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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING FEBRUARY 1934

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 1932 REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged considerably above normal for February at Washington and slightly below normal at Madison and Lincoln. The reading of 1.59 gram calories per minute per square centimeter of normal surface made on the 9th at Washington, on which date the lowest temperature (−6.5° F.) since January 1912, was also recorded, is the highest normal incidence measurement ever obtained by this Bureau in that city, either directly or corrected for mean solar distance; the latter value in this case being 1.56 gram calories. Narrow band spectral measurements obtained on that day also show an exceedingly small water and dust content of the atmosphere.

Through the kind cooperation of Dr. H. H. Kimball, of Harvard University, who read the Marvin pyrheliometer, and Dr. L. B. Aldrich, of the Smithsonian Astrophysical Observatory, who read alternately Smithsonian silver-disk pyrheliometers no. 1 and no. 5, both our substandard pyrheliometers were checked during February and showed no change in their constants. The two recording microammeters in use at Washington were also carefully checked at several points on their scales against a standard microammeter. We therefore are confident that all pyrheliometric apparatus in use at that station is in good condition.

Table 2 shows a deficiency in the total solar and sky radiation received on a horizontal surface at Fresno, Pittsburgh, Twin Falls, La Jolla, and Miami, and an excess at all other stations for which normals have been computed.

Turbidity measurements obtained on the 6th show a decreasing amount of dry dust and water vapor and other measurements on the 9th, 14th, 17th, and 20th show remarkably low dust and water content of the atmosphere.

No polarization measurements were obtained at either Washington or Madison, owing to partially or completely snow-covered ground.

TABLE 1.—*Solar radiation intensities during February 1934*

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*
Feb. 3	1.24		0.60	0.81	1.44						0.96
Feb. 6	1.60				1.22		1.37	1.13	1.04	0.89	1.45
Feb. 9	0.38			1.34	1.54		1.59	1.37	1.18	1.02	.51
Feb. 10	.66			1.32	1.48						.81
Feb. 14	.91	0.80	.93	1.12	1.31	1.63					1.24
Feb. 17	1.37			1.10	1.30	1.63					1.19
Feb. 20	.86		1.03	1.16	1.32	1.71	1.28	1.09	.92		.79
Feb. 21	1.60		.93	1.04							1.52
Feb. 24	.79			1.22	1.39	1.66					.81
Feb. 27	.81		.70	.86	1.27	1.39	1.05				.86
Means		(.80)	.84	1.11	1.36	1.60	1.32	1.20	1.05	(.96)	
Departures		+.07	+.01	+.11	+.16		+.12	+.21	+.19	+.19	

MADISON, WIS.

Feb. 1	1.68	1.04	1.10	1.28	1.45						1.37
Feb. 12	3.81						1.40				3.15
Feb. 19	.86	1.05	1.16	1.31	1.43	1.58	1.40				1.12
Feb. 23	.96		1.05	1.23	1.48						.64
Feb. 26	.74		1.10	1.24	1.28						.74
Feb. 27	.81	.93	1.01	1.15	1.39	1.57	1.36				.86
Feb. 28	1.37	.59	.76	.72	1.10	1.41	1.05				2.06
Means		.90	1.03	1.16	1.36	1.52	1.30				
Departures		−.03	−.04	−.03	±.00		−.06				

TABLE 1.—*Solar radiation intensities during February 1934*—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
Feb. 2	3.86				1.38		1.36	1.17	1.04	0.92	3.99
Feb. 3	3.63	.81	.97	1.14	1.35	1.48					4.37
Feb. 5	2.87	.98	1.10	1.22	1.41	1.49	1.41				3.15
Feb. 6	2.62						1.24	1.00	.85	.70	3.00
Feb. 7	2.87	.88	1.01	1.13	1.26		1.12	.86	.72	.57	3.45
Feb. 12	3.99								1.06	.94	3.81
Feb. 13	2.62	.84	.98	1.12	1.32	1.46	1.34	1.23	1.10	.98	4.57
Feb. 14	3.00	.72	.93	1.16	1.33	1.45	1.32	1.16			4.17
Feb. 15	2.74	1.04	1.14	1.25	1.44	1.56	1.36	1.20	1.06	.88	3.81
Feb. 16	3.15		1.16	1.26	1.43	1.51	1.37	1.18	1.02	.90	3.81
Feb. 20	1.78		.73	.92	1.19	1.46					2.74
Means		.88	1.00	1.15	1.35	1.49	1.32	1.11	.98	.84	
Departures		−.05	−.01	−.03	−.02		−.03	−.05	−.04	−.07	

BLUE HILL, MASS.

