SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING SEPTEMBER 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 above normal at all three Weather Bureau stations.

Table 2 shows an excess in the amount of total solar and sky radiation at all stations with the exception of Washington and Miami.

Polarization measurements obtained on 5 days at Washington give a mean of 58 percent with a maximum of 62 percent on the 26th. At Madison observations obtained on 11 days give a mean of 60 percent with a maximum of 76 percent on the 27th. All of these values are slightly above the September normals.

TABLE 1.—*Solar radiation intensities during September 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*
Sept. 11	9.83	0.54	0.68	0.80	1.00	1.33					9.14
Sept. 13	13.13					1.30					12.68
Sept. 20	14.10	.74	.84	.92	1.17						14.10
Sept. 21	10.97	.48	.62	.73	.95	1.34					15.11
Sept. 23	8.48	.86	.94	1.12	1.21	1.38					7.29
Sept. 24	8.18						1.30	1.20	0.89	0.77	7.57
Sept. 25	10.21	.71	.83	.97	1.14	1.40	1.14	1.01	.91	.81	9.83
Sept. 30	4.75	.95	1.04	1.12	1.27	1.40	1.24	1.10	1.01	.91	4.57
Means		.71	.82	.94	1.12	1.36	1.23	1.10	.94	.83	
Departures		+.02	+.06	+.07	+.07	+.05	+.16	+.23	+.20	+.15	

MADISON, WIS.

Sept. 1	7.87		1.06	1.16	1.32						9.83
Sept. 5	7.29		1.07	1.20	1.36						7.29
Sept. 6	8.48		1.00	1.12		1.45					7.87
Sept. 9	10.21		.98	1.10	1.26	1.48					9.47
Sept. 10	8.81						1.25				8.81
Sept. 11	9.83	0.88	.97	1.12	1.26	1.49					10.59
Sept. 17	13.61	.79	.88	.99	1.13	1.39					16.20
Sept. 18	14.60	.70	.80	.96	1.14	1.38					15.11

* Extrapolated.

TABLE 1.—*Solar radiation intensities during September 1935*—Con.

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

MADISON, WIS.—Continued

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*
Sept. 24	11.81	.54	.64	.76	.93	1.36					14.60
Sept. 27	5.56				1.40	1.59	1.38				4.95
Sept. 30	6.76	.90	.97		1.28						8.18
Means		.78	.93	1.05	1.22	1.45	(1.32)				
Departures		−.06	+.02	+.03	+.06	+.06	+.15				

LINCOLN, NEBR.

Sept. 4	7.04		1.15	1.25	1.39	1.60					7.04
Sept. 6	9.47		.74	.94	1.14						10.59
Sept. 9	8.81	0.87	.96	1.10	1.27	1.57					8.81
Sept. 10	8.81		1.04	1.15	1.31	1.56	1.33	1.17	1.00	0.89	7.29
Sept. 11	8.81		1.01	1.17	1.32	1.58					9.47
Sept. 12	9.47	.80	.91	1.04	1.23	1.47	1.16				12.24
Sept. 13	10.97	.70	.84	1.00	1.20	1.45		1.00	.85	.73	13.13
Sept. 14	12.68	.79	.91	1.04							12.68
Sept. 17	13.61		.87	1.01	1.20	1.46	1.18	.96	.81	.71	16.20
Sept. 18	13.13	.73	.85	1.00	1.17						14.10
Sept. 19	10.59						1.16	.96	.82	.71	11.38
Sept. 21	7.57	.87	1.02	1.15	1.35	1.57					7.87
Sept. 23	12.24	.75	.88	1.03	1.20		1.12	.91	.74	.63	10.97
Sept. 27	4.75						1.31	1.18	1.04	.94	4.37
Sept. 28	4.17					1.58					4.75
Sept. 30	5.94	.93	1.05	1.20	1.38	1.52					6.76
Means		.80	.94	1.08	1.26	1.54	1.21	1.03	.88	.77	
Departures		+.07	+.11	+.12	+.13	+.12	+.05	+.05	+.04	+.03	

BLUE HILL, MASS.

