SM42E-05 1710h

Calibrating a Magnetotail Model for Storm/Substorm Forecasting

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The physics network model called WINDMI for the solar WIND driven Magnetosphere-Ionosphere weather system is calibrated on substorm databases [1] using a genetic algorithm. We report on the use of the network as a digital filter to classify the substorms into three types; a process traditionally performed individual inspection. We then turn to using the filter on the seven Geospace Environmental Modeling (GEM) Storms designated for community wide study. These storms cover periods of days and contain many substorms. First the WINDMI model is run with the 14 parameters set from the study based on the Blanchard-McPherron database of 117 isolated substorms with 80% of the data having the AL below -500nT. In contrast, the GEM storms have long periods with AL in the range of -1000nT. The prediction error measured with the average-relative variance (ARV) is of approximately unity. Reapplying the genetic algorithm the parameters shift such that the one long storm has an ARV=0.59. Physics modifications of the basic WINDMI model including the injection of sheet plasma into the ring current are being evaluated in terms of their impact on the ARV and comparisons with non-physics based signal processing prediction filters. Ensembles of initial conditions are run with 700MHz G3 CPU run times of order 17 sec per orbit per day of real data. The AMD AthlonXP 1700+ processor takes 5sec per orbit per day. The IBM SP-2 speed will be reported. With such speeds it is possible to run balls of initial conditions.
Substrom Classification with the WINDMI Model, W. Horton, R.S. Weigel, D. Vassiliadis, and I. Doxas, Nonlinear Processes in Geophysics, 1-9, 2003.
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SM42E-06 1725h INVITED

Vector and Scalar Field Visualization Techniques for Multispacecraft Space Physics Missions

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We present a new way of visualizing data that makes it possible to view simultaneously a large number of measured time series on the orbits of a large number of spacecraft. We shall show examples of using our "ViSBARD" software to illucidate the structure of the solar wind upstream of the Earth, as well as cases showing magnetic field and particle information from many spacecraft in the magnetosphere. Each measurement is presented by a glyph (symbol or vector) at each point in time and at the position it was measured in the 3-D space. The ecliptic plane and, if appropriate, magnetospheric surfaces are presented to provide context. The software allows scrolling and zooming in time; the usual pan, zoom, and rotate in space; scaling of the data variables; a choice of color palettes; and 2-D graphs that scroll and scale in concert with the 3-D representation to aid the interpretation of the 3-D visualization. As the interval of data changes, the resolution automatically adjusts to maintain rapid response and to limit memory usage. A kinematic projection of all quantities yields a "spatial view" that is particularly effective in fast flows such as the solar wind. The center of rotation can be moved to any data point to allow a detailed examination of a particular region. The software supports stereo viewing. Future extensions will incorporate the viewing of images as well as the simultaneous viewing of data and models.

SM42E-07 1745h

Visualization and Data Analysis for CISM Models

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The Center for Integrated Space Weather Modeling (CISM) is working on developing a model from the surface of the sun to the Earth's ionosphere. Among the many challenges facing this program is the development of visualization and data analysis package which can be used to examine the results from all of the component models. We have begun to use OpenDX as the core of the CISM visualization and data analysis package. OpenDX is an open source data visualization package based upon IBM's Data Explorer visualization software. This package allows us to provide access to simulation results through either web based front end or via a series of module extensions to the OpenDX package which can be installed on the remote user's own machine. Since the software is open source, it is freely available on wide range of platforms ranging from SGIs to Intel machines running either Linux or WinNT. The OpenDX software package includes a set of tools for turning OpenDX visual program into a Java based web page which allows the user simple control over the parameters plotted and viewing angle. We begin this presentation with an overview of OpenDX's capabilities and then present sample visualizations from the ENLIL solar wind model, the LFM and RCM magnetosphere models, and the TING ionospheric model. In addition, we illustrate how this package can be used as part of a more advanced data analysis system. In particular we examine the energy partitioning the magnetosphere during a series of substorms by using OpenDX define regions, e.g. plasma sheet, lobes, and then integrate the energy density within them as a function of time. The combination of visualization tools with data analysis routines allows us to develop a deeper understanding of the coupled Sun-Earth system.

SM51A MCC: 2006 Friday 0800h

The Electrodynamics of the Cusp and the Open/Closed Field Line Boundary Region II *(joint with SA)*

Presiding: **T Yeoman,** University of Leicester**; R F Pfaff,** NASA Goddard Space Flight Center

SM51A-01 0800h

Determining the Origin of Structures Observed in Cusp Ion Dispersions: A Case Study Using Global Simulations and Simultaneous CLUSTER and IMAGE Observations

