It is readily to be seen that the values given by the hygrometric formula are the closest. In all cases where cloud conditions changed after the time of the observation the estimated minimum temperature varies more than 5°. If the evening weather map could have been used in conjunction with the formula the clouds could have been determined beforehand.

During the fall period there were 17 days when conditions were favorable for free radiation and frost. The two formulas gave the following results:

	Hygrometric formula	Maximum-minimum formula
	Nights	*Nights*
No variation	2	0
Variation of 1°	5	4
Variation of 2°	1	0
Variation of 3°	3	2
Variation of 4°	3	3
Variation of 5°	1	0
Over 5°	2	6
	Per cent	*Per cent*
Variation of 3° or less	64. 7	35. 3
Variation of 5° or less	88. 2	64. 7

The spring formulæ were used during the 1925 season with results as follows:

	Hygrometric formula	Maximum-minimum formula
	Nights	*Nights*
No Variation	3	2
Variation of 1°	1	5
Variation of 2°	4	4
Variation of 3°	6	1
Variation of 4°	2	1
Variation of 5°	3	2
Over 5°	2	6
	Per cent	*Per cent*
Variation of 3° or less	66. 7	57. 1
Variation of 5° or less	90. 5	71. 5

Conclusion.—The work described in this paper was of a preliminary nature, the data secured in one or two seasons being too meager to form the basis of any definite conclusions. However, the results obtained by using the two formulæ were of such a nature as to warrant further application and study. Use of the evening weather map is necessary in order to determine the cloud conditions in advance. Also, the probable influence of the wind in preventing stratification of the surface air could be determined from the evening map.

The formula alone can not be counted upon too strongly, but if used in conjunction with the evening weather map reliable predictions of the expected minimum temperature can be made.

The percentage of verification of forecasts from the maximum-minimum formula was not as high as that of the hygrometric formula, but was sufficiently high to justify its use in connection with the hygrometric formula and the weather map.

The median-temperature hour method did not give high enough verification to make its further use worth while.

All the formulæ used could be improved if applied consistently throughout the frost periods and as more data are secured.

A SHORT METHOD OF DETERMINING THE TIME OF MOONRISE AND MOONSET

By F. N. HIBBARD

[Weather Bureau, Grand Haven, Mich., September, 1925]

The following notes and examples will be found useful to observers who find considerable labor and difficulty in computing moonrise and moonset.

Owing to the eastward motion of the moon in its orbit, it rises and sets on the average about 50 minutes later each day. Its velocity, however, is not uniform, nor is its path at a constant angle with the horizon, and the actual times of rising and setting are irregular, the lag varying from less than a half hour to considerably more than an hour.

The Weather Bureau has therefore furnished to each of its stations a nautical almanac and a set of auxiliary tables, the almanac being good for one year and the tables for many years. The almanac gives the risings and settings for various latitudes along the Greenwich meridian, and the tables give the corrections necessary to adapt the Greenwich figures to the Weather Bureau station.

To illustrate the use of the two, Table 1 gives the auxiliary figures as supplied to the Cincinnati station, and Table 2 shows how they are applied to the almanac figures.

Cincinnati lies between the latitudes of 35° and 40°. These two columns in the almanac will therefore be marked by heavy red or blue pencil (see columns a and b in Table 2). Cincinnati lies closer to the 40° latitude, therefore the corrections from the Auxiliary Table 1, A, will be applied to the 40° column (column b). These corrections are given in column c. Note that the corrections are plus when the figures in a are greater than those in b, and minus when less, Cincinnati lying between the two columns.

The results of the corrections are the main figures of column d. After the main figures are entered in pencil for the month, the differences (italic figures in column d) are entered in red ink. To the left of the differences the plus corrections from Auxiliary Table 1, B, are then entered in black ink (bold-face figures in column d), using the red figures for argument. Column e plus column f plus column g, the standard time correction, gives column h, the standard time of moonrise for the date and station. The standard time correction is plus when the station is west of its standard meridian, and minus when east.

