



28th International Conference on Lightning Protection



Topic I: Lightning Discharge

I-A: General Characteristics

I-B: Lightning to Tall Structures

Moderator's Report

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I. SESSION I-A: GENERAL CHARACTERISTICS

This is the conference's first technical session dealing with the general characteristics of the lightning discharge. It is comprised of thirteen papers, seven of which have been assigned to the oral session I-A (I-1 to I-7), while the remaining papers have been placed in the poster session I-P (I-36 to I-41). These oral and poster papers can be divided into two broad categories, namely the characteristics of natural lightning and those of rocket-triggered lightning.

A. Oral Session Papers

Paper I-1 examines the characteristics of a cloud-to-ground lightning flash with four ground terminations using a high-speed digital camera and an electric field measurement system. The distance between adjacent striking points reached 450 meters. The authors point out the importance of studying flashes with multiple ground terminations, as it may have important implications for the protection of various ground facilities.

Paper I-2 studies positive bipolar radiated field pulses generated by lightning in Sri Lanka. The waveform characteristics of these pulses are analyzed. It is suggested that they are produced by electrical discharges of several hundred meters in length that did not culminate in full-scale lightning discharges.

Paper I-3 presents a review of the rocket-triggered

lightning data collected in the north coast of Japan during the winter seasons of 1977-1998. The characteristics of rocket-triggered discharges are discussed, as well as the physical process of rocket-triggered lightning.

Paper I-4 studies current and electric field changes in the vicinity of artificially triggered lightning using the rocket-wire technique in Binzhou, Shandong, China. Waveform characteristics of the lightning return-stroke current and radiated electric field are determined.

Paper I-5 investigates the voltage gradient and energy characteristics of 2 kA and 27 kA rocket-triggered winter lightning in Hokuriku, Japan. The voltage gradient, power and energy are estimated at both 2 kA and 27 kA peak currents.

Paper I-6 investigates peculiarities of spark discharge appearance in artificial clouds of charged water aerosol. The discharge initiation process is explained and the possibility of scaling the obtained results to real thunderstorm conditions is discussed.

Paper I-7 studies the lightning current waveforms estimated based on the observed electromagnetic field in the Hokuriku area of Japan since 1999. Analysis of observations reveals that 60% of lightning strokes that caused transmission line faults during the winter are positive, whereas all transmission line faults that occurred in the summer were caused by negative lightning.

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B. Poster Session Papers

Paper I-36 presents an analysis of comprehensive lightning observations conducted in the Naqu area of the Qinghai-Tibet Plateau during 2002-2004. The goal was to

study the lightning characteristics and charge structures of thunderstorms occurring in that area. The analysis shows that most intracloud lightning flashes occurred between the negative charge regions, and the positive charge regions at the bottom of thunderclouds. The authors point out that studying intracloud discharges in the Tibet Plateau area is relevant to the protection of ground facilities due to the closeness of thunderclouds to the elevated ground level.

Paper I-37 investigates the detailed characteristics of lightning occurring in the city of Lhasa in the Tibet Plateau region of China by analyzing data recorded using several electric field measurement stations. It concludes that Lhasa city's thunderstorms tend to have single-stroke flashes producing mainly positive electric fields.

Paper I-38 studies the characteristics of lightning and thunderstorms in the central Tibetan Plateau (4508 m above sea level). The authors conclude that more than 90% of lightning flashes occur in the afternoon (13:00 to 22:00 Beijing time). Surface electric field observations suggest that thunderstorms have triple-charge structures but with larger than usual lower positive charge centers at the thundercloud bases.

Paper I-39 investigates cloud flash characteristics derived from measurements of electric fields in Sri Lanka. The authors discuss the validity of both the two-stage and three-stage structure of the cloud flash based on new and previous studies.

Paper I-40 presents a comparison between the signatures of the lightning-generated electric fields measured in Colombia and those measured in Sri Lanka. The authors find marked statistical differences in flash and field waveform characteristics, which they suggest to be attributed to the substantial difference in ground elevation, which is (2600 m in Colombia and about 3 m in Sri Lanka).

