SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING MARCH, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**: 42, January, 1925, **53**: 29, and July, 1925, **53**: 319.

Table 1 shows that solar radiation intensities were slightly below the normal values for March at all three stations.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at the three stations for which monthly normals have been determined.

Skylight-polarization measurements at Washington made on three days give a mean of 60 per cent, with a maximum of 63 per cent on the 5th. These are close to the corresponding normal values for Washington for March. At Madison no polarization measurements were made during the month on account of the presence of ice and snow.

TABLE 1.—*Solar radiation intensities during March, 1928*

[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] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Mar. 5	2.06	0.91	1.08	1.20	1.32	------	1.25	0.89	0.74	0.62	1.52
Mar. 6	2.16	------	0.52	0.69	1.01	1.54	------	------	------	------	1.78
Mar. 15	5.16	------	0.72	0.88	------	------	------	------	------	------	4.75
Mar. 19	3.15	0.60	0.72	------	------	------	------	------	------	------	3.45
Mar. 23	4.37	0.80	0.90	1.03	1.18	1.35	1.05	0.89	0.76	0.68	4.75
Mar. 27	4.75	------	------	------	1.30	1.54	------	------	------	------	3.15
Mar. 29	5.16	------	------	0.49	------	------	------	------	------	------	5.33
Mar. 31	3.00	0.82	1.00	1.16	1.31	1.50	------	------	------	------	3.45
Means	------	**0.78**	**0.82**	**0.91**	**1.22**	**1.48**	**(1.15)**	**(0.89)**	**(0.75)**	**(0.65)**	------
Departures	------	**+0.06**	**+0.02**	**−0.03**	**+0.07**	------	**+0.02**	**−0.04**	**−0.05**	**−0.04**	------

Madison, Wis.

Mar. 1	2.06	------	------	1.17	------	------	------	------	------	------	2.49
Mar. 2	2.74	------	------	1.21	------	------	------	------	------	------	3.30
Mar. 3	1.78	------	1.09	------	1.34	1.57	------	------	------	------	1.78
Mar. 5	0.91	------	1.11	1.24	1.40	1.66	1.36	1.20	------	------	1.32
Mar. 7	2.36	------	------	------	1.29	1.61	1.02	------	------	------	1.96
Mar. 16	2.06	------	------	1.13	1.34	1.58	1.29	------	------	------	2.16
Mar. 17	2.36	------	------	------	1.18	------	------	------	------	------	4.17
Mar. 20	3.00	------	0.99	1.13	1.29	1.51	------	------	------	------	3.15
Mar. 21	3.00	------	------	0.97	1.20	------	1.19	------	------	------	4.57
Mar. 22	5.36	------	1.09	1.20	1.35	1.51	1.30	------	------	------	5.36
Mar. 23	4.75	------	------	------	------	------	1.00	------	------	------	7.57
Mar. 27	1.88	------	1.16	1.28	1.44	1.60	1.41	------	------	------	1.88
Mar. 30	2.87	------	------	------	------	1.57	1.34	------	------	------	2.36
Means	------	------	**1.09**	**1.17**	**1.31**	**1.56**	**1.24**	**(1.20)**	------	------	------
Departures	------	------	**+0.04**	**−0.01**	**−0.01**	------	**−0.06**	**+0.03**	------	------	------

Lincoln, Nebr.