Feb. 2	2.8			0.03	1.27			1.26			1.5
Feb. 3	0.6						1.19	1.18			0.7
Feb. 5	1.1						1.39	1.16			.9
Feb. 9	.3				1.31		1.30	1.09	0.93		.4
Feb. 10	.5				1.44		1.43	1.19			.7
Feb. 12	2.4				1.17		1.13				2.7
Feb. 14	.4				1.44		1.33	1.24			.4
Feb. 15	3.6						1.15				3.6
Feb. 17	1.4						1.32	1.14			1.0
Feb. 18	.9						1.20	1.06			1.0
Feb. 21	1.9				1.38		1.32	1.00	.80		1.0
Feb. 24	.5				1.40						.6
Feb. 27	.7				1.30		1.33				1.0
Feb. 28	.7				1.42		1.34	1.13	.90		.6
Means				(.93)	1.35		1.29	1.15	.88		

*Extrapolated.

TABLE 2.—*Total, I_m and screened, I_y, I_r, solar radiation intensity measurements, obtained during February 1934, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in centimeters, 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}	$\frac{I_{w=o}}{1.94}$	$\frac{I_{w=o}-I_m{}^1}{1.94}$	W
									Percentage of solar constant		
Feb. 6	° ′	m	gr. cal.	gr. cal.	gr. cal.						cm
1:04 a	33 26	1.81	1.254	0.903	0.747	0.073	0.087	0.080	69.9	6.9	0.26
0:54 a	34 00	1.79	1.225	.924	.739	.089	.055	.072	71.6	10.0	.57
0:49 a	34 14	1.78	1.307	.930	.744	.056	.048	.052	75.2	9.4	.40
2:51 p	22 22	2.61	1.233	.876	.700	.023	.036	.030	73.6	11.5	1.30
2:58 p	21 28	2.72	1.182	.882	.707	.041	.035	.038	71.0	11.6	1.15
3:17 p	18 55	3.06	1.129	.803	.648	.025	.045	.035	71.0	14.3	2.90
3:21 p	18 02	3.20	1.098	.809	.652	.035	.040	.038	69.0	13.7	2.10
3:44 p	14 26	3.97	1.053	.785	.639	.026	.035	.030	65.5	10.0	1.00
3:48 p	13 48	4.13	1.023	.789	.644	.038	.032	.035	63.5	12.1	.90
Feb. 9											
0:56 a	34 46	1.75	1.582	1.136	.923	.022	.019	.0205	82.6	3.1	.1
0:52 a	35 00	1.75	1.584	1.136	.923	.022	.019	.0205	82.6	3.0	.1
Feb. 14											
0:37 a	37 18	1.65	1.402	1.000	.810	.050	.056	.053	76.4	6.0	.2
0:34 a	37 26	1.64	1.397	1.000	.811	.053	.057	.055	76.0	5.8	.2
Feb. 17											
0:44 a	38 02	1.62	1.400	1.015	.814	.054	.038	.046	78.5	8.2	.4
0:40 a	38 12	1.61	1.421	1.016	.814	.042	.038	.040	79.5	8.2	.4
Feb. 20											
0:45 a	39 02	1.58	1.482	1.071	.860	.040	.027	.034	81.5	6.9	.3
0:41 a	39 12	1.58	1.485	1.070	.855	.041	.023	.033	81.8	7.1	.3

Sky conditions at time radiation measurements were made. International meteorological symbols have been employed to designate clouds, wind, and optical phenomena; hz for haze, v for visibility, ⦶ for solar constant. 6. St. a.m.; clearing at 10 a. Few FrCu noon.

Feb. 9. Highest readings ever obtained by Weather Bureau in Washington. Also coldest day in 22 years.

Feb. 14. Local smoke.

Feb. 17. Local smoke.

Feb. 20. Snow blowing across face of pyrheliometer at times.