Sept. 1	11.5				1.23	1.27	1.15				9.6
Sept. 6	12.3	0.69								0.70	11.9
Sept. 7	9.6	.97	1.07	1.19	1.30	1.40	1.10	0.78			9.2
Sept. 10	11.1					1.40	1.20	1.00			7.6
Sept. 11	8.2	.83	.93	1.04	1.18	1.44	1.15	1.00	0.90	.68	7.4
Sept. 12	9.9	.54	.64	.78	1.00	1.09	1.01				12.8
Sept. 13	8.2				.97						8.2
Sept. 14	7.4				1.14	1.45	1.05				5.8
Sept. 15	14.3					1.38	1.23	1.10			15.3
Sept. 16	6.3			1.09	1.28	1.50	1.29	1.11	.97	.87	6.8
Sept. 17	6.1			1.20	1.36	1.48	1.23	.99			6.8
Sept. 20	14.3			1.03	1.05	1.37	1.05	.90			12.3
Sept. 21	8.6				1.02						8.8
Sept. 22	9.9		1.01	1.10	1.24	1.40	1.10	.89	.78	.70	9.2
Sept. 23	5.4		1.05	1.18	1.35	1.49	1.34	1.14	1.00	.90	5.2
Sept. 24	5.4					1.49	1.13				5.4
Sept. 25	9.6				1.07	1.03	.84	.68	.56		10.3
Sept. 27	13.2				1.16						13.2
Sept. 29	7.6					1.45	1.14				7.9
Sept. 30	4.8	1.10	1.15	1.22	1.35	1.55	1.28	1.08	.95	.80	5.4
Averages		.83	.98	1.09	1.18	1.39	1.13	.97	.86	.78	

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	Friday Harbor	Ithaca	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.*
Sept. 3	201	355	405	333	209	606	398	220	473	414	358	460	499	270	500	292	714
Sept. 10	432	392	554	464	382	568	543	211	454	559	354	364	465	501	283	350	550
Sept. 17	426	346	502	373	376	530	499	125	400	370	358	368	407	452	306	306	719
Sept. 24	454	339	423	324	300	454	385	109	431	316	310	428	398	392	404	250	570
	Departures from weekly normals																
Sept. 3	−169	−20	−54	−1	−95	+39		+12	+5		−72	+23	+6				
Sept. 10	+48	+51	+124	+170	+70	+30		+26	+3		−73	+36	−1				
Sept. 17	+45	+4	+84	+53	+71	+41		−26	+9		−82	−21	−25				
Sept. 24	+76	+41	−55	+60	+21	−9		−12	+3		−112	+71	−16				
	Accumulated departures on Sept. 30																
	−3,836	−8,162	+6,783	+2,226	+6,258	+5,551		+1,467	+4,768		−5,719	+1,071	−6,328				

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

AMERICAN UNIVERSITY, WASHINGTON, D. C.

Date and hour angle, 1935	Solar altitude	Air mass	I_m	I_y	I_r	βI_{m-r}	βI_{y-r}	β_{mean}	$\frac{I_{w=o}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w=o}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
Sept. 1	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
3:07 a. m.	35 42	1.71	1.097	0.836	0.658	0.100	0.042	0.071	72.6	15.4	8.4	N_{PC}
3:02 a. m.	36 35	1.67	1.124	.838	.658	.036	.042	.069	73.8	15.4	8.6	
0:55 a. m.	53 50	1.24	1.272	.894	.710	.072	.044	.056	80.0	14.0	11.5	
0:51 a. m.	53 55	1.24	1.270	.904	.710	.072	.044	.056	80.0	13.9	11.5	
Sept. 13												
0:29 a. m.	54 26	1.23	1.124	.864	.696	.170	.091	.130	70.8	12.5	11.2	N_P
0:22 a. m.	54 48	1.22	1.140	.864	.698	.160	.094	.127	71.4	12.2	11.3	
Sept. 23												
4:10 a. m.	21 09	2.76	1.112	.855	.683	.044	.023	.034	70.7	13.0	5.0	N_{PC}
4:06 a. m.	21 53	2.66	1.139	.855	.683	.035	.025	.030	71.2	12.1	5.2	
Sept. 25												
3:51 a. m.	24 05	2.44	1.083	.799	.651	.054	.051	.054	68.6	12.4	5.7	N_{PC}
3:48 a. m.	25 09	2.34	1.089	.800	.651	.056	.054	.055	68.0	11.5	5.9	
2:25 a. m.	38 29	1.60	1.203	.883	.697	.074	.038	.061	74.8	12.4	8.7	T_M aloft.
2:22 a. m.	39 02	1.59	1.197	.885	.697	.076	.038	.062	74.6	12.5	8.7	

