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The Radiation Climate over India

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ABSTRACT. As solar radiation data for India available at present are not extensive enough to meet the increasing demands for the climatological information of this parameter, use of data of bright hours of sunshine to estimate the radiation receipt is examined. Monthly normal radiation maps based on the estimated solar radiation values for 52 stations are presented and discussed.

1. Introduction

Using Ångstrom's method, various attempts have been made to estimate solar radiation from sunshine data by deriving a linear relationship between the ratio of the radiation actually received to that expected with clear sky with the ratio of the actual to the possible hours of bright sunshine expressed as percentage for the day as a whole.

It may be argued that the use of daily percentage values of the sunshine will lead to incorrect estimates on cloudy days, as the actual hourly distribution of the total bright sunshine hours will markedly influence the radiation receipt. It was, therefore, decided to compare the actual values of radiation at Madras, Poona, Calcutta, New Delhi and Trivandrum with the estimated values using the following formula involving the hourly instead of the daily values of sunshine, *viz.*,

$$Q = \Sigma(x \times y) + [Q_0 - \Sigma(x \times y)] \times K \qquad (1)$$

where, Q=the solar radiation received,

x=the expected clear sky radiation pertaining to an hour,

y=the percentage of bright sunshine for that hour,

Q_0= the expected clear sky radiation for the whole day and

K=the transmission ratio for the most predominent cloud type for the month under consideration.

For the use of the above formula, it is necessary to have estimates of the mean daily clear sky radiation and its hourly distribution. As actual records of clear sky radiation could not be had for the monsoon months, it was initially decided to compare the mean monthly radiation values recorded on clear days at these stations with those estimated by Ramdas and Yegnanarayanan (1954).

The comparison showed that the clear day values of Ramdas and Yegnanarayanan are about 15 per cent greater than the observed values, except at Dum Dum where the over-estimation is 30 per cent and is perhaps due to the presence of larger quantities of suspended industrial impurities.

So in these studies for those months for which actual data of clear day radiation were not available the Q_0 values were taken as 7/8th of those of Ramdas and Yegnanarayanan.

The hourly distribution of the total clear day radiation was obtained by multiplying the hourly values of extra-terrestrial radiation for the station in question (Venkataraman and Krishnamurthy 1965) by the clear day surface radiation ratios which can be defined as the amount of radiation received on a horizontal surface to that, as would have been incident on it at the top of the atmosphere.

In the above formula the value of K will be of significance only during the monsoon period when a significant amount of radiation is received during the periods when direct radiation from the sun is cut off by the clouds. The value of Q/Q_0 for the overcast days in the monsoon months at Delhi, Poona, Calcutta and the Madras was found to range from 0·3 to 0·4. Also considering the monsoon cloud types and making a reference to the work of Haurwitz (1948), Mani, Chacko and Venkiteshwaran (1962) the value of K was taken as 0·4.

The percentage deviation of the computed values obtained by using the above formula from the observed values can be seen in Table 1. This shows only 3 of the average values to exceed $\pm$ 10 per cent deviation. The agreement was also seen to be good even on an yearly basis with only 21 of the 192 values exceeding a variation of $\pm$ 8 per cent.

Since the application of the above formula for a network of 52 sunshine recording stations would have required an elaborate computation effort it was decided to determine the effect of using the daily average sunshine values in place of the

TABLE 1

Mean percentage deviation of estimated values of radiation as obtained by the use of (*i*) daily and (*ii*) hourly values of bright hours of sunshine

