Ion dynamics in lightning-induced heating of the lower ionosphere

D. A. Kotovsky and R. C. Moore

Department of Electrical and Computer Engineering, University of Florida
Gainesville, Florida, USA

Electric field changes produced by powerful lightning discharges are capable of heating the overlying ionosphere, sometimes resulting in ionization and excitation of optical emissions. Although experimental analysis of "transient luminous events" have revealed many details regarding optical emissions, far less is known about the associated electron density changes. Measurements of low-frequency radio-wave scattering from ionospheric disturbances have been used to make general inferences concerning electron density changes; however, a number observed scattering characteristics (e.g., slow onsets and long recoveries) have yet to be fully explained.

In this talk, we discuss the physical mechanisms which affect the temporal dynamics of lightning-induced electron density changes of the lower ionosphere, and their relation to the timescales of very-low frequency (3-30 kHz) radio wave scattering. We present two-dimensional simulations of elves and sprite halos, accounting for dynamics of eighteen ionized species. Ion dynamics affecting the development of electron density enhancements (i.e., detachment of O^-) and recovery of electron density enhancements (i.e., attachment versus recombination controlled recovery) are discussed in detail. Additionally, timescales of electron heating and cooling are discussed in relation to the commonly used quasi-static approximation, in which chemical reaction rates and electrical conductivity are calculated as a function of the instantaneous electric field.