Modeling the Runaway Electron Distributions in Thunderstorm Ground Enhancements

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Abstract

Various high-energy phenomena have been observed in correlation with thunderstorms since the 1990s. These phenomena include Terrestrial Gamma-ray Flashes (TGFs) [1], which are usually observed from low Earth orbit satellites, X-ray bursts from negative cloud-to-ground discharges observed from the ground (e.g., see [2]), and Thunderstorm Ground Enhancements (TGEs) [3]. The latter consist of copious amounts of energetic electrons, gamma rays, and neutrons, detected from the ground at high altidudes. In fact, hundreds of TGEs have been observed at Aragats Space Environment Center (ASEC) with particle detectors located on Mount Aragats at altitudes up to 3200 m. Recently, a few of the largest TGEs measured by ASEC detectors allowed for the first time to measure the energy spectra of electrons and gamma rays well above the cosmic ray background [4, 5].

High-energy phenomena in thunderclouds are believed to root from the acceleration of so-called runaway electrons. Indeed, electrons with high energy and consequently low probability of collision with the air molecules, can propagate in an applied electric field so that the energy they gain from the field is greater than the energy they lose to collisions. In this work, we will focus on the energy distributions of runaway electrons accelerated in electric fields with magnitudes slightly above the relativistic runaway electron avalanche (RREA) threshold in the framework of TGEs by means of Monte Carlo simulations. Comparisons between simulation results obtained by GEANT4 (e.g., see [4]) and a simulation code dedicated from the ground up to modeling runaway electrons acceleration (e.g., see [6]) will be carried out. We will specifically study the electron distribution dependence on the magnitude and layout of the electric field in the cloud and on the distribution of seed energetic electrons produced by cosmic rays.

References

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