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SOLAR OBSERVATIONS

THE COMPUTATION OF β AND w FROM SOLAR RADIATION INTENSITY MEASUREMENTS

By HERBERT H. KIMBALL, Research Assistant, Harvard University

In the MONTHLY WEATHER REVIEW for January 1937, page 18, reference is made to a previous intention that, beginning with January 1937, the Ångström-Hoelper-Feussner curves for the determination of β and w should replace the curves that had been computed by myself and had heretofore been used in the United States. Attention was drawn to the fact, however, that in almost the first attempt to use the new curves for computing β and w from intensity measurements obtained at the Blue Hill Observatory, the difference I_m-I_r fell above the curved line representing $\beta=0$, while from my own curves a definite value of β was consistently obtained. The same circumstance occurred several times during January and February of the present year. Since a value of β less than zero can have no meaning, it is necessary to continue the use of my curves until the above discrepancy is explained.

Apparently, the difference in the two sets of curves arises from a higher value of I_m given by my computations when $\beta=0$; the difference from the European curves appears insignificant when $m=0$, but increases as m increases. The American curves (MONTHLY WEATHER REVIEW, 1933, pp. 82 and 83, figures 2, 3, and 4) were computed from Ångström's well known equations; but for $\beta=0$, data and equations originally developed by Lord Rayleigh and later modified by King, were employed. See *Smithsonian Meteorological Tables*, 5th revised edition, 1931, p. lxxxiii, and table iii, p. 240.

The following example will illustrate the reduction of pyrheliometric observations for the computation of β and w: The first line in the accompanying table gives the observed values at Blue Hill on February 27, 1937. In the second line these values have been reduced to mean solar distance. In the third line: I_m has been divided by 1.940 and is, therefore, represented as a percentage of the solar constant (71.1 percent); I_y and I_r have been further reduced by dividing them by the transmissions of the respective screens for a temperature three degrees higher than the air temperature at the time the measurements were made (table 4, MONTHLY WEATHER REVIEW, January 1936, p. 5).

I have preferred to determine the water vapor content of the atmosphere from the amount of depletion it produces in the intensity of the radiation in the entire spectrum. On the day under consideration, February 27, 1937, β, computed from $I_m - I_r$, is 0.015, and computed from $I_y - I_r$ is 0.033, giving a mean value of 0.024. With this value of β the value of I_m(dry) is 0.800, as compared with 0.711 determined from I_m reduced to mean solar distance and divided by 1.94; the difference, 0.800−0.711 =0.089, represents the absorption of solar radiation in passing over a path $m=1.900$.

The length of the path over which the solar rays pass before reaching the place of observation is a factor in determining the depletion. In plotting the sums of the absorption in individual bands as determined by Fowle, it was found that on an average this depletion (the absorption when $m=1$) was represented by the total measured absorption divided by $m^{1/2}$; i. e., in the case under consideration, the depletion for $m=1.900$ is given by 0.089/1.38=0.064, or 6.4 percent of the solar constant. This is principally absorbed by water vapor, but 0.2 percent to 0.4 percent is attributed by Fowle to absorption by ozone, leaving 6.0 percent to absorption by water vapor.

An equation on page lxxxiii, *Smithsonian Meteorological Tables*, 5th revised edition, 1931, which is there attributed to Fowle, is repudiated by him. He casually mentioned it in the MONTHLY WEATHER REVIEW, Vol. 42, pp. 2–4, 1914, as an approximation formula that might be used when a better method was not available; but Hann appears to have been the originator of this equation (see *Smithsonian Meteorological Tables*, p. lxxii), which served a useful purpose in earlier days before elaborate studies of the great water vapor absorption bands in the infra-red section of the solar spectrum by modern spectroscopic methods were available.

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	β_{m-r}	β_{y-r}	β_{mean}	$\frac{I_{w-e}}{1.94}$	$\frac{I_{w-e}-I_m}{1.94}$	w
1937											
February 27:	° ′	m	gr. cal.	gr. cal.	gr. cal.						mm
(1) 2:14 p. m.	30 55	1.94	1.405	0.933	0.756						
(2)			1.380	.916	.742						
(3)			0.711	1.083	.878	0.015	0.033	0.024	80.0	8.9	6.4

SOLAR RADIATION MEASUREMENTS DURING FEBRUARY 1937

By CHARLES M. LENNAHAN

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

Table 1 shows that solar radiation intensities averaged below normal for the morning observations at Washington. The average intensities were above normal for Blue Hill and for the afternoon observations at Washington. Madison and Lincoln intensities are scattered about the normal values, with no definite positive or negative tendencies.