Atmospheric conditions during turbidity measurements

Sept. 11. Temperature, 16° C.; wind, S. 7; polarization, 54 percent; visibility, 30 miles.
Sept. 13. Temperature, 15° C.; wind, W. 7; polarization, 54 percent; visibility, 30 miles.
Sept. 23. Temperature, 14° C.; wind, N.E. 9; polarization, 60 percent; visibility, 50 miles.
Sept. 25. Temperature, 15° C.; wind, S. 8; polarization 61 percent; visibility, 50 miles.

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle, 1935	Solar altitude	Air mass	I_m	I_y	I_r	βI_{m-r}	βI_{y-r}	β_{mean}	$\frac{I_{w=o}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w=o}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
Sept. 1												
2:40 a. m.	41 12	1.52	1.232	0.854	0.676	0.055	0.024	0.040	79.5	14.9	6.5	P_c
1:15 p. m.	52 05	1.27	1.242	.854	.681	.074	.100	.087	72.5	7.2	6.4	
Sept. 6												
5:25 p. m.	10 22	5.40	.895	.679	.516	----------	----------	----------	----------	----------	----------	N_{pc}
Sept. 7												
4:26 a. m.	25 31	2.32	1.180	.815	.670	.033	.081	.057	69.6	7.8	5.2	N_{pc}
1:20 a. m.	49 55	1.30	1.385	.930	.745	.032	.082	.057	78.9	6.4	5.6	
4:32 p. m.	20 25	2.85	.916	.662	.561	.076	.106	.091	57.0	9.1	5.4	
Sept. 10												
0:46 a. m.	51 31	1.29	1.350	.900	.730	.047	.112	.080	76.9	6.3	5.5	N_{pc}
1:46 p. m.	45 20	1.40	1.360	.930	.735	.027	.050	.038	82.2	11.1	9.0	
2:24 p. m.	29 35	2.02	1.335	.900	.735	.012	.067	.040	76.1	6.7	4.8	
Sept 11												
4:16 a. m.	32 41	1.85	1.200	.825	.680	.051	.117	.084	69.0	6.3	4.7	N_{pc}
1:55 a. m.	50 34	1.29	1.375	.925	.745	.029	.070	.050	82.3	10.3	10.3	
1:12 p. m.	52 26	1.26	1.400	.948	.770	.038	.096	.067	79.2	6.1	5.5	
2:20 p. m.	40 20	1.54	1.280	.852	.710	.049	.146	.098	71.3	4.7	7.9	
4:56 p. m.	15 10	3.77	.925	.701	.580	.049	.062	.056	59.0	9.7	5.0	
Sept. 12												
4:43 a. m.	17 24	3.31	.725	.565	.472	.108	.088	.098	52.5	14.7	7.8	N_p
3:23 a. m.	31 26	1.92	1.025	.750	.610	.104	.117	.110	64.0	10.5	7.7	
1:12 p. m.	49 10	1.32	1.070	.740	.605	.124	.181	.152	66.9	10.7	9.4	
3:04 p. m.	29 33	2.02	1.000	.705	.580	.091	.146	.118	61.6	9.4	6.7	
Sept. 13												
3:16 a. m.	32 50	1.84	.970	.685	.560	.116	.164	.140	61.6	10.0	7.5	P_c, N_p aloft.
Sept. 14												
1:56 a. m.	43 34	1.45	1.350	.888	.710	.015	.075	.045	80.4	10.0	8.4	N_{pc}, N_p aloft.
0:20 p. m.	51 08	1.28	1.360	.905	.722	.030	.083	.056	80.8	9.9	8.8	
Sept. 15												
2:19 p. m.	39 34	1.57	1.215	.875	.680	.035	.042	.038	80.4	14.5	11.7	P_c, T_m aloft.
Sept. 16												
1:58 a. m.	42 36	1.48	1.392	.915	.735	.028	.077	.052	78.6	6.1	5.8	P_c
0:34 a. m.	49 52	1.30	1.430	.950	.780	.028	----------	.028	84.8	10.3	9.1	
1:26 p. m.	46 10	1.39	1.420	.950	.750	.018	.048	.033	83.8	9.8	8.4	
3:28 p. m.	29 15	2.05	1.280	.890	.715	.027	.065	.046	74.4	7.7	5.4	
4:37 p. m.	12 09	3.37	1.050	.750	.610	.031	.069	.050	63.0	7.8	4.3	
Sept. 17												
3:19 a. m.	30 25	1.97	1.365	.920	.740	.004	.049	.026	78.0	7.0	5.0	N_{pc}
0:45 a. m.	48 58	1.32	1.440	.962	.765	.018	.038	.028	84.7	9.7	8.5	
2:23 p. m.	38 20	1.61	1.360	.920	.740	.023	.075	.049	78.2	7.4	5.9	
4:05 p.m.	22 37	2.59	1.055	.758	.620	.050	.076	.063	66.6	11.1	7.0	
Sept. 20												
2:47 a. m.	34 24	1.77	1.050	.705	.580	.084	.131	.108	66.1	12.0	7.1	N_p;
2:27 p. m.	37 27	1.64	1.120	.760	.605	.068	.095	.082	72.9	15.2	12.0	
4:16 p. m.	19 54	2.92	.910	.670	.548	.074	.086	.080	59.4	12.4	7.3	

