

Observation of thundercloud gamma-rays in FY2020 with the GOOSE detector aiming at altitude measurements

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Lightning activity emitting gamma-rays has been observed on the coast of the Sea of Japan in winter season. Those gamma rays are due to bremsstrahlung from electrons accelerated by the electrostatic field in thundercloud, and their energy reaches 30 MeV. Specifically, the gamma-ray emission events observed in an instant of less than 1 ms are called gamma-ray flash, and those observed from the thundercloud itself for a few minutes are called gamma-ray glows. We have been observing thundercloud gamma rays in the coast of the Sea of Japan in winter since 2006. The project is named GROWTH (Gamma-ray Observation of Winter Thunderclouds). In this talk, I will report on the observations in FY2020, aiming to measure the altitude of the accelerator.

For the FY2020 observations, detectors were set up at two locations in Kanazawa City, each ~2 km away from each other. Kanazawa City is an area where lightning frequently occurs, and there have been many gamma-ray observations in the past. We deployed the detector called GOOSE (Gamma-ray Orientation Observing System with Electron-monitor), which consists of collimated detectors and an electron detector. The former consist of four detectors, three of which have lead plates limiting the field of view and also inclined; directly upward, 30° eastward, and 30° westward, respectively. When the size of the accelerator is smaller than the altitude, it can be approximated as a point source. The altitude of the accelerator can be estimated using the time difference in the count rates of the three collimator detectors as they are swept by the wind. When the altitude is less than 100 m, 30 MeV electrons can be detected directly on the ground because their range in the atmosphere is longer.

Observations for FY2020 began at the end of October, and gamma-ray glows were observed at around 18:00 on January 8, 2021, and at around 6:00 on January 9, 2021. It was snowing on both days, and there was a west-southwest wind of 16.6 m/s on the 8th and a west wind of 10 m/s on the 9th events. In the collimator detectors, the count rate observed in the detectors facing upwards was 1.5-2.5 times higher than that in the detectors tilted to the east and west. This is a clear evidence for the beaming effect of bremsstrahlung. In both events, the time difference between westward and eastward included detectors was generally less than 10 seconds, and the altitude was less than ~150 m in the point source approximation. The electron detector also detected an excess of charged particles synchronized with the gamma-ray glow. The origin of this excess is still under analysis.

Keywords: gamma rays from thunderstorms, altitude measurement of the electron accelerator, electron detector