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Seasonal oscillation of bright sunshine in India and neighbourhood

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ABSTRACT. Calculated bright sunshine values are available in India. A study of its seasonal variation has been taken up. The amplitude of the annual and semi-annual variations of bright sunshine are largest in the west central parts of the country.

1. Introduction

Sunshine is the primary factor in photosynthesis, and photosynthesis is the most important nutritional process of the plant. Sunshine has a twofold influence upon plant growth, one part of the spectrum provides the energy for carbon assimilation, and hence for the production of raw material, while another part acts as a stimulus and influences directly the rate of growth and differentiation. Strong light is harmful to fungi and bacteria, in fact bacteria are even killed by an excess of it. So a study of the annual course of bright sunshine is important. The march of bright sunshine at any particular station is to a large extent a systematic oscillation repeating practically in a similar manner year after year. The character of the variation in the bright sunshine during the course of the year is the subject matter of study in this paper. The actual data of sunshine records are available only for about 20 stations. Jagannathan and Ganesan (1966) utilising data of cloudiness at over 250 observatories in India have calculated the mean monthly durations of bright sunshine. For this study the mean bright sunshine data for 186 meteorological stations calculated by Jagannathan and Ganesan have been utilised.

2. Model for annual variation of sunshine

A suitable mathematical model for studying the annual oscillation of bright sunshine appears to be a set of harmonics with the fundamental period as the year. Symbolically, we aim at expressing bright sunshine S_t at any time of the year t in the form—

$$S_t = \overline{S} + a_1 \sin\left(\frac{2\pi t}{P} + \phi_1\right) + + a_2 \sin\left(\frac{4\pi t}{P} + \phi_2\right) \qquad (1)$$

where $\overline{S}$ = mean sunshine over the entire period of length P (here the year),

$a_r \sin\left(\frac{2\pi rt}{P} + \phi_r\right)$ represents the r^{th} harmonic of the fundamental period P,

a_r = amplitude, *i.e.*, half the range between the maximum and the minimum in the oscillation,

ϕ_r = Phase angle of the r^{th} harmonic.

The evaluation of the components in the harmonic has been made as follows —

The monthly values have been assumed to represent the middle of the month. The unequal lengths of the months have been ignored. The amplitude and phase angles of the annual and semi-annual oscillations have been calculated utilizing Conrad and Pollak's schedule (1950). The maximum in the oscillation of the r^{th} order will occur when —

$$\sin\left(\frac{2\pi rt_x}{N} + \phi_r\right) = 1 \qquad (2)$$

i.e., when $\frac{2\pi rt_x}{N} + \phi_r = \frac{\pi}{2}$ or $\frac{5\pi}{2}$

The date of occurrence of the maximum in the oscillation can be calculated from the phase angle from considerations of the facts that the unit of time is a twelfth of the year = 30·4375 days and that the origin of the time axis corresponds to January 16th.

The date of maximum in the annual oscillation is given by —

$D_x = t_x\ 30{\cdot}4375 + 16$ days from 1 Jan (3)

and those in the half-yearly oscillations by —

$d_x = t_x\ 30{\cdot}4375 + 16$ days and

$t_x\ 30{\cdot}4375 + 198{\cdot}625$ days from 1 Jan (4)

where t_x are obtained from equation (2) with $r = 1$ and 2 respectively.

3. Annual oscillation

In Fig. 1 are plotted the amplitudes of the annual oscillation of bright sunshine and isopleths are drawn demarcating different levels. The dates of occurrence of the maximum annual oscillation are calculated, but they show no systematic variation in the country. From Fig. 1 the following

