Introduction and Background

TGFs, or terrestrial gamma-ray flashes, are related to lightning activity on Earth and can be detected but not precisely localized by the GBM instrument aboard the Fermi Space Telescope. The ground-based ENTLN radio lightning detector network allows association of TGFs with individual lightning strokes for localization and analysis of surrounding lightning activity to gain understanding of the TGF generation process. It is hypothesized that IC (intra-cloud) lightning travels from an upper negative charge layer to an upper positive charge layer, generating a TGF, followed by a flurry of further lightning activity between and through the layers.

Correlating TGFs with Lightning Strokes

The timestamps of Fermi TGF detections were compared with those of ENTLN lightning stroke detections corrected for TGF propagation time to the spacecraft. Strokes with <200 µs time difference and P-value <0.05 were considered to be detections of the TGF itself. Other strokes were classified as potentially associated with the TGF if within a certain time and distance window. The figure below, showing distance in km vs. number of strokes, demonstrates the rationale behind a distance cutoff of 30 km, as the number of strokes per bin above approximately 30 km returns to background levels.

Conclusion

As indicated by the figures, the shortest timescale component includes radio signals within ±200 µs of the TGF, and predominantly comprises the TGFs themselves. The middle component includes significant radio signals within ±8 ms of the TGF. The longest timescale component occurs after the TGFs out to approximately 800 ms. This pattern of signals confirms the aforementioned hypothesis of TGF generation in which IC lightning travels vertically from the upper negative charge layer to the upper positive charge layer, as indicated by the strokes observed in the middle timescale. At any time during this process, a TGF may be generated at random, detected as the strokes in the shortest timescale. Further lightning activity follows in both layers, as indicated by the asymmetrical strokes of the longest timescale.

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