Synoptic-scale conditions with occurrence of winter lightning in the Hokuriku district of Japan

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Generally, almost all lightning is negatively charged, while the ratio of positive lightning increase in winter thunderstorm. Some studies have indicated that the positive lightning would be caused by strong vertical wind shear and/or weak updraft. This study examined difference of synoptic-scale atmosphere conditions between the negative and positive lightning with occurrence of winter lightning based on lightning data obtained by Lightning Location System in Hokuriku district of Japan and atmospheric data obtained by Japan Meteorological Agency Meso-Scale Model. The relationships among the causes were evaluated by composite analysis for 8 years from Oct 2006 to Mar 2014.
In the positive lightning cases, from December to March, Hokuriku district were located near the southern part of the cyclone passing over the Sea of Japan. Further, vertical wind shear was relatively strong and updraft was relatively weaken in the positive lightning cases, which are consistent with the results mentioned in some previous studies. In the negative lightning cases, negative and positive geopotential height anomalies appeared in the east and west the Sea of Japan, respectively, and there were the cold air anomalies in the mid-troposphere. In contrast, remarkable differences were not identified in the synoptic-scale atmospheric conditions between the positive and negative lightning cases in October and November.

Keywords: positive cloud-to-ground lightning, winter lightning, thunderstorm

Lightning Observation Network with LF Broadband Sensors around Toyama Bay

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It is well known that lightning flashes during winter thunderstorm seasons in the Japan sea coastal area show a number of remarkable features. Winter lightning causes serious damages in electric power transmission and distribution systems. All lightning processes can be studied by measurement of the EM fields associated with the charge transfer.

We have been designing and installing a lightning location system in 3D based on the broadband digital interferometry technique in LF bands. The LF band sensors consists of four or more observation stations which detect electromagnetic (EM) waves in a wide frequency range from 1kH to 150 kHz associated with lightning discharges. Since each station detects EM waves in LF, the lightning discharges several hundred kilometers away from the sensor are detectable.

During the winter thunderstorm season in 2016-17, we conducted lightning observation campaign with the LF sensors around Toyama bay. The locations for EM waves associated with return strokes, preliminary breakdown process, and continuing current are succeeded. Notable long lightning channels will be discussed in this talk.

Keywords: Winter thunderstorm, Lightning discharges, EM observations

Improving accuracy of locations and lightning charge moment changes using multi-point simultaneous observations of ELF transients

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In this study, we simultaneously observed ELF transients at Rikubetsu, Hokkaido and Tarumizu, Kagoshima prefecture. Source locations of lightning discharges were derived by using the triangulation technique. We compared these estimated lightning locations with those from Japan total lightning network.
Moreover, we derived corresponding charge moment changes (CMCs) by current moment waveforms integrated over time.

Keywords: ELF band sferics, Location of lightning discharges, Charge moment changes

A comparative study on intermittent propagation mode of positive and negative leaders

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The mechanism of intermittent propagation mode of both negative leaders and positive leaders remain on one of the largest mystery in lightning physics. In order to shed some light on this mechanism, recently we have made a comparative study on the optical propagation characteristics of an upward positive leader and an upward negative leader recorded using a high speed video camera operated at 300000 fps. The negative leader is a typical stepped leader with a few branches, while the positive leader exhibited both continuous propagation mode and intermittent mode.
It was found that each step of both positive and negative stepped leaders starts with a stem. For the positive leader, this stem usually initiates at a distance more than 100 m ahead from the tip of the leader, while for the negative leader, the stem usually initiates at a distance of around 50 m. The stem in the negative leader usually lasts less than 25 us, while the positive leader stem could last over 300 us. All the stems tend to progress in bi-direction modes. Although the backward propagation (in relative to the leader propagation direction) speed of the stem for both leaders are similar, the forward propagation speed of the negative leader stem is much larger than that for the positive leader stem. In the final paper, we will not only report on the detailed results but also try to present a schematic to explain the reasons of the differences.

Keywords: lightning, stepped leader, streamer

Multi-point Observations of Thundercloud Gamma-rays: Development of Portable Detectors and Results of Fiscal 2016 Winter Observation

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On-ground detections of bremsstrahlung gamma-rays with energy extending up to 10 MeV from winter thunderstorms indicate electron accelerations inside thunderclouds (e.g. Trii et al., 2002, Tsuchiya et al., 2007). In order to resolve time variation and structure of the electron accelerators, we started to construct a multi-point system to detect thundercloud gamma-rays (Enoto et al., JpGU 2016 M-IS14, Enoto et al. 2017 M-IS05). In fiscal 2016, we have developed a small electronics board consisting of a FPGA/ADC board and a front-end board. The FPGA/ADC board, with 9.5 cm ×9.5 cm area, has a 4ch Analog-to-Digital Convertor which is controlled by Raspberry Pi. The front-end board has preamplifiers and shapers to be coupled with BGO scintillators and PMTs, a GPS receiver, and high voltage suppliers. We set up portable detectors including the electronics board and a BGO scintillator. Five detectors were installed in Kanazawa and Komatsu on October 2016, one in Suzu and two in Kashiwazaki on December 2016. In December 8th to 9th, four detectors in Kanazawa and Komatsu detected thundercloud gamma-rays for several minutes. The gamma-ray enhancements exhibited continuum spectra extending up to 10 MeV. In addition, we succeeded in a multi-point detection of gamma-rays from an identical thunderstorm by two detectors in Komatsu because a difference of the detection time is consistent to a passing time of the thunderstorm. We will report current status of the electronic board development and a result of the fiscal 2016 winter observation.

Keywords: winder thunderstorm, gamma-ray, electric field, electron acceleration

Ground observation of thermal neutrons from Terrestrial Gamma-ray Flash above wind turbine

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During a thunderstorm on December 3rd, 2015, coincident with an upward leader originating from a lightning protection tower next to the wind turbine in Uchinada, the Gamma-ray Observations During Overhead Thunderstorms (GODOT) instrument observed a large, ~100ms duration, flux of radiation with a spectral signature characteristic of thermal neutron production. We will present our observations and show comparisons to monte-carlo simulations, proposing that we have the observed the first neutron glow from a Terrestrial Gamma-ray Flash, produced by photonuclear reactions of gamma-rays with the air and ground molecules around the wind turbine.

Keywords: Lightning, Terrestrial Gamma-Ray Flash, TGF, Radiation, Neutron, Wind Turbine

