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Statistical study of the magnetic storm phase dependence of the inner boundary of the plasma sheet electrons

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The locations of inner boundary of the plasma sheet electrons during magnetic storm have been analyzed statistically by using THEMIS data. Plasma sheet electrons are carried to the earth due to magnetospheric convection, and then drift toward the morning sector in the vicinity of the earth. Thus, the inner boundary of the plasma sheet electrons is formed around 3 - 7 R_E. In addition, plasma sheet electrons can precipitate along a magnetic field line, and produce aurora in the earth's ionosphere.

Previous studies investigated the dependence of the location of the inner boundary of the plasma sheet electrons on geomagnetic indices such as Kp and AE index [Korth et al., 1999; Jiang et al., 2011]. Jiang et al. [2011] reported the local time distribution of the inner boundary of the plasma sheet electrons in both quiet and disturbed conditions by referring AE index. In this study, we focus not only on dependences on Dst index but also on dependences on phase of magnetic storms. The data which we used are obtained by ESA (Electrostatic Analyzer) onboard the THEMIS satellite. ESA measures the energy flux, density and temperature of particles over the energy range from a few eV to 30 keV for electrons and to 25 keV for ions. In the present study, we use ESA data of 1 to 10 keV electrons. We perform analyses of events during two magnetic storms on July 6, 2013 and June 17, 2012. We also perform a statistical analysis of the positions of inner boundary of the plasma sheet electrons.

Event analyses indicates that the inner boundaries were located around 3 - 4 R_E and 4 - 10 R_E in the main phase and the recovery phase of the magnetic storm, respectively. We find that the boundaries are closer to the earth in the main phase than those identified during the recovery phase of the same magnetic storm. In addition, we find in the main phase of the magnetic storm that the identified inner boundaries of the plasma sheet electrons with energy from 0.7 to 9 keV are located around the similar radial distance. On the other hand, in the recovery phase of the magnetic storm, we find that the inner edge of the low energy electron (~1keV) is closer to the earth than that of the high energy electron (~9eV). In the magnetic storm of June 17, 2012, the recovery phase continued for two days. The inner boundary of the plasma sheet electrons was at 3.9 R_E in the first day and 6.1 RE in the second day. The difference between L of 1 keV electrons and that of 9 keV is 1.4 in the first day and 3.7 in the second day, so the energy dependence of the location of the inner boundary of the plasma sheet electrons becomes more evident in the second day than in the first day.

The result of our statistical study shows the similar energy dependences in the recovery phase of small magnetic storms but different tendency in the main phase of the magnetic storm. We also reveal that the typical radial distance of the inner boundary during the storm main phase is 3.9 R_E. Disappearance of the energy dependence of the location of the plasma sheet electrons (the difference between L of 1 keV electrons and that of 9 keV is less than 0.6) suggests the presence of the strong electric field in the vicinity of the earth. Finally, we compared the locations of the inner edge of the plasma sheet electrons obtained by ESA onboard THEMIS satellite with those estimated based on the steady state drift boundary model proposed by Jiang et al. [2011] and Volland-Stern electric field model . As a result, the model cannot fully explain the observed independence of the positions of the inner edges of the plasma sheet electrons on the kinetic energy of the electrons during magnetic storm, especially in the recovery phase of the magnetic storm. The results suggest that there are some additional electric fields in the inner magnetosphere and further investigations on them will be needed in future.

Keywords: plasma sheet inner edge, plasma sheet, convection electric field, magnetic storm, aurora, substorm