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

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY—Continued

Date and hour angle, 1935	Solar altitude	Air mass mmm	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	$\beta_m$mm	$\frac{I_{w=o}}{1.94}$ (Percentage of solar constant)	$\frac{I_{w=o}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
Sept. 22												
4:31 a. m.	16 38	3.47	1.040	0.718	0.600	0022	0.078	0.050	63.2	9.6	5.2	N_{pe}
2:23 a. m.	37 30	1.64	1.310	.860	.690	.021	.082	.052	76.9	9.4	7.4	
1:17 p. m.	44 50	1.42	1.340	.882	.701	.025	.082	.054	79.3	10.2	8.6	
2:25 p. m.	37 06	1.65	1.185	.795	.646	.057	.125	.091	71.8	10.7	8.4	
4:18 p. m.	19 05	3.03	.885	.657	.530	.061	.076	.068	59.0	13.4	7.8	
Sept. 23												
4:04 a. m.	21 48	2.68	1.285	.885	.720	.005	.049	.027	80.8	14.6	5.6	P_e
1:43 a. m.	41 58	1.49	1.455	.925	.785	.008	----------	.008	87.1	12.1	10.0	
0:23 p. m.	47 38	1.35	1.465	.970	.780	.012	.067	.040	81.7	6.2	5.2	
2:41 p. m.	34 13	1.78	1.372	.930	.725	.001	.026	.014	81.4	10.5	8.0	
3:53 p. m.	23 01	2.55	1.220	.846	.692	.020	.097	.058	67.0	4.1	2.6	
Sept. 24												
2:45 p. m.	33 35	1.80	1.195	.830	.665	.029	.065	.047	76.6	15.0	11.5	N_{pe}, N_{tm} aloft.
Sept. 25												
2:13 a. m.	32 42	1.85	1.030	.722	.575	.084	.109	.096	67.0	13.9	10.3	N_{pe}, N_{tm} aloft.
1:19 p. m.	43 34	1.45	.972	.685	.550	.150	.189	.170	62.6	12.5	10.6	
4:28 p. m.	16 21	3.53	.615	.465	.380	.103	.127	.115	39.5	7.8	4.2	
Sept. 27												
3:18 a. m.	28 20	2.10	1.150	.765	.600	.025	.065	.045	74.2	14.8	10.3	N_{ce}
Sept. 29												
0:08 p. m.	45 31	1.39	1.428	.935	.730	----------	.038	.038	79.3	5.7	4.3	P_e
Sept. 30												
4:09 a. m.	18 18	3.16	1.200	.813	.675	.005	.057	.051	70.1	8.2	4.7	P_e
2:46 a. m.	31 34	1.90	1.354	.895	.704	----------	.035	.035	80.1	10.3	7.6	
0:19 a. m.	44 49	1.42	1.438	.942	.734	----------	.028	.028	79.5	5.4	4.6	
3:47 p. m.	22 02	2.65	1.126	.776	.622	.025	.057	.041	70.5	5.6	3.5	

