

Long recovery of the lower ionosphere from the quasi-electrostatic effects of cloud-to-ground lightning

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Early VLF events with a long recovery time on the order of tens of minutes have been studied by several recent works [Cotts and Inan, GRL, 34, L14809, 2007; Haldoupis et al., JGR, 39, L16801, 2012; Salut et al., JGR, 117, A08311, 2012]. It has been suggested that the long recovery is caused by long-lasting conductivity perturbations in the lower ionosphere, which can be created by sprites/sprite halos triggered by cloud-to-ground (CG) lightning [Moore et al., JGR, 108, 1363, 2003; Haldoupis et al., 2012].

We recently developed a two-dimensional fluid model with simplified ionospheric chemistry for studying sprite halos [Liu, JGR, 117, A03308, 2012]. The model chemistry captures major ion species and reactions in the lower ionosphere. The simulation results on sprite halos caused by positive CG lightning indicated when the electron detachment process from O^+ ions is included, electron density may grow even at subbreakdown conditions and the sprite halo front can descend to a lower altitude than previously thought. In this talk, we present the simulation results on the dynamics of sprite halos caused by negative CG lightning. For the halos caused by positive CG, their ionization fronts typically become very sharp as they descend downward, so simulations may suffer from numerical instability eventually [Liu, 2012]. However, the ionization front of a negative halo caused by lightning of similar strength is smoother, and the model can simulate the entire lifetime of the ionospheric perturbations. We show the modeling results on the ionospheric perturbations created by the negative halo and discuss how the ionosphere recovers to its original state.