# Optical observation results of negative GC-type strokes

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## Abstract

In Japan, transmission lines or wind turbines in the coastal area of the Sea of Japan have suffered from higher frequencies of serious troubles due to lightning in winter than those in summer. The lightning flashes hit tall structures in winter in Japan have turned out to be mostly lightning having long upward leaders. Naturally, characteristics of lightning hitting tall structures in winter, as well as its current parameters are different from those of ordina r y downward lightning in summer, which are the present basis of lightning protection standards.

The average absolute peak electromagnetic field of LEMP (lightning electromagnetic impulses) observed simultaneously with transmission line faults was equivalent to that from a negative return stroke (-CG: cloud to ground) of about 200 kA [1]. The lightning electromagnetic field waveforms recorded simultaneously with these transmission line faults had common features, and these kinds of lightning discharges can be distinguished from the field waveforms [1] [2]. Simultaneous photographic images and field waveform records confirm the existence of energetic upward lightning discharges in winter. They were termed as negative GC (ground-to-cloud) strokes [1] [2], as opposed to CG. This type of LEMP was also reported as LBE (large bipolar events) [3]. The GC strokes can be categorized into 3 types, Negative GC (-GC), Positive GC type I (+GC-I) and Positive GC type II (+GC-II). All of them can be numerically reproduced as lightning strokes having long upward leaders [4].

This paper reports on optical observation results of such negative GC type strokes observed by high speed cameras at the coast of the Sea of Japan and Tokyo skytree. A revised scenario for the reproduction of the characteristic current and electric field waveforms by using electromagnetic models is also proposed. Numerical Electromagnetics Code (NEC-4) based on the method of moments is employed for the numerical analysis. At the revised scenario, the characteristic current and electromagnetic field waveforms are produced by high density leader charge generated below winter thunder cloud.

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## Topic Areas

Lightning Physics, Characteristics and Measurements

## Submission Format

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