SHORT NOTE

EXPERIMENTAL STUDY OF THE ORIGIN OF ELF ATMOSPHERICS*

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1. Introduction

It is well estabished that ELF electromagnetic waves of natural origin are random intermittent superposition of isolated pulses and burst pulses on a weak continuous back-ground noise (Ogawa et al. 1966). Extensive effort have been made to correlate diurnal variation of spectral intensity of the continuous back-ground noise with that of the world wide thunderstorm activity (Large and Wormell 1958; Balser and Wagner 1962; Galejs 1965), following the theoretical investigation of resonance in the earth ionosphere cavity by Schumann (1957). Number of group discharges appearing in every moment on the earth may be estimated to be 80 to 100 per second, and the ELF atmospherics is expected to have average time duration of the order of 100 milli-seconds (Sao, Jindo and Yamashita 1964), so that the occurrence rate of lightning discharge on the earth is too high and duration of individual ELF atmospheric in the earth-ionosphere cavity is too long to make it possible to correlate any part of the back-ground noise with a particular lightning discharge by observing simultaneously lightning flash and ELF atmospherics radiating from it using two field sites with a large separation distance, and to attempt to investigate the lightning mechanism which produce ELF atmospherics. Therefore the possible way of approach in this trend, is to investigate pulsive ELF waveforms which can be discriminated from back-ground noise. In this case it will be possible to correlate the ELF atmospherics, which is recorded at a field site well separated from the source field site, with the lightning discharge which appeared close to the source site strictly at the same instance as the appearance of that ELF atmospherics, and which, therefore, may be considered to be the transmitter of them.

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It is generally accepted that one of the most strong transmitter of ELF atmospherics is the return stroke (Raemer1961), but we can not exclude the possibility of ELF emission from a discharge mechanism of a ground discharge other than return stroke, for example, from first leader, continuing current, final process as investigated by Pierce (1963), and lateral corona current after the first stroke as postulated by Rao (1967). Cloud discharge is thought to be another possibility of ELF emission because it lacks in return stroke (Pierce 1963; Ogawa et al. 1966). We have made our experiment to know the nature of lightning discharge which excite pulsive ELF atmospherics.

2. Experiment and Result Obtained

We recorded slow tail and ELF atmospheric waveforms at the four field sites including source signal observation within 15 km distance of lightning discharge at the source site in summer 1965 and repeated it in 1966. Fig. 1 shows the location of the four field sites distributed inside of Japan Islands.

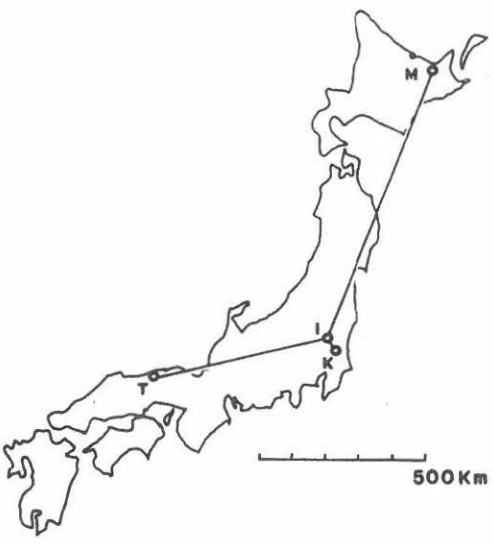

Fig. 1. The four field site locations

The separation distances of the three field sites, Kakioka, Tottori and Memambetsu, from the source site, Imaichi, are estimated to be about 80, 500, and 900 km respectively. High-mu steel cored coil antenna was used at the two field sites, Kakioka and Tottori and an earth current antenna was employed at the field site, Memambetsu. The electro-static field changes due to lightning discharge were most conveniently recorded with a high-impedance vertical antenna at the source site, Imaichi, along with VLF atmospheric waveforms and luminosity changes of a lightning flash when it was dark enough.