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Gaining an understanding of how structures in ion precipitation observed in the cusp are related to the complex topology of the dayside magnetosphere is an important step toward describing the merging processes occurring at the magnetospheric boundary. We report results from a study that employs three-dimensional magnetohydrodynamic and large-scale kinetic simulations in conjunction with simultaneous observations of proton auroras from the IMAGE FUV instrument and ion dispersions measured by CLUSTER CIS. The primary goal of the study is to determine the origin of the multiple structures in the ion dispersions observed in the cusp by CLUSTER on July 14, 2001. Using plasma and magnetic field parameters measured upstream of the bow shock by the ACE spacecraft as input to the simulations, we consider the IMAGE and CLUSTER observations in the context of topological changes and particle trajectories in the dayside magnetosphere, as inferred from the simulations. Results from the simulations indicate that, during periods of predominantly By IMF, merging occurs in two steps: first a merging of unconnected magnetosheath and closed-field lines sunward of the terminator, and then of northern and southern open field lines in the low latitude flanks, tailward of the terminator. The simulations suggest that this two-stage reconnection process could bring about the formation of the large-scale ion dispersion structures in the cusp observed during periods that appear uncorrelated to any obvious changes in IMF direction or dynamic pressure in the upstream solar wind.

SM51A-02 0815h

Multi-spacecraft observations of the structure and motion of field-aligned cusp currents under strong IMF B_X and B_Y conditions

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Field-aligned cusp currents are the mechanism by which momentum and energy are transferred from the solar wind to the ionosphere during reconnection. On 25 August 2001, the Cluster spacecraft flew through the northern polar cusp and observed large-scale deflections of the magnetospheric field (FGM) and field-aligned electrons (PEACE) indicative of strong field-aligned currents, together with dispersed cusp-ion signatures (CIS) that are associated with pulsed reconnection. This occurred during periods of weak southward IMF accompanied by strong IMF $B_Y > 0$ and $B_X < 0$. Similar observations of reconnection pulses have been made in the past and linked to poleward-moving auroral forms (PMAFs), which appear to occur on open field lines. Successive reconnection pulses during these type of events can contribute almost all of the voltage across the magnetosphere. However, these single spacecraft observations in the mid-altitude cusp were constrained by assumptions about the cusp structure and the relative spacecraft and boundary motions - this could easily lead to large errors in the analysis. With multi-spacecraft observations we can better constrain these parameters and make better estimates of the field-aligned currents. The formation of the Cluster spacecraft during this interval also allows us to study in-situ the evolution of the cusp on timescales of minutes to tens of minutes.

SM51A-03 0830h

Case Study of ULF Waves in the Cusp Region

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We investigate properties of ULF wave activity in the cusp region and the high latitude boundary layer (HLBL) during three polar cusp crossings of the Cluster spacecraft in March 2001. Various regions (the HLBL, plasma mantle, magnetosheath and the magnetopause) in a crossing event are identified by examining the signatures of energetic particles (30 - 1500 keV for ions and 20 - 400 keV for electrons) from the RAPID experiment and the variations of magnetic field and plasma parameters. Strong magnetic fluctuations are seen in the magnetosheath adjacent to the magnetopause and in the cusp. The Poynting flux of the waves in the magnetosheath is often seen flowing mainly in the direction of plasma bulk flow. In the cusp, strong wave energy flux is seen in some cases flowing toward the ionosphere, which may provide an important part of the the energy transported from the solar wind into the magnetosphere. We have also examined the signatures of possible wave mode conversion at the magnetopause, a phenomena often seen in the low latitude boundary layer, and compared the signatures with the field and plasma variations (e.g. the gradient of the Alfven velocity), which are predicted to be closely related to the phenomena. In HLBL, we observed the intensity of energetic ions pulsating at periods ranging from 100 to 300 sec. The relationship between these pulsations and the ULF waves will be discussed.

SM51A-04 0845h

Energetic Particles And The Concept Of An Open/Closed Field Line Boundary

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Energetic particles are often used as an indicator of the open/closed field line boundary but they are also a consistent and common feature of the high-altitude dayside cusp. Observing these particles in a region where they cannot be stably trapped is one the most striking findings of the Polar and Cluster satellites. The Polar satellite has documented that the shocked solar wind plasma enters the weak geomagnetic field of the polar region and produces cusp diamagnetic cavities (CDC) of apparent tremendous size well within the traditional magnetosphere. Within these cavities the local magnetic field is depressed and very turbulent and in many cases appears to carry the remnant signature of the upstream interplanetary magnetic field (IMF) in the two transverse components, By and Bz. The intensities of the energetic ions are observed to increase by many orders of the magnitudes during the CDC encounters. Use of the variation of the charge state of solar wind Fe ions at the ACE spacecraft and at Polar has indicated that energization of ions to these high energies is a rapid process. The charge state distribution of these cusp cavity ions is indicative of their seed populations being a mixture of the ionospheric and the solar wind particles in many cases. Although the Cluster satellites occasionally observe similar features in crossing the region of the cusp/high latitude boundary layer the features are significantly smaller and lack the close association of shocked solar wind plasma, CDCs, and energetic particles seen by Polar. Simultaneous individual case comparisons between Polar and Cluster will be presented in an attempt to resolve these differing impressions from the two data sets and the whether the concept of an open/closed field line boundary is valid in this region.

