X-ray Emissions Produced by Stepping Lightning Leaders

Wei Xu[1], Sebastien Celestin[2], and Victor P. Pasko[1]

[1] Communications and Space Sciences Laboratory, Pennsylvania State University, University Park, Pennsylvania, USA

[2] Laboratory of Physics and Chemistry of the Environment and Space (LPC2E), University of Orleans, CNRS, Orleans, France

X-ray bursts have been observed in association with rocket-triggered lightning and natural cloud-to-ground lightning [e.g., *Dwyer et al.,* Science, 299, 694-697, 2003; *Saleh et al.,* JGR, 114, D17210, 2009; *Schaal et al.,* JGR, 117, D15201, 2012]. Moreover, recent measurements at the International Center for Lightning Research and Testing (ICLRT) [e.g., *Dwyer et al.,* GRL, 32, L01803, 2005; *Howard et al.*, GRL, 35, L13817, 2008] have established a correlation between these X-ray measurements and the stepping process of lightning leaders. Additionally, it has been suggested that the Relativistic Runaway Electron Avalanche (RREA) mechanism is not likely to be responsible for this phenomenon [*Dwyer et al.*, GRL, 31, L12102, 2004]. These X-rays may instead originate from the acceleration of runaway electrons in the lightning leader field during negative corona flash processes [*Celestin and Pasko,* JGR, 116, A03315, 2011]. However, the properties of X-ray bursts from lightning are poorly known, mainly due to the low fluence of photons detected from the ground.

In the present study, we employ Monte Carlo models to simulate the acceleration of runaway electrons in the electric field produced around the lightning leader tip region and transport of the associated bremsstrahlung photons in the atmosphere. X-ray emissions measured by the Thunderstorm Energetic Radiation Array (TERA) [e.g., *Saleh et al.,* 2009; *Schaal et al.,* 2012] are utilized as a reference to infer the properties of X-ray emissions associated with the stepping phase of lightning flashes. We specifically investigate the energy spectra, deposited energy, and effective radiation dose at ground corresponding to this high-energy radiation.