Illustrated in Fig. 2 are the simultaneous record of electro-static field changes due to a ground discharge at the source site, slow tail atmospherics at the 500 km distant field site, Tottori and ELF atmospherics at the 80 and 900 km distant sites Kakioka, and Memambetsu, respectively. It has been found that nine ground

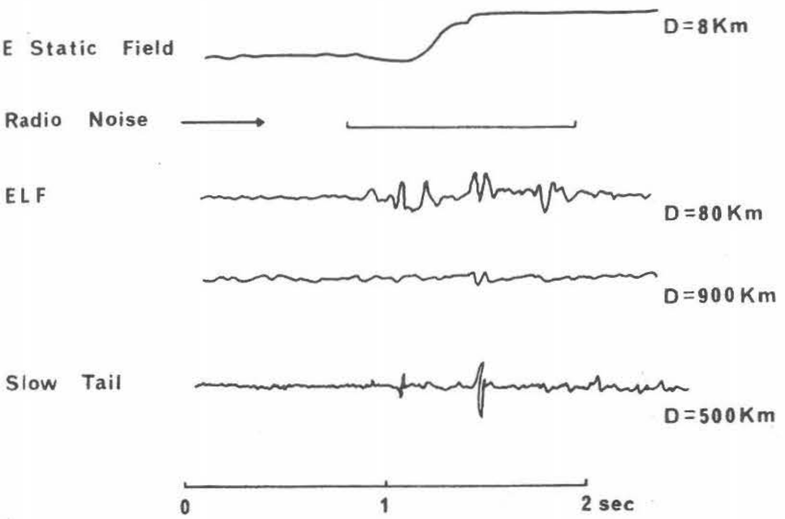

Fig. 2. Simultaneous record of ELF atmospherics and electro-static field changes due to a ground discharge.

discharges, where we succeeded in the confirmation of simultaneous atmospherics and lightning observation at the two respective field sites, all produced slow tails, while twelve out of sixteen cloud discharges examined in the same way actually produced slow tails. The result has been found to be the same for the case of ELF atmospherics too, and we have found that eleven ground discharges examined all produced ELF atmospherics, while twenty-five out of thirty-seven cloud discharges examined produced ELF atmospherics. The return stroke including the discharge process directly relating to it, e. g., "the C-portion" of a ground discharge, has been found to be a good radiator of slow tail and ELF atmospherics and in fact seven out of nine ground discharges, where we succeeded to correlate with pulsive ELF waveforms simultaneously recorded at the 500 km distant field site, have been found to emit slow tails from the return stroke portions. ELF atmospherics have been found to radiate from return stroke portion in ten cases out of eleven ground discharges where we had the confirmation of the corresponding pulsive ELF waveforms. It will be worthwhile to note that two out of nine confirmed ground discharges produced slow tails from the discharge section preceeding the first return stroke and five out of eleven confirmed ground discharges produced ELF atmospherics from the same section. As to the final discharge process in a ground discharge, it has been found that four out of nine ground discharges which were confirmed in the same way emitted slow tails from the final section, and four out of eleven confirmed ground discharges emitted ELF atmospherics from the same section. Of the eleven ground discharges on which we confirmed correspondence of pulsive ELF waveforms on the record obtained at a distant field site, eight cases have been found to have only one return stroke. This indicates the possibility that a return stroke is enough to radiate a pulsive ELF atmospherics.

3. Conclusion

The results so far obtained from the simultaneous observation of source lightning discharge and ELF atmospherics corresponding to it at the four field sites of wide separation distances, seem to indicate a higher probability of radiating slow tail and ELF atmospherics from ground discharge than from cloud discharge. The return strokes have been found to be the strongest radiator of FLF atmospherics including slow tails. It must be noted that single return stroke can emit them.

Finally we have confirmed the evidence that a discharge mechanism involved in a ground discharge, other than a return stroke, can be a radiator of slow tail and ELF atmospherics too. The initial section of a ground discharge, which preceeds the first return stroke portion, and the final process of it which occasionally appears after the last return stroke passed by, are the confirmed discharge processes belonging to this category.

4. Acknowledgement

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