Particle Modeling of Sprite Halos

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Introduction

Sprite halos are brief and diffuse flashes at an altitude of 70-85 km, preceding the development of streamer structures of sprites. A sprite halo is often followed very closely (<1ms) by the brighter sprite discharge, so that the observation becomes hard. Although using the previous theoretical models, we can simulate the overall structures of sprite halos, it is impossible to obtain the nonequilibrium characteristics such as electron energy distribution.

Method and Results

The Monte Carlo collision scheme is used to study the particle dynamics of sprite halos. The main idea is to combine the particle simulation and the quasi-electrostatic model. The particle simulation is applied at the altitude over 65 km to obtain the electron conductivity, which governs the total conductivity. We consider 36 kinds of electron-neutral particle collisions, involving 2 elastic, 22 exciting, 8 ionizing, 1 attaching and 3 photoionizing collisions.

Fig. 1 shows the simulation results of sprite halos. The neutral gases of 80% N_2 and 20% O_2 and the lightning discharge duration of 1 ms are assumed. The thundercloud charges are regarded as separate dipole charges. The positive and negative charges are set to be distributed around the altitude of 5 km and 2.5 km.

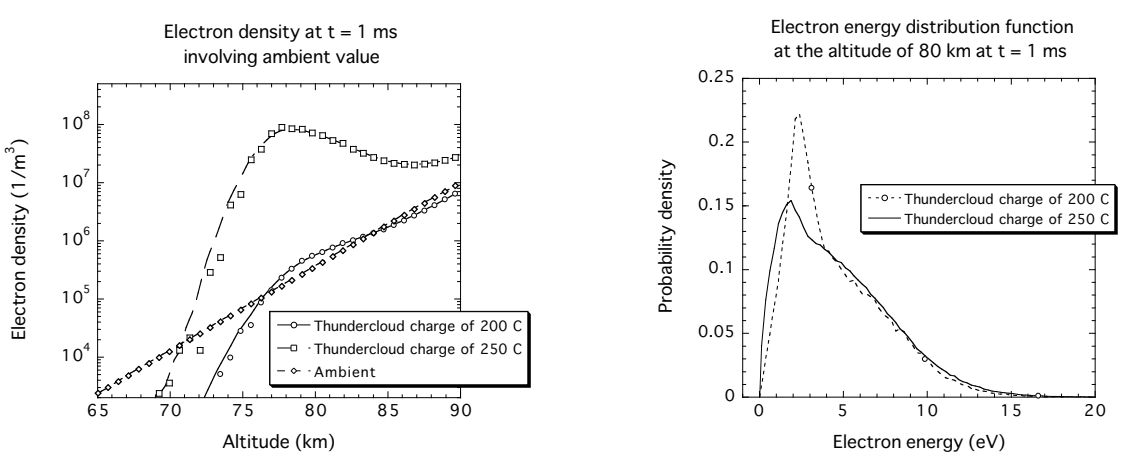

Fig. 1 The distributions of electron density and electron energy during the sprite halo discharges