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Fading of VLF atmospherics associated with torrential rain due to monsoon depression*

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सार — 1976 में उग्रमानसून अवदाब के कारण मूसलाधार वर्षा के दौरान कलकत्ता पर के वी० एल० एफ० वायुमंडलिकी प्रलेख रात और दिन दोनों में भिन्न–भिन्न दीर्घावधि क्षीणन दर्शाते हैं। इस लेख में दिन रात के वायुमंडलीय आंकड़ों और संबध मौसम प्राचलों का विश्लेषण करके रोचक परिणामों को रिपोर्ट किया गया है और एक अस्थाई निष्कर्ष निकला है कि क्षीणन का मूल मानसून अवदाब की सक्रियता के केन्द्र में जनित वायुमंडलीय गुरूत्व तरंग है।

ABSTRACT. The records of VLF atmospherics over Calcutta during the torrential rainfall due to violent monsoon depression in 1978, exhibit distinct long period fadings both at day and night. Interesting results obtained from an analysis of the round-the-clock atmospherics data and associated meteorological parameters, are reported in this paper. A tentative conclusion is reached suggesting an origin of the fading from atmospheric gravity waves generated in the centre of activity of the monsoon depression.

1. Introduction

The study of monsoon activity in the tropical region has been a subject of great interest in recent years. During the southwest monsoon season (June to September) the rainfall over large parts of India fluctuates between epochs of heavy and light rainfall. A period of heavy rainfall is usually known as active monsoon and that of light rainfall, as weak monsoon (Paul and Sikka 1976). The present paper deals with an abnormal characteristic of 'active' monsoon as noticed during 27-30 September 1978, when a heavy to very heavy rainfall was experienced in in and around Calcutta causing a devastating flood in West Bengal. The incessant and torrential rain received during these days was, in fact, the century's heaviest rainfall. With a view to study this anomalous behaviour of monsoon in relation to cloud discharges we were prompted to study our round-the-clock records of VLF atmospherics. Some interesting results obtained are discussed here.

2. Equipment

The receiver used to record atmospherics at 30 kHz was constructed with a large dynamic range with a view to handling a fairly wide range of field intensities originating from local sources. The charging and discharging time constants of the receiver were 3 sec and 25 sec respectively with an overall bandwidth of 1 kHz.

3. Analyses and results

The atmospherics records during the period are shown in Fig. 3. The upper one, marked (a), exhibits the general diurnal variation noticed on a day when Calcutta was free from rainfall but the depression was situated at a far distance. The remaining four records, (b), (c), (d) and (e), are as observed during the heavy rainy days. The records from (b) to (e) clearly show a long period fading in the noise level both during day and night. The date-wise number of

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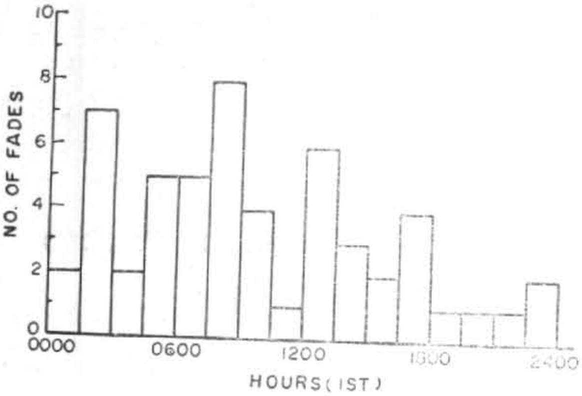

Fig. 1. Diurnal occurrences of the fading pattern during the four disturbed days

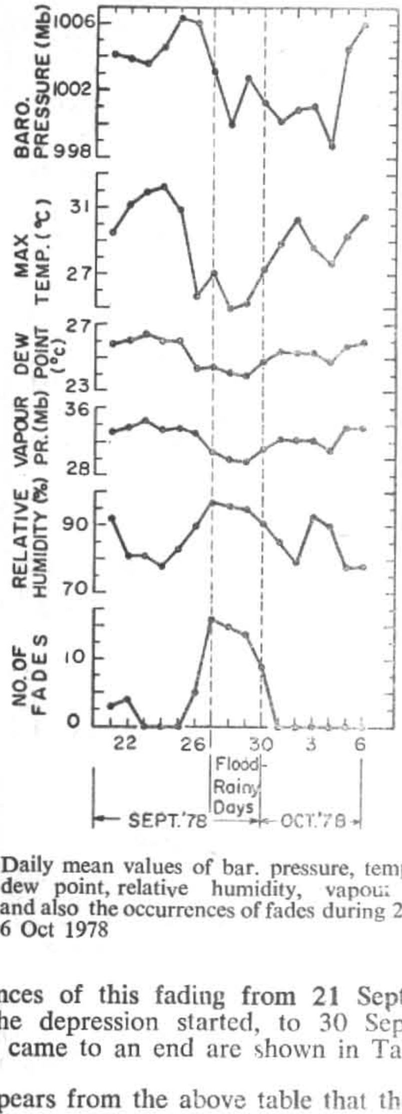

Fig. 2. Daily mean values of bar. pressure, temperature, dew point, relative humidity, vapour pressure and also the occurrences of fades during 21 Sep to 6 Oct 1978

