Intiation and propagation characteristics of upward positive leaders

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By using an automatic lightning progressing feature observation system (ALPS), we have measured the correlated sub-microsecond E-fields and high-speed images of three upward leaders initiated from a high tower at Hokuriku area, a famous place for winter lightning. All three leaders are inferred to be of positive types. Their speeds are, respectively, 1.1*10^6 m/s, 1.0*10^6 m/s and 6.5*10^5 m/s. A detailed comparison between the E-fields and the high-speed images show that the upward leaders started without any precursory E-field changes. It appears that all three leaders are initiated without any in-cloud discharge activity as their triggers.

Pulse discharge processes are observed for all three leaders. Those pulse discharges can be apparently classified into two types from their rise time and propagation features. The first type of discharges have a rise time less than 1 microsecond and they apparently started at the tip of a positive leader and propagate backward with a speed near to 1.0*10^8 m/s. They second type of discharges have a rise time more than 10 microseconds and they do not have any apparent propagation direction and speed.

It is inferred that those two types of discharges are involved in two different mechanisms. During the forward propagation of a positive leader, each time when the electric field at the leader tip becomes too smaller to sustain a continuous propagation, the leader will stop for a moment. During this period, the leader will accumulate energy to its tip and the electric field there will be recovered. Once the electric field reach to a critical value, a breakdown will occur. This breakdown may be the first type of discharge. Each time when the leader approaches to a region with negative space charge, apparently the charge will be transferred to ground through the leader. The neutralization process of space charge may correspond to the second type of pulse discharges.

The second type of pulse discharges have same features as M-components. In recent literatures, an M-components was treated as a guided wave process that involves a downward-progressing incident wave and an upward-progressing wave that is a reflection of the incident wave from the ground. Based on our observed data, we suggest that an M-component is actually a composite of many small discharge waves. Although for each small wave, there is physical meaning in speed, for M-component as a composite, there should be no physical meaning in propagation direction and speed.