Moonset is found in the same manner by using the moonset page in the almanac.

In actual practice the figures of column d only are set down, using the proper squares of Form 1078 for the purpose, the final figures, column h being entered directly in the daily local record, corrections c, f, and g being applied mentally. It is thus possible to list the essential figures, column d, for the entire year on two sheets of 1078, one for the moonrise and one for the moonset. And at no point in the operation has any figure been listed twice. The saving of time by this method is considerable.

In summarizing the operation, it may be helpful to know just where we are at the different points. Column a gives the time of moonrise on the Greenwich meridian for latitude 35°, and column b, for latitude 40; while column c gives the latitude correction. Column d gives the time (European system) on the Greenwich meridian at latitude 39° 6′, and column e the same time on the American system. Column f allows for the lag of the moonrise, or the time lost in the approximately six-hour trip from the Greenwich meridian to the Cincinnati meridian. And column g corrects to standard time. Column g may be eliminated to advantage by reconstructing Auxiliary Table B to include the standard time correction.

A further shortening of the computation may be effected by combining Table A and Table B and the standard time correction in a single table, card form, by the use of which the times of moonrise and moonset can be found directly by inspection. Table 3 illustrates such a form, made for Cincinnati. By using it in conjunction with column b, the figures in column h are arrived at directly, except in two cases, where the card gives a value one minute off. This one-minute error occurs two or three times per month and is due to the fact that the card applies the Table B corrections to the differences in column b instead of to the differences in column d. The card form is exceptionally rapid and is commended to all stations in the Bureau.

TABLE 1.—*Auxiliary tables for computing the time of moonrise and moonset at Cincinnati, Ohio*

Latitude, 39° 6′ north;—40°—0.9°. 0.9°/5°=0.18
Longitude, 84° 30′ or 5.63 hours west of Greenwich. 5.63/24=0.235

A.—*Latitude correction.* (*0.18×tabular difference for latitude*)

Tabular difference (minutes)	0	1	2	3	4	5	6	7	8	9
	Correction (minutes)									
0	0	0	0	1	1	1	1	1	1	2
10	2	2	2	2	3	3	3	3	3	3
20	4	4	4	4	4	4	5	5	5	5

B.—*Longitude correction.* (*0.235×tabular difference for one day*)

Tabular difference (minutes)	0	1	2	3	4	5	6	7	8	9
	Correction (minutes)									
20	5	5	5	5	6	6	6	6	7	7
30	7	7	8	8	8	8	8	9	9	9
40	9	10	10	10	10	11	11	11	11	12
50	12	12	12	12	13	13	13	13	14	14
60	14	14	15	15	15	15	16	16	16	16
70	16	17	17	17	17	18	18	18	18	19
80	19	19	19	20	20	20	20	20	21	21

TABLE 2.—*Computation of moonrise and moonset at Cincinnati, Ohio, June, 1925*

[Latitude 39° 6′; longitude 84° 30′]

	a	b	c	d	e	f	g	h
					p. m.			*p. m.*
1	13 20	13 18	±0	13 18	1.18	+15	−22	1.11
				+15 *64*				
2	14 21	14 22	±0	14 22	2.22	+15	−22	2.15
				+15 *65*				
3	15 24	15 28	−1	15 27	3.27	+16	−22	3.21
				+16 *68*				
4	16 30	16 36	−1	16 35	4.35	+17	−22	4.30
				+17 *71*				
5	17 38	17 48	−2	17 46	5.46	+17	−22	5.41
				+17 *71*				
6	18 48	18 59	−2	18 57	6.57	+16	−22	6.51
				+16 *70*				
7	19 56	20 10	−3	20 07	8.07	+15	−22	8.00
				+15 *65*				
8	21 01	21 14	−2	21 12	9.12	+13	−22	9.03
				+13 *57*				
9	21 59	22 11	−2	22 09	10.09	+12	−22	9.59
				+12 *49*				
10	22 49	23 00	−2	22 58	10.50	+10	−22	10.46
				+10 *42*				
11	23 33	23 41	−1	23 40	11.40	+9	−22	11.27
12								
				+9 *37*	*a. m.*			*a. m.*
13	0 12	0 18	−1	0 17	0.17	+8	−22	12.03
				+8 *32*				
14	0 47	0 50	−1	0 49	0.49	+7	−22	12.34
				+7 *31*				
15	1 21	1 20	±0	1 20	1.20	+7	−22	1.05
				+7 *31*				
16	1 53	1 50	+1	1 51	1.51	+7	−22	1.36
				+7 *30*				
17	2 26	2 20	+1	2 21	2.21	+8	−22	2.07
				+8 *32*				
18	3 00	2 52	+1	2 53	2.53	+8	−22	2.39
				+8 *35*				
19	3 36	3 26	+2	3 28	3.28	+9	−22	3.15
				+9 *38*				
20	4 16	4 04	+2	4 06				

