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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING DECEMBER 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 slightly below normal at Washington for December, and above normal at both Madison and Lincoln.

Table 2 shows an excess in the amount of total solar and sky radiation at New York, Fresno, Fairbanks, Twin Falls, and Miami. All other stations were below normal for the month.

Table 3 shows relatively low water-vapor content for the 2 days on which turbidity measurements were obtained.

Polarization measurements obtained on 3 days at Washington give a mean of 57 percent, with a maximum of 63 percent on the 4th. Both of these values are close to the December normals. At Madison, only one polarization was obtained owing to snow and ice cover after the 4th. This gave a value of 61 percent, which is lower than either the maximum or mean normals for the month.

For the year, Washington, Madison, and Riverside received less radiation from the sun and sky on a horizontal surface than normal; New Orleans was normal, while all the other stations received more radiation than their yearly normals.

TABLE 1.—*Solar radiation intensities during December 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
1935	*mm*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Dec. 4	1.96	0.92	1.22	1.31	1.43	------	------	1.27	1.10	1.00	1.24
Dec. 5	2.06	------	------	------	1.33	------	1.20	.97	.86	.70	2.49
Dec. 6	2.87	------	------	------	------	------	1.22	1.10	.93	.70	2.74
Dec. 9	8.48	------	.87	1.03	1.33	------	------	------	------	------	6.27
Dec. 21	.96	.57	.73	.97	1.24	------	------	------	------	------	1.02
Dec. 26	.81	------	------	.53	.95	------	1.27	1.12	------	------	1.19
Dec. 31	2.06	.46	.53	.74	.84	------	------	------	------	------	2.16
Means	------	65	.84	.92	1.19	------	1.23	1.06	(.90)	(.76)	------
Departures	------	−.14	−.07	−.13	−.04	------	+.06	+.02	−.01	−.03	------

MADISON, WIS.

Dec. 2	1.52	------	------	------	------	------	------	1.20	------	------	1.88
Dec. 4	1.52	1.02	1.13	1.28	------	------	------	------	------	------	2.06
Dec. 20	.21	------	------	------	------	------	------	1.36	------	------	.79
Dec. 26	.56	------	------	------	------	------	------	1.30	------	------	.48
Means	------	(1.02)	(1.13)	(1.28)	------	------	------	1.29	------	------	------
Departures	------	+.06	+.03	+.06	------	------	------	+.05	------	------	------

* Extrapolated.

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

LINCOLN, NEBR.

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
1935	*mm*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Dec. 1	3.00	1.21	1.30	1.43				1.39	1.25	1.15	1.68
Dec. 2	2.26	1.02	1.12	1.30				1.29	1.09	1.02	3.30
Dec. 7	5.79			1.12				1.08	.90	.77	5.36
Dec. 8	3.99							1.22	1.05	.93	4.75
Dec. 10	2.06							1.22	1.12	1.00	1.96
Dec. 11	3.81							.94	.85	.71	4.37
Dec. 16	2.87			1.25				1.30	1.17	1.11	3.45
Dec. 17	2.36	1.01	1.12	1.26				1.28	1.14	1.01	3.05
Dec. 18	3.15	.79	.97	1.17							3.45
Dec. 19	2.06							1.36	1.25	1.13	1.37
Dec. 26	.96	1.10	1.25	1.38				1.30	1.20	1.08	.86
Dec. 30	3.00							1.20	1.08	1.01	2.62
Means		1.03	1.15	1.27				1.23	1.00	.99	
Departures		+.09	+.08	+.04				+.03	+.03	+.03	

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

BLUE HILL, MASS.

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
1935	*mm*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Dec. 3	2.5	0.37	0.90	1.14	1.31		1.27	1.15	0.95	0.78	2.4
Dec. 4	3.2						1.40	1.16	1.05	.81	2.5
Dec. 5	1.7			.72							1.5
Dec. 6	1.1	60	83	1.12	1.50		1.50	1.24	1.09	1.01	1.3
Dec. 12	4.2	.83									3.6
Dec. 17	2.9								1.02		2.5
Dec. 18	2.0	.87	.96	1.09	1.25		1.25	1.06	1.00		2.1
Dec. 21	1.7	.88	.98	1.14	1.32		1.32	1.15			1.7
Dec. 22	1.1	1.07	1.20	1.33	1.43		1.43	1.22	1.09	.75	1.3
Dec. 23	1.3		.97	1.12	1.25						1.5
Dec. 24	1.5						1.32	1.19			1.8
Dec. 25	1.4	1.06	1.15	1.28	1.44		1.44	1.25	1.10	1.03	1.7
Dec. 27	1.4						1.42	1.25	1.11	.99	1.5
Dec. 28	1.3	1.06	1.13	1.21	1.44		1.44	1.27	1.16	1.06	1.4
Dec. 31	1.5	1.24	1.34	1.39	1.42		1.42	1.25	1.20	1.16	1.5
Means		.89	1.05	1.15	1.38		1.38	1.20	1.08	.95	

