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Summer solar radiation and temperature in relation to monsoon rainfall

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ABSTRACT. An examination of observational records of global and diffuse solar radiation during summer from 1964 to 1972 at all stations has been made. The results indicate that year-to-year variations of the mean daily radiation received at the surface is small. Further, these variations are not linked to the variations of sub-divisional rainfall during the subsequent monsoon season. Similar results have been obtained from an analysis of sub-divisional mean summer temperatures and monsoon rainfall over the period 1936 to 1965.

1. Introduction

There is a popular belief among many sections of the lay public that an unusually hot summer is a sign of forthcoming heavy monsoon rains, whereas a relatively comfortable summer is a forewarning of a bad monsoon. This idea is found in the folklore of many parts of India, for example, in Hindi, '*Jeth mas jab tapai mahina, tab jano varsha hai hona*', or in Punjabi, '*Jeth men jara pare sawan kora jae, Dakh kahe, sun Bhadli, Chulian mir bikai*'.

The tenability of this popular concept has been examined in this paper from the meteorological point of view. It is already known (Ramakrishnan *et al.* 1958) that there is a warm area over central India at the 850 mb level in May as a result of surface heating. According to Ramage (1971), direct solar heating of the desert and release of latent heat from pre-monsoon thunderstorms over the Indian sub-continent indicate that monsoon rains may be closely related to previous local effects. If such an association between summer heat and monsoon rain exists, and can be stated in quantitative terms, it could be used in a long-range forecasting model.

2. Methodology

The number of solarimeter stations in India has been steadily growing in recent years. The instrumentation employed at these stations is of the Moll Gorczynski pyranometer type with and without shading ring for blocking direct solar radiation. Continuous records of global solar radiation and integrated daily values are available uniformly for 11 stations in India since 1964. Similar data are also available for diffuse solar radiation at 5 of these stations.

In the present study, daily values of global and diffuse solar radiation during the three summer months, March to May, were averaged over a 9-year period 1964-1972. In order to correlate the year-to-year variation in the mean summer radiation with variation in the rainfall in the subsequent monsoon period, June-September rainfall amounts were analysed for the sub-divisions in which the radiation stations are situated. Rainfall averages were computed for the same 9-year period 1964-1972. This was done since the sub-divisional rainfall would be more representative of the overall rainfall pattern than the rainfall at the individual radiation stations.

In view of the relative abundance of temperature data, a parallel study was carried out to seek a correlation between summer temperatures and monsoon rainfall. Here, monthly sub-divisional means of maximum and minimum temperatures in March, April and May from 1936 to 1965 were used. From this, normal summer temperatures were derived sub-divisionwise as $\frac{1}{2}$ (Max.+Min.). Normals of sub-divisional monsoon rainfall were evaluated from monthly rainfall data for June to September from 1936 to 1965. Year-to-year deviations of summer mean temperature and monsoon rainfall from the 30-year normal were then obtained for each of the years 1936 to 1965. The analysis was restricted to the 10 sub-divisions considered in the radiation study.

3. Discussion

Fig. 2 shows the distribution of the mean daily global solar radiation during summer (March-May)

