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Demeter high resolution observations of the ionospheric thermal plasma response to magnetospheric energy input during the magnetic storm of November 2004

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High resolution Demeter plasma and wave observations were available during one of the geomagnetic storms of November 2004 when the ionospheric footprint of the plasmasphere was pushed below 64 degrees in the midnight sector. We report here onboard observations of thermal/suprathermal plasma and HF electric field variations with temporal resolution of 0.4 s, which corresponds to a spatial resolution of 3 km. Local perturbations of the plasma parameters at the altitude of 730 km are analysed with respect to the variation of the field-aligned currents, electron and proton precipitation and large-scale electric fields, measured in-situ by Demeter and by remote optical methods from the IMAGE/Polar satellites.

Flow monitoring in the 21 and 24 MLT sectors during storm conditions reveals two distinct regions of O^+ outflow, i.e. the region of the field-aligned currents, which often comprises few layers of opposite currents, and the region of velocity reversal toward dusk at sub-auroral latitudes. Average upward O^+ velocities are identical in both local time sectors and vary between 200 and 450 m s^{-1}, with an exception of a few cases of higher speed ($\sim$1000 m s^{-1}) outflow, observed in the mid-night sector. Each individual outflow event does not indicate any heating process of the thermal O^+ population. On the contrary, the temperature of the O^+, outflowing from auroral latitudes, is found to be even colder than that of the ambient ion plasma. The only ion population which is observed to be involved in the heating is the O^+ with energies few times higher than the thermal energy. Such a population was detected at sub-auroral latitudes in the region of duskward flow reversal. Its temperature raises up to few eV inside the layer of sheared velocity.

A deep decrease of the H^+density at heights and latitudes where according to the IRI model these ions are expected to comprise $\sim 50\%$ of the positive charge indicates that the thermospheric balance between atomic oxygen and hydrogen was re-established in favour of oxygen. In consequence, the charge exchange between oxygen and hydrogen does not effectively limit the O^+ production in the regions of the electron precipitation. According to Demeter observations, the O^+ concentration is doubled inside the layers with upward currents (downward electrons). Such a density excess creates the pressure gradient which drives the plasma away from the overdense regions, i.e., first, from the layers of precipitating electrons and then upward along the layers of downward current.

In addition, the downward currents are identified to be the source regions of hiss emissions, i.e. electron acoustic mode excited via the Landau resonance in the multi-component electron plasma. Such instabilities, which are often observed in the auroral region at 2-5 Earth radii, but rarely at ionospheric altitudes, are believed to be generated by an electron beam which moves through the background plasma with velocity higher than its thermal velocity.