Mausam, (1980), **31**, 3, 465-468

551.515.4 : 551.553.11

Sea-thunderstorms and associated atmospherics

S. K. SARKAR and A. B. BHATTACHARYA

Department of Physics, University of Calcutta, Calcutta

(*Received 8 February 1979*)

ABSTRACT. It is shown that the occurrence of sea-thunderstorms in the Bay of Bengal, as observed by a radar study, is frequently associated with an increase in the integrated field intensity of atmospherics recorded over Calcutta at 10 and 20 kHz simultaneously. Some of the interesting results obtained from an analysis of the observations during June 1976 to May 1978 are reported in this paper and the results are discussed in the light of the present knowledge of sea-thunderstorms.

The first observation of the field intensity of atmospherics at night over Calcutta (22° 34′ N, 88° 24′ E) during June 1976 to May 1978 due to night-time thunderstorms in the Bay of Bengal is being reported here. The records were taken by using two T.R.F. receivers constructed with some modifications of the design adopted by Ellison (1955) to have a wide dynamic range in the VLF band at 10 and 20 kHz simultaneously. The night-time radar data of sea-thundercells for the same period have been obtained from local meteorological observatory. Usually the cloud cells owe their origin to scattered precipitation echoes as seen on the PPI scope which after sometimes increase in number and size to form a full fledged storm. Some of the typical records showing the effect of sea-thunderstorm on the record of night-time atmospherics hereinafter referred to as 'night-time effect' are reproduced in Fig. 1. The corresponding polar diagrams showing radar observations of thundercells observed over the Bay of Bengal are represented in Fig. 2 to document more explicitly the relationship between thunderstorms and atmospherics. Each record of 'night-time effect' embodies a first enhancement and then a distinct fall. In between these two variations there is a nearly steady level, in general. The records further reveal that the effect starts simultaneously at both the frequencies but with different magnitudes. During the period the total occurrences of the 'night-time effect' in Calcutta and the nights showing thundercells over the Bay of Bengal are given in Table 1.

TABLE 1

Number of nights showing 'night-time effect', sea-thundercell or common events during 1976-78

Period (1-yr)	'Night-time effect'	Sea-thundercell	Common events
1976-77	94	86	81
1977-78	110	97	89

Both the events are noticed mainly during the local summer (March to May) and monsoon (June to September) months of a year. In the winter months they are rare, none is found in November.

All the 204 night-time effects at 10 and 20 kHz have been analysed in relation to the start and end time, duration of enhancement and fall as also their magnitudes. Important results obtained from the analysis are summarised below : (*i*) For most of the cases the onset of the effect

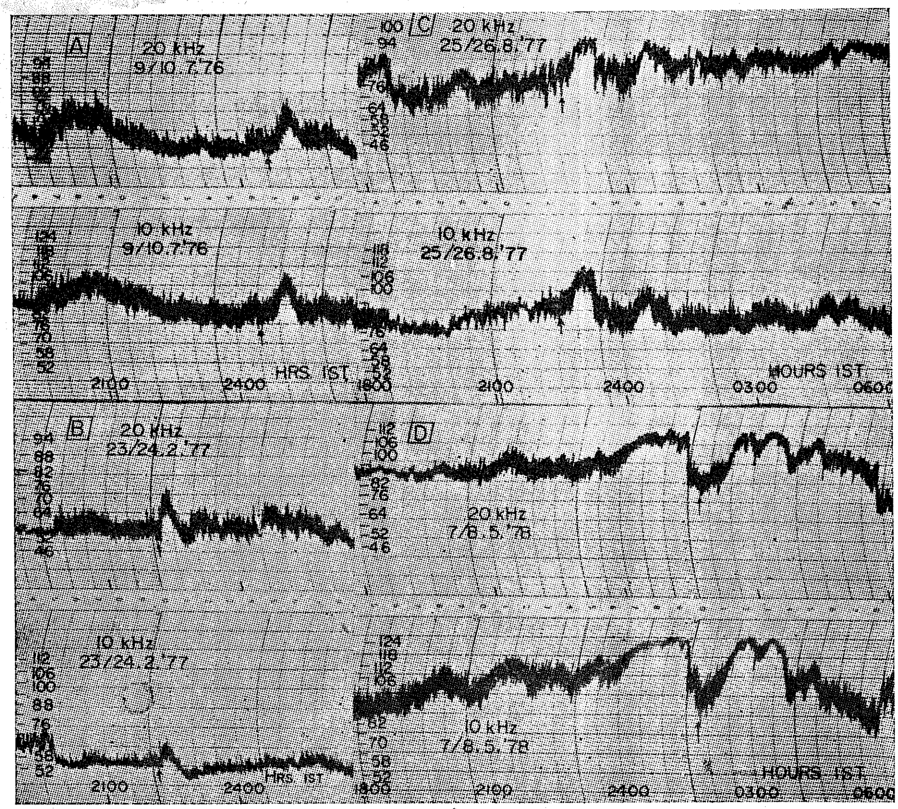

Fig. 1. Typical records of the 'night-time effect' of IFIA over Calcutta. The arrow indicates the time of start of the effect. The ordinates are in dB above 1 μV/m

occurs after midnight in between 2300-0100 IST and the end occurs after midnight in between 2400-0300 IST. (*ii*) The enhancement and fall time for majority of the cases lie in the range of 10-20 and 30-40 minutes respectively while the total duration for most of the cases is 90 to 110 minutes. (*iii*) A good correspondence is noticed between the duration of enhancement and fall. Calculation shows that the correlation coefficient between them is 0.936. (*iv*) The magnitudes of enhancement and fall are, in general, greater at 10 kHz than at 20 kHz.