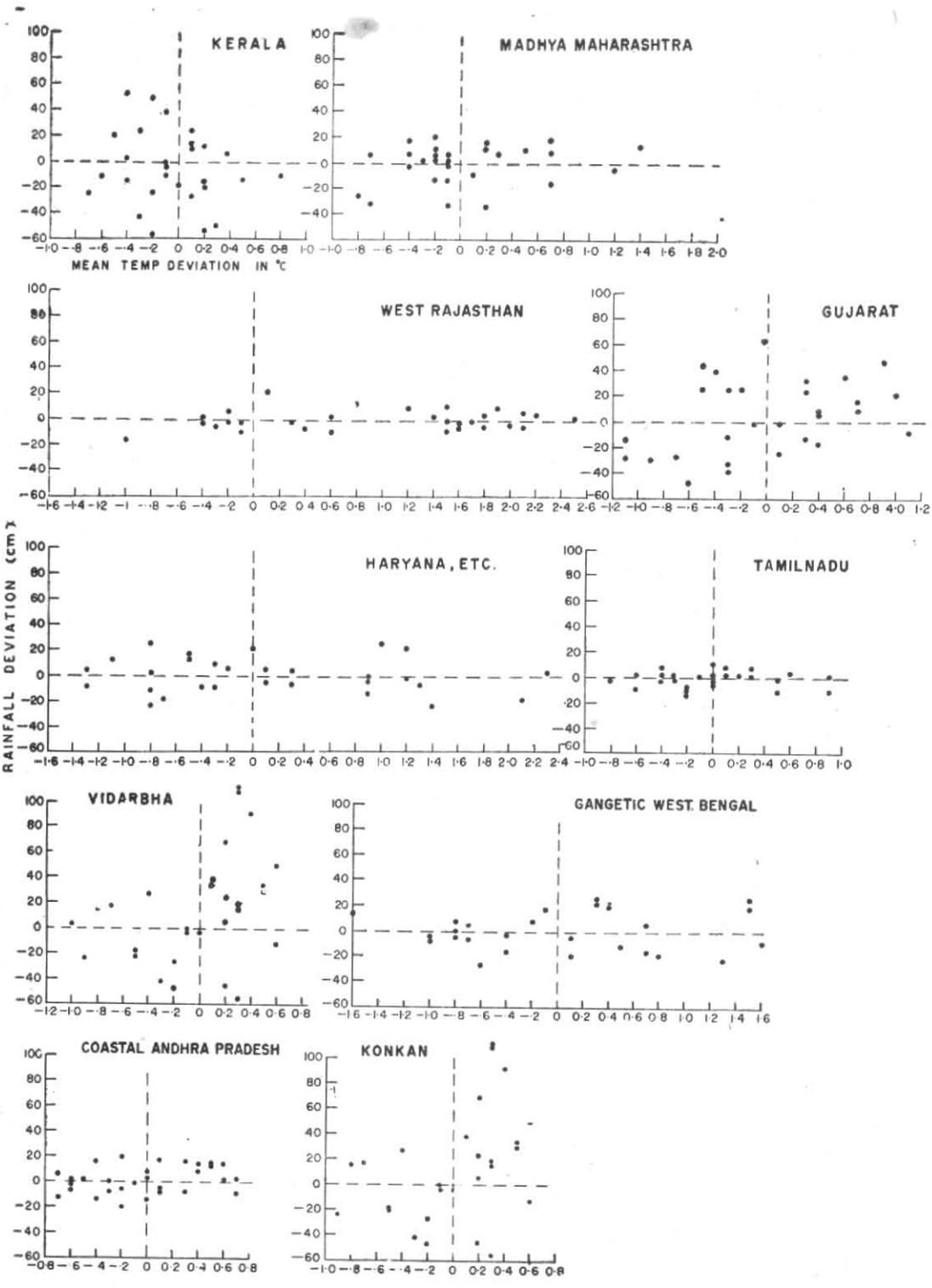

Fig. 1. Deviations from normal of (1) sub-divisional summer mean temperature (°C) along x-axis (2) sub-divisional monsoon rainfall (cm) along y-axis

TABLE 1

Percentage departure of Global Radiation during summer (March to May) (from 9-year average)

Year	Ahmadabad	Dum Dum	Goa	Madras	Jodhpur	Nagpur	Delhi	Poona	Kodaikanal	Trivandrum	Visakhapatnam
1964	+0 2	−7 5	−1·2	+4·0	+2·1	+6·5	+2 5	+2·5	+3 6	+3·0	+0·7
1965	−0 9	−4·4	+2·0	−1·3	−0·7	−0·4	+1·1	+2·8	+0·1	−0·8	+1·0
1966	+1·4	−3 0	−1·7	2 2	+3·3	+1·1	+2·4	+0·8	−1·1	+2·8	+0·5
1967	−2 0	+2 6	+2 9	+0·9	+2·6	+1·4	−1·7	0	−1·7	−0·5	+2·0
1968	+3 0	−4·0	+2 5	+1 2	+1·1	+3·7	+1 5	+3 5	+2·4	+3·6	−1·9
1969	−1·0	+10 5	−4·3	−2·6	−5·8	−4·0	+0·5	+0 3	+1·6	−1·3	−5·8
1970	+0 3	+1·4	0·4	0	−5·3	−4 2	−2·1	−3.7	0	−6·7	+3·3
1971	−0 1	+5·1	+1·8	−1 5	+2·7	−2·4	−2·8	0	−3·9	−0·3	−1·9
1972	−0 7	−0·9	−1·8	+1 6	+0·3	−1·9	−1·4	−6 1	−1·2	+3 0	+2·2

