Lightning-Triggered Termination of a Gamma-ray Glow in a Japanese Winter Thunderstorm (AE33A-3397)

Yuuki Wada (University of Tokyo / RIKEN : wada@juno.phys.s.u-tokyo.ac.jp)
G.S.Bowers, T.Enoto, M.Kamogawa, Y.Nakamura, T.Morimoto, D.M.Smith, Y.Furuta, K.Nakazawa, T.Yuasa, A.Matsuki, M.Kubo, T.Tamagawa, K.Makishima, H.Tsuchiya

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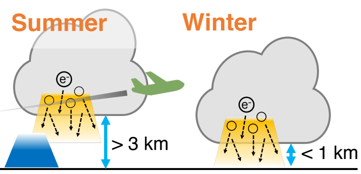
1. Introduction

Thunderclouds produce minute-lasting emissions: gamma-ray glows / thunderstorm ground enhancements.
(e.g. McCarthy & Parks 1985, Eack+1996, Kelley+2015, Chilingarian+2011)

Bremsstrahlung of avalanche electrons in strong E-field.

Glows sometimes cease with a lightning discharge.
(e.g. McCarthy & Parks 1985, Tsuchiya+2013, Chilingarian+2017)

Fundamental questions of gamma-ray glows:
- **Life cycle, acceleration mechanisms, energetics**
- **Do glows assist or prevent lightning initiations?**

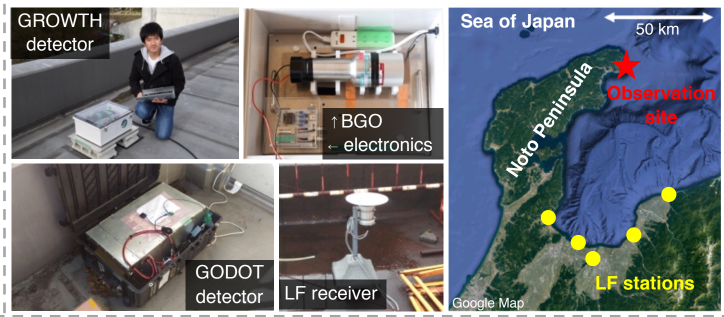


- Suitable target: **winter thunderstorms**
- Lower cloud bases allow us to detect glows at sea level.

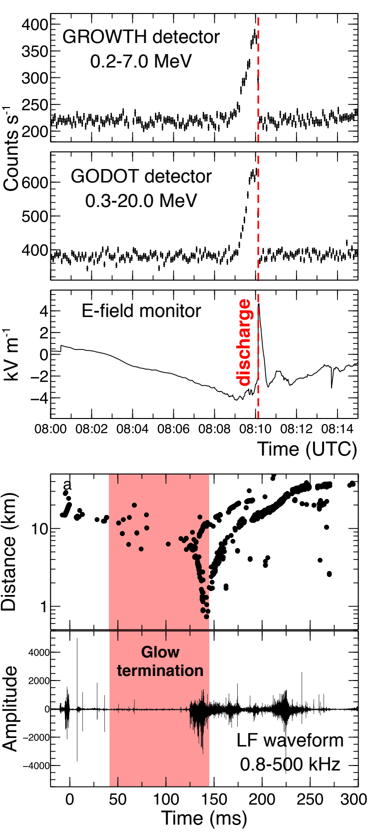
2. Instruments

Observation site: ***Kanazawa University Noto School***
- GROWTH detector: 3-inch cylindrical BGO (Enoto+2017)
- GODOT detector: 5-inch cylindrical NaI (Bowers+2017)
- Atmospheric E-field monitor: Boltek EF-100

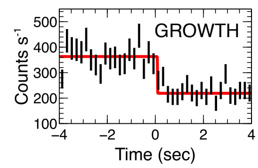
LF network to detect lightning discharges (0.8-500 kHz)
- Lightning mapping with 5 stations (time-of-arrival).



3. Results



We detected a gamma-ray glow on 11th February 2017 during heavy winter thunderstorms.
- The glow lasted for ~60 sec, with energies up to 20 MeV.

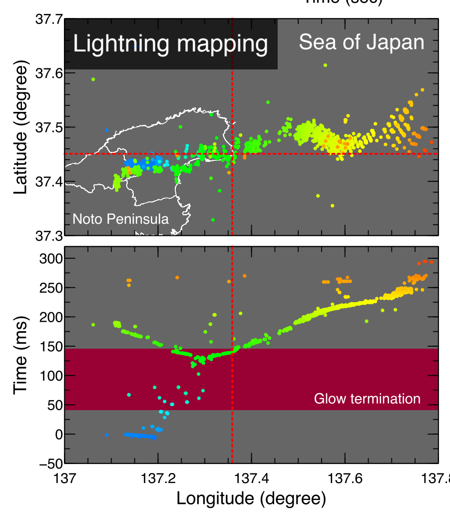


Before, during, after the glow, electric field was negative, indicating the cloud base was negatively charged.

The glow ceased with a lightning discharge.
- Termination at 08:10:08.093 +/- 0.052 UTC (evaluated by fitting with a step function)

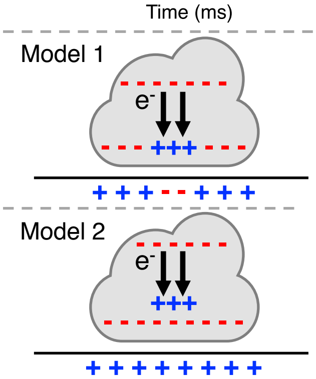
LF network detected the lightning discharge.
- It continued to develop for ~300 ms, spread ~70 km wide in east-west direction. (one of winter lightning's features)

The discharge passed above observation site.
- Six faint in-cloud pulses within 1 km.
- Timing of the passage is consistent with when the glow terminated.



4. Discussion

The glow was terminated by pulses of an IC.
- The pulses might make electric filed lower than the threshold for electron avalanche.
- Even small pulses can disturb the glow.



Was the glow related to the lightning initiation?
- No. The IC initiated 15 km west from the glow.

What is charge structure inside the thundercloud responsible for the electron acceleration?
- E-field between cloud base and ground was too low.
- Two possibilities:
  1. Traditional local positive charge region.
  2. A charge pair above a negative charge layer.

5. Summary

- **Winter thunderstorms are suitable for gamma-ray glow studies.**
- **We detected a glow terminated by an IC discharge.**
- **The IC passed nearby the glow.**
- **The nearby pulses destroyed E-field region for the glow.**
- **E-field measurement suggests two possible charge structures.**
- **The glow was not related to the lightning initiation.**

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