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Terrestrial Gamma-ray Flashes: Twentieth Anniversary and Recent Fermi GBM Results

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The TGF field has advanced remarkably in the twenty years since the publication of the paper "Discovery of intense gamma-ray flashes of atmospheric origin" by G. J. Fishman et al. I will review the BATSE observations and how the following space-based observations of RHESSI, AGILE and Fermi advanced the field. BATSE discovered TGFs, including multi-pulse ones, and established the correlation of TGFs with thunderstorms. Retrospective analysis of BATSE data identified electron-beam events. RHESSI observations extended the spectra to higher energies and indicated a lower source altitude. The shape of the spectrum measured with AGILE challenges the predictions of the large-scale relativistic runaway electron avalanche (RREA) model. Much progress has been made with the combination of space-based gamma-ray and ground-based radio observations.

Finally, I will review Fermi GBM results. The high effective area of GBM enables improved measurements of pulse profiles. Some multi-pulse events have separations as short as 1/4 ms, so that the pulses partially overlap. Short events are typically asymmetric, consistent with a Compton tail, while longer events are commonly symmetric, consistent with the Compton tail being hidden within the longer pulse. GBM also found electron-beam events to include positrons. Recent ground-based search of individual photon data uncovered fainter and shorter TGFs. Radio observations of GBM TGFs and a strong TGF duration / radio-detection anti-correlation show that the radio detections that are very close in time (< tens of microseconds) to a TGF are due to the TGF itself rather than from lightning. Analysis of the first year of continuous individual photon data found more than 800 TGFs.