.....	.....	.....	.....
July 9	−46	+67	+54	−94	−61	−17	.....	+105	+17	.....	−26	+34	−69	.....	.....	.....	.....	.....
July 16	−38	+51	+26	−140	+2	+41	.....	−21	0	.....	−62	−103	−16	.....	.....	.....	.....	.....
July 23	+10	−8	+47	−106	+34	+80	.....	−42	+68	.....	−41	−36	−8	.....	.....	.....	.....	.....
	Accumulated departures on July 29																	
	−3,941	−8,050	−7,021	−700	+3,234	+3,262	.....	+2,870	+1,379	.....	−3,465	−1,568	−4,753	.....	.....	.....	.....	.....

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during July 1935, and determinations of the atmospheric turbidity factor,* B, *and water-vapor content, w=depth in millimeters, if precipitated*

AMERICAN UNIVERSITY, WASHINGTON, D. C.

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	β_{mean}	$\frac{I_{w=0}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w=0}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
July 11, 1935	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
4:23 a. m.	32 10	1.87	1.100	0.770	0.592	0.044	0.050	0.047	76.4	7.8	11.0	N_{PC}
4:18 a. m.	33 00	1.83	1.118	.773	.594	.046	.050	.048	75.6	6.6	9.0	

Atmospheric conditions, July 11. Temperture 18° C.; wind, N-11; visibility, 30 miles; blueness of sky, 5; polarization, 61 percent.

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during July 1935, and determinations of the atmospheric turbidity factor,* B, *and water-vapor content, w=depth in millimeters, if precipitated*—Continued

Thermopheric turbidity

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	β_{mean}	$\frac{I_{w=e}}{1.94}$	$\frac{I_{w=o}-I_m}{1.94}$	w	Air-mass type
									Percentage of solar constant			
July 1, 1935	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
2:49 p. m.	50 15	1.30	1.370	0.954	0.748	0.033	0.048	0.040	82.6	9.4	10.8	P_e
July 2												
4.27 a. m.	32 10	1.87	1.290	.884	.724	.025	.074	.050	75.2	6.6	7.0	N_{pe}
0.29 a. m.	69 54	1.06	1.420	.965	.766	.036	.052	.044	84.9	9.1	14.0	
July 3												
0.33 a. m.	69 34	1.06	1.410	.949	.749	.034	.052	.043	85.0	9.3	14.4	N_{pe}
2:28 p. m.	54 29	1.23	1.300	.892	.697	.054	.073	.064	79.6	10.5	11.3	
5:19 p. m.	22 33	2.61	1.080	.778	.634	.046	.067	.056	67.2	9.5	7.2	
July 4												
1:33 a. m.	62 39	1.12	1.170	.799	.629	.101	.134	.118	73.4	11.0	12.5	N_{pe}
0:18 a. m.	70 25	1.06	1.170	.799	.629	.108	.148	.128	75.0	12.6	13.5	
July 5												
4:55 a. m.	27 23	2.17	1.030	.729	.584	.063	.076	.070	68.8	14.2	7.2	T_G
0:19 p. m.	71 10	1.06	1.190	.807	.633	.102	.167	.134	73.8	10.4	13.2	
July 11												
4:11 a. m.	35 20	1.73	.824	.570	.428	.113	.118	.116	65.5	11.6	8.2	N_{pe}
0:10 p. m.	69 47	1.06	1.110	.750	.608	.149	.179	.164	70.6	11.5	13.4	
2:48 p. m.	39 44	1.56	1.130	.783	.609	.070	.075	.072	74.6	14.4	9.3	
4:23 p. m.	32 19	1.87	1.030	.723	.579	.085	.113	.099	65.1	10.3	8.5	
July 12												
3:21 a. m.	43 41	1.45	1.050	.727	.598	.130	.158	.144	66.0	10.1	9.6	T_G
July 20												
2:16 p. m.	64 00	1.11	1.006	.722	.583	.187	.175	.181	67.7	14.1	9.8	
3:23 p. m.	42 08	1.49	.976	.700	.560	.139	.150	.144	65.1	13.1	9.7	
July 23												
2:45 a. m.	49 28	1.31	.971	.697	.568	.170	.196	.183	63.7	5.1	9.8	T_G
1:52 a. m.	58 15	1.18	1.041	.747	.598	.188	.182	.185	65.6	3.9	9.7	
July 27												
5:01 a. m.	23 31	2.50	1.090	.790	.648	.048	.055	.052	70.9	13.0	5.8	P_p and P_e
3:25 a. m.	41 50	1.53	1.242	.859	.687	.049	.075	.062	76.1	10.1	8.7	
1:42 a. m.	58 28	1.18	1.375	.933	.736	.035	.054	.044	83.1	10.0	11.7	
0:03 a. m.	66 57	1.09	1.345	.903	.722	.067	.001	.034	85.7	14.3	13.0	
0:57 p. m.	64 02	1.11	1.237	.859	.682	.098	.107	.102	76.6	10.9	12.3	
4:48 p. m.	25 55	2.28	1.075	.771	.663	.061	.090	.076	66.1	9.0	6.0	
July 28												
5:14 a. m.	21 00	2.77	1.065	.781	.653	.051	.076	.064	64.0	7.1	4.4	N_{pe}
4:01 a. m.	44 29	1.43	1.237	.864	.687	.075	.115	.095	72.7	6.6	8.3	
1:44 a. m.	58 01	1.18	1.390	.933	.741	.029	.065	.047	82.9	8.7	9.5	
1:19 a. m.	61 23	1.14	1.394	.938	.746	.029	.069	.049	83.2	8.7	12.0	
0:06 p. m.	66 44	1.09	1.399	.947	.752	.057	.073	.065	81.5	6.7	12.0	
1:10 p. m.	62 27	1.13	1.444	.967	.761	.019	.046	.032	85.8	8.7	12.0	
3:08 p. m.	44 08	1.44	1.340	.913	.722	.030	.055	.042	81.0	9.4	9.6	
5:29 p. m.	18 15	3.18	1.080	.786	.643	.031	.050	.040	68.1	10.3	6.5	
July 30												
3:48 a. m.	36 40	1.67	1.282	.872	.699	.028	.062	.045	78.7	9.6	8.2	N_{pp}
2:15 p. m.	53 00	1.25	1.325	.916	.723	.050	.065	.058	80.6	10.2	11.1	
2:33 p. m.	50 01	1.30	1.325	.916	.723	.047	.060	.054	80.4	10.0	10.9	