occurrences of this fading from 21 September, when the depression started, to 30 September when it came to an end are shown in Table 1.

It appears from the above table that the overall number of fades during day is larger than those at night. Again the occurrences are found to be maximum on 27 September, the first day of the heavy ranifall in Calcutta.

TABLE 1

Fadding occurrences during 21-30 September 1978

	Dates									
	21	22	23	24	25	26	27	28	29	30
Day-time fades	0	0	0	0	0	0	10	10	6	8
Night-time fades	3	4	0	0	0	5	6	5	8	1

TABLE 2

Observed meteorological data during the four disturbed days

Date & time of obsn. (IST)	Factors					
	Bar. press. (mb)	Temp. (°C)	D.P. (°C)	R.H. (%)	V.P. (mb)	Rain-fall (mm)
27 Sep 0830	1005.1	31.9	24.9	098	31.5	223.9
1130	1004.1	24.4	23.8	096	29.5	
1730	1000.5	25.0	24.7	098	31.1	
28 Sep 0830	1000.8	25.0	24.0	096	29.8	369.6
1130	1000.4	25.0	24.1	095	30.0	
1730	0998.9	25.0	24.1	098	30.0	
29 Sep 0830	1004.0	25.0	23.9	098	29.7	129.3
1130	1002.8	25.4	24.2	093	30.2	
1730	1001.7	25.5	23.7	095	29.3	
30 Sep 0830	1003.3	25.5	24.2	093	30.2	004.9
1130	1001.8	28.0	25.4	086	32.4	
1730	0998.8	28.3	24.7	095	31.1	

D.P. = Dew Point, R.H. = Relative humidity, V.P. = Vapour pressure.

The distribution of the diurnal occurrences of fades during 27-30 September are presented in Fig. 1, which shows that the model group during daytime is in the range 0730-0900 IST while during night-time it lies between 0130-0300 IST. It is also seen that the occurrences of the fade is considerably higher during midnight to mid-day period than those during mid-day to mid-night.

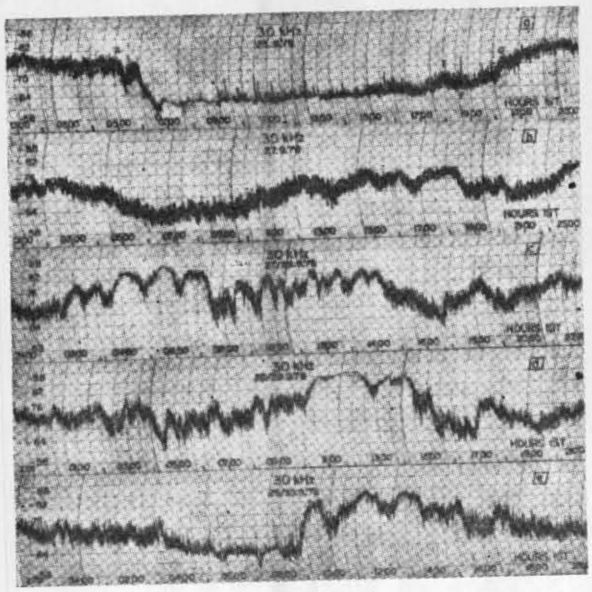

Fig. 3. Atmospherics record as observed over Calcutta. The ordinates show the intensity level in dB above 1 μV/m

