Downward Terrestrial Gamma-ray Flashes Coincident with Enegetic In-cloud Pulses

*Yuuki Wada[1], Teruaki Enoto[1], Takeshi Morimoto[2], Yoshitaka Nakamura[3], Mitsuteru Sato[4], Tomoo Ushio[5], Kazuhiro Nakazawa[6], Takayuki Yuasa[7], Daisuke Yonetoku[8], Tatsuya Sawano[8], Masashi Kamogawa[9], Hideo Sakai[10], Yoshihiro Furuta[11], Kazuo Makishima[1,12], Harufumi Tsuchiya[11]

1. RIKEN, 2. Kindai University, 3. KCCT, 4. Hokkaido University, 5. Osaka University, 6. Nagoya University, 7. Private Company, 8. Kanazawa University, 9. University of Shizuoka, 10. University of Toyama, 11. Japan Atomic Energy Agency, 12. University of Tokyo

Terrestrial gamma-ray flashes (TGFs) are millisecond-long energetic emissions coincident with lightning discharges (Fishman et al., Science, 1994, Smith et al., Science, 2005). In addition to upward-oriented TGFs, which are routinely detected by in-orbit satellites, several ground-based experiments have detected downward-oriented ones (Dwyer et al., GRL, 2004, Hare et al., JGR Atmospheres, 2016, Abbasi et al., JGR Atmospheres, 2018). In particular, downward TGFs during winter thuderstorms in Japan are sometimes powerful enough to trigger photonuclear reactions in the atmosphere (Enoto et al., Nature, 2017, Wada et al., PRL, 2019). Recent studies on TGFs and associated radio-frequency (RF) emissions have presented that a distinct class of RF lightning pulses called “energetic in-cloud pulse” (EIP) are deeply connected to upward TGFs, and have predicted that negative-polarity EIPs could be connected to downward TGFs (Lyu et al., GRL, 2015, 2016). However, the connection between EIPs and downward TGFs has never been reported. We have performed the Gamma-ray Observation of Winter Thunderclouds experiment in coastal areas of the Sea of Japan since 2006 (Tsuchiya et al., PRL, 2007). In Kanazawa, one of our observation sites, two downward TGFs were detected in December 2017 and January 2018. Both TGFs coincided with negative-polarity RF pulses whose peak currents were lager than 150 kA, reported by JLDN. Based on RF waveforms obtained by our broadband low-frequency observation network, they are categorized into negative-polarity EIPs. We present the first report on the connection between EIPs and downward TGFs (Wada et al., JGR Atmospheres, 2020).

Keywords: thunderstorm, terrestrial gamma-ray flash, high-energy atmospheric physics, atmospheric electricity