SM51A-05 0900h

Investigation of cusp dynamics with IMAGE-FUV

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The Earth's cusps constitute the regions of critical coupling and most direct access of solar wind plasma into the terrestrial magnetosphere/ionosphere. Ionospheric observations at the cusp footprint can thus be used to investigate the coupling process and its dynamics. Ground-based and in-situ measurements of cusp signatures are limited in time and spatial coverage. Recently, observations of proton aurora signatures by the IMAGE-FUV instrument demonstrated the long-duration coverage of precipitation signatures into the cusp. Global observations do not just provide the context information but allow for long-term observation of the cusp dynamics during varying solar wind conditions. We will summarize the results of such investigations demonstrating the different morphology of cusp precipitation during northward and southward IMF, the dynamic responses to changes in the IMF east-west component, the connection between cusp precipitation and reconnection at the high- and low-latitude magnetopause, and the overall importance of proton and electron precipitation into the ionosphere at the cusp footprint.

SM51A-06 0915h

Optical Signature of Polar Cusp During Southward IMF Bz Observed by TIMED/GUVI and DMSP

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The GUVI instrument on board the TIMED satellite provides unique multi-wavelength observations of polar region emissions. In this study we focus on the identification of the polar cusp region during southward IMF conditions. Using simultaneous DMSP particle observations, the optical signatures and dynamics of the polar cusp region are investigated. We will address which of the five GUVI wavelengths can best be used for optical identification of the cusp precipitation by comparing images of various wavelengths. These new GUVI observations suggest that cusp aurora in the FUV extends over a relatively wide MLT range during a large southward IMF Bz. Characteristics and morphology of the cusp auroras in the FUV will also be discussed.

URL: http://guvi.jhuapl.edu

SM51A-07 0930h

Maps of Precipitation by Source Region, Binned by IMF, with Convection Streamlines

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Eleven years ago we presented the first map of dayside particle precipitation according to the source of the precipitation (cusp, mantle, polar rain, etc). Here we present a modernization of the effort with several enhancements. The maps are created in a fully automated fashion, with, for example, the cusp centered at its centroid latitude for each half hour bin of MLT, with a width equal to the statistical difference between the poleward and equatorward edges. The data is binned according to the sign of the IMF clock-angle in the By-Bz plane. SuperDARN convection patterns compiled under the identical conditions are overlayed. The results include at least one "surpise" that likely should have been predicted years ago. Specifically the mantle is asymmetric about noon. The pre-noon mantle is appreciably thicker than the postnoon mantle, especially for By> 0. This asymmetry matches well an asymmetry in convection flows, in which most of the conversion of closed field lines to open occurs prenoon - and where the flow patterns are also more perpendicular to the open-closed boundary. Only a minority of the open-closed field line conversion on the dayside occurs near the cusp. The matching of the convection patterns with the particle data shows clearly that field lines are converted from closed regions to open away from noon. Merging is thus active throughout the frontside magnetosphere, and not just near the subsolar region. Field lines which merge well away from noon do not experience enough particle inflow against the solar wind direction to produce anything more than a weak, deenergerized (mantle) precipitation in the ionosphere.

SM51A-08 0945h

Temporal/spatial structure of magnetic merging at the magnetopause inferred from 557.7-nm all-sky images

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We demonstrate that high-resolution 557.7 nm all-sky images are useful tools for investigating the spatial and temporal evolution of merging on the dayside magnetopause. Analysis of ground and satellite measurements leads us to conclude that high-latitude merging events can occur at multiple sites simultaneously and vary asynchronously on time scales of 30 s to 3 min. Variations of 557.7 nm emissions were observed at a 10 s cadence at Ny-Ålesund on December 19, 2001 while significant changes in the IMF clock angle were reaching the magnetopause. The optical patterns are consistent with a scenario in which merging occurs around the rim of the high-latitude cusp at positions dictated by the IMF clock angle. Electrons energized at merging sites represent plausible sources for 557.7nm emissions in the cusp. Polar observations at the magnetopause have directly linked enhanced fluxes of $\geq$0.5 keV electrons with merging. Spectra of electrons responsible for some of the emissions, measured during a DMSP F15 overflight, exhibit "inverted-V" features indicating further acceleration above the ionosphere. SuperDARN spectral width boundaries, characteristic of open-closed field line transitions, are located at the equatorward edge of the 557.7-nm emissions. Optical data suggest that with IMF $B_Y > 0$, the Northern Hemisphere cusp divides into three source regions. When the IMF clock angle was $\sim 150^\circ$ structured 557.7 nm emissions came from east of the 1300 MLT meridian. At larger clock angles the emissions appeared between 1200 and 1300 MLT. No significant 557.7 nm emissions were detected in the prenoon MLT sector. MHD simulations corroborate our scenario, showing that with the observed large dipole-tilt and IMF clock angles, merging sites develop near the front and eastern portions of the high-altitude cusp rim in the Northern Hemisphere and near the western part of the cusp rim in the Southern Hemisphere.