Fading at 27 kHz atmospherics due to winter depression

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The VLF atmospherics at 27 kHz over Kalyani (West Bengal) during winter depression exhibit distinct long period fadings both at day and night. Results obtained from the round-the-clock atmospherics data and associated meteorological parameters are reported. Some interrelationships between the magnetic activity, fadings and violent storms are indicated. The origin of the fading pattern is critically discussed considering the gravity wave perturbations affecting the lower ionospheric characteristics.

1 Introduction
The study of winter depression in the tropical region has been a subject of great interest in recent years. It is well known that the solar energy reaching the earth and its atmosphere is the prime source of meteorological activities. King suggested that the earth's magnetic field may influence the behaviour of the lower atmosphere through some unknown mechanism which causes climatic variations. The present paper deals with an abnormal characteristics of atmospherics associated with winter depression as noticed during 8-10 Nov. 1995 over Kalyani (lat., 22°58'N; long., 88°28'E). Some interesting results obtained from the analysis are reported here. The results obtained are important to carry out correlation studies of atmospherics with several parameters of basic importance.

2 Observations
Figure 1 shows the records of atmospherics as observed during the winter depression in the Bay of Bengal including two dates before its onset. The records clearly show a long period fading in the noise level both during day and night. Such fading starts, as evident from Fig.1, two days prior to the onset of the depression. From the analysis of the atmospherics record the following results are obtained:

(i) The number of fades during midnight-midday period is considerably higher than that noticed during midday-midnight. In the night hours, between 1800 hrs IST and midnight, the number is only a few. The model group during daytime lies in between 0730 and 0900 hrs IST, while that during nighttime lies in the range 0130-0300 hrs IST.

(ii) For the majority of the cases (>50%) the duration of a fade varies from 15 to 60 min, while its amplitude varies from 5 to 20 dB. The amplitude of a fade, in general, tends to increase with its duration.

2.1 Meteorological activity
Observations of maximum and minimum values of temperature and relative humidity as well as the total rainfall recorded during 8-10 Nov. 1995 are presented in Table 1.

The deep depression of 8 Nov. 1995 originated from west-central bay moved north-westwards and intensified into a severe cyclonic storm and lay centre on 8 November evening almost 900 km south-west of Calcutta. It was then intensified further and moved in a north-westerly direction and crossed north-Andhra south-Orissa coast between Kakinada and Puri by 9 November evening. The severe cyclonic storm over the Bay of Bengal crossed the coast close to Gopalpur of Orissa on 9 November. The system moved in northerly direction, gradually weakened and lay centred in the evening as a cyclonic storm over north Orissa, about 300 km west of Calcutta. The system on 10 November moved in a northerly direction and weakened further.
3 Long period fading and geomagnetic activity

It is interesting to note that the long period fadings noticed in the atmospherics record reveal a dependence on geomagnetic activity. The deep depression of 8 Nov. 1995 and the associated character figure show that the $C_p$ values from 4 to 8 November were as high as 0.6, 1.0, 1.1, 0.5 and 0.3, respectively. From these observations, it appears that there might be some interrelationship between the magnetic activity, fadings and violent storms.

In the present analysis we have also considered energetic solar particles and plasma data corresponding to a few days prior to the severe winter depression considered. A series of data plots are presented in Fig.2 surrounding the dates of winter depression of 8-10 Nov. 1995, using the data obtained by the NASA spacecraft IMP8. The purpose of the plot is to convey as near continuous a basis as possible the state of the interplanetary particle environment. The plots consist of hourly averaged solar wind plasma parameters and representative fluxes of energetic proton particles. In an actual experiment two spacecrafts (IMP 7 and IMP 8) were instrumented to measure the plasmas, fields and energetic particle fluxes found in the interplanetary medium and in the distant magnetosheath and magnetotail. Plasma plots contain data only for hours during which the appropriate spacecraft was beyond the earth's bow shock. Hourly averaged plasma parameters (bulk speed, proton number density, most probable thermal speed) were determined from the MIT plasma experiments. It may be noted here that the thermal speed plot has scales for both speed and temperature. Figure 2 clearly represents the variation of bulk speed, proton number density and most

<table>
<thead>
<tr>
<th>Date (in Nov. 1995)</th>
<th>Temp (°C)</th>
<th>R.H. %</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>At 8.30 a.m.</td>
</tr>
<tr>
<td>06</td>
<td>32.5</td>
<td>20.0</td>
<td>82</td>
</tr>
<tr>
<td>07</td>
<td>32.7</td>
<td>20.7</td>
<td>93</td>
</tr>
<tr>
<td>08</td>
<td>31.7</td>
<td>23.4</td>
<td>91</td>
</tr>
<tr>
<td>09</td>
<td>23.9</td>
<td>22.7</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>29.6</td>
<td>23.6</td>
<td>100</td>
</tr>
</tbody>
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probable temperature for different dates. The hourly averages are based on preliminary plasma parameters computed by fitting the observations to a convected, isotropic Maxwellian distribution function. It is interesting to note from a close scrutiny of the figure that there is a simultaneous fluctuation of all the above parameters showing an enhanced value just prior to the violent depression. The long period fading as noticed at 27 kHz atmospherics at such times believed to originate from the energetic solar particles and plasma which, in some way, initiate and stimulate the lower ionosphere.

4 Discussion

It is likely that at such times the sources of lightning flashes due to depression serve as a localized transmitter. Observations by Gherzì\(^2\), in fact, revealed that long period oscillations in the level of atmospherics often occur when a thunderstorm centre becomes active within a range of 300-600 km from the observing station. Centre of the concerned winter depression is likely to produce atmospheric gravity wave perturbations which may affect the lower ionospheric characteristics. Direct evidence of coupling of energy from the troposphere into the ionosphere has also come from observations of the temporal variations in the phase and frequency of ionospherically reflected radio waves\(^3\). It was suggested that the air movements in thunderstorms might generate acoustic gravity waves which could reach ionospheric heights and also an apparent relationship between certain ionospheric disturbances like TID (Travelling Ionospheric Disturbances) and the occurrences of severe weather in the troposphere are expected\(^4,5\). It was assumed that such disturbances might be due to the perturbation of the electron density in the ionosphere by gravity waves in the neutral atmosphere which have propagated upward from below and then travel horizontally, affecting the lower ionospheric characteristics. Observations indicated that energy flux of \(10^{-3}\) Wm\(^{-2}\) at ionospheric heights derived from the tropospheric disturbances is sufficient to produce changes in the number of ions per cm\(^3\). It may well be that the depression analyzed being very severe is responsible for the tropospheric disturbances. Their effects on the ionosphere remain unobscured by any superposition of gravity wave perturbations, causing the observed long period fading\(^6\).

When such powerful disturbances occur at a sufficiently remote location the effects on the VLF atmospherics may not be recognizable in the presence of normal atmospheric noise. We have, in fact, noticed short period fading when the centre of activity is at far off places. Previous reportings of fading\(^7,8\) were made only during nighttime. In the present case, the fading was noticeable both during day and night, which appears to be an indication of violent nature of the disturbances producing gravity wave perturbations at a rather low ionospheric heights.

From the analysis it also appears that the gravity wave perturbations in some way initiate and stimulate the meteorological activity in the region. Even the long period fading of VLF atmospherics observed at such times believed to originate from the gravity wave perturbations affecting the lower atmosphere\(^9\).

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**References**