A Radio-Informed Search for Weak Terrestrial Gamma-Ray Flashes with Fermi GBM

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Terrestrial gamma-ray flashes (TGFs) are sub-microsecond bursts of radiation that are known to occur in association with strong, intracloud lightning (IC). These bursts typically last fractions of a millisecond and have strong enough photon emissions (>40 MeV) that they can be seen, quite clearly, from space. The Fermi Gamma-ray Space Telescope's Gamma-ray Burst Monitor is able to detect such phenomena from its low-Earth orbit. Presently, we are trying to determine the occurrence of possible, weak TGFs (too weak to be statistically significant with just gamma-ray data alone) by combining data from ground based, low frequency radio sensors and from the Fermi Gamma-ray Space Telescope. We first use National Lightning Detection Network (NLDN) data to identify events that are classified by the NLDN the same way as TGF-associated signals are, namely high peak current in-cloud events, and that occur within 300 km of the Fermi nadir point. Ground based radio signal waveforms are then examined to distinguish between the early stage IC flash signals that are known to be associated with TGFs and other types of lightning events. We are able to identify possible TGFs based on their shape, characterized by a very large pulse preceding a slower, more identifiably sinusoidal signal. Given the peak of an identified possible TGF from these radio waveforms, we are able to determine the precise timing of the event to within several tens of μs. We can then calculate propagation time for the weak TGF's photon emissions to reach the Fermi satellite using Fermi's known position at the time of the proposed weak TGF. We then examine, both individually and statistically, the Fermi satellite's Gamma-ray Burst Monitor data at the specific time of the weak TGF and search for any slight change in the detector's photon count that may occur as a result. Our findings could give us crucial scientific insight into the occurrence of these weak TGFs in Earth's atmosphere.