GEM Dayside Focus Area on Dayside Field-Aligned Currents and Energy Deposition

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Description, Timeliness, and Research Area Relations: Recent efforts to improve satellite drag prediction have revealed a set of events with anomalous thermospheric density signatures (B. Bowman, *personal comm.*). These events are associated with interplanetary shocks and large in-the-ecliptic interplanetary magnetic field (IMF) values, often, but not exclusively, while the IMF B_Z is positive (Knipp *et al.*, GEM Meeting 2009). Crowley *et al*. (submitted 2009) used the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure to verify extreme values of Joule heating at the foot points of the near-cusp and polar cap field lines during such events and associate them with unmodeled density enhancements. A new Poynting flux data set from the DMSP F-15 satellite (Fig. 1) confirms the localized dayside energy input (Knipp *et al.*, Work In Progress (WIP), 2009) and further links these events with instances of strong upward ion flow. Although we cite mostly northward IMF literature below, such events also occur with neutral and slightly southward IMF in the presence of a large IMF B_Y component.

Several case studies reveal that ground based indices such as Dst and AE offer little indication that these localized dayside magnetosphere-ionosphere energy exchanges are occurring. However, a climatological study of Joule heating by McHarg *et al.*, (2005) hint at their occurrence. Efforts to simulate such events typically have been limited to near steady-state or very slow changes of the IMF B_Y (Vennerstrom *et al.*, 2005, Yang *et al.*, 2008) and have not taken into account the effect of IMF B_X (Merkin *et al.*, 2007). Eriksson *et al.*, (2008) illustrate the need to model time-varying effects and Anderson *et al*. (2008) highlight the importance of the clock angle for high-latitude field-aligned current distributions. Preliminary results from LFM MHD model exercised by the Center for Integrated Space Weather Modeling (CISM) team suggest a heretofore undetected high latitude dayside current system (a current system in addition to the NBZ current systems) that develops on the bowshock and activates when solar wind pressure and IMF values exceed a specific threshold. Simulations from the GUMICS MHD model hint at a bowshock current system (T. Pulkkinen, *personal comm.*). Lopez *et al.*, (WIP, 2009) suggest that during such events the energy flows from the solar wind through the bowshock to the magnetopause and then directly to the dayside thermosphere with no mediation by the magnetotail.

The proposed focused research is timely and well positioned to leverage other GEM and space weather activities. MHD and thermospheric simulation capabilities are improving and offer the ability to follow energy flow, although at low spatial resolution. A new DMSP F-15 dayside Poynting flux data set has been developed. The NSF's AMPERE satellite system will offer new field-aligned current monitoring capabilities. AF Space Command is actively funding a thermospheric research area in neutral atmosphere density, where much of the energy carried by field aligned current is deposited.

This new dayside research focus area would strongly link to GGCM activities and the MI coupling interests. The degree to which this energy source is independent of solar wind-magnetotail interactions is a new discovery area related to both dayside and nightside focus areas. Further, this focus effort would potentially involve SHINE and CEDAR participants. SHINE participants could provide insight into the origin of the solar wind structures (eg. CMEs driving shocks with large in-the-ecliptic IMF). CEDAR participants would provide insight about the likely effects on the coupled ionosphere-thermosphere system. Such an effort has strong ties to space weather and direct application to satellite drag specification and prediction.

Goal: Explain the relation between enhanced dayside field-aligned currents, their sources in the solar wind and the impacts in the ionosphere-thermosphere system.

Anticipated Deliverables: Improved GGCM specification of dayside energy input possibly associated with improved bowshock, dipole tilt, and IMF B_X modules. Paper collection describing data-model comparisons of the magnetospheric drivers of localized heating that produces unanticipated regions of thermospheric expansion at very high latitudes.

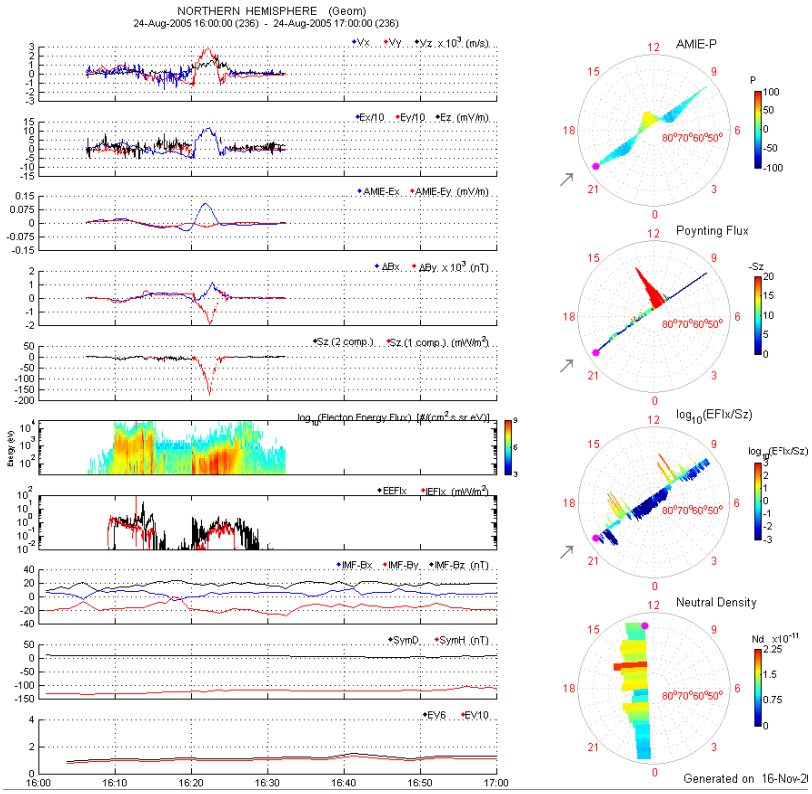

Fig. 1. Output from DMSP F-15 Data Visualizer tool . The tool combines DMSP particle, ion, and field observations with AMIE output along the DMSP path. The pass illustrates large Poynting flux deposition (> 150 mW/m^2) during a period of IMF B_Z >0 and B_Y < 0. Similar results (not shown) develop during IMF B_Z <0 and B_Y > 0.

Expected Activities and Research Topics: We propose to investigate the disturbances described above. There is a significant likelihood that such events direct energy into the dayside thermosphere with little energy input to the magnetotail. Thus the Dst index, could remain unperturbed or even show storm recovery while the coupled dayside high-latitude region is greatly disturbed. We anticipate the following will be fruitful research topics.

Dayside energy sources and transport for events with large IMF B_Y and B_X (with Bz +/-)
Dayside field-aligned current systems for large in-the-ecliptic IMF (B_Y and B_X with Bz +/-)
The location and nature of Poynting and particle energy deposition for IMF B_Z>0 and large B_Y
The role of enhanced solar wind density and speed during such events
The relation of such events to cusp region thermospheric density anomalies
Overall energy contributions to the coupled magnetosphere-ionosphere-thermosphere
Methods for detecting such disturbances; indices vs. space based monitors
More realistic MHD modeling of such disturbances
Overall magnetospheric structure during such disturbances
Daily and seasonal conductivity effects of high-latitude Joule heating events

References:

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