Mar. 1	2.16	------	------	1.18	1.41	1.63	------	------	------	------	2.26
Mar. 2	1.88	------	1.02	1.20	1.35	------	------	------	------	------	2.87
Mar. 4	3.15	------	------	------	------	1.46	1.27	1.10	0.97	0.81	2.26
Mar. 6	2.87	------	------	------	------	1.33	1.15	0.98	0.89	0.76	4.37
Mar. 7	3.30	------	0.92	1.03	1.29	1.48	------	------	------	------	3.81
Mar. 9	4.17	------	------	------	------	1.42	1.25	1.05	0.90	0.80	3.63
Mar. 13	3.63	------	------	------	------	1.48	1.30	1.14	0.97	0.81	3.30
Mar. 16	2.36	------	------	------	------	------	------	1.09	0.94	0.78	1.68
Mar. 20	2.62	------	------	------	------	1.48	1.27	1.08	0.95	0.85	2.16
Mar. 21	3.45	0.73	0.92	1.06	1.17	1.53	1.20	1.02	0.87	0.70	4.75
Mar. 22	5.16	------	0.77	0.94	1.13	1.40	1.14	0.98	0.89	------	6.27
Mar. 23	5.79	0.87	0.98	1.10	1.27	1.51	------	------	------	------	6.27
Mar. 30	2.62	------	------	------	1.28	------	------	------	------	------	1.78
Means	------	**(0.80)**	**0.92**	**1.08**	**1.27**	**1.47**	**1.23**	**1.06**	**0.92**	**0.79**	------
Departures	------	**−0.06**	**−0.03**	**−0.02**	**−0.02**	------	**−0.05**	**−0.03**	**−0.02**	**−0.03**	------

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1928	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Feb. 26	312	346	408	258	292	260	+17	+55	+59
Mar. 4	349	259	368	168	303	234	+36	−35	+19
Mar. 11	228	312	352	195	219	303	−101	+12	−23
Mar. 18	399	424	417	326	286	305	+39	+89	+6
Mar. 25	395	378	361	214	240	160	+44	+47	−46
Excess or deficiency since first of year on Mar. 31							+434	+665	−665

POSITIONS AND AREAS OF SUN-SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories]

(The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column)

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928	*h. m.*	°	°	°			
Mar. 1 (Naval Observatory)	12 1	−35.0	315.4	−8.0	------	37	------
		−26.5	323.9	−5.5	247	------	------
		−14.5	335.9	−19.5	31	------	------
		−9.0	341.4	−19.5	22	------	------
		−4.0	346.4	−19.0	------	31	------
		+48.0	38.4	−8.5	108	------	------
		+49.0	39.4	−19.0	31	------	------
		+60.0	50.4	−3.5	------	216	------
		+67.5	57.9	−3.0	------	139	------
		+69.0	59.4	−11.0	------	185	------
		+76.0	66.4	−12.5	370	------	1,417
