

Correlation between lightning discharges and terrestrial gamma-ray flashes observed with a rearranged Los Alamos Sferic Array (LASA)

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LASA Sensor



- Analog bandwidth: 200 Hz – 500 kHz
- Digitizing rate: 1 MSPS
- Digital resolution: 15 bit
- Triggering: Software-based noise riding
- Dead time: Zero
- Data format: Full E-field change waveform
- Timing accuracy: 1 μ s

Summary

In 2006, LASA [Shao et al., 2006] has observed five additional lightning discharges that were closely related to terrestrial gamma-ray flashes (TGF) detected by the RHESSI satellite [Smith et al., 2005]. Same as the eight TGF-related lightning events observed by LASA in 2005 [Stanley et al., 2006], all the 2006 events were intra-cloud discharges (IC) that transported negative charge upward. Among the five events, three were detected by three or more LASA stations, and their geolocations can be accurately determined. The three lightning events were found within 300 km of RHESSI's sub-satellite position. Taking account for the propagation times from the source to the LASA stations and to the RHESSI satellite, TGFs were found to consistently lead the lightning events by 2-5 ms. Even with the possible 1.8 ± 0.2 ms correction for the RHESSI clock, the TGF that occurred on 26 September 2006 would still lead the narrow-bipolar-event (NBE) lightning signal by ~ 3.0 ms. We note here that a TGF that was related to a similar NBE in 2005 led the lightning signal by 3.3 ms [Stanley et al. 2006] after the 1.8 ms correction for RHESSI. For the other two geolocated events, the TGF lead times are no less than 0.2 and 0.3 ms.

Two of the five events show distinguishable ionospheric reflected pulses, and the height of the sources can be estimated. The NBE event on 26 September 2006 was estimated ~ 16.5 km above the earth surface, and the event on 24 September 2006 was estimated ~ 12.0 km. The height difference between the two might due to the convective depth of the storms at different geographic latitudes. The former was located at low latitude of 13.35°N , while the latter at mid-latitude of 29.03°N . For the two events that Stanley et al. [2006] were able to estimate the lightning height, they found 13.6 and 11.5 km. These two were both located at mid-latitude, 30.37 and 25.45°N , respectively. All the estimated lightning heights, except for the 26 September 2006 event, are significantly lower than the theoretically predicted height for the gamma-ray sources [Dwyer and Smith, 2005]. The 16.5-km event is within the theoretical height of 15-21 km, although the lightning signal lags behind the TGF by 3.0 ms (after RHESSI time correction).

References:

- Shao, X.-M., et al., 2006, Total lightning observations with the new and improved Los Alamos sferic array (LASA), *J. Atmos. Ocean. Tech.*, 23, 1273-1288.
 Smith, D.M., et al., 2005, Terrestrial gamma-ray flashes observed up to 20 MeV, *Science*, 307, 1085-1088.
 Stanley, M. A., X.-M. Shao, et al., 2006, A link between terrestrial gamma-ray flashes and intracloud lightning discharges, *Geophys. Res. Lett.*, 33, L06803, doi:10.1029/2005GL025537.
 Dwyer, J. R. and D. M. Smith, 2005, A comparison between Monte Carlo simulations of runaway breakdown and terrestrial gamma-ray flash observations, *Geophys. Res. Lett.*, 32, L22804, doi:10.29/2005GL023848.

TGF-Related Lightning Events

RHESSI TGF time: 09/26/2006 UTC
 19:23:55.812

- Number of stations: 4
- Lightning location: (13.35° , -79.47°)
- Source to sub-sat distance: 177 km
- Source to nearest station: 1321 km
- Source height: 16.5 ± 1.5 km
- TGF lead time: 4.8 ms
- Lightning type: +NBE

RHESSI TGF time: 09/24/2006 UTC
 05:37:36.836

- Number of stations: 3
- Lightning location: (29.03° , -96.15°)
- Source to sub-sat distance: 133 km
- Source to nearest station: 1155 km
- Source height: 12.0 ± 1.5 km
- TGF lead time: 2.2 ms
- Lightning type: +NBE/+IC

RHESSI TGF time: 09/17/2006 UTC
 09:19:34.802

- Number of stations: 4
- Lightning location: (10.50° , -77.00°)
- Source to sub-sat distance: 296 km
- Source to nearest station: 1619 km
- Source height: N/A
- TGF lead time: 2.3 ms
- Lightning type: +IC

RHESSI TGF time: 09/11/2006 UTC
 04:17:08.476

- Number of stations: 2
- Lightning location: (?) (12.50° , -76.00°)
- Source to sub-sat distance: (?) 182 km
- Source to nearest station: (?) 2017 km
- Source height: N/A
- TGF lead time: (?) 0.7-2.0 ms
- Lightning type: +IC

RHESSI TGF time: 06/05/2006 UTC
 08:28:51.549

- Number of stations: 2
- Lightning location: N/A
- Source to sub-sat distance: N/A
- Source to nearest station: (?) 1900 km
- Source height: N/A
- TGF lead time: N/A
- Lightning type: +NBE/+IC

