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Seasonal variation of the Radio Refractive Index over India and neighbourhood

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ABSTRACT. From the mean monthly surface value of the radio refractive index, a reduced sea level value of the parameter has been computed and charts prepared for the four selected months of the year, *viz.*, February, May, August and November. A network of 62 stations in and near India has been utilized for this purpose. It is seen that the climatic differences are very prominently depicted by the variation in the value of the refractive index for these months. The maximum seasonal variation is observed in the northern and the central parts of the country. North-south and east-west cross-sections of the radio refractive index structure are also presented.

1. Introduction

The radio refractive index has been extensively used as a synoptic parameter or as a climatic characteristic as it has the advantage of combining the three variables of atmospheric pressure, temperature and humidity into one parameter. The utility of the radio refractive index as a synoptic parameter has been studied by the author in the case of a moving pressure system during winter months in north India (Maheshwari 1962). The present study is concerned with the seasonal variation in the average surface value of the refractive index for 0000 and 1200 GMT observations for India and neighbourhood. Analysis of the 12-hourly variation of the parameter which is also important from the view point of the climatic characteristic has also been attempted. As is well known there are two main air masses that play an important role (Roy 1946) in making of the climate of India. One is the air mass of the northeast monsoon season of the winter months and the other of the southwest monsoon of the summer months. The diversity of the air mass structure is very characteristically reflected in the relatively different annual ranges of the value of the refractive index, which could be profitably used to identify the different air masses.

2. Choice of the parameter and analysis of the data

It has become customary to determine the value of the radio refractive index (Smith and Weintraub 1953) with the help of the following formula —

$$N = (n-1)\,10^6 = (77\cdot 6/T)\,[\,p + (4810\,e/T)\,] = (77\cdot 6/T)\,[\,p + (4810\,e_s H/T)\,] \qquad (1)$$

where N is the modified refractive index, n is the radio refractive index, p is the total atmospheric pressure in mb, T is the temperature in °A, e is the vapour pressure in mb, e_s is the saturation vapour pressure in mb and H is the relative humidity in per cent. The above formula has been found to be valid in V.H.F. as well as in the micro-wave region. The C.C.I.R. has also recommended these values of the constants in the formula for calculation of the refractive index.

The value of the refractive index when referred to the station level pressure, temperature and humidity is denoted by the notation N_s. Due to the decrease of density with altitude, N_s also decreases systematically with it and it was observed that the coastal stations showed high values of N_s while stations in the Himalayan ranges exhibited the lowest values of the index. Thus in order to separate out the contribution of altitude it is essential to calculate the values of N_s reduced to zero level of the altitude, *i.e.*, to the sea level.

The average variation of density with altitude in the atmosphere may be approximately expressed by the formula —

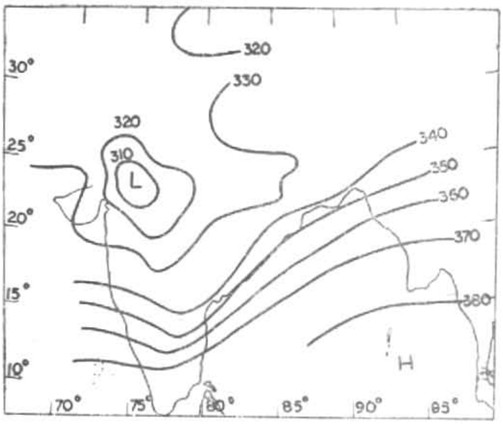

Fig. 1. Average N_0 structure for February 1961 (00Z)

