Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

MIS026-04 Room:201B Time:May 24 09:15-09:30

Recent progress of research on characteristics of winter lightning in Japan

Masaru Ishii[1*]

[1]IIS, The University of Tokyo

Regarding winter lightning in Japan, such characteristics as occurrence of frequent upward lightning or frequent occurrence of positive ground flashes have been known. On the engineering side, similar number of lightning damages on transmission lines or wind turbines to that in summer has been experienced in winter in the winter thunderstorm area of Japan, despite the number of lightning strokes observed by lightning location systems (LLS) is much less than that in summer. From this aspect, it is inferred that the characteristics of lightning strikes and of lightning currents in winter differ from those in summer. In recent years, damages on wind turbines by winter lightning have attracted attention in the research community, and there has been much progress in the research on characteristics of winter lightning in Japan through accumulation of observation data.

Electromagnetic field waveforms associated with lightning discharges simultaneously observed with faults of high voltage power transmission lines were investigated. The field waveforms observed in the frequency range of several to several hundreds of kHz showed different characteristics from those associated with lightning return strokes. The field waveforms observed in this frequency range closely relate to waveforms of lightning current. If the location of lightning striking point is known, the peak magnitude of lightning current can be estimated from the observed peak field strength. As a result, it was known that the lightning discharges resulted in outages of power transmission lines had peak currents in the order of 200 kA or higher, regardless of the polarity. They are inferred to be initiated by upward leaders from transmission towers. The lightning strokes of this kind were named as GC (Ground-to-cloud) lightning strokes [1]. Like return strokes, there is difference in the characteristics of negative GC and positive GC. The polarity is defined by the polarity of charge in cloud neutralized by GC strokes.

On the other hand, frequent lightning damages of plastic blades of wind turbines were experienced in winter after many wind turbines had been constructed on Honshu Island along the coast of the Sea of Japan. The cause of these damages is inferred to be large charge transfer associated with lightning strikes to wind turbine blades. According to observation by LLS, proportion of high current lightning flashes is also much higher than that in summer. The reason why comparable number of lightning damages on transmission lines or wind turbines in winter to that in summer is experienced is that upward lightning is generated even from structures of several tens of meters high. This characteristics result in high number of lightning strikes to tall structures even under low lightning ground flash density.

The peculiar characteristics of lightning discharges in winter is inferred to be related to the charge structure in clouds in winter, which was confirmed by location of VHF radiation sources and of neutralized charge in clouds. A model of charge structure in lightning cloud that charges of each polarity exists according to the temperature height in a similar way to that in summer, reported in the early 1980s, had long been believed. In this model, positive charges neutralized by positive ground flashes reside in the -30 degrees Celcius region; however, according to recent observations, charges neutralized by lightning ground flashes in winter reside around the -10 degrees Celcius region in most of the cases regardless of their polarities [2].

References

[1] M. Ishii, and M. Saito, Lightning Electric Field Characteristics Associated with Transmission-Line Faults in Winter, IEEE Transactions on Electromagnetic Compatibility, vol. 51, No. 3, pp.459-465, 2009.

[2] M. Ishii, M. Saito, J. Hojo, and K. Kami, Location of charges associated with positive C-G flashes in winter, Proc. 12th Int. Conf. on Atmospheric Electricity, Versailles, pp. 151-154, June 2003.

Keywords: winter lightning, lightning current, lightning discharge