*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	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.*
Dec. 3	171	82	101	70	131	177	101	9	131	209	286	182	211	152	77	106	474
Dec. 10	81	80	125	56	60	227	70	5	143	292	310	178	245	64	55	60	517
Dec. 17	126	101	152	60	115	244	122	6	194	250	328	284	231	172	97	102	503
Dec. 24 [1]	168	116	115	105	156	165	116	5	140	213	299	163	193	188	80	113	436
	Departures from weekly normals																
Dec. 3	+10	−35	−73	+1	+30	−12		+2	+21		−19	+14	−2	+18			
Dec. 10	−57	−32	−39	−20	−31	+39		−1	+26		−2	+12	+32	−68			
Dec. 17	−18	−18	−28	−26	+21	+85		0	+78		+51	−69	+3	+28			
Dec. 24	+19	−6	−63	+19	+42	+25		+1	+4		+14	−20	−29	+33			
	Accumulated departures on Dec. 31																
	−5,840	−9,561	+2,261	+2,441	+7,273	+5,925		+1,562	+5,379		+791	−8	−6,614				
	Percentage departure for year																
	−4.7	−8.1	+1.6	+2.6	+7.0	+3.6		+2.0	+3.7		+0.5	0	−4.2				

[1] 8-day period.

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during December 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,	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	β_{mean}	$\frac{I_{w=o}}{1.94}$	$\frac{I_{w=o}-I_m}{1.94}$	w	Air-mass type
									Percentage of solar constant			
1935												
Dec. 21:	° ′		*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*					*mm*	
2:32 a. m.	18 12		3.18	1.080	0.823	0.713	0.040	0.104	0.072	59.2	5.4	1.4	P_c
2:24 a. m.	19 07		3.03	1.089	.827	.715	.038	.106	.072	60.0	5.7	1.5	
Dec. 26:												
1:52 p. m.	22 25		2.61	1.176	.933	.768	.030	.068	.049	68.9	10.3	6.2	P_c
2:00 p. m.	21 40		2.69	1.172	.930	.765	.025	.062	.044	68.7	10.3	5.9	

Atmospheric conditions during turbidity measurements

Dec. 21, temperature, −10° C.; wind, NW. 20; visibility, 30 miles.
Dec. 26, temperature, −14° C.; wind, NW. 18; visibility, 20 miles,

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during December 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

Date and hour angle, 1935	Solar altitude	Air mass	I_m	I_y	I_r	$\beta_{I_{m-r}}$	$\beta_{I_{y-r}}$	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
1935	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
Dec. 3:												
0:05 p. m.	25 44	2.30	1.235	0.867	0.712	0.062	0.056	0.059	70.2	8.3	5.4	P_c
2:19 p. m.	18 20	3.16	1.139	.837	.696	.050	.054	.052	63.1	6.0	3.3	
Dec. 4:												
1:36 p. m.	23 22	2.51	1.292	.937	.776	.050	.054	.052	68.7	4.0	2.4	P_c
2:45 p. m.	15 11	3.77	1.152	.839	.712	.039	.056	.048	61.2	3.6	2.8	
Dec. 5: 2:06 a. m.	19 12	2.99	.700	.550	.468	.163	.154	.158	45.0	9.9	5.5	P_c
Dec. 6:												
0:25 a. m.	24 57	2.36	1.351	.961	.792	.061	.046	.054	70.1	2.5	1.3	P_c
2:50 p. m.	14 35	3.84	1.109	.822	.693	.043	.052	.048	60.6	5.1	2.5	
Dec. 12: 3:12 a. m.	11 03	5.12	.818	.646	.561							P_c
Dec. 17: 2:42 p. m.	14 33	3.94	1.046	.774	.660	.048	.067	.058	57.5	5.3	3.0	P_A
Dec. 18:												
2:28 a. m.	16 21	3.53	1.002	.755	.648	.075	.087	.081	54.3	4.3	2.2	
0:03 p. m.	24 26	2.41	1.184	.848	.711	.070	.074	.072	65.6	6.5	4.0	P_F
2:36 p. m.	15 12	3.77	1.021	.762	.650	.060	.074	.067	56.5	5.6	2.8	
Dec. 21:												
2:35 a. m.	15 32	3.72	1.013	.766	.646	.062	.064	.063	57.1	6.5	3.2	P_c
0:34 p. m.	24 19	2.42	1.248	.874	.749	.060	.083	.072	65.4	3.1	2.0	
1:35 p. m.	21 04	2.76	1.179	.826	.701	.051	.095	.073	62.4	3.6	2.0	
Dec. 22:												
0:20 a. m.	24 17	2.42	1.385	.974	.799	.027	.025	.026	77.0	7.9	4.9	P_c
2:36 p. m.	15 24	3.51	1.135	.853	.712	.051	.047	.049	62.3	5.7	2.9	
Dec. 23:												
2:24 a. m.	16 33	3.49	1.067	.775	.651	.047	.049	.048	62.4	9.1	4.8	P_F above N_{Pc}
0:26 a. m.	24 04	2.44	1.191	.848	.719	.070	.102	.086	68.8	9.4	5.8	
Dec. 24:												
0:20 p. m.	24 11	2.43	1.264	.923	.744	.048	.034	.041	72.8	9.8	7.2	P_c
2:00 p. m.	18 48	3.08	1.186	.875	.729	.049	.045	.047	65.9	6.8	3.7	
Dec. 25:												
2:25 a. m.	16 27	3.51	1.208	.884	.743	.035	.047	.041	64.8	4.6	2.3	P_c
0:40 a. m.	23 23	2.51	1.361	.965	.794	.033	.041	.037	72.5	4.7	2.8	
2:48 p. m.	13 46	4.13	1.188	.866	.720	.020	.031	.026	66.7	7.5	3.5	P_c
Dec. 27:												
0:44 a. m.	24 00	2.45	1.322	.922	.768	.037	.064	.050	70.0	4.1	2.5	P_c
0:08 p. m.	24 46	2.37	1.319	.905	.770	.059	.044	.052	70.2	4.5	2.8	
1:55 p. m.	23 12	2.53	1.193	.850	.721	.045	.056	.050	70.1	8.3	5.1	
Dec. 28:												
2:35 a. m.	20 29	2.84	1.227	.895	.757	.055	.074	.064	63.9	2.7	1.4	P_c
0:51 a. m.	23 24	2.51	1.383	.973	.805	.028	.028	.028	75.3	6.4	3.9	
0:38 p. m.	23 53	2.46	1.378	.956	.805	.032	.032	.032	74.4	5.7	3.5	
2:08 p. m.	18 06	3.16	1.252	.915	.739	.026	.026	.026	70.8	8.4	4.6	
Dec. 31:												
3:05 a. m.	11 59	5.12	1.242	.880	.744							P_c
1:47 a. m.	20 20	2.86	1.358	.966	.802	.023	.040	.032	71.7	4.0	2.2	
0:49 p. m.	23 30	2.50	1.398	1.000	.840	.039	.056	.048	71.6	1.7	0.9	
3:20 p. m.			1.021	.785	.684							

