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Steadiness of average incoming long wave radiation

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ABSTRACT. Analysis of the pyrgeometer data on the incoming long wave sky radiation available in India shows that while there is variation in the mean value from month to month, the variation from hour to hour in a night and from year to year for the same month is quite small. The variations of the incoming long wave radiation run closely parallel to the variations in the precipitable water content of the atmosphere.

As pyrgeometer observations are not available outside India, the net radiation data between the hours 2200 to 0300 LAT for a number of stations in Asian and European U.S.S.R., Canada, Australia, England and Europe are examined for the year 1966. From this study it is inferred that the night time variation in sky radiation is quite small even in other parts of the globe.

1. Introduction

The outgoing long wave radiation from the earth's surface consists of thermal radiation at the temperature of the earth's surface and reflected radiation from the surface of the earth. The thermal radiation is given by Stefan's law. The albedo for long wave radiation, being independent of the nature of the reflecting surface, about 0·03 (Anderson 1954), can be estimated provided the value of the incoming long wave radiation is known.

Actual measurements of the incoming long wave radiation are generally made at night to avoid complications caused by the short wave fluxes. Estimates of long wave incoming radiation are generally made using empirical methods based on long wave sky radiation measurements made at night. Excellent reviews on this subject are available in the literature. The methods apart from being indirect are also very laborious.

2. Examination of data for India

Observations of sky radiation are made at a number of stations in India at the main synoptic hours of observation. Earlier work by Raman (1936) and Narayanaswami (1941) on night time variations of sky radiation at Poona and Bombay dealt with only 4 to 10 clear nights. It was, therefore, thought worthwhile to analyse the available data to see if the average values of the incoming long wave sky radiation (including cloudy and non-cloudy days) show any significant variations during night and whether the average monthly values vary from year to year. For this purpose, the mean monthly values of the sky radiation for the four night observations were taken and the percentage departure of the highest and lowest values from the mean value for the four hours of observations were worked out. This was done for all the stations using the readily available, tabulated data for the years 1964, 1965 and 1966. A longer series of observations from 1960-1966 were used to study the year to year variation of the long wave sky radiation.

The results show that there is very little deviation in the mean sky radiation between the four hours of observation. The variation between the years are also negligible.

3. Global studies

To determine if the nearly steady nature of the incoming long wave radiation observed at night at Indian stations is valid at other stations as well, an examination was made of the data from 27 stations in Asia, Europe and Australia. In the absence of pyrgeometer observations the net long wave radiation values were examined. Net radiation is the resultant of two large quantities, *viz.*, the incoming long wave radiation and the outgoing thermal radiation and small variations in atmospheric radiation result in large variations in net radiation.

Net radiation data for Indian stations were first studied. An examination of the variation of the departures (*i.e.*, highest *minus* lowest) of the net radiation at night from the mean, expressed as percentage of the mean for each month for all the Indian stations, showed that this extreme variation usually lies within 25 per cent. All these stations do not also, on an average, show any significant change in the incoming night long wave radiation with time at night. So at places where the variation of night net radiation lies within 25 per-cent, the incoming long wave radiation may also be expected to be steady.

