磁気嵐時のプラズマシート電子内側境界に関する研究
Study of the plasma sheet electron inner boundary during the magnetic storm

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The locations of the inner boundary of the plasma sheet electrons during magnetic storm have been analyzed by using the dataset from Time History of Events and Macroscale Interactions during Substorms (THEMIS) satellites.
The dependence of the location of the inner boundary of the plasma sheet electrons on geomagnetic indices such as Kp and AE was investigated in several previous studies [Korth et al., 1999; Jiang et al., 2011]. In addition, several empirical convection electric field model such as Volland-Stern model [Volland, 1973; Stern, 1975], McIlwain's E5D model [McIlwain, 1986], Weimer model [Weimer, 1996], and Matsui Model [Matsui et al., 2013] have been proposed based on the statistical analyses. So, we can trace the expected drift path of the plasma sheet particles in these electric filed models, and compare them with observed locations of the plasma sheet inner boundary.
In this study, we investigated the locations of the inner boundary of the plasma sheet electrons during the magnetic storms by using the electron flux data of 9 keV obtained by Electrostatic Analyzer (ESA) onboard the THEMIS satellites. We determined open/close boundary of the drift paths of plasma sheet electrons in Volland-Stern electric field during the recovery phase of the magnetic storm by performing the test particle simulation, and compared it with the position of the inner edges of the plasma sheet 9-keV electron measured by THEMIS ESA in the same period, because it is a simple macroscopic electric field model depending on slow variation of Kp, and good for the reference to find out the contributions of storm-time electric fields probably with rapid changes and microscopic structures.
We performed the statistical analysis of the positions of the inner edge identified in the recovery phase in the case that differences between the observed plasma sheet electron inner boundary and the open/close boundary of the energetic electron drift path calculated with Volland-Stern convection electric field model [Volland et al., 1973] are less than 0.5 RE. The agreement in these events suggests that the storm-time electric field does not exist around the calculated drift paths. However, as for three of twenty-two events, the calculated drift paths overlap the intense storm-time electric field reported by Nishimura et al. [2008]. In the event on December 20, 2015 around 20:00 MLT (Case-1), the geocentric distance of open/close boundary of the drift path of plasma sheet electrons, Rmodel, is 3.97, and that of the inner edge of the plasma sheet electrons in the magnetic equatorial plane, Robs, is 3.93. We calculated the electric field without the corotation electric field at the plasma sheet electron inner boundary found using Volland-Stern model, and compared it with the storm-time electric field reported by Nishimura et al. [2008]. Ex in the GSM coordinate calculated with Volland-Stern model (Exvs) is 0.23 mV/m while that reported by Nishimura et al. [2008] (Exni) is about -4.00 mV/m. If such large electric field exists on the drift path, the open/close boundary based on Volland-Stern electric field deviates from that of the inner edge of the plasma sheet electrons. From the analysis of another event on October 1, 2012 around midnight (Case-2), Rmodel is 3.50, Robs is 3.18, Exvs is 0.06 mV/m and Exni is about -3.00 mV/m. And as for a event obtained on July 9, 2012 around 20:00 MLT (Case-3), Rmodel is 6.18, Robs is 6.00, Exvs is 0.14 mV/m and Exni is about -1.00 mV/m. In this event, the calculated drift path doesn't overlap

the intense storm-time electric field reported by Nishimura et al. [2008]. From the analysis of another event on February 2, 2015 around 19:00 MLT (Case-4), Rmodel is 7.01, Robs is 7.39, Exvs is 0.07 mV/m and Exni is about -1.00 mV/m.
We focus on Dst index in order to check the above difference. From the analysis of Case-1, Dst index is the smallest in all event and is -155 nT. From the analysis of Case-2, Dst index is the second smallest, and -102 nT. On the other hand, in the event of Case-3 and Case-4, Dst index is -66 and -46 nT. It is considered that plasma sheet ions and electrons distributed in a wide MLT region from the dusk to postmidnight are gathered into the dusk to premidnight sector in the region of enhanced electric field due to the strong ExB drift [Nishimura et al., 2008]. Although the storm-time electric field reported by Nishimura et al. [2008] is the average electric field distributin, from the result obtained on Case-1 - 4, it is considered that the actual storm-time electric field exists more inside during high activities, over 100 nT.

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