TABLE 3.—*Corrections to apply to time of moonrise and moonset at latitude 40° N., meridian of Greenwich, to obtain the ninetieth meridian time of moonrise and moonset at Cincinnati, Ohio, latitude 39° 06′ N. and longitude 84° 30′ W.*

Long. Diff. \ Lat. Diff.	−25 to −20	−19 to −14	−13 to −9	−8 to −3	−2 to +2	+3 to +8	+9 to +13	+14 to +19	+20 to +25
20 to 23	−21	−20	−19	−18	−17	−16	−15	−14	−13
24 to 27	−20	−19	−18	−17	−16	−15	−14	−13	−12
28 to 31	−19	−18	−17	−16	−15	−14	−13	−12	−11
32 to 36	−18	−17	−16	−15	−14	−13	−12	−11	−10
37 to 40	−17	−16	−15	−14	−13	−12	−11	−10	−9
41 to 44	−16	−15	−14	−13	−12	−11	−10	−9	−8
45 to 48	−15	−14	−13	−12	−11	−10	−9	−8	−7
49 to 53	−14	−13	−12	−11	−10	−9	−8	−7	−6
54 to 57	−13	−12	−11	−10	−9	−8	−7	−6	−5
58 to 61	−12	−11	−10	−9	−8	−7	−6	−5	−4
62 to 65	−11	−10	−9	−8	−7	−6	−5	−4	−3
66 to 70	−10	−9	−8	−7	−6	−5	−4	−3	−2
71 to 74	−9	−8	−7	−6	−5	−4	−3	−2	−1
75 to 78	−8	−7	−6	−5	−4	−3	−2	−1	0
79 to 82	−7	−6	−5	−4	−3	−2	−1	0	+1

NOTES, ABSTRACTS, AND REVIEWS

DAYLIGHT ILLUMINATION ON A SLOPING SURFACE: A CORRECTION

By HERBERT H. KIMBALL

In the MONTHLY WEATHER REVIEW for December, 1922, **50**: 625, equation (3) has been improperly used to determine the angle of incidence of a solar ray with a sloping surface. The angle of incidence $(90^\circ - a')$ is best computed by the second method given in the above reference. Mr. Edgar W. Woolard has also called attention to the fact that it may be computed by the law of cosines, as follows:

$$\cos \theta = \cos v \sin a + \sin v \cos a \sin w,$$

in which v = angle between a horizontal surface and the sloping surface,

a = solar altitude,

$90^\circ - w$ = azimuth of sun from the meridian of the place,

and θ = angle of incidence of a solar ray with the sloping surface.

All values given in Tables 8, 9, and 10, pages 625–26 of the above-mentioned REVIEW are too high, with the exception of those for hour angle of the sun from the meridian = 0° (w = 90°). The maximum error occurs when w = 0°. Since the component of the radiation received diffusely from the sky is not affected by the above equation, for surfaces sloping 10° from the horizon the error can not exceed 1 per cent, and may be disregarded. For surfaces sloping 20° from the horizontal the error can not exceed 4 per cent, and is unimportant. For surfaces sloping 30° from the horizontal the error in extreme cases may approximate 10 per cent.