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Radio refractive index associated with the onset phase of southwest monsoon

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सार — दक्षिणपश्चिम मानसून के आरंभिक चरण से संबद्ध करके 1980 और 1981 में एक तटीय स्टेशन, बंबई के लिए विचरण का रेडियो अपवर्तनांक अध्ययन किया गया है। देखा गया है कि बंबई में यह अपवर्तनांक मानसून के आगमन से तीन सप्ताह पूर्व विशेष कर 900 से 850 मि. बार वाले स्तरों पर जल वाष्प (N_m) की वजह से सार्थक वृद्धि प्रकट करता है। इसके बाद यह अपवर्तनांक प्राय: स्थिर हो जाता है।

ABSTRACT. Variations of radio refractive index (RRI) over a coastal station, Bombay, in association with the onset phase of southwest monsoon during 1980 and 1981 have been studied. It is observed that RRI due to water vapour (N_m) shows a significant rise particularly at 900 and 850 mb levels about three weeks in advance of the arrival of monsoon at Bombay. Afterwards the index is found to be more or less steady.

1. Introduction

The study of radio refractive index variation with height is of great importance to radio communication engineers and radio physicists. But the utility of this parameter is also of great importance to a meteorologist because it can be used as a synoptic parameter incorporating three variables — pressure, temperature and humidity.

Several workers have studied the variation of radio refractive index with different synoptic situations. Jehn (1960), Bean and collaborators (1959) had studied the RRI variation with extra tropical depressions of middle latitudes. Maheswari (1962) has discussed some features of RRI distribution associated with an active western disturbance. Venkataraman *et al.* (1963) have studied the RRI variations over a station with the passage of tropical cyclones and Srivastava (1963) with monsoon depressions.

In an earlier communication authors have studied the vertical variation of radio refractive index in the lower troposphere over Bombay. They reported that the radio refractive index gradient over Bombay falls into two broad groups, namely, monsoon and non-monsoon — the index value at different levels is higher in the former group. In the present work, more emphasis has been given to study the variation of radio refractive index in association with onset phase of southwest monsoon.

2. Data and calculation

The radiosonde data at 0000 GMT over Santacruz during the year 1980 have been used to compute the radio refractive index using the following relation (Smith and Weinturb 1953):

$$N = (n-1) \times 10^6 = \frac{77.6\,P}{T} + 373000\,\frac{e}{T^2}$$

where N is the modified radio refractive index (Kulshrestha and Chatterjee 1966). Other symbols have their usual meanings. Two terms on r.h.s. represent the contributions due to dry air (N_d) and water vapour (N_m) respectively. Thus $N = N_d + N_m$.

These two parts have been separated out and the results for the latter have been discussed.

3. Discussion of results

3.1. *Monthly variation of N_m at* 1000, 900, 850 *and* 700 *mb levels*

The wet component (N_m) of the radio refractive index was computed for *individual* ascents taken at 0000 GMT and monthly mean obtained.

Fig. 1 shows the monthly variation of mean N_m at four different levels 1000, 900, 850 and 700 mb over Bombay for the year 1980. From the figure, the following general observations are made:

(*i*) N_m in the lower troposphere shows an annual variation; being minimum during winter and maximum during monsoon months.

(*ii*) N_m at 1000 mb is lowest (about 70 N units) during February and increases gradually to

