Relationships of the transversely accelerated ions with auroral electrons and field-aligned currents in the Reimei observations

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After the launch in August, 2005, the Reimei satellite has been observing numerous types of the polar ionospheric plasma signatures especially during three winter seasons in the nightside northern polar region. It should be noted that the angular coverages of the plasma particle instrument on Reimei were sufficient for the northern hemisphere observations to investigate the detailed pitch-angle distributions influenced by the satellite velocity for the low-energy heavy ion measurements. Although the altitudes of the Reimei observations were not as low as the orbits of the previous satellite missions like DE-1, the Reimei high-time resolution data obtained from almost three-year operation of both ion and electron instruments could provide us with new insights into what kinds of properties of the plasma conditions at the low-altitudes initiate/control so-called transversely accelerated ion events often found in the auroral oval crossings. The successive measurements by Reimei are useful for studying this type of the ionospheric ion accelerations in the direction perpendicular to local magnetic fields due to the interaction with plasma waves even when the ion mass discrimination could not be done with the Reimei plasma instruments and neither electric field nor plasma wave observations are performed,

The survey of the Reimei ion and electron energy-time spectrograms indicates that it is quite rate to observe the TAIs with their uppermost energies up to 100 eV in largely developed inverted-V electron signatures correspondent to the intense upward field-aligned current regions, while the high-flux or high-energy (more than 1 keV in some cases) TAIs have frequently been found particularly in the poleward edge of the auroral oval. The preliminary comparisons between the TAIs inside/outside the electron inverted-Vs and the field-aligned current distributions show that the most intense and energetic TAIs tend to occur in the strong downward field-aligned current regions on the poleward side not on the inside of but adjacent to the large-scale inverted-Vs and auroral forms in the equatorward. These relationships imply that the high-flux/energy electron precipitations like the inverted-V events are not preferable for the high-flux/energy TAIs. It is also likely that time variations of the energy inputs like the sharply field-aligned precipitating electron (so-called Alfvenic electron) fluxes and/or the field-aligned currents into a fixed area affect the energization and flux of the ionospheric ions while remarkable electron signatures are not always associated with the intense/energetic TAIs. These observational facts mean that in-situ measurements by a single satellite would be insufficient because the time variations of the source energy inputs could not be addressed only with one satellite passing through the interesting region.

In this paper, we present the Reimei observations for discussing the TAIs and their relations with the energetic electron signatures and the field-aligned currents and propose the necessity to realize a space exploration mission using comprehensive and integrated measurements of plasma particles/waves and electric/magnetic fields with formation flight techniques for 2 - 4 compact satellites for extending these Reimei achievements.