Mar. 2 (Naval Observatory)	11 41	−19.5	317.9	−8.0	------	31	------
		−12.5	324.9	−5.5	216	------	------
		−1.0	336.4	−19.0	31	------	------
		+4.5	341.9	−19.0	15	------	------
		+8.0	345.4	−19.0	------	31	------
		+60.5	37.9	−9.0	123	------	------
		+61.0	38.4	−19.0	31	------	------
		+72.0	49.4	−3.5	------	216	------
		+80.0	57.4	−3.0	------	123	------
		+83.0	60.4	−11.0	------	185	1,002
Mar. 3 (Naval Observatory)	11 58	−55.0	269.1	+8.5	------	46	------
		−8.0	316.1	−8.5	------	31	------
		+1.0	325.1	−5.5	216	------	------
		+12.0	336.1	−19.0	31	------	------
		+18.5	342.6	−19.0	15	------	------
		+22.0	346.1	−18.5	------	31	------
		+73.0	37.1	−9.0	123	------	493
Mar. 4 (Naval Observatory)	11 49	−74.0	237.0	+17.5	------	185	------
		−42.0	269.0	+8.0	------	123	------
		−41.0	270.0	+10.5	------	15	------
		+4.5	315.5	−8.0	------	22	------
		+13.0	324.0	−5.5	216	------	------
		+25.0	336.0	−19.0	------	15	------
		+36.0	347.0	−18.5	------	9	585
Mar. 5 (Naval Observatory)	11 44	−64.0	233.8	+17.5	------	154	------
		−59.5	238.3	+17.0	------	185	------
		−28.5	269.3	+8.5	------	154	------
		−24.0	273.8	+6.5	108	------	------
		+19.0	316.8	−8.0	------	31	------
		+27.5	325.3	−5.5	216	------	848
Mar. 6 (Naval Observatory)	11 44	−60.0	224.6	−10.5	46	------	------
		−48.0	236.6	+17.5	------	154	------
		−43.0	241.6	+15.0	------	108	------
		−17.5	267.1	+8.5	------	154	------
		−11.0	273.6	+5.5	------	154	------
		+17.5	302.1	+27.5	------	62	------
		+39.5	324.1	−5.0	201	------	879
Mar. 7 (Naval Observatory)	11 45	−45.5	226.0	−10.0	9	------	------
		−38.0	233.5	+17.5	------	46	------
		−30.5	241.0	+15.0	------	139	------
		−6.0	265.5	−20.0	------	6	------
		−2.5	269.0	+7.5	------	154	------
		+3.5	275.0	+5.5	------	139	------
		+30.0	301.5	+27.0	------	123	------
		+52.0	323.5	−5.0	216	------	------
		+63.0	334.5	−9.0	6	------	838
Mar. 8 (Naval Observatory)	11 46	−31.0	227.3	−10.0	12	------	------
		−25.0	233.3	+17.5	------	62	------
		−17.0	241.3	+15.0	------	123	------
		+12.0	270.3	+8.5	------	370	------
		+18.5	276.8	+5.5	------	185	------
		+40.0	298.3	+28.5	77	------	------
		+45.0	303.3	+27.0	------	46	------
		+65.0	323.3	−4.5	185	------	------
		+73.0	331.3	−8.5	46	------	1,106

