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Predictions on Optical Emissions Associated with Terrestrial Gamma-ray Flashes

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Terrestrial Gamma-ray Flashes (TGFs) are high-energy photon bursts originating from the Earth's atmosphere. After their discovery in 1994 by the Burst and Transient Source Experiment (BATSE) detector aboard the Compton Gamma-Ray Observatory [*Fishman et al.*, Science, 264, 1313, 1994], this phenomenon has been further observed by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) [*Smith et al.*, Science, 307, 1085, 2005], the Fermi Gamma-ray Space Telescope [*Briggs et al.*, JGR, 115, A07323, 2010] and the Astrorivelatore Gamma a Immagini Leggero (AGILE) satellite [*Marisaldi et al.*, JGR, 115, A00E13, 2010]. Measurements have correlated TGFs with initial development stages of normal polarity intracloud lightning that transports negative charge upward (+IC) [e.g., *Lu et al.*, GRL, 37, L11806, 2010; JGR, 116, A03316, 2011]. Recently, *Østgaard et al.* [GRL, 40, 2423, 2013] have reported for the first time space-based observations of optical emissions from TGF-associated IC lightning flashes.

The purpose of the present work is to predict the intensities of optical emissions resulting from the excitation of air molecules by the large amount of low- and high-energy electrons involved in TGF events based on two production mechanisms: relativistic runaway electron avalanches (RREAs) [*Dwyer and Smith,* GRL, 32, L22804, 2005] and production of runaway electrons by high-potential +IC lightning leaders [e.g., *Celestin and Pasko*, JGR, 116, A03315, 2011; *Xu et al.,* GRL, 39, L08801, 2012]. We use a Monte Carlo model to simulate the propagation of electrons in either large-scale homogeneous electric fields sustaining RREAs or highly inhomogeneous electric fields produced around the lightning leaders tips region. A model similar to that described in [*Liu and Pasko*, JGR, 109, A04301, 2004] is used to estimate intensities from the first and second positive band systems of N_2 and the first negative band system of N_2^+. The optical emissions produced by RREAs are compared to those recently estimated by *Dwyer et al.* [GRL, 40, 4067, 2013]. We will specifically investigate the differences obtained between optical emissions produced by both TGF production mechanisms considered as they could be used to determine which is truly responsible for TGF production.