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Measurements and implications of the source altitude of terrestrial gamma-ray flashes

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Radio emissions continue to provide a unique view into the electrodynamics of terrestrial gamma ray flash (TGF) production. It is generally agreed that most and perhaps all TGFs are produced during the early, upward leader stage of normal polarity IC lightning flashes. Observations have shown that at least some TGFs are effectively simultaneous with a distinct low frequency pulse, indicating likely production of that pulse by the TGF-generating electron acceleration process itself [Cummer et al., GRL, 2011]. Additional observations of an anti-correlation between the TGF-radio association rate and TGF duration [Connaughton et al., JGR, 2013], and detailed comparisons of simulation and measurement [Dwyer and Cummer, JGR, 2013] strongly support this picture.

A subset of TGF events detected over the past several years by the GBM instrument on the Fermi satellite, and also measured by our network of low frequency radio sensors, produced radio emissions that are sufficiently distinct to estimate the TGF source altitude from multiple ground-ionosphere reflections. By combining the gamma ray measurements, radio measurements, and Monte Carlo modeling, the self consistency of the source altitude, gamma ray flux, and radio emission duration and magnitude can be rigorously and quantitatively tested in the context of TGF generation theories. We will present several of these observations and associated analysis, and attempt to draw some firm conclusions about the physics behind TGFs.