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EVALUATION OF MEAN DAILY NET LONG WAVE RADIATION FLUX USING PYRGEOMETRIC DATA

Lack of data on net long wave radiation over crop surfaces poses a difficult problem in investigations on the agroclimatology of the moisture factor. In pyrgeometic measurement of net long wave radiation, the thermal back radiation is allowed for at ambient air temperatures. In studies on the estimation of net long wave radiation, attempts have been directed to derive meteorological functions for estimating the incoming component of the long wave flux, *viz.*, atmospheric radiation from clear skies and to relate this, in turn to measures of cloud cover so as to obtain atmospheric radiation from cloudy skies. The mean daily radiative temperature of a ground covering short green crop not subject to a moisture stress or advection would nearly be the same as the mean ambient air-temperature. Hence, in this note an attempt has been made to find an expression for extrapolating pyrgeometric data which are recorded at night time to obtain estimate of net long wave radiation flux for the day as a whole.

2. The formula suggested for deriving atmospheric radiation (Bolz 1949) is of the form:

$$R = R_o\ (1+Kc^2) \qquad (1)$$

where, R and R_o are the atmospheric radiation from cloudy and clear skies respectively, c is the cloud cover of the sky in tenths and K has a varying value depending on cloud type.

From Eqn. (1) the difference in the net long wave flux between clear and cloudy conditions corresponding to a screen level radiative temperature T°A may be written as:

$$(R - \sigma T^4) - (R_o - \sigma T^4) = R_o K c^2 \qquad (2)$$

where, σ is the Stefan-Boltzmann constant. Denoting the mean daily and night time values by subscripts a and n respectively, Eqn. (2) may be rewritten as:

$$(R_n - \sigma T_n^4) - (R_{no} - \sigma T_n^4) = R_{no} K_n (c_n)^2 \qquad (3)$$

and

$$(R_a - \sigma T_a^4) - (R_{ao} - \sigma T_a^4) = R_{ao} K_a (c_a)^2 \qquad (4)$$

If we now assume that the night time cloud cover c_n is the same as the mean daily cloud cover c_a and $K_n = K_a$, it would follow from Eqns (2), (3) and (4) that

$$\frac{(R_n - \sigma T_n^4) - (R_{no} - \sigma T_n^4)}{(R_a - \sigma T_a^4) - (R_{ao} - \sigma T_a^4)} = \frac{R_{no}}{R_{ao}} = \frac{R_n}{R_a} \qquad (5)$$

In other words, the ratio of the differences in net long wave flux from the expected clear sky values at night times to a similar difference for the day as a whole would be the same as the ratios of the corresponding values of atmospheric radiation, if cloud cover remains unchanged.

3. Askloff (1920) and Phillips (1940) have formulated an expression to derive net long wave radiation from overcast skies in terms of the clear sky figures. Their postulation is of the form:

$$\frac{R - \sigma T^4}{R_0 - \sigma T^4} = a \qquad (6)$$

in which the value of a depends on the height of the cloud base.

Again assuming no change in cloud cover as at Eqn. (5) above and using similar notations for subscripts a and n, from Eqn. (6) we obtain:

$$\frac{R_n - \sigma T_n^4}{R_{n0} - \sigma T_n^4} = a = \frac{R_a - \sigma T_a^4}{R_{a0} - \sigma T_a^4} \qquad (7)$$

Combining Eqns. (5) and (7) we get

$$\frac{a\ (R_{n0} - \sigma T_n^4) - (R_{n0} - \sigma T_n^4)}{a\ (R_{a0} - \sigma T_a^4) - (R_{a0} - \sigma T_a^4)} = \frac{R_n}{R_a} \qquad (8)$$

Eqn. (8) then reduces to the form:

$$\frac{R_{n0} - \sigma T_n^4}{R_{a0} - \sigma T_a^4} = \frac{R_n}{R_a} \qquad (9)$$

Using Eqn. (7) in Eqn. (9) we get:

$$\frac{R_n - \sigma T_n^4}{R_a - \sigma T_a^4} = \frac{R_n}{R_a} \qquad (10)$$

and

$$\frac{R_n - \sigma T_n^4}{R_n} = \frac{R_a - \sigma T_a^4}{R_a} \qquad (11)$$

Eqn. (11) may be rewritten as:

$$\frac{R_n - \sigma T_n^4}{T_n^4} = \frac{R_a - \sigma T_a^4}{T_a^4} \qquad (12)$$

The implication of Eqn. (12) is that for extrapolating the night time pyrgeometric values of net long wave flux to the day as a whole the ratio of net long wave radiation to thermal back radiation could be taken as invariable if there is no change in cloud cover pattern (cloud type, base and amount). It may be emphasised that Eqn. (12) is not an universal one as the ratio of net to back radiation even under clear conditions would show both areal and time variations and that use of Eqn. (12) is to be limited only to the day time extrapolation of night time pyrgeometric readings under a constant cloud cover.

4. In India observations of the nocturnal long wave radiation recorded with Angstrom's pyrgeometer at 2030, 2330 0230 and 0530 IST are available for a number of stations for over a decade. These observations cover a wide range of sky conditions ranging from clear to partly cloudy skies of the non-monsoon months to cloudy to overcast skies of the monsoon months. For each observation the ratio of net long wave to back radiation would be valid for the cloud cover prevailing at the time of observation. For a given month and station the mean of the cloud cover at the 4 hours of observation over a number of years would be a reliable climatological measure of the average cloud cover. Therefore, for the pyrgeometric station the average monthly values of the ratio of net to back radiation multiplied by σT_a^4, where T_a is the mean air temperature, in °A, of the corresponding month would give climatological estimates of the mean daily net long wave flux in the different months over a green crop cover.

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