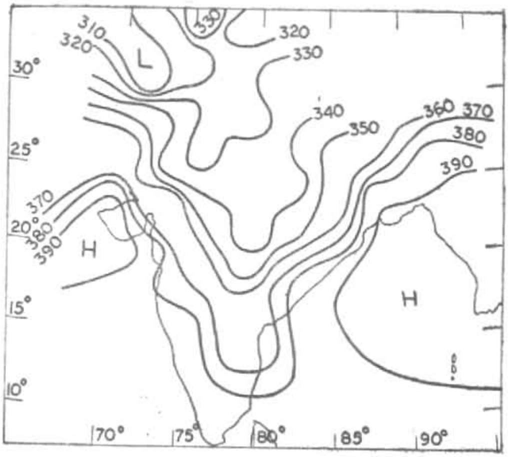

Fig. 2. Average N_0 structure for May 1961 (00Z)

$$\rho = \rho_0 \exp(-z/H) \qquad (2)$$

where z is the altitude, ρ_0 is the average sea level value of the density of moist air and H is the average scale height between zero and z. It has been shown that the average refractive index variation with height is well represented by the exponential formula similar to (2) above (Bean 1953). Each value of N calculated from the surface meteorological elements can be corrected by a positive quantity to obtain the value N_0 at sea level. It has also been shown (Bean 1962) that the following arbitrarily adopted reduced to sea level value of the refractivity,

$$N_0 = N_s \exp(h/7 \cdot 0) \qquad (3)$$

where h is expressed in kilometres, effectively removes the station level dependence of N_s and allows the emphasis of air mass differences. The above expression (3) has, therefore, been employed in the present analysis for calculating the values of N_0 from N_s.

In conformity with the recommendations of the study programme (V) of the C.C.I.R., the months chosen for the present study are February, May, August and November. For countries in the northern latitudes these months may represent the seasonal variation faithfully; it is, however, felt that these months may not be very representative in case of India. Perhaps a better picture may emerge from the month to month study of contours. Mean monthly meteorological data for the year 1961 for 0000 and 1200 Z observations have been utilized for the calculations of the surface value of N.

3. Average N_0 Charts

To give a proper coverage to all the regions in and around India, 62 stations were selected and as explained above the values of N_s for the months of February, May, August and November were first calculated from the mean monthly meteorological data. From the values of N_s thus obtained, the values of N_0 were computed by applying the formula (3) given above. These values were then plotted

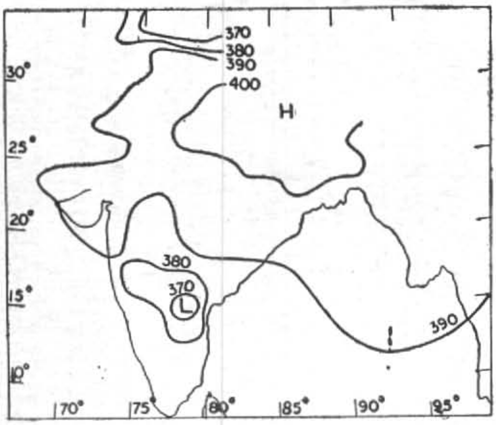

Fig. 3. Average N_0 structure for August 1961 (00Z)

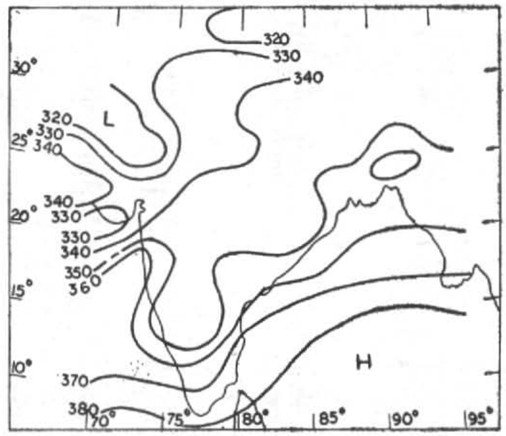

Fig. 4. Average N_0 structure for November 1961 (00Z)

on the maps of India and contours of the equal value of the index drawn.

Fig. 1 shows the average N_0 structure for the month of February. The minimum value of the contour is 310 units and occurs over south Rajasthan and adjoining parts of Gujarat and Madhya Pradesh. The value of the index increases progressively southwards along the coastal areas of Madras and adjoining Andhra Pradesh where the air mass in the northeast monsoon season is chiefly tropical maritime and is humid in the lower levels due to travel over sea.

