The University of Alabama in Huntsville

UAH Analysis of TIDE/PSI Data for ISTP Solar Maximum Extended Mission

Final Report

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During the course of this research, several investigations have been carried out at both high and low altitudes. The low altitude studies are those associated with perigee observations of ion field-aligned flows measured by POLAR/TIDE near 5000 km altitude. High altitude studies employed ion observations near apogee (above 6 R_E geocentric). In both cases the observations occur at high latitudes, in or near the polar regions: the southern polar region for the low altitude studies and the northern polar region for the high altitude studies.

A study of the relationship between field-aligned flow velocities, fluxes, and densities to convection speeds *[Stevenson et al., 2000*] was published in the *Journal of Atmospheric and Terrestrial Physics* . Here we have demonstrated an anti-correlation between the O^+ densities and the convection speeds, and a correlation between the parallel upward velocities and the convection speeds, and have discussed these results as being compatible with the Cleft Ion Fountain concept for supplying O^+ ions to the polar cap magnetosphere.

Another topic investigated was the relationship between TIDE-observed upward and downward parallel O^+ bulk velocities near 5000 km altitude over the southern polar regions, and near-simultaneous auroral observations by the Ultra-Violet Imager. We have prepared several overlaid plots of such auroral images across an MLT-ILAT dial plot of the polar regions with upward and downward velocities, as well as other parameters such as ion densities and fluxes. The overlaid plots show quite nicely how upward velocities and crossovers between upward and downward velocities occur in association with auroral forms, while downward flows are associated with dark regions of the polar cap. A paper was submitted to the *Journal of Geophysical Research* and appeared [*Stevenson et al., 2001*]

A further project has involved combining observations by POLAR/TIDE of field-aligned flows and other parameters along the POLAR track over an MLT-ILAT dial plot together with similar near-simultaneous observations from two DMSP satellites of vertical flows and other parameters. The DMSP spacecraft were at 840 km altitude, while POLAR was at 5000 km altitude. We have done this for four separate intervals of combined DMSP and POLAR spacecraft passes through the Southern perigee during April, 1996. The morphology of the upward and downward flows was generally consistent for the three spatially-separated tracks for each case, but the downward flows were more widespread at the lower DMSP altitudes than at the higher DMSP altitudes. There is also a suggestion that when the IMF is northward, the POLAR flows tend to be almost uniformly northward at 5000 km altitude. The flux magnitudes and densities at 840 km are much larger than those at 5000 km, while the flow velocity magnitudes at 840 km were lower. A paper has been submitted to the *Journal of Geophysical Research* and appeared [*Zeng et al., 2001*].

Two further new preliminary studies were presented at the recent American Geophysical Union meeting in San Francisco. One of these studies [*Tu et al., 2000*] employed a Dynamic Fluid Kinetic (DyFK) model of field-aligned plasma transport to compare with POLAR/TIDE observations of densities and field-aligned flow velocities along an essentially anti-sunward Southern perigee track on May 6,1996. By essentially modeling the dynamic transport along a flux tube as if it were going directly anti-sunward along the POLAR track, we obtained surprisingly good agreement between the data and modeling results. The second of the AGU-presented studies [*Zeng et al., 2000*] examined the DMSP-POLAR thermal plasma comparison further by including the ionospheric electron temperatures measured by DMSP and examining such issues as the relationships between those electron temperatures and the thermal ion flows.

Studies with the high altitude TIDE data, included a study on the relationship of polar cap ion properties observed by TIDE near apogee with solar wind and IMF conditions. We found that in general H+ did not correlate as well as O^+ with solar wind and IMF parameters. O^+ density correlated best with the solar wind dynamic pressure, solar wind speed, E_{sw}, $V_{sw}B_{IMF}$, and Kp. At lower solar wind speeds, O^+ density decreased with increasing latitude, but this trend was not observed at higher solar wind speeds. By comparing these results with results from other studies of O+ in different parts of the magnetosphere, we concluded that O^+ ions often leave the ionosphere near the foot point of the cusp/cleft region, pass through the high-altitude polar cap lobes, and eventually arrive in the plasma sheet. We found that H^+ outflows are a persistent feature of the polar cap and are not as dependent on the geophysical conditions; even classical polar wind models show H^+ ions readily escaping owing to their low mass. Minor correlations with solar wind drivers were found; specifically, H^+ density correlated best with IMF By, $V_{sw}B_{IMF}$, and E_{sw}. Initial results were presented to an IAGA symposium at the IUGG99 Meeting in Birmingham, UK [*Elliott et al., 1999*] Later results were presented to the 2000 Spring AGU Meeting [*Elliott et al., 2000*]; and a paper on this investigation was published in the *Journal of Geophysical Research* [*Elliott et al., 2001a*].

We also carried out a detailed examination of observations on April 19, 1996 when the solar wind velocity was high and Alfvén waves were present in the solar wind. We have found similar large scale features in the solar wind velocity, IMF Bx, polar cap ion outflow energy of both O^+ and H^+, polar cap magnetic field fluctuations, and electrons precipitating in the polar cap. The high activity and the electron spectrum suggest that a 'polar squall' formed. The large amounts of O^+, and the linear relationships found between polar cap data and the solar wind data mentioned above all lead us to conclude that the solar wind is driving a parallel electric field on the order of tens of volts in the polar cap, which in turn drives the polar ion outflows. Initial results were presented to the 2001 Spring AGU Meeting [*Elliott et al., 2001b*]. A draft paper on this study has been prepared and is undergoing revision for publication in the *Journal of Geophysical Research* [*Elliott et al.*, 2001b]. These studies also formed the basis for a PhD dissertation [*Elliott, 2001*].

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