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

Date and time from apparent noon	Air temperature	Wind Beaufort	Visibility (0–10)	Sky blue	Cloudiness and remarks
December 1935	°*C.*				
3; 2:32 a. m.	−4.4	NW 4	8	7	Few Ci., few Acu.
4; 1:52 p. m.	−9.5	NW x W 7	9	8	1 Acu.
6; 1:59 a. m.	−12.3	NW 6	9	8	Few Cu. Moderate haze to north.
6; 0:12 a. m.	−9.9	NW 5	10	8	Few Cu. Light haze to north and northeast.
12; 2:54 a. m.	+1.1	NNW 3	7	7	1 Cu. Moderate haze.
17; 4:06 p. m.	−1.7	W x N 5	9	8	3 Ci., 1 Cu.
18; 2:51 a. m.	−6.7	W 5	8	8	Few Ci., few Acu., few Cu. Moderate haze to north and east.
21; 3:02 a. m.	−9.6	NW 5	8	7	3 Ci. Light haze.
21; 0:18 a. m.	−7.2	NW 5	8	7	3 Ci. Light haze.
22; 2:56 a. m.	−13.3	NW 4	9	7	Few Cu. Moderate haze to northeast.
22; 0:16 a. m.	−8.6	NW 5	9	6	No clouds. Light haze to north and east.
23; 1:40 a. m.	−7.8	N 4	7	7	1 Ci. Moderate to dense haze.
25; 0:35 a. m.	−6.7	WNW 4	9	8	Few Cu. Light water haze to south.
27; 0:23 a. m.	−9.0	WNW 5	9	6	No clouds. Light haze.
28; 0:17 p. m.	−8.2	NNW 5	9	8	Few Ci., few Frcu. Light haze.
31; 0:21 p. m.	−3.9	NW 3	9	9	No clouds. Moderate haze.

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*	°	°	°				
Nov. 1	11 25	−37.0	60.7	−24.0		25		Mt. Wilson.
		+79.0	176.7	+18.0	130		155	
Nov. 2	12 4	−23.0	61.3	−25.5		185	185	U. S. Naval.
Nov. 3	19 25	−68.0	359.0	−27.0		1,215		Mt. Wilson.
		−8.0	59.0	+13.0		27		
		−3.0	64.0	−22.0		247	1,489	
Nov. 4	13 40	−60.0	357.0	−28.0		962		Do.
		+3.0	60.0	+14.0		66		
		+8.0	65.0	−24.0		222	1,250	
Nov. 5	11 3	−53.5	351.8	−29.5		926		U. S. Naval.
		+12.0	57.3	−27.0		62		
		+15.0	60.3	+14.5		123		
		+20.5	65.8	−24.5	154		1,265	
Nov. 6	11 33	−40.0	351.8	−29.5		741		Do.
		+28.5	60.3	+14.5		154		
		+34.0	65.8	−25.0	154		1,049	