Hydrometeor distribution in a thundercloud related to a gamma-ray emission event

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Lightning events are frequently bought about by a shallow convective cloud in Hokuriku region during the cold-air outbreak in winter. Gamma-ray emission events have been simultaneously observed from thunderclouds in the region. The Gamma-ray Observation of Winter Thunderclouds (GROWTH) field campaign has been conducted to investigate gamma-ray events from thunderclouds by multiple sensors around Kanazawa City, Japan (Enoto et al. 2017, Wada et al. 2019).
The gamma-ray glow, which is a kind of gamma-ray emission, is lasting a few seconds to several minutes. The gamma-ray glow is considered that phenomena originate from relativistic runaway electron avalanches (RREAs) in strong electric fields due to positively charged particles in the lower part of the cloud and negatively charged ones in the upper part of it (Wada et al., 2019). Although several gamma-ray glow events have been observed in recent years by the GROWTH field campaign, microphysical properties in a thundercloud brought about gamma-ray emission events have not been clarified. Hisadomni et al. (2020) reported double gamma-ray glows in Kanawaza at 0203 and 0206 JST on 13 January 2020. This study shows 3-dimensional hydrometeor distributions in the thunderclouds brought about the gamma-ray emission event using a hydrometeor classification algorithm (Kouketsu et al. 2015). Polarimetric parameters, i.e., reflectivity, differential reflectivity, specific differential phase, correlation coefficient between horizontal and vertical polarizations, which are obtained by XRAIN radar at the Noumi site.
High reflectivity area that exceeds 40 dBZ is observed above the gamma-ray observation sites at least 5 minutes before the gamma-ray glow. At that time, the echo-top height reaches at a height of 6 km that is relatively higher than typical one of snow clouds. Wet graupel (0.5 ~ 2 km) and dry graupel (2 ~ 5.5 km) are detected with the high reflectivity area that should correspond to the convective core. The surface temperature is 6.6 degrees Celsius at Kanazawa Meteorological Observatory at 02:00 JST. Thus, graupel particles in the lower part of the thundercloud should be positively charged by the riming electrification (Takahashi, 1978).

Keywords: Hokuriku winter thundercloud, lightning discharge, gamma-ray glow