Table 2 shows that the values of the total solar (direct and diffuse) radiation received on a horizontal surface were below normal at half (7) of the stations for which normals are used, and were above normal at the others.

The turbidity values for Washington, as shown in table 3, are relatively low. It should also be noted that the variation in water-vapor is very slight.

No polarization observations were made during February because of the presence of a snow cover on the days which were otherwise favorable for such observations.

TABLE 1.—*Solar radiation intensities during February 1937*

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

WASHINGTON, D. C.

Date	Sun's zenith distance: 7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	87.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	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. 2	1.78	0.43	0.67	0.96	1.13		1.15				1.45
Feb. 3	1.68	.70	.88	1.08	1.38		1.29	1.12	1.00	0.83	1.52
Feb. 6	2.36	.41	.52	.76	.97						2.87
Feb. 10	3.00	.48	.56	.76	1.08						2.49
Feb. 11	1.37	.49	.64	.86	1.27		1.25	1.10	.90	.84	1.24
Feb. 12	2.74			.90	1.18						2.74
Feb. 14	8.18						1.24	.79			2.49
Feb. 15	3.81	.72	.86	.98	1.29						3.30
Feb. 17	1.88		1.16	1.30	1.52		1.39	1.21			2.26
Means		.54	.76	.92	1.19		1.26	1.06	(.95)	(.84)	
Departures		−.17	−.07	−.09	−.01		+.65	+.06	+.09	+.07	

TABLE 1.—*Solar radiation intensities during February 1937*—Con.

MADISON, WIS.

Date	Sun's zenith distance: 7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	87.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	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.	al.	al.	cal.	mm.
Feb. 2	0.53	0.98	1.10								1.37
Feb. 6	1.68	1.08	1.14	1.32							1.02
Feb. 9	.66	.79	.76	1.29	1.40						1.07
Feb. 10	.51	.60	1.00	1.18	1.38						.79
Feb. 16	2.16	.85	.94	1.14	1.54		1.54				2.06
Feb. 18	3.81	.82	1.00	1.17	1.38		1.30				3.63
Feb. 23	1.37	.85	1.00	1.11							1.45
Feb. 25	1.24				1.35						1.96
Means		.85	.99	1.20	1.41		(1.42)				
Departures		−.07	−.07	.00	+.05		−.03				

LINCOLN, NEBR.

Feb. 2	1.45	1.07	1.23	1.35	1.50		1.48	1.32	1.16	1.01	1.45
Feb. 4	.81				1.47		1.46				1.12
Feb. 9	.91						1.49	1.30	1.13	1.05	.96
Feb. 10	1.07		1.07	1.26	1.44		1.31	1.15	.95		2.62
Feb. 13	4.37			1.33	1.45						2.74
Feb. 16	2.06	1.01	1.14	1.29	1.47		1.46	1.12			2.74
Feb. 18	2.87			.78	.21			.10	.30		3.45
Feb. 23	2.62						1.44				1.60
Feb. 24	1.68		1.28								1.85
Feb. 25	1.12	.90	1.03	1.16	1.39						1.37
Means		.99	1.15	1.08	1.30		1.44	1.00	.82	(1.03)	
Departures		+.06	+.13	+.03	−.07		+.08	−.15	−.19	+.11	

BLUE HILL, MASS.

Feb. 1	3.5				1.38		1.38	1.10			2.5
Feb. 2	2.0				1.20						1.0
Feb. 3	1.5				1.23		1.35	1.25	1.15	1.05	1.7
Feb. 4	1.5	1.12	1.18	1.25	1.32		1.35	1.25			1.7
Feb. 7	2.1			1.00	1.30		1.30	1.23			1.6
Feb. 10	3.3						1.34	1.23	1.13		3.2
Feb. 11	2.0				1.28		1.43	1.33	1.19	1.08	1.2
Feb. 12	2.1						1.13	1.10	.85		2.4
Feb. 16	2.5			1.20							2.6
Feb. 17	1.4						1.37	1.26	1.15	1.06	.6
Feb. 19	2.9		.84	1.10	1.27		1.14	1.07	1.02	.96	1.9
Feb. 23	2.3			1.05	1.10		1.10	.97	.86	.79	2.0
Feb. 24	3.0						1.03				3.5
Feb. 26	2.8						1.03				2.0
Feb. 27	2.1				1.40		1.40	1.30	1.21	1.13	1.2
Feb. 28	1.3			1.24	1.36		1.40	1.31	1.20	1.14	1.5
Means		(1.12)	(1.01)	1.16	1.28		1.27	1.20	1.08	1.03	
Departures		+.24	+.02	+.09	+.02		+.01	+.04	+.01	+.02	

*Extrapolated.