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VLF atmospherics in relation to winter thunderstorms

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ABSTRACT. Simultaneous studies on 10 and 20 kHz over the tropical region Calcutta show that VLF atmospherics are intimately related with winter thunderstorms. In the record, the sudden enhancement of the integrated field intensity of atmospherics preceded by an initial gradual rise seems to be closely associated with the developmental stage of thunderclouds while the steady recovery marking its decay starts with a sudden decrease indicating the vanishing of its bipolar structure associated with rainfall. The maximum activity of winter thunderstorms as indicated by the atmospherics occur at local afternoon.

1. Introduction

It is now well established that electromagnetic radiation in the form of atmospherics due to lightning discharges is connected with different types of thunderstorms (Schonland *et al.* 1940, Kimpara 1955, Das Gupta and Sen 1965, Sen 1967, Taylor 1973). Usually very few thunderstorms occur in the winter season and hence their properties in relation to the associated atmospherics have not yet been well studied (Takeuti *et al.* 1973, 1976). In fact, as far as is known to the authors no such clear investigation has been made in India regarding the winter thunderstorms and the associated atmospherics. This prompted us to examine our daily records of the integrated field intensity of atmospherics (IFIA) over the tropical station, Calcutta (Lat. 22° 34'N, Long. 88°24' E) during the last winter season, November to February 1976/77.

2. The present study

The receivers used to record IFIA at two harmonically related frequencies, *viz.*, 10 kHz and 20 kHz simultaneously are basically tuned R. F. receivers, each of which is followed by a D. C. amplifier which feeds the pen recorder through an integrating circuit. The aerial used is of the inverted L-type with vertical and horizontal lengths 10 m and 50 m respectively. The aerial is connected through a rejector circuit for rejecting the unwanted signal components and is fed to the two receiver inputs by employing a cathode follower aerial mixer unit.

From a careful study of our daily records of IFIA for the winter season an unusually large enhancement of atmospherics following an initial gradual rise was noticed before the onset of a thunderstorm. During the winter months under consideration four such cases were observed over Calcutta. Figs. 1(a) and 1(b) show the typical records of IFIA at 10 kHz and 20 kHz respectively exhibiting the enhancements observed in presence of winter thunder clouds at our station. It is evident from the typical records that the initial gradual rise and the subsequent sudden enhancement occur at 1101 and 1150 I.S.T. respectively while the steady recovery starts with a sudden decrease at 1340 I.S.T. simultaneously at both the frequencies. Results of the analysis of the data are shown in Table 1.

It is evident from the above table that (*i*) starting time of initial gradual rise and the sudden enhancement of IFIA precede the reported onset time of thunderstorm by 2-3 and 1-2 hr respectively and (*ii*) the respective values of the rise time and the recovery time lie in the range 1-2 hr and 15-30 min.

The sharp rise of IFIA seems to be closely associated with the onset of precipitation during the initial stage of the development of a winter thundercloud. The difference of time between the start of initial gradual rise of atmospherics and that of the thunderstorm is probably due to the gradual building up of the thunderclouds overhead. In the final stage of the development of thunderclouds the observed steady recovery starting with a sudden decrease associated with heavy rainfall may be explained by considering the

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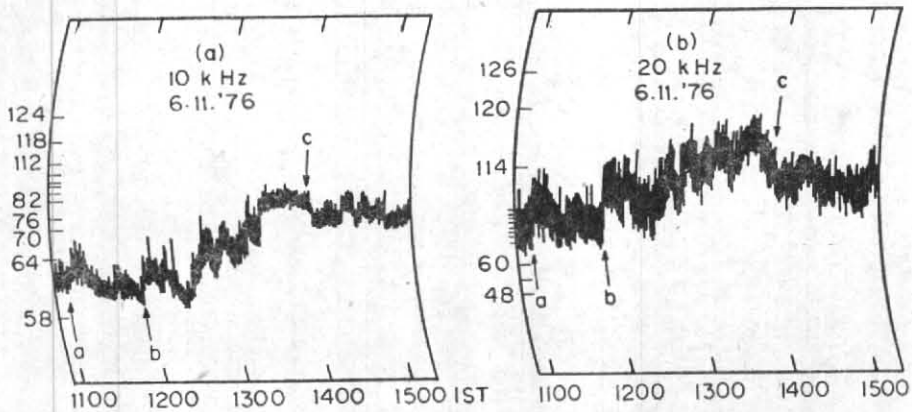

Figs. 1 (a) & (b). IFIA on a day when a severe thunderstorm was experienced over Calcutta (a : initial gradual rise, b : sudden enhancement, c : steady recovery starting with a sudden decrease). The ordinate shows the r.m.s. field strength for a 1 kHz bandwidth in decibels above 1 μV/m.

TABLE 1

IFIA at 10 kHz and 20 kHz in relation to winter thunderstorms

Date of observations	Onset times of			Total rise time		Recovery time (min)	Reporting time of thunderstorm (TS) (IST)	Delay between GRA & TS		Delay between SEA & TS	
	Gradual rise of atmospherics (GRA)	Sudden enhancement of atmospherics (SEA)	Steady recovery of atmospherics (SRA)	hr	min			hr	min	hr	min
6 Nov 76	1,101	1,150	1,340	2	25	22	1,230	1	29	—	40
16 Jan 77	1,105	1,154	1,425	1	10	16	1,350	2	45	1	56
23 Feb 77	1,155	1,252	1,530	1	22	35	1,450	2	55	1	58
25 Feb 77	0,435	0,548	0,835	1	35	20	0,710	2	35	1	22

vanishing of the bipolar structure of thundercloud due to the falling out of charged rain (Sen 1966).

It is important to note here finally that the activity of local thunderstorms in association with atmospherics reaches its maximum at local afternoon over Calcutta while that observed over the ocean near Japan was found to be at local midnight (Krumn 1962, Sao *et al.* 1972). This difference of time may be explained by the particular geographical location of the observatories and may, infact, depend on whether a thunderstorm occurs over land or sea and it requires a thorough investigation with a large number of such incidents.

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