TABLE 2.—*Total, I_m and screened, I_y, I_r, solar radiation intensity measurements, obtained during February 1934, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in centimeters, if precipitated*—Continued

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

[Data furnished through the courtesy of Dr. Herbert H. Kimball]

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	β^1_{m-r}	β^1_{y-r}	β_{mean}	$\frac{I_{w=o}}{1.94}$	$\frac{I_{w=o}-I_m{}^1}{1.94}$	W
									Percentage of solar constant		
Feb. 2	° ′	m	gr. cal.	gr. cal.	gr. cal.						cm
1:54 a	25 20	2.33	1.156	0.848	0.690	0.065	0.071	0.068	67.3	9.4	5.0
Feb. 3											
0:34 p	30 36	1.96	1.196	.887	.740	.094	.112	.103	64.6	4.7	1.4
Feb. 5											
1.37 p	27 38	2.15	1.331	.967	.794	.048	.060	.054	71.6	4.9	1.3
Feb. 10											
2:16 a	25 32	2.32	1.418	1.019	.826	.018	.032	.025	77.4	6.2	2.0
2:25 p	24 24	2.41	1.313	.964	.769	.031	.021	.026	75.8	9.9	6.5
Feb. 12											
1:59 a	32 34	1.85	1.133	.825	.687	.104	.112	.108	65.2	8.3	4.0
0:03 a	34 02	1.78	1.221	.870	.703	.074	.087	.080	71.0	9.7	7.5
Feb. 14											
1:36 p	30 27	1.97	1.334	.994	.814	.068	.059	.064	71.6	4.5	1.3
Feb. 15											
2:38 p	24 20	2.41	1.050	.797	.646	.088	.075	.082	63.6	10.8	10.0
Feb. 18											
0:06 p	36 04	1.70	1.316	.918	.750	.055	.091	.073	72.7	6.5	2.5
1:42 p	31 15	1.93	1.207	.845	.691	.063	.098	.080	69.8	9.0	4.9
3:08 p	21 00	2.77	1.083	.803	.652	.057	.062	.060	66.0	11.5	10.1
Feb. 21											
1:52 a	31 17	1.92	1.395	.976	.786	.026	.041	.034	78.4	8.1	3.7
0:50 a	35 49	1.71	1.442	.985	.790	.020	.042	.031	80.5	7.8	3.6
0:10 p	37 06	1.65	1.490	1.028	.823	.015	.033	.024	82.6	7.5	3.3
2:12 p	29 10	2.05	1.320	.933	.738	.028	.030	.029	78.2	11.7	16.0
4:04 p	13 09	4.34	.843	.657	.538	.055	.055	.055	55.0	12.5	9.5
Feb. 25											
1:16 a	35 50	1.71	1.480	1.030	.833	.026	.020	.023	82.2	7.4	3.2
Feb. 27											
2:24 a	29 46	2.01	1.322	.971	.784	.052	.042	.047	74.7	7.9	3.4
Feb. 28											
2:28 a	29 29	2.02	1.407	1.012	.817	.031	.032	.032	78.1	6.9	3.6
0:40 a	38 58	1.59	1.450	1.028	.824	.037	.035	.036	79.9	6.5	2.6
2:18 p	30 44	1.95	1.401	1.002	.810	.033	.039	.036	77.5	6.6	2.4

[1] Reduced to value at mean solar distance.

NOTE.—The decimal points in this column for January 1934 should be placed 2 positions to the right.

TABLE 3.—*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
	Gram calories per square centimeter														
1934	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 29	230	195	258	133	178	200	118	54	222	209	307	259	277	218	201
Feb. 5	261	209	282	155	271	290	146	49	261	378	365	173	318	294	286
Feb. 12	235	216	329	168	248	340	140	68	273	283	356	315	327	287	280
Feb. 19	363	289	240	184	233	239	144	106	197	230	399	252	236	306	254
	Departures from weekly normals														
Jan. 29	+21	+8	+33	+16	+35	−33	−3	+24	+23	−44	−40	+59	------	------	------
Feb. 5	+51	+1	+25	+20	+115	+20	−2	+4	+26	+113	+8	−40	------	------	------
Feb. 12	+8	−12	+52	+20	+75	+56	−30	−2	+8	+9	−12	+97	------	------	------
Feb. 19	+4	+34	−58	±0	+38	−59	−31	−6	−81	−84	+23	+23	------	------	------
	Accumulated departures on Feb. 25														
	+168	−686	−679	+707	+2,079	−555	−959	+84	−546	+1,701	−441	+1,351	------	------	------

