ON FAIR-WEATHER AND THUNDERSTORM ELECTRICITY

- Basis for Construction of an Atmospheric Electrical Station in Sri Lanka

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ABSTRACT

The work performed on the two branches of `atmospheric electricity´, namely `fair-weather electricity´ and `thunderstorm electricity´ are presented with much emphasis on the building up of an atmospheric electricity research station in Sri Lanka. Reviews of previous investigations and introductory remarks on both the above branches are made with particular reference to the work presented here.

The first part of this thesis deals with fair-weather electricity. Instruments that have been constructed to measure atmospheric vertical electric field, space charge density, small ion number density and conductivity in Colombo are described. The average values of those electrical parameters, measured for the first time in Sri Lanka, are presented.

It is shown that theoretically there is a relationship between temperature and space charge density fluctuations associated with the turbulent mixing of the planetary boundary layer. The results of the affiliated experiment confirm the theory and also give evidence for the existence of the turbulent electrode effect.

Errors that may occur due to distorted atmospheric electric field lines caused by nearby grounded conducting objects, earth's orography, or elevated measuring instruments themselves in measuring atmospheric electrical parameters are discussed. It is shown that the measured atmospheric polar ion number density values can deviate by as much as 16 per cent from their real values due to the proximity of a grounded conducting rod of height 6 m. Rough criteria are presented for choosing a site in the proximity of a grounded conducting object for the measurement of atmospheric electrical parameters within an error of 5 per cent.

The second part of this thesis mainly supplies more information about lightning discharges in the tropics, a region with the most active thunderstorms and yet the least investigated.

Oscillograph pictures of radiation field waveforms from distant lightning flashes transporting negative charge to ground were recorded using a video camera set-up. Four different types of first return-stroke waveforms and the most common type of subsequent stroke waveforms observed in Sri Lanka are presented. The high average number of branches per channel and the low percentage of spatially separate channels observed are explained. Statistical distributions of first and subsequent return stroke zero crossing times, multiplicity and interstroke time interval of negative ground flashes are presented with the mean values of those parameters. A new hypothesis is introduced to classify lightning parameters according to the climatological zones of the world, instead of the unsuccessful attempts that have been made to classify them according to the geographical latitude.

Simultaneous recordings were made on the fast electric field and high frequency (HF) emissions at 3 MHz at times close to the first and subsequent return strokes. It is shown that steps are the source of HF generation at 3 MHz in the leader phase of ground flashes. In the return stroke phase, it is suggested that the tiny sub-branches of the order of 10 to 100 m in length, which are probably created during the formation of the corona sheath, are the source of HF at 3 MHz.

A numerical procedure for calculating the transformation of the electromagnetic pulses generated by a lightning return stroke over the sea as it crosses the sea-land boundary is presented.