TABLE 2

Percentage departure of diffuse radiation during summer (March to May)

(From 9-year average)

Year	Dum Dum	Madras	Delhi	Poona	Trivandrum
1964	−3·5	+3·7	−1·1	+2·2	+8·3
1965	−9·5	+0·9	−0·6	−5·4	−1·3
1966	−1·2	−0·7	+1·1	−2·2	+7·5
1967	−3·7	−0·5	−0·5	−0·8	−1·7
1968	−3·7	−1·9	−7·3	−4·0	−2·3
1969	+13·8	+8·3	+5·5	+8·9	+2·0
1970	+5·4	−6·2	−0·9	−0·6	−3·3
1971	+8·9	+5·3	+0·5	−4·0	−2·7
1972	+6·3	−8·1	−3·8	+6·8	−6·6

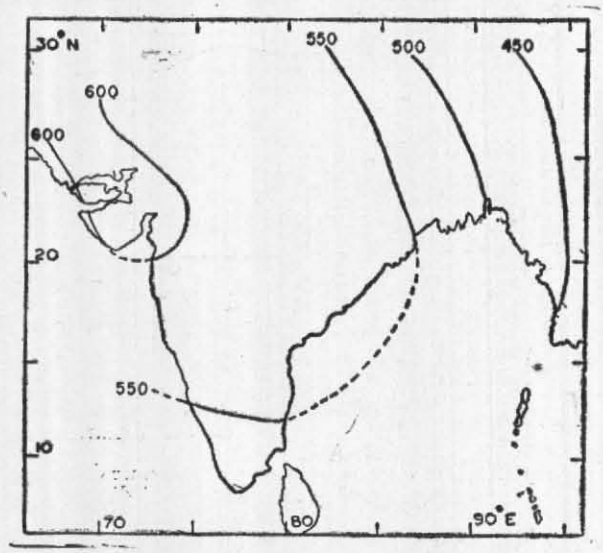

Fig. 2. Average daily global solar radiation in summer (Mar-May) in ly/day

derived from 1964 o 1972 data. Over most of the country, values of the order of 550-600 ly/day are commonly observed except over parts of Rajasthan and Saurashtra where they exceed 600 ly/day and northeast India where they are as low as 450 ly/day.

The pattern of distribution deviates little from year to year from the average. This is clearly seen from Table 1 which shows the percentage deviation from the average of mean daily global solar radiation received in summer from year to year. The deviations are smaller than ±5 per cent except in stray cases. Table 2 gives similar information in the case of diffuse radiation. This means that although the summer of one year may be different from that of another year on considerations of human comfort and other bioclimatic parameters the basic input of solar radiation changes only marginally from year to year.

Fig. 3 shows the inter-annual deviations from the 9-year average of the daily global solar radiation in summer in relation to deviations of the sub-divisional rainfall in the monsoon. If the association of a warmer summer with good monsoon rain is to hold good, the points on this type of graph should lie approximately along a straight line. However, for none of the eleven stations examined was any such linearity noticed. Most of the points are randomly dis ributed showing no indication of any such correlation to exist. At those stations which are in low-rai fall areas such as Jodhpur, Kodaikanal and Madras, the points more or less lie along the x-axis showing that the inter-annual variation of rainfall is