ATMOSPHERIC CONDITIONS DURING SOLAR RADIATION MEASUREMENTS

Date and time from apparent noon	Air temperature	Wind	Visibility	Sky blueness	Clouds	Remarks
February 1934	°C					
2, 1:54 a	−4.4	NW 6	8	3	5 Ci, Cicu, Frcu	Lt. hz.
3, 0:34 p	−12.2	NNW 3	8	4	None	
5, 1:37 p	−8.9	NW 4	8	3	Few Ci	Lt. smk.
10, 2:16 a	−14.4	NW 4	8–9	4	Few Ci	
2:25 p	−7.5	W&NW 2	9	4	1 Ci	Lt. smk.
12, 1:59 a	−2.2	SW 1	6–7	3	None	Dns. hz. & smk.
0:03 a	+0.4	SSW 2	7–8	4	None	Dns. hz.
14, 1:36 p	−11.1	NW 4	9	4	None	Lt. smk.
15, 2:38 p	+4.4	WSW 3	7	3	None	Hz.
18, 0:06 p	−3.9	NNE 3	8	3	Few Ci over sun	Dns. hz.
1:42 p	−2.5	N 1	8	4	None	
3:08 p	−1.6	NE 1	8	4	Few Ci	Lt. hz.
21, 1:52 a	−8.9	WNW 4	9	4	None	Lt. smk.
0:50 a	−6.1	W 4	9	4	Few Cu	Lt. smk.
0:10 p	−4.4	WxS 3	9	3	Few Ci	
2:12 p	------	------	------	------	------	
4:04 p	−0.6	WxS 2	9	4	None	Lt. hz.
25, 1:16 a	−13.0	NW 1	8	3	Few Ci, Cicu, Ast.	
27, 2:24 a	−13.3	NW 4	9	4	Few Stcu	
28, 2:28 a	−13.3	NW 2	9	4	None	Hz. line.
0:40 a	−16.1	SWxW 1	9	4	None	Hz. disap'ng.
2:18 p	−4.5	SW 2	8–9	4	Few Ci	

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. Difference in longitude is measured from the central meridian, positive west. 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
1934	*h. m.*	°	°	°				
Feb. 1	10 45	−18.0	223.2	+31.0	------	81	81	Mount Wilson.
Feb. 2	12 30	−4.0	223.1	+31.0	16	------	16	Do.
Feb. 3	11 6	+9.0	223.7	+30.0	25	------	25	U.S. Naval.
Feb. 4	13 27	No spots	------	------	------	------	------	Do.
Feb. 5	11 5	−41.0	147.4	−23.0	------	12	12	Mount Wilson.
Feb. 6	11 8	−28.0	147.2	−22.5	------	31	------	U.S. Naval.
		+43.0	218.2	+28.5	9	------	40	Do.
Feb. 7	11 12	+59.0	221.0	+28.5	31	------	31	Do.
Feb. 8	12 45	+4.0	152.0	+1.0	1	------	------	Mount Wilson.
		+75.0	223.0	+28.0	------	49	50	Do.
Feb. 9	11 30	−76.0	59.5	+8.0	77	------	77	U.S. Naval.
Feb. 10	11 35	−63.0	59.3	+8.0	62	------	62	Do.
Feb. 11	13 15	−48.0	60.2	+7.0	151	------	151	Mount Wilson.
Feb. 12	12 55	−35.0	60.2	+7.0	124	------	124	Do.
Feb. 13	11 5	−22.0	61.0	+8.0	46	------	46	U.S. Naval.
Feb. 14	11 12	−9.0	60.8	+7.5	46	------	46	Do.
Feb. 16	13 10	+18.0	60.4	+7.0	------	89	89	Mount Wilson.
Feb. 17	11 39	+31.0	61.1	+7.5	------	31	31	U.S. Naval.
Feb. 18	12 6	+45.0	61.6	+7.5	------	31	31	Do.
Feb. 20	11 7	No spots						Do.
Feb. 21	11 19	No spots	------	------	------	------	------	Do.
Feb. 23	11 15	No spots	------	------	------	------	------	Do.
Feb. 24	11 8	No spots	------	------	------	------	------	Do.
Feb. 27	11 13	No spots	------	------	------	------	------	Do.
Feb. 28	11 13	No spots	------	------	------	------	------	
Mean daily area for February	------	------	------	------	------	------	40	

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR FEBRUARY 1934

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

[Data furnished through the courtesy of Prof. W. Brunner, Eidgenössische Sternw arte Zurich, Switzerland]

February 1934	Relative numbers	February 1934	Relative numbers	February 1934	Relative numbers
1	11	11	9	21	0
2	*a* 10	12	9	22	0
3	9	13	16	23	0
4	0	14	17	24	*Mc* 10
5	*Ec* 10	15	*a* 10	25	7
6	11	16	11	26	0
7	*Wc* 19	17	11	27	0
8	8	18	10	28	0
9	*d* 14	19	8		
10	8	20	0		

Mean: 28 days=7.8.

a=Passage of an average-sized group 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 zone.
d=Entrance of a large or average sized center of activity on the east limb.