Atmospheric conditions during solar radiation measurements. Blue Hill Observatory of Harvard University

Date and time from apparent noon	Air temperature	Wind (Beaufort scale)	Visibility (scale 0-10)	Sky blueness	Cloudiness and remarks
July 1935	°C.				
1;2:26 p. m.	22.78	NE 2	9	10	3 Ci, 1 Cu, light haze in N.
2;0:26 a.m.	20.56	E 3	9	10	6 Ci, few Cu, light haze in N and W.
4;3:02 a.m.	22.22	SW 5	9	7	4 Acu, light haze.
4;0:36 a.m.	23.89	SW 5	8	6	3 Acu, light haze.
8;3:51 p. m.	23.89	SSE 5	9	9	Few Acu, 6 Cu, light water haze.
10;3:28 p. m.	25.00	SW 1	8-9	10	3 Acu, 3 Cu, light haze in N.
11;2:34 p.m.	27.78	S 1 1	8	8	3 Ci, 4 Cu, light haze.
12;2:42 p.m.	30.56	WSW 5	8	8	3 Cu, Frcu, moderate haze.
17;2:51 a.m.	22.22	W 2	7	7	2 Ci, 3 Cu, heavy water haze.
18;2:30 p.m.	28.33	WSW 5	8	8	7 Cu, Frcu, moderate haze.
20;4:40 a.m.	21.56	NNE 3	7	4	Ci haze.
20;3:42 a.m.	22.22	NNE 3	7		Ci haze, Cu increasing.
20;3:23 p.m.	21.67	NE 3	7		Light haze.
23;2:51 a.m.	27.78	WxS 4	8	4	Ci haze.
26;0:04 p. m.	20.68	NE 5	9	7	Clear.
26;3:52 p.m.	21.56	E 2	9		1 Ci, Cu.
27;4:58 a. m.	16.94	N 2	9	6	Few Ci in E.
27;1:34 a. m.	16.11	NNE 2	9	6	Clear.
27;0:58 p. m.	15.56	NE 3	9	6	Cu on horizon.
28;3:54 a. m.	20.00	SE 2	9	4	Few Ci in E.
28;1:32 a.m.	21.67	SE 2	9	9	2 Ci, No haze.
28;0:08 a.m.	22.50	SE 2	9	9	3 Ci. No haze.
28;2:46 p. m.	24.44	SSE 3	9	9	2 Ci, few Acu, few Cu, no haze.
30;2:24 a. m.	22.11	N 5-6	9	6	Ci, highest near sun.
30;1:10 p. m.	23.33	NE 2	9	6	Thin Ci?