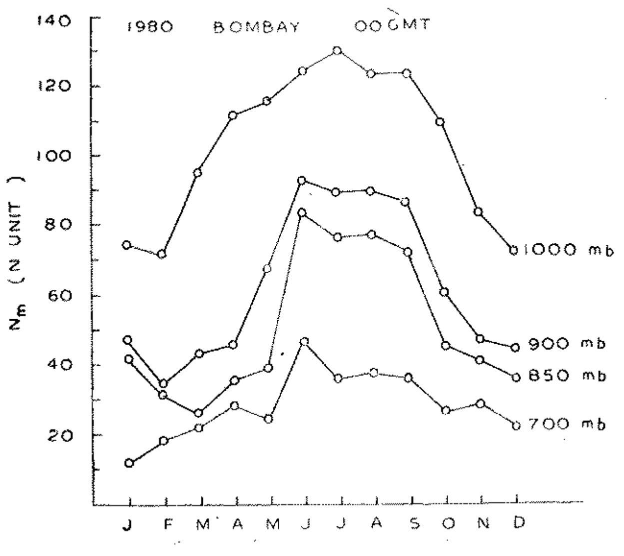

Fig. 1. Monthly variation of N_m at different levels over Bombay

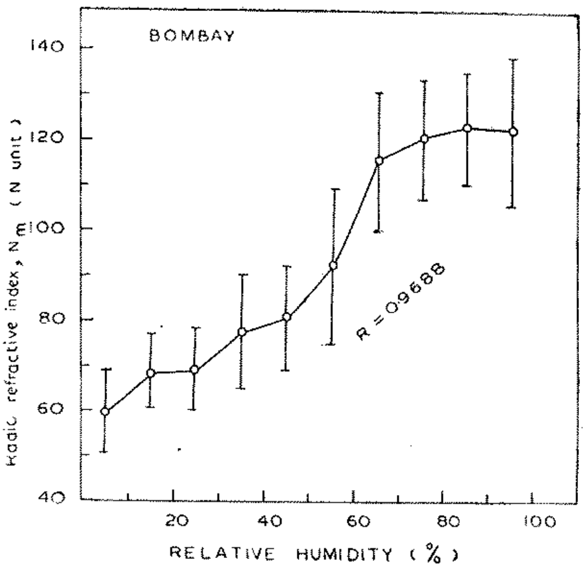

Fig. 3. Variation of N_m with R.H. at 1000 mb

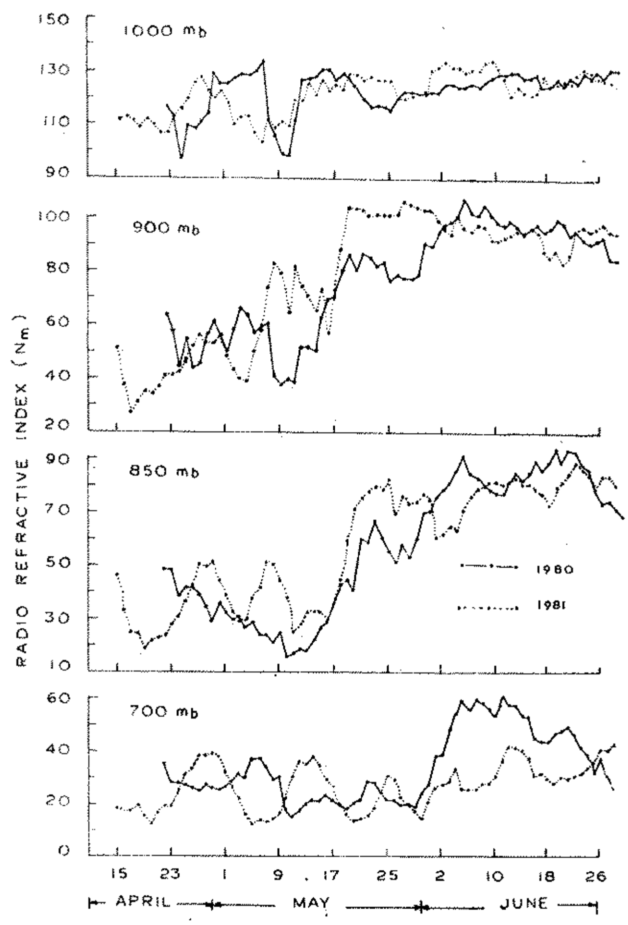

Fig. 2. Five-day moving average of radio refractive index (N_m) at different levels over Bombay

a value more than 120 N till June. Afterwards it does not show any significant change until September and then it decreases.

(*iii*) N_m at 900 mb is also minimum (about 35 N) during February but it shows a sharp significant rise (about 50 N units) from April to June and then no significant variation till September. Afterwards it also decreases.

(*iv*) N_m at 850 mb shows minimum (about 25 N units) during March and increases sharply from May to June. The decrease in N_m is observed after September.

(*v*) At 700 mb, N_m shows minimum (about 20 N) during January and shows less significant rise from May to June.

3.2. *Daily variation of N_m at* 1000, 900, 850 and 700 *mb levels*

From observations (*ii*), (*iii*) and (*iv*) made above, it was thought desirable that daily variation of N_m should be watched for its significant rise, particularly with the onset phase of monsoon. Since a single N_m value might not be a good representative of the day, the average of consecutive five-day N_m values has been considered more appropriate to show the trend of variation at the centred day. Further the analysis was extended and selected for the period from mid-April to third week of June for two years 1980 and 1981. Fig. 2 depicts the five-day moving average of the wet component (N_m) of the radio refractive index at different levels over Bombay. From the figure, the following inferences can be drawn :

(1) There appears an increase in (N_m) value at all the four levels – the increase being observed at 1000 mb first and subsequently at the high levels. The significant rise of about 40 N is observed at 900 mb and 850 mb levels between 15 and 20 May, which is well in advance of the arrival of the monsoon over the station.

(2) N_m shows more fluctuations at 1000, 900 and 850 mb levels upto the middle of May, and afterwards it becomes more or less steady. However, at 700 mb, fluctuation continues even after this period. This indicates that moisture content at this level may not reach a steady value.

(3) The steadiness of N_m is first observed at 1000 mb as compared to higher levels. The percentage steadiness (as evident from curves) is also higher at this level.

(4) The steadiness of N_m at 1000, 900 and 850 mb levels occurs at about 125 $\pm$ 10 N, 95 $\pm$ 15 N and 80 $\pm$ 20 N.

(5) The N_m gradient in the layer 1000-900 mb and 1000-850 mb appreciably decreases, as the above mentioned changes occur.

3.3. *Relation between R.H. and N_m*

From the second term of the Smith and Weinturb's relation, it is clear that its value, *i.e.*, N_m will depend upon *e* and *T*. As the effect of the variation of air temperature on RRI near the ground during April to June may not be so evident, it was considered worthwhile to relate the wet component (N_m) of the radio refractive index with relative humidity only. For this purpose relative humidity over Bombay for a large number of 00 GMT temperature data (TT and TdTd) at 1000 mb were extracted from the Hygrometric Tables. These were grouped in the ranges 1-10, 11-20, 21-30,.... 91-100 and mean of the corresponding N_m in each of these RH ranges were obtained. Fig. 3 shows the variation of wet component (N_m) with relative humidity (RH). Vertical lines show the standard deviations. From Fig. 3 the following points are observed at 1000 mb level :

(1) There is a high linear correlation 0.9688 between N_m and RH.

(2) N_m tends to a specified value between 50 and 60 N units as the RH decreases below 10%.

(3) There is a significant rise in N_m by about 25 N units with the increase of RH from 55 to 65%.

(4) Above 70% RH, the increase in N_m is not appreciable and it appears to be steady between 120 & 125 N.

It may be noticed from Figs. 1 and 2 that N_m at 1000 mb level reaches steady value at about 125 N units.

4. Conclusion

The period of significant rise in N_m and then attaining steady value, particularly at 900 and 850 mb levels may give a fairly advance indication of the arrival of monsoon over a station and this can be used as an indicator of the onset of monsoon.

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