Characteristics of the mesoscale field-aligned currents in the dusk sector of the auroral oval based on data from the Swarm satellites

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Abstract

This dissertation investigates the characteristics of the mesoscale field-aligned currents embedded in the diminished Region 1/ 2 field-aligned current system in the dusk sector of the auroral oval by utilizing magnetic field data obtained by the multi-satellite Swarm constellation.

Chapter 1 provides an outline of the field-aligned current including its generation in the magnetosphere and its closure in the ionosphere. The purpose of the dissertation is also stated in this chapter.

Chapter 2 describes the overview of the instruments and data that are used in the dissertation. The magnetic field data obtained by the multi-satellite Swarm constellation are mainly used. Besides, 630.0-nm aurora image data from a ground-based all-sky imager, magnetic field and precipitating particle data from the Defense Meteorological Satellite Program (DMSP) satellite, and solar wind/interplanetary magnetic field (IMF) data from the OMNI database are used.

In Chapter 3, through the conjugate observations with the Swarm constellation and the all-sky imager on 22 December 2014 and 17 January 2015 the features of the irregular magnetic perturbations in the dusk sector of the auroral oval are presented. The multi-satellite observations at the same position but at two different times demonstrate that the irregular magnetic perturbations, which were obtained at 1-Hz resolution, are a result of mesoscale structure of the quasi-static field-aligned currents whose typical latitudinal size of the upward field-aligned currents is 20–30 km, not dynamic Alfvén waves. The analysis of the aurora images shows that in each region of the upward field-aligned currents 630-nm aurora emissions are relatively strong, indicating that the energy flux of precipitating electrons having energies of a few hundred electron volts is high in each of the upward field-aligned current regions. The analysis of the aurora images also shows that the enhanced mesoscale auroras continue to exist over at least approximately 30 min. These findings indicate that the mesoscale field-aligned

structures have quasi-persistent features. The precipitating particle data from the DMSP satellites indicate that the source of the precipitating particles is the duskside low-latitude boundary layer. The mesoscale field-aligned currents in the dusk sector of the auroral oval are thought to be phenomena that are pertinent to the magnetosphere for a northward IMF condition, not a simple remnant of the typical Region 1 field-aligned current. A possible scenario of the generation of the mesoscale field-aligned currents in the low-latitude boundary layer, which is associated to the cold dense plasmas entering across the duskside flank of the magnetopause, is also discussed.

Chapter 4 presents the statistical analysis based on a large amount of magnetic field data obtained by the Swarm satellites for more than three years. Events of quasi-static mesoscale field-aligned currents embedded in the diminished Region 1/2 field-aligned current system are identified in 577 satellite orbits passing through the high-latitude part of the dusk sector (defined as 14–18 magnetic local time) of the auroral oval by the method of automated event identification. The occurrence ratio of the events has a dependence on the northward IMF, showing more than 20% for the B_Z greater than 2 nT. The current density of the field-aligned currents shows a modest tendency to increase as the solar wind proton density increases. These statistical results strongly suggest that multiple pairs of field-aligned currents are generated in the duskside low-latitude boundary layer through a mechanism related to the solar wind plasma entry processes that can be more easily attained as the northward component of the IMF increases.

Finally, in Chapter 5 the results obtained from this study are summarized, and the conclusions are presented including a possibility of future research relevant to the main result from this study.