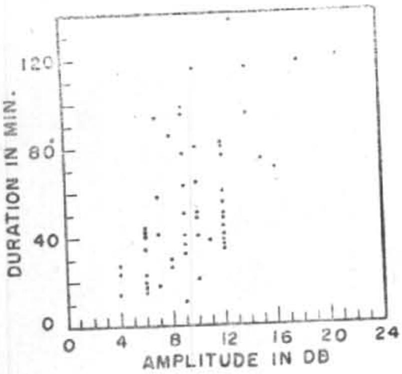

Fig. 4. Scatter plot showing the duration and amplitude of fades

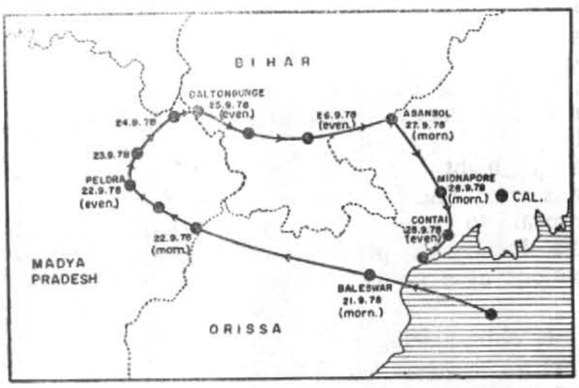

Fig. 5. A schematic diagram showing the track of the depression

Observations of barometric pressure, temperature, dew point, vapour pressure and relative humidity at three specific hours of a day from 21 September to 6 October considering a few preceeding and following dates surrounding the four flood-rainy days have been taken into account. Their mean values are plotted in Fig. 2. The number of occurrences of the fades against the corresponding date are also shown in the same figure. The figure clearly shows that there is an almost simultaneous fluctuations of all the above parameters during the monsoon top activity of 27 to 30 September 1978. The above allied meteorological parameters of interest as recorded during the four disturbed days over Calcutta at three specific hours 0830 (morning), 1130 (noon) and 1730 (evening) in addition to the 24 hours' rainfall ending at 0830 for each of the date are presented in Table 2.

The scatter diagram of fades having different durations and amplitudes for the four disturbed days have been plotted in Fig. 4. The figure shows that the duration of a fade varies from about 15 to 120 minutes with a majority of cases ($>$ 50 per cent) during 15-60 minutes while the amplitude of the fade varies from about 5-15 dB with most of the cases occurring in the range of 5-10 dB. The figure also shows that the amplitude of the fade tends to increase with an increase of the duration, in general.

4. Discussion

It appears that the occurrences of the long period fading is noticed mainly during the active monson days. It is likely that at such times the sources of lightning flashes due to depression serve as a localised transmitter. Observations by Gherzi (1961), 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. Centres of monsoon depression are likely to produce atmospheric gravity wave perturbations which may affect the lower ionospheric characteristics (Hines 1963, Sen *et al.* 1973, Sen *et al.* 1977, Hung *et al.* 1978). Direct evidence for 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 (Barry *et al.* 1966, Baker and Davies 1968). Pierce and Coroniti (1966) suggested that the air movements in thunderstorms might generate acoustic gravity waves which could reach ionospheric heights. Georges (1968) pointed out an apparent relationship between certain ionospheric disturbances and the occurrences of severe weather in the troposphere. He suggested that such disturbances might be due to perturbation of the electron density in the ionosphere by gravity waves in the neutral atmosphere which have propagated upward from below. That such waves can reach ionospheric heights had also been well established by studies of the effects of low altitude nuclear explosions (Baker and Davies 1968). Observations by Gossard (1962) indicated that energy flux of 10^{-3} watts m^{-2} at ionospheric heights derived from the tropospheric disturbances is sufficient to produce changes of ionisation. It may well be that the depression causing the heavy rain, in the present case, induced gravity wave perturbations in the lower ionosphere causing the observed long period fading. In fact, the range of fade period 15-120 min. in our observations is comparable to that of gravity wave perturbations with periods in the range 10-200 min. noted by Gossard (1962).

It may be noted here that the tropospheric disturbances in the present case being very severe and isolated in nature, its effect on the ionosphere remain unobscured by any superimposition of gravity wave perturbations from any minor disturbances around the centre of activity of the depression. Again, 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 no long period fading when the centre of activity is at far off places such as that between 23rd and 25th. Previous reportings of fading (Sachdev 1958, Gherzi 1961, Sen 1967) were made only during night-time. In the present case, the fading was noticeable both during day and night which appears to be an indication of violent nature of the disturbance producing gravity wave perturbations at a rather low ionospheric heights.

It is interesting to note here that the depression concerned has got an early history of development starting outside West Bengal on 21 September 1978. The origin of the depression was in the Bay of Bengal and came throgh Orissa, Madhya Pradesh and Bihar, as shown by the Schematic diagram (Fig. 5), to West Bengal (Asansol) on 27 September in the form of a cyclone in association with heavy and widespread rain. One would expect long period fading similar to that of ours if the observing stations are located in the vicinity of the track. A simultaneous multistation study at such times would be very informative. Occurrences of the long period fading both during day and night appear to be an indication of violent monsoon activity.

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