

# Characteristics of Lightning Discharge in Winter -Observational results at 200m-high chimney-

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## 1. Introduction

Lightning discharge is one of the plasma phenomena in the space. Three types of luminosity called blue jets, red sprites, and elves were observed above the thundercloud with the lightning ground flash. It is well known that positive lightning discharge often occurs in winter in Japan. Recently, Tohoku university group succeeded in observing sprites and elves in winter in Japan. To make clear the characteristics of the luminosity, it is necessary to study the relationship between positive ground flash and luminosity phenomenon.

## 2. Characteristics of lightning in winter

Lightning discharge has been observed at many different places in winter in Japan. The main features of winter lightning are as follows.

(1) About 50 percent of lightning in winter is positive lightning discharge that carries positive charge from the thundercloud to the ground.

(2) Lightning current in winter sometimes have a long duration of several hundreds milliseconds and the total charge exceeds several hundreds coulombs.

(3) The number of strokes per flash in winter is less than that in summer and lightning current often have a continuing current in winter.

(4) Lightning current which change the polarity from negative to positive or from positive to negative are often observed in winter.

(5) The rate of upward-initiated lightning from the high structure increases in winter because the base of thundercloud in winter is low compared to summer thundercloud.

(6) Many striking points of lightning flashes are often observed in the time of several tens of milliseconds in the area of several kilometers in winter.

(7) Lightning current more than 100 kA are sometimes observed in winter.

## 3. Lightning observation at 200m-high chimney

The values of lightning parameters that are estimated by using data observed in many different places have a wide range. In order to clear the lightning features in detail, it is necessary to collect the statistical data at the same observational point. So we have been observing the lightning discharge at 200m-high chimney in the Fukui thermal power plant of Hokuriku electric power company in winter in Japan. The lightning strikes to the chimney about 30 to 40 times in a winter season. Almost all lightning at the chimney is the lightning discharge initiated by an upward leader. The main results are as follows.

### 3.1 Occurrence condition of upward-initiated lightning

The upward-initiated discharge called upward leader progresses from the top of the 200m-high chimney in the next conditions.

(1) The electric field strength is more than 10 kV/m at the ground level.

(2) The electrical discharge occurs in the thundercloud at a height of 4 km to 5 km in the time of 20 ms to 40 ms before the upward leader development.

(3) The base of thundercloud is less than 1.5 km and the strong down draft occurs with the speed of more than 16 m/sec in the cloud during the developing stage of thundercloud.

### 3.2 Characteristics of upward-initiated lightning

(1) Most lightning (about 90 percent) is the lightning discharge initiated by an upward positive leader and about 10 percent is the lightning initiated by an upward negative leader.

(2) In the lightning initiated by an upward positive leader, about one quarter of the lightning produced the subsequent discharge composed of downward leader from the thundercloud and upward return-stroke sequences following the upward positive leader development.

(3) In the subsequent discharge of the upward-initiated lightning, there is a positive stroke that the total transferred charge is several hundreds coulombs.

In this report, the recent observational results of upward-initiated lightning from the 200m-high chimney in winter are

reported in detail. Observational method based on the simultaneous measurements of positive ground flash and sprites is proposed.