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Radio refractive index variations associated with the passage of two tropical cyclones

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ABSTRACT. Radio refractive index variations have been studied with the passage of two tropical cyclones. It is observed that the refractive index values show a marked rise upto about 800 mb with the approach of the cyclone and register a fall with its weakening.

1. Introduction

The prediction of refractive index conditions from the synoptic weather situation is receiving considerable attention on account of its utility in the study of propagation of electromagnetic waves. Arvola (1957) has examined some of the synoptic situations in the middle west of U. S. A. that gave super-refractive profiles. Recent studies by Jehn (1960) and Bean and collaborators (1959 a, b) were made with the extra-tropical depressions of the middle latitudes. Maheshwari (1962) has described some of the features of the radio refractive distribution associated with an active western disturbance and found that the behaviour of this system was analogous to the extra tropical depression wherein the refractive index showed a significantly high value in the warm sector and fell to a markedly low value in the cold sector. In the present communication, an attempt has been made to study the radio refractive index variations with height over a station, associated with the passage of two tropical cyclones. This would, therefore, enable one to anticipate the propagation characteristics of radio frequency waves with approach of a tropical cyclone.

2. Modified radio refractive index

The propagation of V. H. F. and U. H. F. radio signals depends upon the distribution of refractive index with height. A modified refractive index N given by

$$N = (n-1)\times 10^6 = \frac{77P}{T}\left(\frac{1+7\cdot 71q}{T}\right) \qquad (1)$$

where n is the usual radio refractive index, P the pressure in millibars, T the temperature in degree Kelvin and q the specific humidity expressed in gm/kg, is best suited for the study of the variations and has been used in the present study.

For the propagation of electromagnetic waves, the variations of refractive index with height are of great significance and therefore, an investigation has been made of the changes in the refractive index values from the time-section charts for Calcutta at the pressure levels of 900, 850, 800 and 700 mb in the case of two cyclones which crossed coast close to that station. The variations of the refractive index with the lower pressure values could not be studied since on some occasions the radiosonde ascents did not reach beyond 700 mb. A time-section has also been prepared for Allahabad which came under the influence of the low pressure area resulting from the northwesterly movement and the weakening of one of the cyclones.

3. Weather situation

Case I—A well marked low pressure area in the Bay of Bengal developed into a depression on 28 September 1959 with its centre within a degree of Lat. 18°N and Long. 89°E. This depression intensified into a severe cyclonic storm on 30 September centred about 250 km, south of Calcutta, with the associated cyclonic circulation extending at least upto 10 km. On 1 October, the cyclonic storm crossed the coast near Balasore and

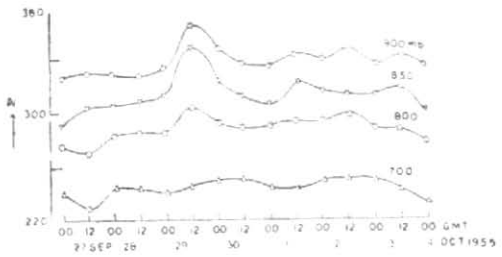

Fig. 1. Time-section of modified refractive index for Calcutta from 27 Sep to 4 Oct 1959

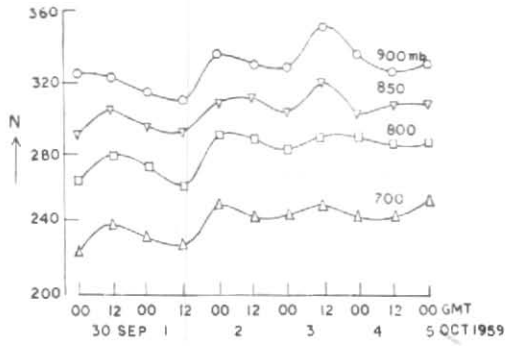

Fig. 2. Time-section of modified refractive index for Allahabad from 30 Sep to 5 Oct 1959

then weakened into a depression on 2 October with its centre near Daltonganj. On 3 October, it weakened further and lay as a low pressure area over Bihar and adjoining areas of east Uttar Pradesh and of West Bengal. It moved westnorthwestwards on 4 October and lay over east Uttar Pradesh, northeast Madhya Pradesh and Bihar. The low pressure area became diffuse on 5 October.

