MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 69, No. 5
W. B. No. 1329

MAY 1941

CLOSED JULY 3, 1941
ISSUED JULY 30, 1941

DAILY SOLAR RADIANT ENERGY AT THE EXTERIOR OF THE ATMOSPHERE

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[U. S. Bureau of Reclamation, Denver, Colo., March 1941]

A graph of average daily air-mass values was published in the MONTHLY WEATHER REVIEW for November 1940, page 302; its practical use involves, among other things, the total daily solar radiation on a horizontal surface at the exterior of the atmosphere, denoted by I_0 in equation (2) of the article. Tables from which I_0 may be computed have been available for over 50 years, but their form is not very convenient. Figure 1 is here offered, which graphically gives the data, directly in B. t. u. per square inch per day; it is arranged in the same form as the air-mass graph. To change to calories per square centimeter per day, multiply by 39.06.

This graph is based on a solar constant of 1.94 calories per square centimeter per minute; it takes into account the variations of the earth's radius vector, and is applicable to any place in the Northern Hemisphere for any day of the year by entering with the latitude of the place and the declination for the day. It is not applicable to the Southern Hemisphere.

Its construction was based on the computation of 134 points. It was checked at convenient places by reference to the tabulation first published in the *Annual Report of the Chief Signal Officer*, 1885, Part 2, page 427, by Wm. Ferrel, and now available in several publications of the Smithsonian Institution (e. g., Table 688, p. 556, in the Eighth Revised Edition, First Reprint, June 1934, *Smithsonian Physical Tables*, with the voluminous title: "Mean intensity J for 24 hours of solar radiation on a horizontal surface at the top of the atmosphere and the solar constant A, in terms of the mean solar constant A_0, at the earth's mean distance from the sun.")

The construction of this graph was much simpler and more straightforward than that of the air-mass graph. The cosine of the zenith angle measures the component of the solar ray normal to a horizontal surface. The total daily intensity is proportional to the sum of these cosines. The average cosine for either the day or the half day is equal to the area under the cosine curve divided by the hour angle from noon to sundown. Using the equation (1) and the terminology of the previous article, we have

$$\cos Z = a + b \cos t;$$

$$\text{Area under cosine curve} = \int_0^t (a + b \cos t)\,dt = at + b \sin t;$$

$$\text{Average daily } \cos Z = a + \frac{b}{t} \sin t.$$

To obtain the daily total, this is multiplied by the solar constant, the number of minutes of daylight, and the reciprocal of the earth's radius vector squared. It is divided by 39.06 to convert to B. t. u. per square inch per day. To check with the Ferrel table, or to use the table in case it is preferred to a graph, multiply the tabulated values therein by $\frac{1.94 \times 1440}{39.06} = 71.5$.

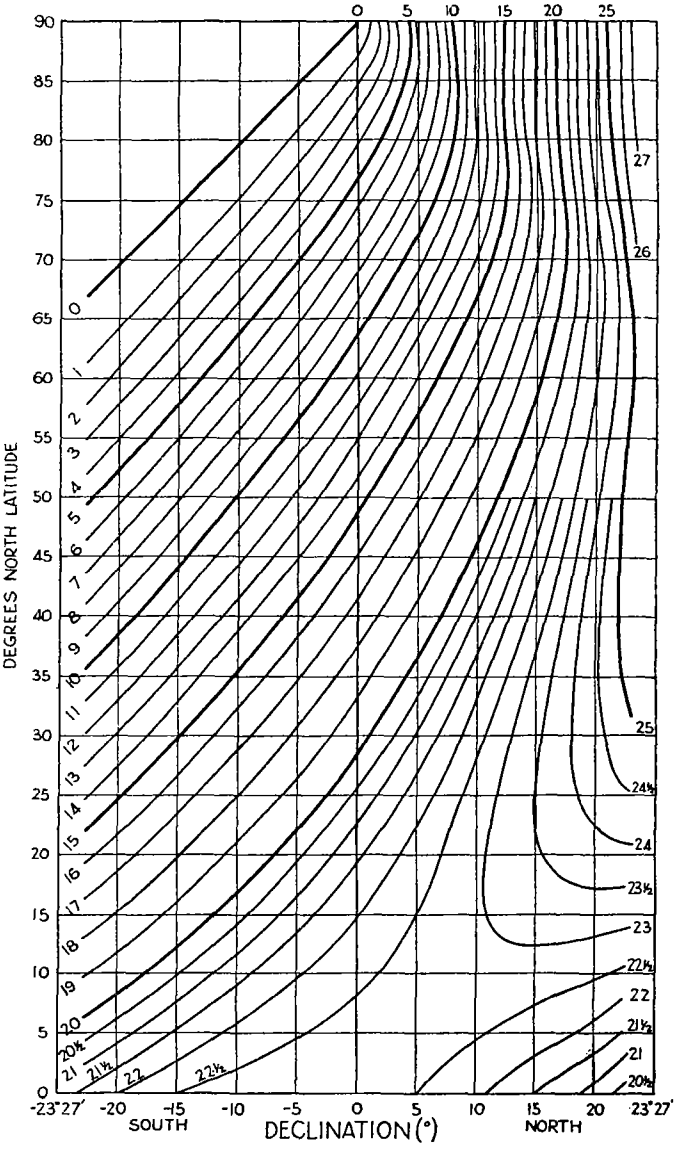

FIGURE 1.—Solar heat at exterior of atmosphere, B. t. u. per square inch per day.