Positions and areas of sun-spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928	h. m.	°	°	°			
Mar. 9 (Mount Wilson)	14 30	−83.0	160.6	−19.0	489		
		−44.0	199.6	−15.0	5		
		−22.0	221.6	−9.0		11	
		−17.0	226.6	−10.0	4		
		−2.0	241.6	+15.0		149	
		+29.0	272.6	+7.0		548	
		+57.0	300.6	+26.0		52	
		+81.0	324.6	−5.0	122		1,380
Mar. 10 (Naval Observatory)	12 45	−70.0	161.4	−19.0	309		
		−9.0	222.4	−8.0		93	
		−3.5	227.9	−10.0	6		
		+2.5	233.9	+18.0		31	
		+8.0	239.4	+17.0		108	
		+12.5	243.9	+15.0		62	
		+39.0	270.4	+10.5		586	
		+43.0	274.4	+5.0		62	
		+48.0	279.4	+7.0	123		1,380
Mar. 11 (Harvard)	14 5	−81.0	136.5	−22.5	344		
		−55.0	162.5	−19.5	392		
		+8.0	225.5	−7.5		257	
		+25.5	243.0	+17.0		287	
		+58.0	275.5	+9.0		1,370	2,650
Mar. 12 (Naval Observatory)	13 25	−74.0	130.7	−22.0		617	
		−44.5	160.2	−19.0	231		
		+13.0	217.7	−18.0		62	
		+17.5	222.2	−8.5		46	
		+21.0	225.7	−9.0	170		
		+37.5	242.2	+17.0		247	
		+66.0	270.7	+11.0		586	
		+74.0	278.7	+7.0		216	2,175
Mar. 13 (Naval Observatory)	14 42	−83.0	107.8	+10.5	309		
		−69.0	121.8	+15.0		154	
		−67.0	123.8	−23.0		62	
		−61.0	129.8	−22.0		494	
		−31.0	159.8	−19.5	216		
		+24.0	214.8	−19.0		46	
		+31.0	221.8	−18.5	62		
		+35.5	226.3	−9.0	185		
		+48.0	238.8	+18.5		62	
		+53.5	244.3	+16.0		123	
		+79.0	269.8	+12.0		463	2,176
Mar. 14 (Naval Observatory)	11 54	−72.0	107.2	+10.5		432	
		−61.5	117.7	+16.5	93		
		−54.0	125.2	+15.0	108		
		−53.0	126.2	−23.5		93	
		−48.5	130.7	−22.0		370	
		−45.0	134.2	−17.5	15		
		−19.0	160.2	−20.0	201		
		+35.0	214.2	−20.0	9		
		+43.5	222.7	−17.5	139		
		+47.5	226.7	−9.0	170		
		+68.0	247.2	+15.0	93		1,723
Mar. 15 (Naval Observatory)	12 2	−57.5	108.4	+10.0		340	
		−48.0	117.9	+16.0	170		
		−39.0	126.9	+14.5	247		
		−38.5	127.4	−23.5		62	
		−35.5	130.4	−22.0		340	
		−29.5	136.4	−14.5		62	
		−6.5	159.4	−20.0		201	
		+57.0	222.9	−18.0	123		
		+60.5	226.4	−9.0	216		1,761
Mar. 16 (Harvard)	10 54	−41.0	112.5	+9.0		476	
		−28.5	125.0	+15.0		470	
		−20.0	133.5	−23.0		456	
		−13.5	140.0	−14.5		221	
		+8.5	162.0	−21.5		236	
		+73.0	226.5	−17.5	185		
		+76.5	230.0	−8.5	174		2,218
Mar. 17 (Harvard)	14 9	−25.0	113.5	+8.5		368	
		−12.5	126.0	+16.0		651	
		−4.5	134.0	−22.0		284	
		+2.0	140.5	−14.0		122	
		+23.5	162.0	−19.5	117		1,542
Mar. 18 (Naval Observatory)	12 43	−65.5	60.5	−5.5	15		
		−16.0	110.0	+8.5		386	
		−7.5	118.5	+17.5		154	
		+1.5	127.5	+14.5		401	
		+4.0	130.0	−22.5		278	
		+10.5	136.5	−16.5		93	
		+25.0	151.0	−13.5		62	
		+32.5	158.5	−20.5		77	
		+60.0	186.0	+16.0		9	
		+63.5	189.5	+2.5	15		1,490
Mar. 19 (Naval Observatory)	11 40	−2.5	110.8	+8.5		370	
		+7.0	120.3	+17.5		123	
		+14.5	127.8	+15.0		463	
		+16.0	129.3	−22.5		309	
		+23.5	136.8	−16.5		46	
		+39.0	152.3	−14.0		216	
		+45.5	158.8	−20.5	77		
		+50.5	163.8	−20.5	9		1,613
Mar. 20 (Naval Observatory)	11 46	+10.5	110.6	+9.0		340	
		+18.0	118.1	+17.5	62		
		+26.5	126.6	+15.5		525	
		+29.5	129.6	−23.0		309	
		+39.0	139.1	−15.0		31	
		+49.5	149.6	−14.5		77	
		+56.0	156.1	−13.5		154	
		+59.0	159.1	−20.5	77		1,675
Mar. 21 (Naval Observatory)	11 45	−25.5	61.5	−5.5		31	
		+24.0	111.0	+9.0		340	
		+30.5	117.5	+17.5	46		
		+37.0	124.0	+17.5		154	