The maximum activity of sea-thunderstorm occurs at about midnight (Krümm 1962 ,Aiya 1965, Mühleisen 1967, Heydt 1971, Trent and Gathman 1972, Takeuti 1974) which in turn produces the 'night-time effect' in our records. The cause for the occurrence of thunderstorms at night-time over sea is possibly due to the instability in the top part of the cloud by radiative cooling (Watanabe 1959). The lifetime of a thunderstorm mainly consists of three different stages, *viz,* developing, mature and dissipating. In the mature stage the updrafts and downdrafts exist side by side resulting heavy downpour while in the dissipating stage the downdrafts gain over the updrafts when the rain intensity gradually decreases (Sarkar *et al.* 1978). These three stages of a thunderstorm are perhaps the contributing factors for the different stages of the night-time effect in the record of atmospherics.

The observed higher maginitude of the effect at 10 kHz than that at 20 kHz may be suitably explained if the atmospherics producing the effect is presumed to originate mainly from return strokes. From an extensive series of observations Kimpara (1965) observed that atmospherics emitted from return strokes exhibit a peak intensity at about kHz. Takeuti and his group (1975, 1976) from a series of photographic

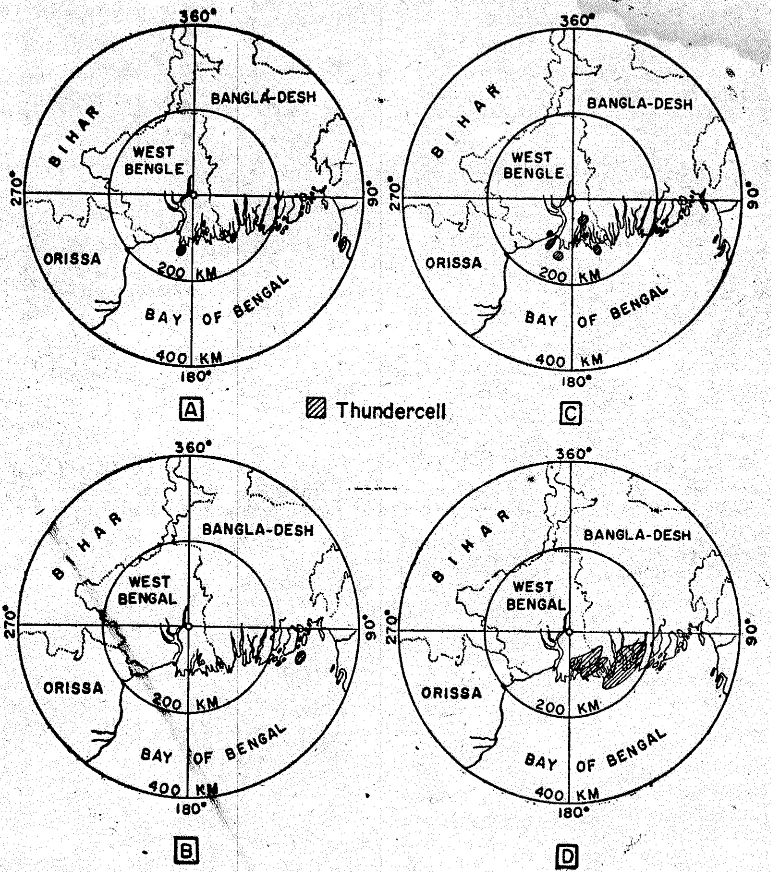

Fig. 2. Polar diagrams (A, B, C, D) representing location of thundercells over the Bay of Bengal on different nights

documents further concluded that the frequency distribution of the multiplicities of return strokes for the cloud-to-sea and the cloud-to-ground discharges are similar and that the distribution of time intervals between adjacent return strokes for cloud-to-sea discharges is similar to that for the cloud-to-ground discharges. The observed higher magnitude of the effect at 10 kHz is therefore reasonably expected.

There were a few occasions when the 'night-time effect' and the sea-thundercell had not been observed on the same night. This might be due to a limitation of the hourly data taken as a routine job by the meteorological department. A continuous PPI presentation of the radar echoes in combination with the records of atmospherics could give an improved result regarding the development of cloud cells and the corresponding electrical activity of the sea-thunderstorms.

We thank Dr. A. K. Sen of Radiophysics and Electronics, Calcutta University, for valuable suggestions and to the Director, Regional Meteorological Centre, Calcutta for providing the relevant data.

References

Aiya, S. V .C., 1965, *Nature*, **208**, pp. 641-644.

Ellison, M.A., 1955, *URSI Inform. Bull.*, No. **92**, p. 12.

Heydt, G., 1971, Der VLF-Atmospherics-Analyser, VLF AA 3/70.

Kimpara, A., 1965, Recent Advances in Atomspheric Electricity, pp. 352-365.

Krümm, H.-Chr., 1962, *Z. Geophysik*, **28**, pp. 85-104.

Mühleisen, R., 1967, *Z. Geophysik*, **33**, pp. 273-284.

Sarkar, S. K., Sen, A. K. and Bhattacharya, A. B, 1978, *Indian J. Phys.*, **52B**, pp. 160-166.

Takeuti, T., 1974, NRL Report 7763, pp. 392-397.

Takeuti, T., Nakano, M. and Nagatani, H., 1975, *J. Met. Soc., Japan*, **53**, pp. 360-361.

Takeuti, T., 1976, *Proc. Res. Inst. Atmos.*, **23**, pp. 17-20.

Trent, E. M. and Gathman, S. G., 1972, *Pure Appl. Geophys.*, **100**, pp. 60-69.

Watanabe, K., 1959, *J. Met. Soc., Japan*, **37**, pp. 164-189.