Paper I-41 presents the common features of return-stroke optical travelling waves and offers some hypothetical interpretations. It aims to provoke a discussion on the physics of lightning and on the measurement of the return-stroke velocity.

II. SESSION I-B: LIGHTNING TO TALL STRUCTURES

This is the conference's second technical session dealing with lightning to tall structures. It is comprised of twelve papers, seven of which have been assigned to the oral session I-B (I-8 to I-14), while the remaining papers have been placed in the poster session I-P (I-42 to I-46). These oral and poster papers can be divided into two broad categories, one dealing with lightning to extremely tall towers, such as the Toronto CN Tower, and the other with lightning to moderately tall towers (or structures) constructed on flat or elevated ground.

A. Oral Session Papers

Paper I-8 presents an analysis of inductive effects in measurements of impulsive lightning currents using resistive transducers. The paper emphasizes the need to correct the measured voltage waveform in order to recover the original current instead of the usual practice of determining the current directly from the low-frequency resistance of shunt resistors.

Paper I-9 investigates the characteristics of positive upward-initiated lightning flashes measured at the instrumented Gaisberg Tower. The waveform parameters of the recorded lightning currents are determined and compared with those of published data for negative upward- and downward-initiated lightning.

Paper I-10 presents a comparison of pulses superimposed on continuous currents in upward lightning initiated from tall objects with those in rocket-triggered lightning. Based on the obtained results, the mechanism of initial continuous current pulses is discussed.

Paper I-11 presents an extensive statistical analysis of the visual characteristics of lightning flashes that struck the CN Tower using video camera images recorded during 1991-2000 and high-speed digital camera images recorded during 1996-2005. The analysis focuses on the determination of the number of flashes per storm, flash duration, number of strokes per flash and inter-stroke time.

Paper I-12 compares the characteristics of CN Tower lightning flashes occurring during snowstorms with the characteristics of those occurring in ordinary thunderstorms. The analysis is based on the lightning current derivative signals recorded at the tower during 1995-2001. The paper focuses on the determination of the number of flashes per storm, flash duration, number of strokes per flash, inter-stroke time and return-stroke current wavefront parameters (maximum steepness, risetime to maximum steepness, peak, and risetime to peak).

Paper I-13 presents simultaneous measurements of return-stroke currents as well as electric and magnetic fields at three locations associated with lightning strikes to the CN Tower. Preliminary discussions on the current-field relationship and propagation effects are included.

Paper I-14 presents a summary of extensive observations of winter lightning at Maki in Japan's west coast area. The lightning current waveforms recorded at a 150-m tower show that winter lightning often has very long duration and sometimes has very large current amplitudes exceeding 200 kA.

B. Poster Session Papers

Paper I-42 uses the time derivative of Heidler function to model the CN Tower lightning return-stroke current derivative. Compared to the traditional use of Heidler

function to simulate the current, the current derivative simulation using this new function produced a better match with the measured current derivative signal, resulting in a better fit between the current obtained from simulation and the current computed from measurement.

Paper I-43 investigates the effect of ground-finite conductivity on the electromagnetic field radiated by lightning to tall towers. The results of the investigation show that the attenuation of the initial peak of the radiated field depends strongly on the current risetime, the tower's height and the ground conductivity.

Paper I-44 deals with the effect of travelling waves of current on the electromagnetic response of a tall Franklin rod, considering various lightning return-stroke models. The presented computations take into account the travelling current waves and their reflections at the top and bottom of the rod. It is shown that such reflections are responsible for significant over-shoots in voltage and current waveforms, especially when the rod's height reaches or exceeds 30 m.

Paper I-45 uses a numerical code based on antenna theory to investigate the travelling-wave phenomena of a direct lightning stroke to a telecommunications tower. In order to take the travelling wave process in the tower into consideration, the wave shape of the source current was modified according to reflection coefficients at the tower's top and base. The computation results show significant changes in current and voltage waveshapes in comparison with those of the non-modified source current.

Paper I-46 presents the first steps of the lightning current measurement at the "Eagle Nest" instrumented tower in Spain. The paper gives a description of the current measurement system, which employs a Rogowski coil and a digitizer equipped with GPS timing.