Positions and areas of sun-spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928	h. m.	°	°	°			
Mar. 21 (continued)	11 45	+41.0	128.0	+15.0	309		
		+42.5	129.5	−23.0		247	
		+61.0	148.0	−14.5	62		
		+69.5	156.5	−13.0	185		
		+71.5	158.5	−20.0	77		1,451
Mar. 22 (Naval Observatory)	11 37	−68.5	5.3	+19.5		185	
		−11.0	62.8	−6.5		46	
		+37.5	111.3	+8.5		370	
		+43.5	117.3	+17.0	31		
		+50.5	124.3	+16.5		185	
		+55.0	128.8	+15.0	309		
		+56.0	129.8	−23.0		216	
		+83.0	156.8	−13.5		185	1,527
Mar. 23 (Naval Observatory)	11 43	−86.0	334.6	−13.0		216	
		−72.5	348.1	−9.5	154		
		−54.0	6.6	+19.5		154	
		+1.5	62.1	−6.5		31	
		+51.0	111.6	+9.0		370	
		+63.5	124.1	+17.0		216	
		+67.5	128.1	+15.0	340		
		+68.5	129.1	−23.0		185	1,666
Mar. 24 (Naval Observatory)	11 39	−80.5	326.9	−19.0		93	
		−72.5	334.9	−12.5		216	
		−60.0	347.4	−10.0	139		
		−39.5	7.9	+20.0		108	
		+14.5	61.9	−6.5		15	
		+63.5	110.9	+9.0	309		
		+80.0	127.4	+16.5		340	
		+82.0	129.4	−23.0		247	1,467
Mar. 25 (Naval Observatory)	11 43	−69.0	325.2	−1.0		19	
		−67.0	327.2	−19.0		77	
		−59.5	334.7	−13.0		216	
		−47.0	347.2	−11.0	108		
		−27.0	7.2	+19.5		93	
		+4.5	38.7	−9.5		9	
		+78.0	112.2	+9.0	247		769
Mar. 26 (Naval Observatory)	11 47	−55.0	326.0	−1.5	9		
		−52.5	328.5	−19.5		62	
		−45.5	335.5	−13.0		201	
		−33.5	347.5	−11.0	93		
		−12.5	8.5	+19.5		77	442
Mar. 27 (Naval Observatory)	13 28	−80.0	286.9	+22.0		247	
		−72.5	294.4	+7.5	77		
		−39.0	327.9	−19.5		62	
		−30.5	336.4	−13.5		216	
		−19.0	347.9	−11.0	108		
		+0.5	7.4	+19.5		62	772
Mar. 28 (Naval Observatory)	11 41	−68.0	286.7	+22.0		309	
		−60.0	294.7	+7.5	77		
		−28.5	326.2	−1.0	9		
		−27.5	327.2	−19.5		46	
		−18.0	336.7	−13.0		154	
		−7.0	347.7	−11.0	108		
		+12.0	6.7	+19.5		15	718
Mar. 29 (Naval Observatory)	13 16	−69.5	271.1	+10.5	123		
		−58.5	282.1	+22.0		154	
		−52.5	288.1	+23.0	154		
		−46.5	294.1	+7.5	62		
		−3.5	337.1	−12.5		139	
		+7.0	347.6	−11.0	93		725
Mar. 30 (Mount Wilson)	13 45	−55.0	272.4	+9.5	72		
		−39.0	288.4	+21.0		305	
		−32.0	295.4	+6.0	51		
		0.0	327.4	−19.5		25	
		+10.0	337.4	−13.0		138	
		+20.0	347.4	−12.5		159	750
Mar. 31 (Naval Observatory)	11 45	−43.0	272.0	+10.0	62		
		−33.5	281.5	+21.0		46	
		−26.5	288.5	+22.0		170	
		−20.0	295.0	+9.5		31	
		−19.5	295.5	+6.0	31		
		+15.0	330.0	−18.5		19	
		+22.5	337.5	−13.0		93	
		+33.5	348.5	−11.0	108		560
Mean daily area for March							1,284

PROVISIONAL SUN SPOT RELATIVE NUMBERS FOR MARCH, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

March	Relative numbers	March	Relative numbers	March	Relative numbers
1	79	11		21	81
2	70	12	108	22	99
3	55	13		23	60
4	52	14		24	
5	70	15		25	71
6	76	16	109	26	50
7	91	17	103	27	
8		18	116	28	50
9		19	139	29	72
10		20	105	30	62
				31	53

Number of observations, 22; mean, 80.5.