

# Multiple ion species fluid modeling of sprite halos

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## Abstract

Sprite halos are brief descending glows appearing at the lower ionosphere boundary, which follow strong cloud-to-ground lightning discharges [e.g., *Barrington-Leigh et al.*, JGR, 106, 1741, 2001; *Pasko*, JGR, 115, A00E35, 2010]. They last for a few milliseconds and extend about tens of kilometers radially. According to global survey of occurrence rates of transient luminous events by the ISUAL instruments on the FORMOSAT-2 satellite, on average sprite halos occur once every minute on Earth [*Chen et al.*, JGR, 113, A08306, 2008]. It has been established that sprite halos are caused by electron heating and molecule excitation and ionization in the lower ionosphere due to lightning quasi-electrostatic field [e.g., *Barrington-Leigh et al.*, 2001; *Pasko*, 2010]. They modify the atmospheric conductivity, which may cause perturbations in the propagation of very low frequency electromagnetic waves in the Earth-ionosphere waveguide [e.g., *Moore et al.*, JGR, 108, 1363, 2003].

Past modeling work on sprite halos was conducted by using either a zero dimensional model of multiple ion species or a two dimensional (2D) model of at most three charged species. In this talk, we report a modeling study of sprite halos by using a recently developed 2D fluid model of multiple ion species. The model species include electrons, light positive and negative ions, and positive and negative cluster ions. This ion species set was used by *Lehtinen and Inan* [GRL, 34, L08804, 2007] to study upper atmospheric ion chemistry. In addition, another charged species,  $O^-$ , is added to this species set, because electron detachment of  $O^-$  can proceed very fast under certain conditions [*Rayment and Moruzzi*, Int.. J. Mass Spectrom., 26, 321, 1978], requiring a separate treatment from the other light negative ions. We present modeling results of time variations of ion densities due to strong cloud-to-ground lightning discharges and show the resulting dynamics of atmospheric conductivity profile. We also discuss the effects of the electron detachment of  $O^-$  on electron density change in sprite halos.