	Poona		Madras		New Delhi		Trivandrum	
	(*i*)	(*ii*)	(*i*)	(*ii*)	(*i*)	(*ii*)	(*i*)	(*ii*)
January	—9	—5	—15	—7	—4	—2	—2	—1
February	—5	—2	—12	—4	—4	—1	—1	—6
March	—6	—1	—5	—3	7	—8	0	—3
April	—4	—2	—6	—6	—2	—2	—3	—3
May	—4	5	—3	—5	3	—2	—10	0
June	1	3	—2	—4	0	—3	—10	15
July	6	13	—1	—3	—6	—4	3	7
August	8	4	0	—4	—7	—4	1	6
September	5	1	—3	—1	—5	—1	16	16
October	2	—1	—6	—9	—10	—1	15	10
November	—4	—4	—15	—8	—6	—3	5	5
December	—12	—5	—12	—8	—7	—3	0	4

hourly values by using the following formula, *viz.*,

$$Q = Q_0\,(0{\cdot}70\,S + 0{\cdot}4) \qquad (2)$$

The values of 0·70 was used to allow for the fact that even on clear days the value of S is only 0·90 due to the sunshine cards not being burnt by the milder rays of the sun in the morning and evening. The percentage deviation of the estimated values of radiation as obtained by the use of the daily values are given in Table 1 and are seen to be very nearly the same as those obtained by use of hourly values.

2. Radiation maps

Mean monthly radiation estimates for a network of 52 stations were prepared by means of the above formula in which Q_0 values were taken as 7/8 of those published by Ramdas and Yegnanarayanan (1954).

The monthly and annual solar radiation maps are presented in Figs. 1 to 13. The distribution of the 52 stations used in the study is also shown in Fig. 13.

The maps are seen to have a broad similarity with those of Mani, Swaminathan and Venkiteshwaran (1962) and give additional details of the regional variations of the radiation climate of northeast India. The general features of the radiation climate brought out by these are discussed below—

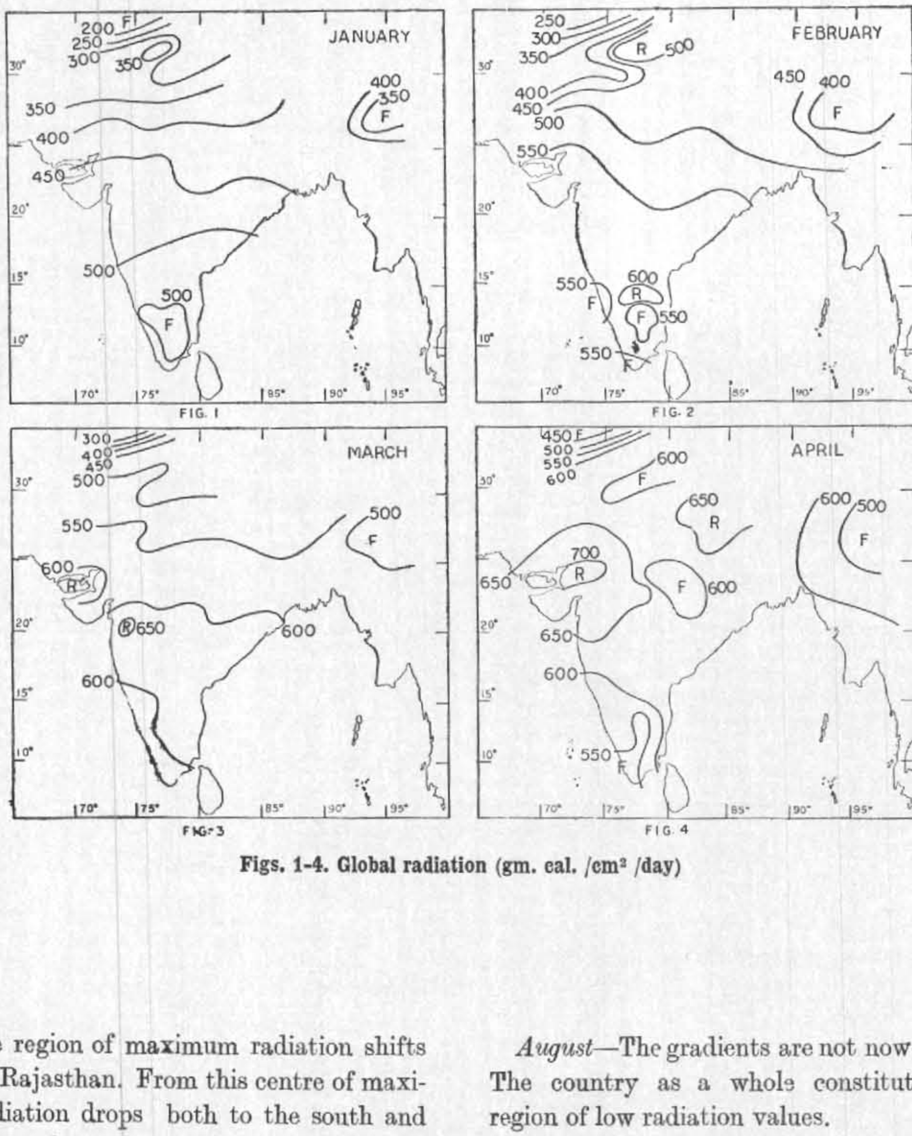
January—Between 35°N and 18°N the radiation increases from north to south. In northeast India a drop occurs from west to east. The peninsular region between 18°N and southern tip constitutes a diffuse region of high radiation except over interior Mysore, interior Madras and Rayalaseema where a radiation low is present.

