Measurements and Analyses of Fast Transient Electromagnetic Fields Generated by Ground and Cloud Flashes with Special Attention to Lightning Direction Finding

By

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Abstract

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Measurements were carried out to understand the microsecond and sub-microsecond signatures of lightning generated electric fields and corresponding 3 MHz oscillation in Sri Lanka in the tropic and Denmark and Sweden in the temperate region using a measuring system with bandwidth more than 20 MHz. Measured electric fields were analyzed to understand the electric field variations and pulses activity preceding the first return stroke and subsequent return strokes. A detectable pulse activity prior to the return stroke field change was observed only about 16.5 milliseconds and 29.2 milliseconds in Sweden and Sri Lanka respectively. However, an average detectable change of the electric field could observe about 120 millisecond prior to the start of the first return stroke. Data were also used to understand the sub-microsecond structure of electric field pulses (cloud pulses) embedded in electric field changes associated with cloud flashes. Rising portion of the cloud pulses shows a slowly rising field change up to about 24% of the peak amplitude followed by an abrupt change up to the peak electric field. Remarkable similarities were observed in characteristics of the slow front of cloud pulses and subsequent return strokes, which suggest that there could be some similarities of initiation of subsequent return strokes and cloud pulses. Undistorted electric field pulses measured in this study were used to understand the fine structure of positive return strokes. The average normalized peak electric field observed for positive return strokes was about 13.9 V/m, which is twice larger than that of negative return strokes. Similar differences were observed for rise time, full-width at half maximum, slow front duration, and ratio of slow front amplitude to peak amplitude in positive return strokes compared to those of negative return strokes. The effect of ground conductivity on electric fields of positive return strokes and time derivative of electric fields associated with negative return strokes were also studied. Possible attenuation on electric field derivative when they propagate over finitely conducting ground was analyzed. Results show that the average peak amplitude of time derivative of electric field of first return strokes could be attenuated by about 20% after propagating over ground of conductivity 0.01 S/m. The average attenuation for the same distance over ground of conductivity 0.001 S/m is 50%. Results show that the full-width at half maximum and the rise time of field derivative change drastically when a lightning electromagnetic wave propagates over finitely conducting ground. Therefore, in modeling and many engineering applications it is necessary to take in to account the distortion caused by propagation effects on electric field as well as on electric field derivatives generated by lightning flashes.