

Lightning-Driven Electrodynamics of the Middle Atmosphere

Umran S. Inan

Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, CA 94305

Tel: 650-7234994; FAX: 650-7239251; EMAIL: inan@nova.stanford.edu

The decade of the 1990s brought to fore spectacular new evidence for the long-suspected electrical breakdown effects at high altitudes (mesosphere/lower ionosphere) that are driven by lightning discharges at tropospheric altitudes. We now know that intense heating of ambient free electrons in these regions, driven by intense quasi-electrostatic fields released in lightning discharges, leads to luminous glows, eventually producing ionization channels and ionization waves known as streamers, all of which constitute what we refer to as "sprites". We also know that electromagnetic fields radiated by both cloud-to-ground and intra-cloud discharges produce similar heating and ionization in the lower ionosphere, leading to brief flashes of luminosity over typically a much wider region, known as elves. In addition to these breakdown phenomena that are caused/initiated by the heating of ambient free electrons, the intense quasi-static fields accelerate energetic relativistic (MeV) electrons upward, producing intense beams via an avalanche process, leading to the production of terrestrial gamma-ray flashes. These intense energetic electron beams escape upward to the radiation belts, and may become trapped therein or precipitate out in the geomagnetically conjugate hemisphere, once again producing intense but brief flashes of luminosity. These spectacular luminous effects result from at least three classes of electrodynamic interactions driven by fields released by lightning discharges, which also lead to several other (non-luminous) effects such as conductivity changes and precipitation of energetic electrons. In this talk, we shall review the state-of-the-art in our understanding of the underlying theoretical basis of lightning-driven electrodynamics of the middle atmosphere, emphasizing comparison and calibration of theoretical predictions with experimental data.