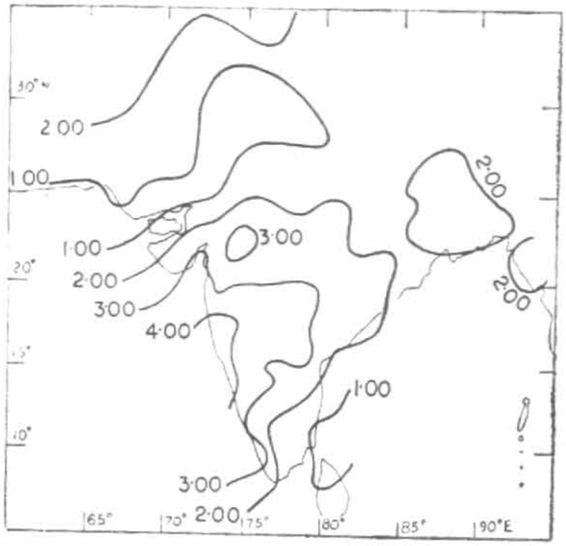

Fig. 1. Amplitude of annual oscillations of sunshine hours

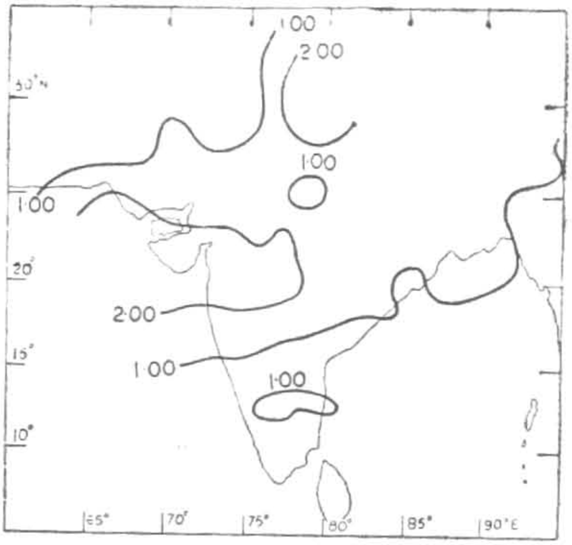

Fig. 2. Amplitude of semi-annual oscillation of sunshine hours

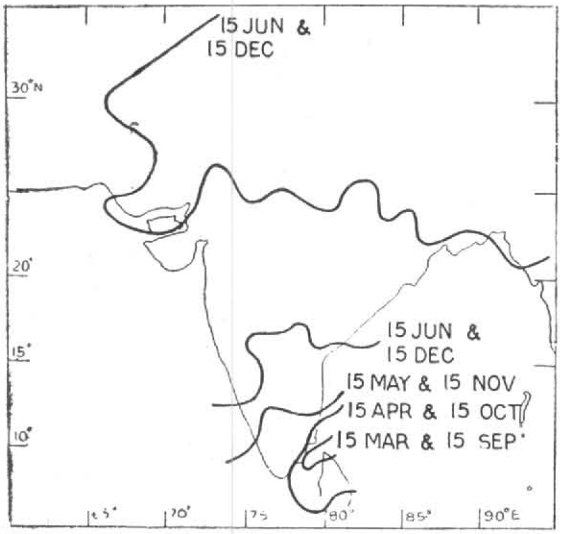

Fig. 3. Dates of maximum semi-annual oscillations of sunshine

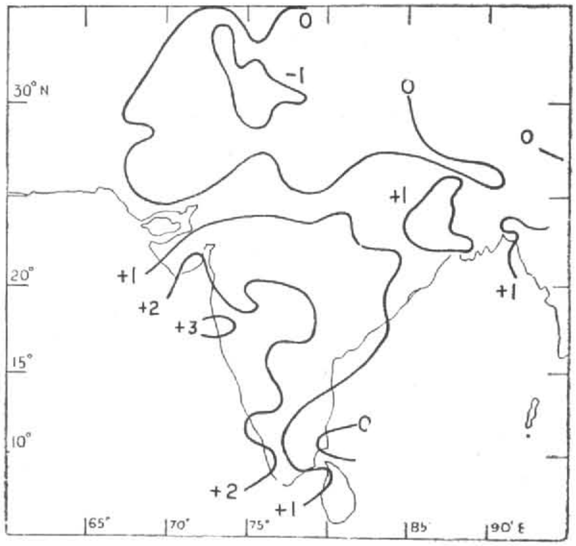

Fig. 4. Anomalies of a_1—a_θ

a_1—Amplitude of annual variation
a_θ—amplitude of annual varation expected

conclusions can be drawn—

(1) The lowest values of amplitude are obtained in the Coromandel coast, west Uttar Pradesh, east Punjab, some parts of Rajasthan and Gujarat.

(2) The amplitudes of 3 hours occur in Maharashtra, north Mysore, coastal Mysore and some parts of Telengana.

(3) Over the rest of the country, the amplitudes are of the order of 2 hours.

4. Semi-annual oscillation

In Figs. 2 and 3, are plotted the amplitudes of the half-yearly oscillation of bright sunshine and the date of occurrence of the maximum in the half-yearly oscillation and isopleths are drawn demarcating different levels. These figures bring out the following—

(1) The one-hour amplitudes are in south Peninsula and Punjab, Kashmir regions.

(2) Highest values more than 2 hours occur over Kutch, Gujarat and north Maharashtra.

(3) The maximum oscillation occurs towards the end of March or early April in the southeast Peninsula and gets delayed as we proceed northwards upto 15°N from where upto about 25°N the maximum occurs in the second half of June; further north it occurs earlier in the first half of June. The semi-annual oscillations will have two maxima and two minima occurring with an interval of 6 months.

5. Anomalies of the annual oscillation

In this section the anomaly of the annual oscillation from the planetary oscillation of sunshine is outlined. The monthly duration of sunshine expected, if there is no clouding, have been prepared for each latitude circle (the time of sunrise and sunset given in Nautical Almanac 1966 have been utilized). The sequence of monthly sunshine values were subjected to harmonic analysis and the amplitude and phase angles in respect of the different latitudes have been worked out. Fig. 1 shows the variation of the amplitude of the annual oscillation with latitude. The differences a_1-a_θ (where a_1 is the amplitude of annual variation and a_θ is the amplitude of annual variation expected when there is no clouding) are plotted in Fig. 4. It is seen that along the west coast the anomalies are of the order of 3 hours and gradually decrease eastwards as well as northwards. The values along northeast India show another maximum but much less. The values in north India beyond nearly 25°N are negative indicating that the summer maximum in the sunshine is somewhat suppressed due to the monsoon clouding and appears as a reduction in the amplitude of the annual oscillation. During the monsoon season heavy clouding is present along the coasts of southwest India. This is shown by the positive anomaly pattern present in that region. That is to say the annual variation is more than expected due to the monsoon clouding only.

6. Acknowledgement

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REFERENCES

Eric Ashby	1931	*Environment and Plant Development,* Edward Arnold and Co., pp. 7-63.
Conrad, V. and Pollak, L. W.	1950	*Methods in Climatology,* Harvard University Press, Cambridge, Mass.
Jagannathan, P. and Ganesan, H. R.	1966	Distribution of Solar Radiation in India, Sci. Rep., 13, ITM, Poona.
India met. Dep.	1966	*The Indian Ephemeris and Nautical Almanac.,* pp. 330-337.