Case II—A low pressure area in the Bay of Bengal shifted northwards on 26 May 1960 and concentrated into a depression. It deepened on 27th and was centred as a deep depression at 0830 hours near Lat. 20·5°N and Long. 89°E and intensified into a severe cyclonic storm by the same evening. It crossed Sunderbans coast, weakened and lay on the morning of 28th as a cyclonic storm of small extent with centre within half a degree of Lat. 22°N and Long. 89°E; then it moved in a northerly direction, weakened further and lay as a deep depression with its centre within 50 km of Bogra on the 29th morning. The depression was breaking up over Assam hills on 30 May.

4. Results and Discussion

Case I—The time-sections for the modified refractive indices for the pressure levels 900, 850, 800 and 700 mb from 27 September to 4 October for Calcutta are given in Fig. 1. It may be noticed that N values registered a rise as the Bay depression intensified and approached the coast towards Calcutta. A significantly high value of N may be noted at the 900, 850 and 800-mb levels on 29 September at 1200 Z when the Bay depression was apparently intensifying into a cyclonic storm. On 30 September, although the cyclone was severe, N values had started showing a fall. With the weakening of the cyclone, N values also registered a fall. The slight irregular nature of the curves may be due to the temporary incursion of moisture from the Bay of Bengal, besides any other periodic variation which might be present. The refractive index variations decrease at higher levels and at 700 mb, N values are not sensibly affected even with the passage of a severe cyclone.

The time-sections for Allahabad from 30 September to 5 October for 900, 850, 800 and 700-mb levels are given in Fig. 2. It may be noted that N values showed a sharp rise with the approach of the low pressure area; N values reaching a maximum on the 3rd at 1200 Z. The changes are again large at the 900 and 850-mb levels, while at higher levels, namely 800 and 700 mb, the curves become rather flat. The earlier small rise on the 2nd morning apparently marks the position when the system started affecting Allahabad. The small irregular variations in the curves are no doubt due to diurnal and other effects. On comparison with the time-section at Calcutta it is seen that in the case of the low

pressure area, the marked changes in the refractive index distribution were confined upto 850 mb even at a place directly affected by the pressure system whereas the severe cyclone affected N values upto 800 mb even at Calcutta not directly in its path. This is obviously due to the transport of moisture to much higher levels in the more severe system.

Case II—The time-sections for Calcutta from 26 to 30 May 1960 for 900, 850, 800 and 700-mb levels are given in Fig. 3. It may be seen that N values showed a rise on 27 May at 00 Z, at 900, 850 and 800-mb levels when the depression in the Bay was intensifying into a cyclonic storm. At a lower pressure level, 700 mb, the curve again becomes rather flat. N values started falling with the weakening of the cyclone. Well marked decrease in the refractive index

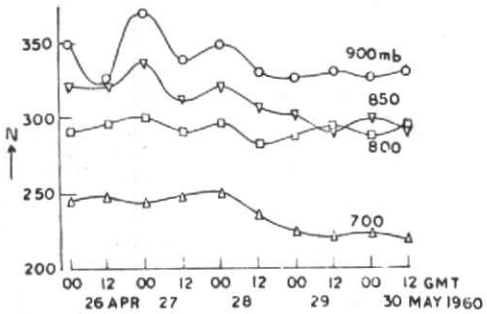

Fig. 3. Time-section of modified refractive index for Calcutta from 26 to 30 May 1960

values is observed at all the pressure levels on 29 and 30 May when the system had considerably weakened and had started breaking up. This is due to the fact that with the moving away of the system to the northeast of Calcutta, the moist currents over Calcutta were replaced by drier air.

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