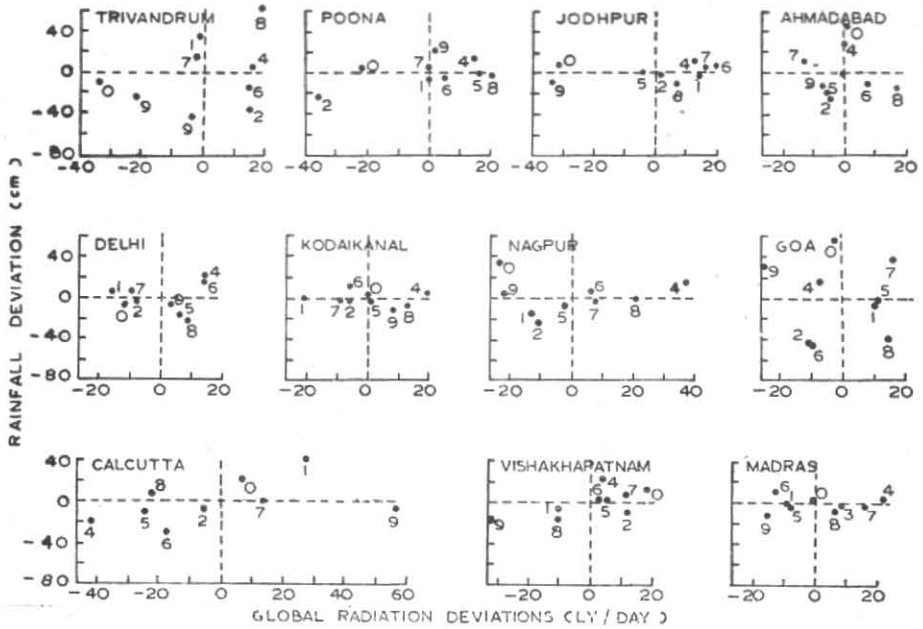

Fig. 3. Deviations from average of (1) Summer global radiation (ly/day) along x-axis and (2) Sub-divisional rainfall (cm) along y-axis. Years are indicated as 4-1964, 5-1965,....., 0-1970, 1-1971, 2-1972.

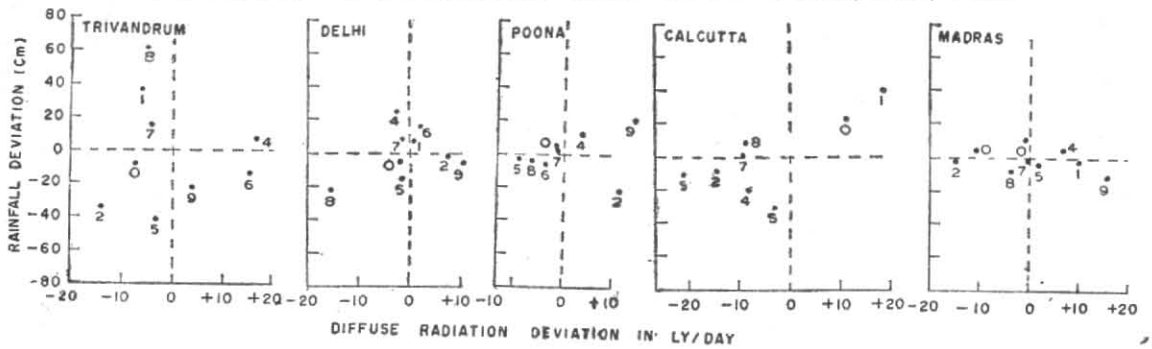

Fig. 4. Deviations from average of (1) Summer diffuse radiation (ly/day) along x-axis and (2) Sub-divisional rainfall (cm) along y-axis. Years are indicated as 4-1964, 5-1965, ...,0-1970, 1-1971, 2-1972.

quite independent of solar radiation. The same trend is observed in the case of diffuse radiation also (Fig. 4).

The parallel study carried out with sub-divisional mean summer temperature and monsoon rainfall also yielded results not different from the above. Fig. 1 shows the year-to-year deviations from the 30-year normal of these two parameters in relation to each other. Here again, the points are randomly scattered except in areas of less rainfall, *e.g.*, west Rajasthan, Tamil Nadu, etc where they lie close to the x-axis. In addition to the graphical analysis, the above data was also processed on the IBM 1620 Computer to obtain correlation coefficients. For all the sub-divisions considered, the correlation coefficients were positive but mostly insignificant.

4. Conclusion

The study has shown that year to-year-variation of mean daily global solar radiation during summer is small. These variations and also those of summer mean temperatures do not have any significant correlation with variations of sub-divisional rainfall in the subsequent monsoon. The usefulness of these parameters in long-range forecasting models therefore appears to be very limited.

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