February—There is a general increase in radiation all over India. The general distribution is the same as that of January.

March—There is a further increase in the amount of radiation all over India. In the peninsula a pocket of maximum radiation occurs over the northern region of Madhya Maharashtra. A secondary maximum is also noticed over Gujarat, Saurashtra and Kutch. Over coastal Mysore and Kerala, a slight drop occurs from the interior to the coast.

April—Between latitudes 35°N and 15°N there is a marked increase in radiation recieved over that in March. The region comprising west Madhya Pradesh, Rajasthan, Saurashtra and Kutch constitutes a region of high radiation receipt with the maximum occurring over north Gujarat. A radiation high is also seen over interior Madhya Pradesh. In the southern Peninsula a drop in radiation occurs from east to west.

May—For the country as a whole there is a decrease in radiation received. The region of maximum radiation receipt lies over north Maharashtra, northwest Madhya Pradesh, Gujarat, Saurashtra and Kutch. A radiation low is seen over west Uttar Pradesh, Punjab and west Rajasthan. The southward drop in radiation receipt in southern Peninsula is slightly more steep than in April.



Figs. 1-4. Global radiation (gm. cal. /cm² /day)

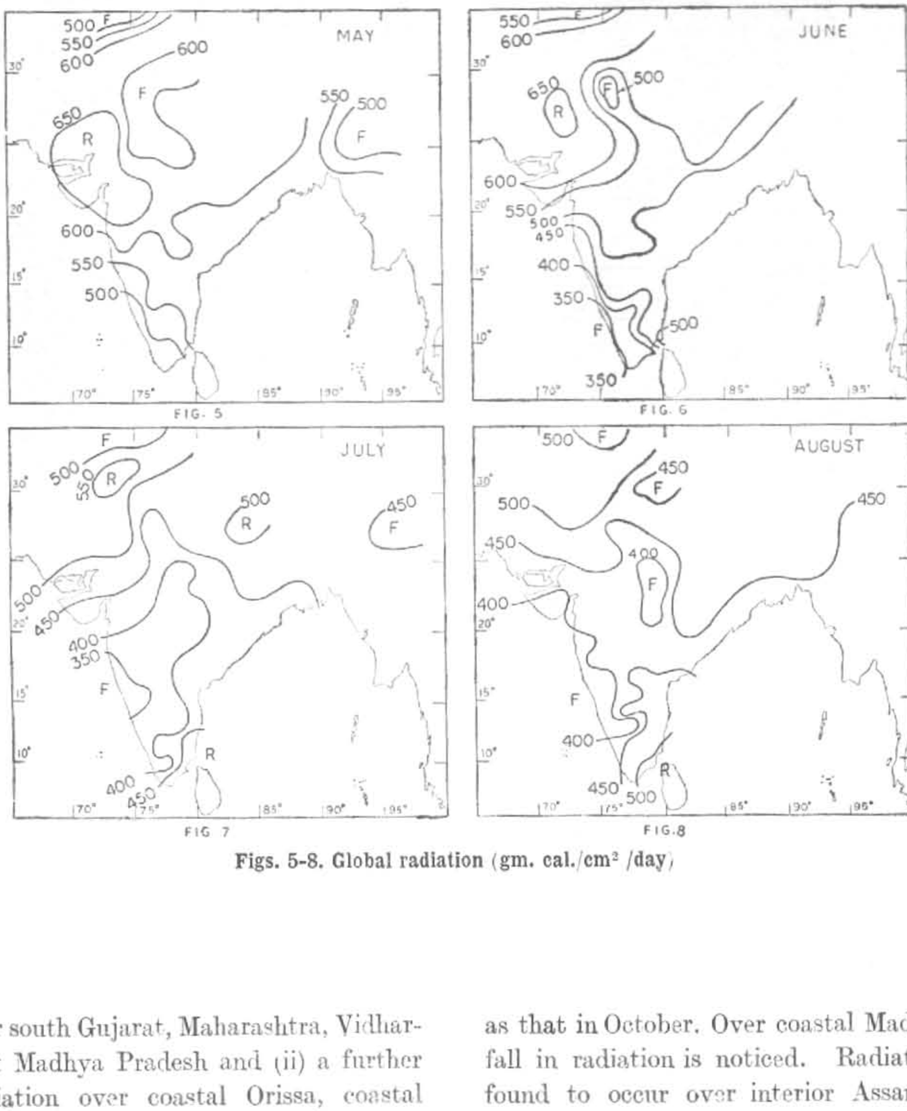
June—The region of maximum radiation shifts over to west Rajasthan. From this centre of maximum the radiation drops both to the south and east. In the southern Peninsula the drop is very marked over the coastal regions than in the interior. In Madras State the radiation received is less than that in May but it is more than the neighbouring regions.

