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Radio emissions from RHESSI TGFs

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The discovery of bursts of energetic photons coming out to space from the Earth's atmosphere, referred to as terrsetrial gamma-ray flashes (TGFs), has stimulated research activity investigating different aspects of the TGF generation and accompanying processes. Two models of the TGF production are nowadays competing to explain the observations of the TGFs and related phenomena. One of the models involves the feedback mechanism enhancing the production rate of the runaway electrons in the ambient electric field of a thundercloud. Another model considers runaway electrons accelerated in the strong local electric field in front of the upward propagating negative leader of the +IC.

We performed a detailed analysis of RHESSI TGFs detected between August 2004 and September 2015. It was reported that the RHESSI satellite clock has a systematic error of ~ 1.8 ms, but the exact value remained unknown, also it was unclear if this systematic clock error is changing with time or not. We compared RHESSI TGFs with the world wide lightning location network (WWLLN) database and found the distribution of the time delays between the TGF peak times and associated WWLLN detections. This distribution allowed us to find the value of the RHESSI systematic clock offset with the microsecond accuracy level. Also we found that this offset experienced two changes: in August 2005 and in October 2013, which was confirmed by two independent ways.

We found that in case of double TGFs WWLLN detection corresponds to the second TGF of the pair. VLF magnetic field recordings from the Duke University also attribute radio sferics to the second TGF, exhibiting no detectable radio emission during the first TGFs of the TGF pairs. We have proposed a possible scenario that is consistent with the observations. This scenario supports the leader-based model of the TGF generation.

Spectral characteristics of 77 sferics recorded by the Duke University VLF sensors and related to the RHEESI TGFs show that maximal power is emitted between 6 and 12 kHz, which implies the characteristic current pulse width of ~ 15 to $30\ \mu s$. This suggests that the observed TGFs might have substructures including brief intense bursts that are responsible for the radio emissions.