Fig. 2 depicts the N_0 structure for the hot weather season of May. The gradient of the index is steeper and the lowest value contours shift towards north. The maximum value contours (390 N_0) lie along the coast of Gujarat and Bengal. In the central and northern parts of the country the contours of the index have values between 330 and 350 units. Fig. 3 exhibits the conditions during the month of August which might be taken as the representative month of the southwest monsoon season. The highest value of the index which is 400 N_0 units is found over Uttar Pradesh, Bihar, Bengal and the adjoining parts. The lowest values are found over Deccan area. Fig. 4 shows the N_0 structure during the post monsoon month of November.

4. Annual range of variation of the index

The annual variation of N_0 — the difference between the maximum and the minimum monthly means throughout the year — is shown in Fig. 5. The climatic differences are very clearly brought out by the annual range of N_0. The maximum range of more than 50—70 N_0 units is found in the central and northern parts of the country. Regions south of about 18° N show a variation of only 20—40 units. Figs. 6 and 7 depict the seasonal variation of N_0 for 0000 Z observations for a few selected stations. Fig. 7 is drawn for coastal stations. Except Bombay all the other coastal stations show a negligible variation throughout the year.

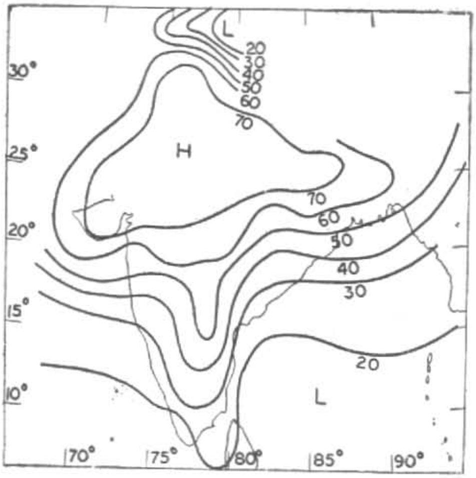

Fig. 5. Annual range of $\overline{N}_0$

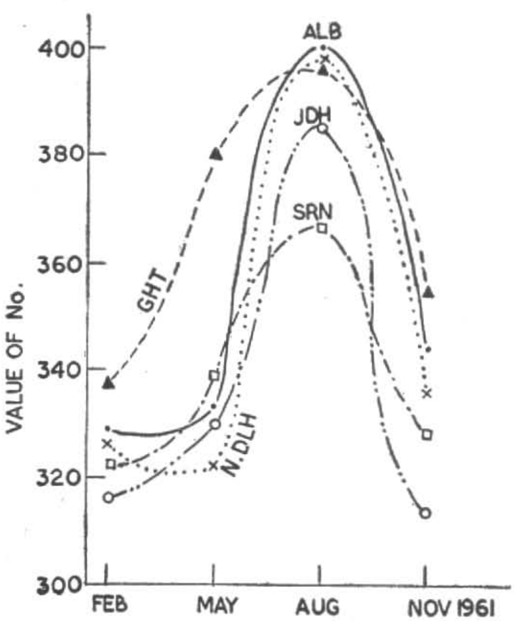

Fig. 6. Seasonal variation of N_0 (00Z)

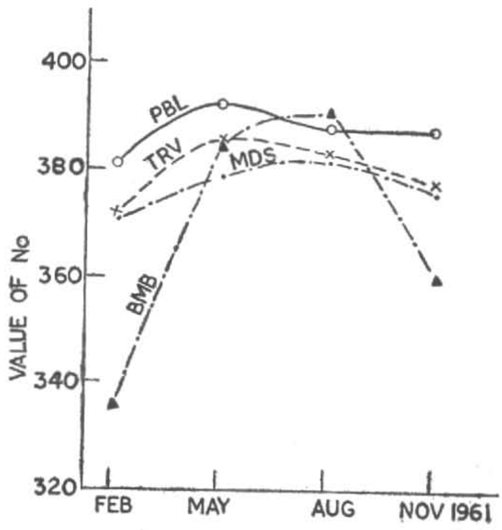

Fig. 7. Seasonal variation of N_0 (00Z)

