Gamma-ray Observation of Winter Thunderclouds: the progress of multi - point observation in 2019

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It has been known that gamma-rays emitted from lightning discharge and thunderclouds themselves, and resolving their generation mechanism is an important theme in both high-energy physics and atmospheric physics. The phenomenon called TGF(Terrestrial Gamma-ray Flash)originates from lightning discharge and its duration is less than 1 ms. The long burst has a duration of a few minutes and known to drift along with the thundercloud itself. In 2018, it was observationally shown for the first time that, short bursts which are a ~ 100 ms radiation event originates from high-energy neutrons generated by the photonuclear reaction between downward TGF and Atomic nucleus of atmospheric molecules(Enoto et al.2017). However, even the location of the electron accelerator is not resolved yet and the condition of its birth and death is also not known. So, detailed observation of the acceleration region is required. In addition, the phenomenon that long burst disappears due to lightning discharge, and TGF/ short burst simultaneously occurs is observed in 2017 (Wada et al.2019). Therefore, the relation between the long burst, the TGF and short burst, as well as the lightning discharge itself is an important issue. Specifically, the possibility of lightning discharge caused by long bursts and roles played by TGF/short burst under that situation and so on.
We are observing gamma-ray events in *Hokuriku*-regions from 2006. The project is named GROWTH(Gamma-ray Observation of Winter Thunderclouds). We installed 26 gamma-ray detectors in FY 2019. Especially, we installed 20 detectors in *Kanazawa* City, *Ishikawa* prefecture within an area of 10 km square at ~ 3 km intervals to track the drift of acceleration area of thunderclouds in detail. In 2019, we newly developed a high-speed readout detector for the detection of downward TGF and the short burst and installed near a tower that lightning is expected. On the coast in *Kanazawa* City, we installed a directional gamma-ray detector that augmented the lead plate, able to detect direct 10 MeV gamma-ray photons. The purpose of this is to measure the altitude of the acceleration region by using wind velocity. On January 13th, 2020, two long bursts were detected at *Izumigaoka* and *Kindaifuzoku* high school in *Kanazawa* City, *Ishikawa* prefecture, and these long bursts disappeared in the middle of observation. After we checked lightning data of JLDN(Japanese Lightning Detection Network) and analyzed gamma-ray time data, we confirmed that termination of the two long bursts is coincident with. In addition, we revealed that a TGF/short burst was associated with the lightning discharge. We report mainly on 2020/01/13 events about the result of 2019's winter observation.

Keywords: Lightning discharge, Gamma-ray , High-energy atmospheric physics