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)	Skyblueness	Cloudiness and remarks
September 1935	° C.				
6; 5:57 p. m.	14.4	N 4	7	5	7 Cist, few Acu, dense haze.
7; 4:09 a. m.	15.0	NNW 3	8	8	3 Ci, light haze.
7; 4:34 p. m.	20.6	WSW 4	9	6	5 Cist, few Cu.
16; 5:05 p. m.	15.0	NW 4	10	8	3 Cu.
17; 2:53 a. m.	12.2	WNW 2	9	10	4 Ci, Ci moved near sun during observation.
17; 2:55 p. m.	17.8	WNW 3	9	8	2 Ci, few Acu, few Cu.
17; 4:09 p. m.	18.8	SSW 1	9	10	Few Ci, few Acu, few Cu.
20; 2:41 p. m.	21.7	W 3	8	7	7 Acu, few Ci.
20; 4:42 p. m.	21.1	NNW 5	9	6	2 Acu, few Ci, test interrupted because of Cu near sun.
22; 2:25 a. m.	16.7	SW 1	9	5	1 Ci, 1 Cu,
22; 1:47 a. m.	19.1	SW 1	9	5	1 Ci, 1 Cu,
22; 1:39 p. m.	20.7	WNW 5	9	5	Few Ci; 1 Cu; gusty wind.
22; 4:58 p. m.	20.3	WSW 3	9	6	1 Cu,
23; 1:49 a. m.	9.9	NW 5	10	10	Few Cu.
23; 10:51 p. m.	13.3	WNW 5	10	10	1 Ci.
23; 4:20 p. m.	14.8	NW 5	10	10	Few Cu.
24; 2:42 p. m.	16.4	W 1	9	5	5 Acu, few Ci.
25; 2:17 a. m.	17.2	SSW 3	7	8	1 Ci, few Acu, mod. haze.
25; 1:06 p. m.	22.6	SW 5	7	7	Zero clouds; mod. haze.
29; 1:09 p. m.	15.6	SW 2	9	6	2 Cu.
30; 2:45 a. m.	7.7	WNW 5	9	7	Few Acu.
30; 4:28 p. m.	13.9	SW 3	9	7	1 Cu.

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 measured 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: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1935	*h. m.*							
Sept. 1	12 15	−59.0	123.3	+28.0	13	--------	--------	Mount Wilson.
		−36.0	146.3	+21.0	293	--------	--------	
		+19.0	201.3	+31.0	74	--------	380	
Sept. 2	12 20	−45.0	124.1	+28.0	8	--------	--------	Do.
		−22.0	147.1	+21.0	321	--------	--------	
		+32.0	201.1	+31.0	59	--------	--------	
		+46.0	215.1	−22.0	--------	10	398	
Sept. 3	12 20	−32.0	123.9	+27.5	11	--------	--------	Do.
		−8.0	147.9	+21.5	303	--------	--------	
		+29.0	184.9	−39.0	--------	7	--------	
		+44.0	199.9	+32.0	56	--------	--------	
		+59.0	214.9	−22.0	--------	7	384	
Sept. 4	12 25	−18.0	124.5	+27.0	5	--------	--------	Do.
		+4.0	146.5	+21.0	282	--------	--------	
		+25.0	167.5	+23.0	--------	16	--------	
		+41.0	183.5	−39.0	3	--------	--------	
		+58.0	200.5	+31.0	72	--------	378	