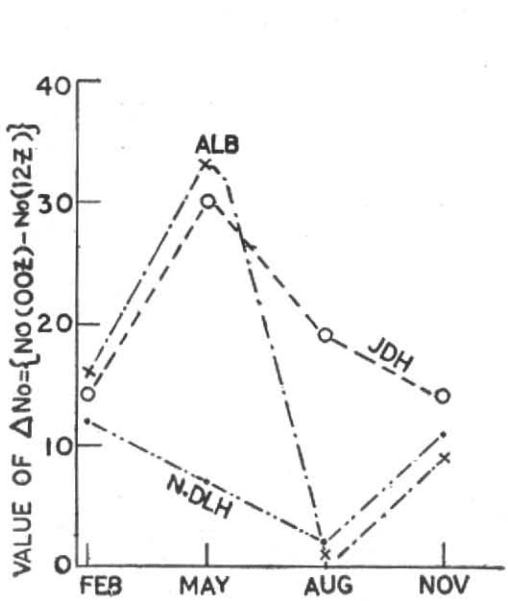

Fig. 8. 12-hourly (00Z-12Z) variation of N_0 for different seasons of 1961 — inland stations

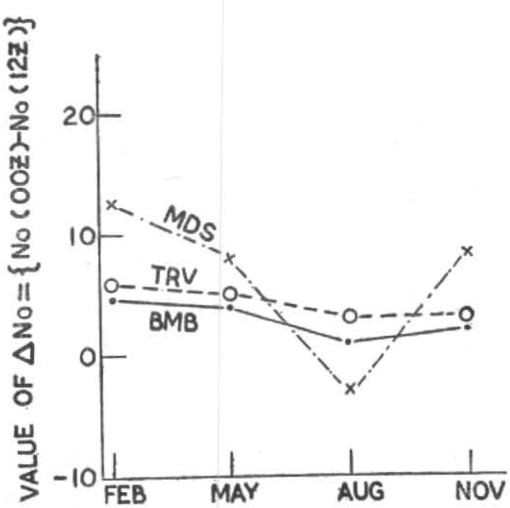

Fig. 9. 12-hourly variation (00Z-12Z) of N_0 for different seasons of 1961 — coastal stations

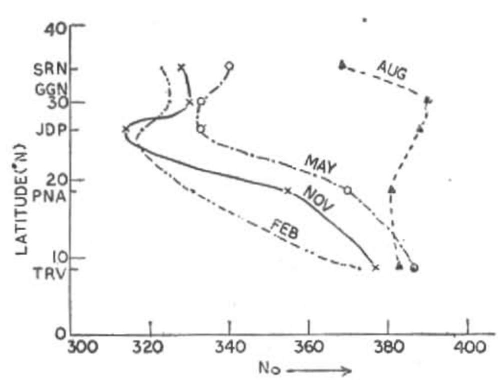

Fig. 10. North-South N_0 cross-section fo different seasons of 1961

Fig. 8 shows the 12-hourly variation of N_0 (obtained by subtracting the 1200 Z values of N_0 from the 0000 Z values of N_0) for the months of February, May, August and November. The same information is plotted for a few coastal stations in Fig. 9.

Fig. 10 brings out the north–south cross-section of N_0 for the different months. For this purpose Srinagar, Ganga nagar, Jodhpur, Poona and Trivandrum lying approximately along the same longitude were chosen. All the above diagrams are self-explanatory.

5. Acknowledgement

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REFERENCES

Bean, B. R.	1953	*Proc. Inst. Radio Engrs*, **41**, pp. 549-550.
	1955	*Ibid.*, **43**, pp. 1419-1429.
	1962	*Ibid.*, **50**, pp. 261-273.
Bean, B. R. and Cahoon, B. A.	1957	*Ibid.*, **45**, 11.
Maheshwari, R. C.	1962	*Indian J. Met. Geophys.*, **13**, 1, pp. 57-62.
Roy, A. K.	1946	*India met. Dep. Tech. Note.*, 16.
Smith, Jr., E. K. and Weintraub, S.	1953	*Proc. Inst. Radio Engrs*, **41**, p. 1035.