Observation of Lightning Channel with Photodiode Array System

Atsushi Wada[1]

[1] CRIEPI

1. Introduction

Many instruments were developed for the last thirty years to make clear the characteristics of lightning channel. In this report, the observation of lightning channel using a photodiode array system is described.

2. Instrument

The idea of observing the progressive characteristics of lightning using photodiodes was proposed by Nakano et al.(1). Similar systems were used by Radda and Krider(2), Hubert and Mouget (3), and Mach and Rust (4-6). The instruments used in these systems incorporated only several detectors mounted vertically so that only the velocity of a vertical lightning channel was measured instead of the actual velocity for a complicated-shaped channel. The progressive characteristics of lightning were observed by the ALPS (7). The ALPS has a high resolution of two-dimensional space and time. The ALPS has been improving the performance in point of the resolution of space and time. ALPS4 has 40x40 pin photodiodes. The luminosity observed by a 24 mm single-lens camera is transmitted to a 40x40 pin photodiode array through optical fiber cables, then converted into electric signals. The ALPS4 is characterized by a maximum sampling time of 100 ns, recording capacity of 12.8M bytes, and resolution of 4 bits.

3. Observational results

The progressive characteristics of lightning were observed at a height of 0 m to 1000 m from the top of a 200 m-high chimney in winter. At a distance of 630 m from the chimney, leader and return stroke speeds were measured (8). The mean value of upward positive leader speeds was 3.6x105 m/sec with a range from 0.6x105 to 14x105 m/sec without any appreciable stepped motion. Upward negative leader was observed with stepped motion. The average speed of an upward negative leader was 3x106 m/sec and the mean value of each step speeds was 3x107 m/sec. In the rare case, downward return stroke was observed at average speed of 1.6x108 m/sec after the upward positive leader developed at a speed of 2.3x106 m/sec. The downward return-stroke decreased the speed from 2.3x108 m/sec to 4.0x107 m/sec as it developed towards the ground. A difference in conductivity at the top and bottom of the upward positive leader is assumed. The characteristics of the downward return-stroke speed which decreases with propagation are similar to those of the upward return-stroke. The downward return-stroke is believed to occur when the upward positive leader reaches the negative charge region but the attachment process that combines the upward and downward leaders near the thundercloud was not confirmed.

4. Summary

The observation of lightning channel using a photodiode array system was described. The leader and return stroke speed of upward-initiated lightning was estimated. Interestingly, a downward return stroke was observed after the upward negative leader development. However, the performance of the ALPS, which we have been using for lightning observation, is not enough to make clear the lightning progressing feature in the stage of weak brightness leader. I have a plan to develop a new ALPS system with the performance of 32x32 pin photodiode array, resolution of 12bits, and a sampling time of 100ns. It is expected that the new ALPS will contribute to understand the progressive characteristics of lightning in winter in more detail.

References

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