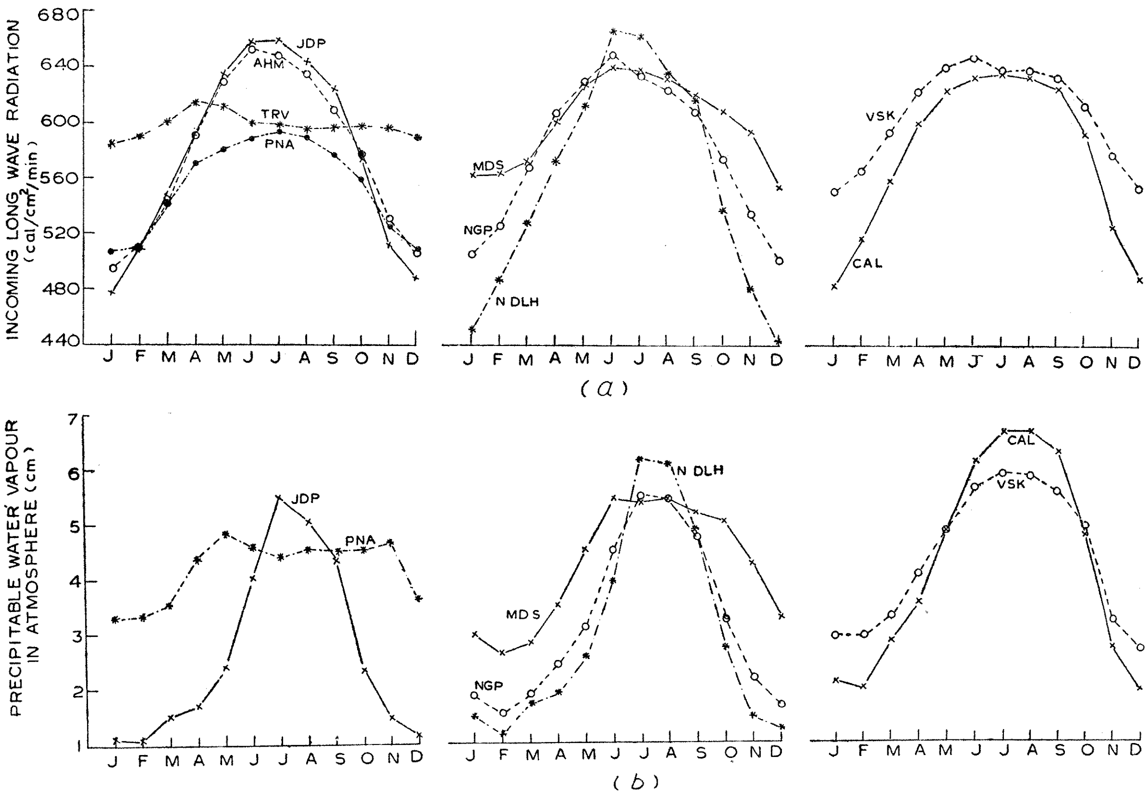

Fig. 1. Seasonal variation of (a) the incoming long wave radiation and (b) precipitable water vapour content

Net radiation data for 1966 for the period 2200 LAT to 0300 LAT for a number of stations lying between 60°N and 60°S latitudes in Asia and European USSR, Europe, Canada, Australia and Aden were analysed. It was found that in all the months in Aden, in about 90 per cent of the station—months in Asian USSR, Canada and Australia, in 80 per cent of the station—months in England, European USSR and 70 per cent of the station—months of Europe, net radiation has an extreme variation of less than 25 per cent from the mean. From a comparison of these findings with that for the Indian stations mentioned earlier, one can conclude that for all these stations the variations in the average incoming long wave radiation at night are quite small.

4. Some additional findings

The monthly distribution of long wave downward flux on clear nights at a number of stations based on data upto 1962 has been studied by Mani, Chacko and Iyer (1965). A few important additional characteristics of the mean monthly incoming long wave radiation observed in course of the analysis of the data are presented here.

Fig. 1(a) shows the mean monthly incoming long wave sky radiation measured at 2030 IST for the years 1960 to 1966. The stations are grouped into 3 sections, *viz.*, those lying between (*i*) 70° to 77°E (*ii*) 77° to 83°E and (*iii*) 83° to 90°E.

An examination of these figures reveal some interesting details —

1. The amplitude of the annual wave increases from south to north.

2. The southernmost and the northernmost stations (Trivandrum and Delhi) show the smallest and the highest month-to-month variation respectively.

3. Stations lying on the same latitude show the same annual pattern (*vide*, Ahmedabad, Nagpur and Calcutta, all of which lie near the 22°N latitude).

As the incoming long wave radiation is mainly a function of the total amount of water vapour in the column, its seasonal variations with the precipitable water content of the atmosphere were compared (Fig. 1b). Precipitable water data in the atmosphere below the freezing level have been taken from the unpublished work of Ananthakrishnan, Mary Selvam and Chellappa. (*See* Ref.). According to Kondrat'yev (1965), 90 per cent of the atmospheric emission comes from the first 600 m. Since carbon dioxide is well mixed in these layers one can expect the incoming long wave flux to be mainly influenced by the precipitable water in the lower layers of the air and this is clearly illustrated by the close parallelism in the variations of these two parameters at all the stations.

5. Conclusions

1. Climatologically speaking, there is very little variation in the incoming night long wave radiation with time at night.
2. Mean monthly values of the incoming sky radiation at a station in India show little variation from year to year.
3. The annual amplitude of the variation of night incoming long wave radiation increases from south to north.
4. The seasonal march of the incoming long wave radiation closely parallels that of the precipitable water content of the atmosphere.

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