July—Now between 20° and 35°N there is a marked fall in the radiation receipt, except over Assam. The region of maximum radiation shifts over to West Pakistan. In the southern Peninsula also there is a drop in radiation receipt.

August—The gradients are not now well-defined The country as a whole constitutes a diffuse region of low radiation values.

September—There is a general increase in radiation all over the country except Assam, coastal Kerala, Orissa and coastal Andhra Pradesh. The maximum radiation is received over Rajasthan.

October—A drop in radiation occurs over north-east India with maximum fall being noticed over interior Assam. The region of maximum radiation now lies over Saurashtra and Kutch. The marked features of the month are—(i) the sharp rise in



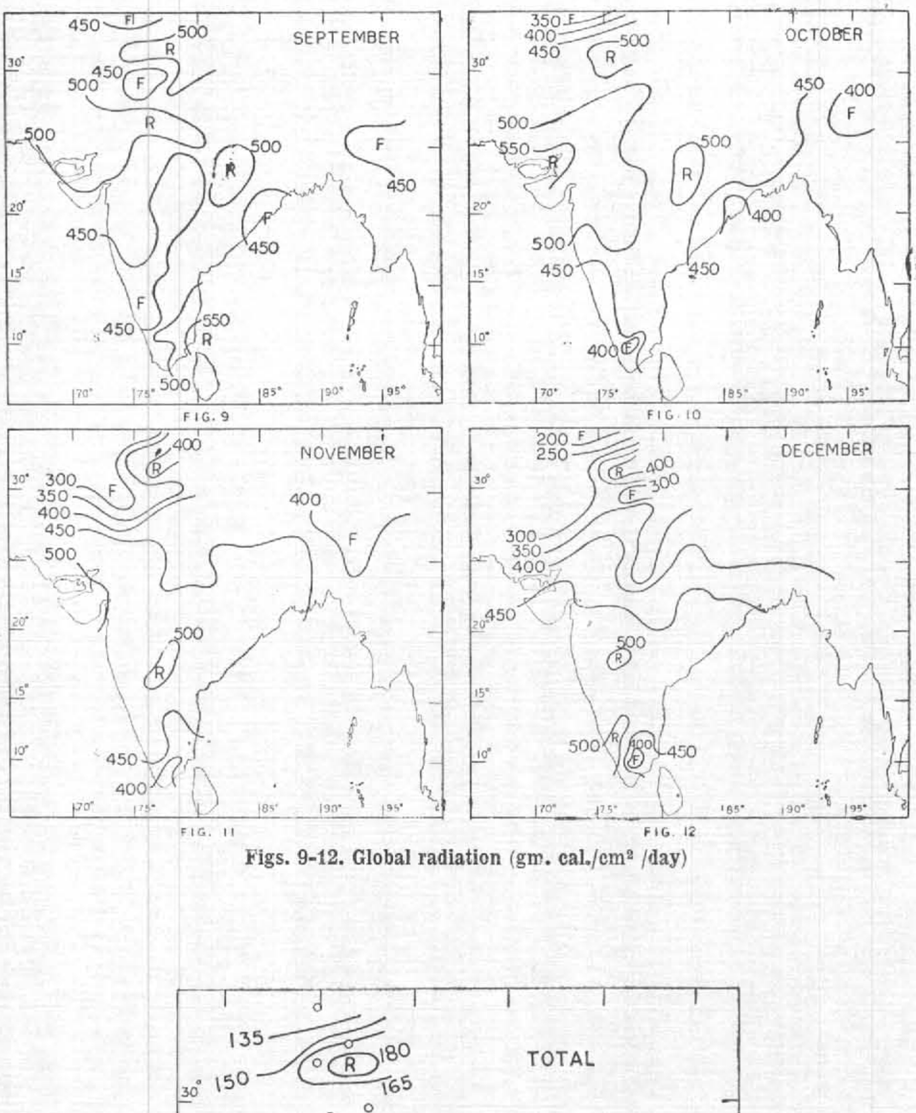
Figs. 5-8. Global radiation (gm. cal./cm² /day)

