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Research paper

Characteristics of Narrow Bipolar Pulses observed from lightning in Sri Lanka

T.A.L.N. Gunasekara [a,*], M. Fernando [a], U. Sonnadara [a], V. Cooray [b]

[a] Department of Physics, University of Colombo, Colombo 3, Sri Lanka
[b] Department of Engineering Sciences, Uppsala University, Uppsala, Sweden

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ABSTRACT

A detailed study on electric field characteristics of Narrow Bipolar Pulses (NBP) observed in Sri Lanka is presented here. NBPs analyzed in this work were recorded at a coastal location in the Southern part of Sri Lanka (Matara: 5.95 °N, 8.53 °E), from five highly active consecutive thunderstorm days during the month of May in 2013. The waveforms were recorded with a 10 ns resolution within a 100 ms time window. Both positive and negative NBPs were observed in this study with the negative type being the most frequent. Parameters presented in this study were the rise time (Tr), zero crossing time (Tz), the duration of slow front (Ts), the full width of half maximum (FWHM), the pulse duration and the ratio of amplitude of overshoot to the corresponding peak amplitude (Os/Pa). The corresponding average values of negative NBPs for these parameters were found to be 0.58 μs, 3.01 μs, 0.20 μs, 1.38 μs, 19.21 μs and 0.19 respectively. Similarly, for positive events corresponding values were 1.38 μs, 4.66 μs, 0.48 μs, 1.93 μs, 16.42 μs and 0.37 respectively. The above values conforms to a much narrower bipolar events when compared to previously reported values which is considered to be caused by the propagation effects of signals captured by the apparatus.

1. Introduction

Broadband electric field analysis of lightning has identified pulses of very narrow nature with strong radio frequency radiation mainly in sub tropical and tropical regions. These are known as Narrow Bipolar Pulses (NBP) or Compact Intra Cloud Discharges (CID) as they are considered to be associated with lightning activity inside thunderclouds. But a proper explanation on the origin of these events inside a cloud is yet to be discovered. NBPs have been reported with both polarities and are identified as Positive Narrow Bipolar Pulses (PNBP) and Negative Narrow Bipolar Pulses (NNBP) (Willett et al., 1989; Smith et al., 1999, 2004; Eack, 2004). Classification of the polarity depends on the sign convention used. In this study we use the atmospheric sign convention where, NBPs which have the same initial polarity as of the electric field change shown by downward negative charges are considered as positive.

The first historic observation of these activities was by Le Vine (1980) which were observed as highly energetic lightning events at high and very high frequency bands which did not accompany any other known signals. Since majority of the recorded pulses occurred after first return strokes, Le Vine (1980) speculated this to be an activity related to K processes.

Cooray and Lundquist (1985) published results of a study where similar pulses were observed in a similar tropical location (Sri Lanka) with much wider durations and of greater frequency of occurrence. But, it was Willett et al. (1989), who first carried out a detailed analysis of the electric field and its time derivative changes of NBPs. The classification of pulses based on polarity and the fact that these events had no association with other lightning processes were the main findings of their study. In addition, they observed that amplitudes of NBPs were comparable to the values of first return strokes in cloud to ground (CG) lightning observed in the same experiment. Also they reported that these pulses radiated much stronger radio frequencies when compared to first return strokes. Thus the above study gave the NBP events much more recognition in the area of lightning research.

Medelius et al. (1991) published another study where similar events were identified using wide band electric field sensors at the Kennedy Space Center. Over 150 narrow pulses with close characteristics to that of NBPs were identified in this study. Similar to Willett et al. (1989), the data consisted of pulses of both polarities with the negative type outnumbering the positives by a ratio of 16 to 1.

The source locations of NBPs were identified by Smith et al. (1999). According to them, the pulses originated from the most active areas of a thunderstorm which was in close proximity to

* Corresponding author.
E-mail address: lasitha.niwanka@gmail.com (T.A.L.N. Gunasekara).

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