磁気嵐時のCleft ion fountain中における電子密度増加現象

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Electron density enhancements in the cleft ion fountain during a geomagnetic storm

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Recent satellite observations have clarified that plasma outflows play an important role in abrupt changes in the ion composition in the plasmasheet and ring current during geomagnetic storms. Kitamura et al. [2010] reported high electron densities and upflowing ions dominated by O^+ ions with large flux, which likely originated from the cusp/cleft (cleft ion fountain), in the dayside polar cap at about 9000 km altitude during geomagnetic storms. However, the velocity filter effect of ions (upward ion velocities decrease with increasing distance from the cusp/cleft), which is the characteristic of the cleft ion fountain, was not identified due to the limitation of the orbit (dawn-dusk). To identify the velocity filter effect, we performed a case study of electron density enhancements and ion upflows during the geomagnetic storm on 6 April 2000 using the electron density (Akebono/PWS) and ion distribution function data (Polar/TIDE).

During the main and early recovery phases of a super geomagnetic storm occurring on 6 April 2000 (a minimum SYM-H index of -320 nT), the Akebono satellite observed electron density enhancements (more than 10 times larger than the quiet-time level) at about 7000 km altitude in the southern polar region (6 consecutive passes, for about 15 h).

During the main phase, the Polar satellite traversed the northern polar cap (lobe) in an altitude range from about 40,000 (noon) to 13,000 km (midnight). The parallel velocities and temperatures of He^+ and O^+ ions decreased with decreasing altitude and moving to nightside. These features are consistent with the velocity filter effect of the cleft ion fountain. Large upward O^+ ion fluxes (about $5 * 10^8$ /cm^2/s mapped to 1000 km altitude) were detected up to 85 degrees in ILAT. The region of O^+ ion outflows with large fluxes (>$1 * 10^8$ /cm^2/s mapped to 1000 km altitude) was widespread in noon-midnight direction (about 20 degrees in ILAT from the cusp/cleft) in the polar cap (lobe) above ˜20,000 km altitude.

Around the minimum of the SYM-H index, the Polar satellite traversed the southern polar region from premidnight to noon in an altitude range of 5200-15,200 km. The feature of the parallel velocity of O^+ ions is consistent with the velocity filter effect of the cleft ion fountain as with the observation in the Northern Hemisphere. These simultaneous observations of the electron density enhancement by the Akebono satellite and the cleft ion fountain by the Polar satellite near and above the altitude of the Akebono observations directly proves that the electron density enhancements are caused by the cleft ion fountain. The region of large fluxes (>$5 * 10^8$ /cm^2/s) was widespread in latitude (about 10 degrees in ILAT from the cusp/cleft) in the dayside polar cap at about 9000 km altitude.

These observations by the Polar satellite imply that the very-low-energy ion outflows through the dayside polar cap, which are the very-low-energy component of the cleft ion fountain, are similarly or more important than the higher energy component of the cleft ion fountain, which is observed near the cusp, in the respect of O^+ ion fluxes.