EVIDENCE FOR INFRASOUND IN THE F-REGION ASSOCIATED WITH THUNDERSTORM ACTIVITY

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ABSTRACT

The events of short period phase height oscillations observed on 5-6 MHz pulsed signal at Waltair are identified as due to infrasonic waves in the F-region of the ionosphere. The occurrence of such events has been found to be associated with the local thunderstorm activity.

The existence of short period waves with periods of the order of a few tens of seconds to a couple of minutes is known on various occasions in the F-region of the ionosphere. These are identified as ionospheric manifestations of acoustic waves propagating from earth's lower atmospheric regions. Evidence from various investigations suggests that these waves are caused either due to natural sources or due to artificial reasons. This low frequency region of acoustic waves in the atmospheric wave spectrum is generally referred as infrasound or in infrasonic waves. Ionospheric oscillations due to infrasound ranging from 1 to 5 min periods with a prominence about 3 minutes is observed to be a special feature of waves associated with thunderstorm activity in the troposphere. This phenomenon has gained considerable interest in recent years giving evidence for the coupling of energy from troposphere into the ionosphere. All such earlier observations have come from mid-latitudes mostly from central United States. The aim of this report is to present experimental evidence for the events of infrasound in the F-region associated with thunderstorm activity observed for the first time at a low altitude station, Waltair (Geographic 17° 43' N, 83° 18' E, Geomag. 7° 24' N).

The investigations have been made from the measurement of phase path changes of F2-region echoes at vertical incidence on 5-6 MHz pulsed signal at Waltair. The experimental details and the method of analysis of phase path records are similar to those adopted by Reddy and Rao. The associated weather information is obtained from weather maps of India Meteorological Department (IMD).

When an infrasonic wave passes through the ionosphere the motion of neutrals are transferred to the electrons via collisions. The electron movement results in an up and down motion of reflection height of radio signals which in turn produces fluctuations in phase height of reflection and thereby causes corresponding reversals in phase path changes of the received signal. Fig. I (A, B, C, D) shows samples of phase path records of short period reversals depicting phase height oscillations of infrasonic order in the F-region. In Fig. 1A the time period between reversals is about 70 seconds which corresponds to a wave of about 2-3 minutes. Such a pair of reversals occur in the form of periodic signals as a sequence in the length of the record. When the echo contains both the 'O' and 'X' magnetoionic components the reversals due to each wave occur earlier on 'X' than on 'O' with a time delay of the order of a few couple of seconds. This is a consistent feature in case of each wave perturbation throughout the length of the record. Fig. 1B and 1C are two such samples from different records showing earlier occurrence on 'X' and latter on 'O' (indicated as T_X and T_O respectively) with a time delay of about 15 seconds in sample B and about 8 seconds in sample C. The wave period which is twice the time interval between the corresponding reversals is about 3-3 minutes in Fig. 1B and about 3 minutes in Fig. 1C. The observed short period oscillations with consistent earlier occurrence on 'X' (the reflection height of 'X' is less than that of 'O') suggest that they are caused by smaller period waves propagating preferably from lower regions. Also the pair of reversals corresponding to a wave at certain parts of the records have appeared only on

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"X" component and are absent on "O" component. One such sample of record is shown in Fig. 1D. The presence of wave oscillations only on "X" component further suggests that these waves travel from lower regions quite likely in an oblique way propagation, during which it is not traversing the "O" reflection point. This is because the "O" and "X" reflection points are different both in vertical as well as in horizontal planes. Taking the centre point of reversal as the time of occurrence the time delays in the occurrence of each wave perturbation between "O" and "X" is estimated from the original record. The observed time delays generally range from about 5 seconds to a maximum of about 20 seconds. The order of time delays indicates that these waves are travelling faster than the normally observed medium scale TIDs. Such a phenomenon is possible in the case of acoustic waves propagating from lower regions whose speeds are greater than that of medium scale TIDs of internal gravity wave origin.

Figure 2 shows a plot of phase path record for an event observed on 18 May, 1976 showing sequence of short period oscillations. These oscillations are superposed on a long period variation due to diurnal changes in the reflection height. To see the spectrum of the observed short period waves the long period changes are first removed by numerical filtering. Plot B in Fig. 2 is the filtered series of short period oscillations after removing the variations greater than the acoustic cut-off period which is taken as about 13 minutes in this case. These filtered series are subjected to spectrum analysis and the normalised amplitude spectrum is shown in Fig. 3A. The spectrum clearly indicates distinct prominent peaks showing the presence of waves at 2.4 minutes, 3.5 minutes and about 6 minutes, the last one being less prominent.

The meteorological conditions as observed from the weather maps of IMD for 18 May 1976 based upon the 12 GMT (1730 IST) observations are as follows. A low pressure area over the regions of Eastern Uttar Pradesh and Madhya Pradesh is found to exist with a prominent trough extending from it up to Tamil Nadu. The trough passes through Gondia, Wardha, Nizamabad, Raichur, Arogavaram and Tuticorin. Overlying this surface low, a cyclonic circulation has extended up to 1.5 km a.s.l. (above sea level) in U.P. and M.P. A trough has extended from this region up to Tamil Nadu along 80°E longitude at same level. Besides the above North-South trough, an East-West trough at 0-9 km is clearly seen to pass through Aligarh, Allahabad, Bhagalpur and Chirrapunji. Thus in this pre-monsoon period the above lower tropospheric troughs are the potential regions for the thunderstorm activity. Fig. 3B shows the weather distribution for the period of 1430 to 1730 IST on 18 May 1976. The symbols C, O and R indicate partly cloudy sky, overcast sky and thunderstorm activity respectively. From the figure, it is clearly seen that right over Visakhapatnam thunderstorm has been reported. Besides the above stations there could have been several other places where the thunderstorm activity is prevalent. As the above observatories are situated beyond 100 km distance apart, on a bad weather day, even some of the nearby thunderstorms may go unnoticed by weather observers unless radar pictures are taken on a regular basis.

In about 5 events phasepath records possessing the sequence of these short period oscillations have sufficient length of about 1 hour duration. This has facilitated to obtain the spectra in case of all these lengthy records. The details of all 5 events and the prominent spectral peaks in each case are shown in Table I.

From the knowledge of weather maps for all other events the synoptic situations and the thunderstorm activity have existed almost similar to the one described for 18 May, 1976 event, which clearly indicate a strong association for the observed short period oscillations. The season and the time of occurrence of these waves as it inferred from Table I are in accordance with the occurrence of peak thunderstorm activity in the evening hours during the pre-monsoon period. Phasepath records obtained during pre-monsoon period on all the days mentioned in Table I do not show the sequence of the short period oscillations.
This further supports the evidence of association of the short period waves with the thunderstorm activity which is more active in the evening hours.

The prominent period of waves of about 2 to 3.5 minutes in all the events in Table I is in close agreement with the preferred period of ionospheric oscillations due to propagation of acoustic waves associated with tropospheric storms\(^9\). The preference of ionospheric response to the observed narrow band of acoustic spectrum is suggested to be a combined effect of atmospheric filtering by refraction, absorption and acoustic cut-off effects\(^10\). The double peaks in the spectra might be a characteristic feature of wave generation mechanism in the oscillatory motion of cloud tops in the troposphere due to thunder cells\(^8\).

So far, such observations have not been reported from low latitude stations. As such the present investigation is a representative one for a low latitude station like Waltair. Attempts are in progress in correlating similar events with more direct evidence from radar weather maps.

The authors are thankful to the Cyclone Warning Centre of IMD, Visakhapatnam, for providing necessary weather information.