[1] Wind direction variable.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measure from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time		Heliographic			Area		Total area for each day	Observatory
			Diff. in longitude	Longitude	Latitude	Spot	Group		
1935	h	m	°	°	°				
July 1	9	4	+24.0	308.0	−23.5		1,124	1,124	Harvard.
July 2	14	10	+35.0	302.9	−25.0		772	772	U. S. Naval.
July 3	11	4	−80.0	176.4	+25.0	46			
			+46.0	302.4	−25.5		556	602	Do.
July 4	10	30	−71.0	172.5	+27.0	276			
			+64.5	308.0	−22.0		375	651	Harvard.
July 5	11	37	−75.0	154.6	−35.0		77		U. S. Naval.
			−56.0	173.6	+25.0	62			
			+75.0	304.6	−26.0		278	417	
July 6	10	9	−62.0	155.2	−34.0		247		Do.
			−44.0	173.2	+24.5	46		293	
July 7	11	58	−48.0	154.9	−34.0		247		Do.
			−30.0	172.9	+24.5	46		293	
July 8	9	50	−69.0	121.9	−19.5	224			Mt. Wilson.
			−51.0	139.9	+22.0		30		
			−32.0	158.9	−34.0		257		
			−18.0	172.9	+25.0	48		559	
July 9	10	58	−58.0	119.0	−19.0	139			U. S. Naval.
			−37.0	140.0	+22.0		62		
			−19.5	157.5	−34.0		154		
			−4.0	173.0	+24.0	46		401	
July 10	12	4	−44.0	119.2	−19.0	123			Do.
			−23.0	140.2	+22.0		46		
			−7.0	156.2	−34.0	108			
			+9.5	172.7	+24.0	31		308	
July 11	11	47	−30.0	120.1	−20.0	139			Do.
			−9.0	141.1	+21.5		46		
			+7.0	157.1	−35.0	93			
			+21.5	171.6	+24.0	15		293	
July 12	10	55	−65.0	72.4	−28.0		62		Do.
			−19.0	118.4	−20.0	139			
			+5.0	142.4	+21.0		31		
			+12.0	149.4	−20.0	123			
			+19.5	156.9	−35.5	123			
			+35.0	172.4	+24.5	15		493	
July 13	12	14	−51.0	72.4	−28.0		139		Do.
			−4.0	119.4	−20.0	123			
			+35.0	158.4	−35.0	93			
			+48.0	171.4	+25.0	15		370	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time		Heliographic			Area		Total area for each day	Observatory
			Diff. in longitude	Longitude	Latitude	Spot	Group		
1935	h	m	°	°	°				
July 14	10	59	−38.0	72.8	−28.0		216		Do.
			+9.0	119.8	−20.0	139			
			+45.0	155.8	−35.0	93		448	
July 15	13	16	−75.0	21.4	−18.5	15			Do.
			−24.0	72.4	−28.5		185		
			+22.0	118.4	−20.0	123			
			+59.0	155.4	−35.0	77		400	
July 16	11	27	−60.0	24.1	−19.0	62			Do.
			−11.0	73.1	−28.5		185		
			+36.0	120.1	−19.5	123			
			+71.0	155.1	−35.0	62		432	
July 17	11	40	−49.0	21.8	−19.0	46			Do.
			+4.0	74.8	−28.0		185		
			+49.0	119.8	−19.5	123		354	
July 18	11	14	−35.5	22.3	−19.0	31			Do.
			+16.5	74.3	−28.5		185		
			+62.0	119.8	−19.5	123		339	
July 19	11	35	−28.5	15.9	+29.0		123		Do.
			−21.0	23.4	−19.0	31			
			+29.0	73.4	−28.5		185		
			+76.0	120.4	−19.5	108		447	
July 20	12	12	−15.0	15.8	+29.0		278		Do.
			+44.0	74.8	−28.0		247	525	
July 21	12	40	−1.5	15.8	+29.0		247		Do.
			+60.0	77.3	−28.0		185	432	
July 22	11	19	+12.5	17.3	+29.0		247		Do.
			+73.0	77.8	−28.0		93	340	
July 23	10	57	+25.0	16.8	+29.0		247	247	Do.
July 24	9	45	−42.0	297.2	−24.0	3			Mt. Wilson.
			+38.0	17.2	+29.0		334	337	
July 25	11	14	+52.0	17.2	+28.5		247	247	U. S. Naval.
July 26	13	30	+64.0	14.7	+28.0		264		Mt. Wilson.
			+80.0	30.7	+17.0	10		274	
July 27	11	10	+69.0	7.8	+28.0	123		123	U. S. Naval.
July 28	11	30	+85.0	10.3	+28.0	84		84	Mt. Wilson.
July 29	11	4	No spots						U. S. Naval.
July 30	11	41	−70.0	188.8	−19.0		77	77	Do.
July 31	13	40	−56.0	188.5	−18.0		77	77	Do.

Mean daily area for 31 days, 379.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, JULY 1935

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

July 1935	Relative numbers	July 1935	Relative numbers	July 1935	Relative numbers
1	41	11	*a* 44	21	36
2	29	12	*Ec* 59	22	32
3	29	13	63	23	30
4	24	14	*a* 51	24	29
5	*d* 28	15	49	25	23
6	29	16	49	26	19
7	22	17	*a* 47	27	11
8	*d* 50	18	46	28	8
9	44	19	*Ec* 51	29	0
10	38	20	*b* 60	30	*Ec* 8
				31	8

Mean, 31 days=34.1.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.