radiation over south Gujarat, Maharashtra, Vidharbha and west Madhya Pradesh and (ii) a further drop in radiation over coastal Orissa, coastal Andhra Pradesh, Madras and Kerala.

November—Compared to October in north India above 19°N there is a general decrease in radiation except over Orissa where an increase is noticed. Over the Konkan, coastal Mysore and coastal Andhra Pradesh the radiation is found to increase. This trend also continues into coastal Kerala except over the extreme south where the radiation received is less than that in October. Over interior Mysore, interior Madras, Rayalaseema and Telengana the radiation received is the same as that in October. Over coastal Madras a further fall in radiation is noticed. Radiation lows are found to occur over interior Assam and West Pakistan.

December—In north India above 25°N a further fall in radiation compared to that received in November occurs. Over the rest of the country, but for an increase over southern Kerala the radiation field is more or less the same as in November.

Annual—In the Peninsula the radiation received is seen to be more or less uniform except for a well-marked drop towards Konkan, coastal



Figs. 9-12. Global radiation (gm. cal./cm² /day)

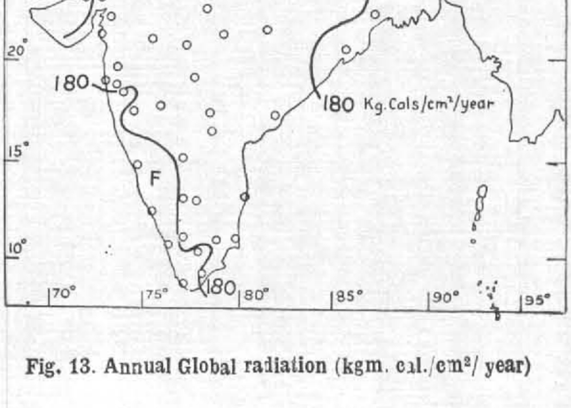


Fig. 13. Annual Global radiation (kgm. cal./cm²/ year)

Mysore and Kerala. The region of maximum radiation lies over Gujarat, Saurashtra and Kutch. A secondary maximum is also seen over north Punjab. In north India, in general, a southward and eastward decrease in radiation is noticed except over Jammu and Kashmir which constitutes a region of low radiation receipt.

3. Conclusion

1. The clear-day radiation values for India published by Ramdas and Yegnanarayanan are seen to be about 15 per cent higher than the observed values.

2. Even daily averages of percentage hour of sunshine can be used to build up a fairly good short-wave radiation climatology.

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