concepts and models of solar particle access across a wider range of particle rigidity (10's to 100's MV) and with better statistics than has been done in the past. At the meeting we will quantify non-uniform particle illumination in many events from 1992-2003, including the 14-24 April 2002 interval, and discuss its impact on calculations of the solar particle energy deposit into the atmosphere. M. Scholer, J. Geophys. Res. 77, 2762-2769, 1972.

SM42D-06 1455h

Energetic and dynamic impact on the upper atmosphere during the April 2002 geomagnetic storm

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The April 2002 geomagnetic storm has been associated with a wide range of disturbances that occurred on the Sun, including high-speed coronal mass ejections, and several M- and X-class flares. This event therefore offers a unique opportunity to define and unravel the geoeffectiveness of various energy inputs originating from the Sun. This talk focuses on the impact of precipitating particles on the upper atmosphere. Numerical experiments are carried out to study the response of the thermosphere and ionosphere to the different particle inputs, such as the auroral electrons and energetic protons, and the intense high-energy polar rain that was observed during the storm. We also show the generation and propagation of the large-scale traveling atmospheric and ionospheric disturbances (TADs and TIDs) and their relation to the impulsive magnetospheric energy inputs via precipitating particles and Joule heating. Storm-time changes in neutral temperature, neutral winds and composition, as well as electron density will be discussed in light of the model simulations.

SM42D-07 1510h

Energization of Ionospheric Plasma During the April 17, 2002 Storm

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Statistical studies as well as recent multi-fluid simulations have demonstrated a correlation between the outflow of ionospheric plasma with the solar wind conditions and especially with the sign of the interplanetary magnetic field (IMF). This paper investigates the energization of ionospheric and solar wind plasma during the April 17, 2002 storm. This storm provides an excellent means of not only investigate the size of the ionospheric outflows but also the energization of these outflows as a function of solar wind conditions. It is show that will ionospheric outflows are enhanced by the arrival on the magnetic cloud at Earth, much of the ionospheric plasma remains relatively could for the first couple of hours during the event. Variability in the IMF conditions produces some local heating of heavy ions, but during the first part of the event it is the light ions that experience the bulk of the heating. It is only after a few hours when there is a prolonged period of southward IMF, that there is significant depletion of light ions in the magnetotail and the preferential heating of heavy ions occurs. These results demonstrate that conditions between storms and substorms can be very different in the magnetotail, and that this difference will lead to changes in the characteristics of the energetic populations in the tail even for very similar IMF conditions.

SM42D-08 1525h

Atmospheric Effects of Solar/Geomagnetic Disturbances: the Role of Initial Atmospheric States

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This paper will investigate how the initial atmospheric composition, temperature, and wind and dynamic states affect the extent and duration of the neutral atmosphere and ionosphere response to various solar and geomagnetic disturbances. The variable energy inputs during solar and geomagnetically disturbed times drive important chemical reactions involving energetically-important minor species such as O and NO throughout the high-latitude mesosphere and lower thermosphere. These changes are transported in latitude and altitude, affecting the global thermal structure and composition. Changes in the thermal structure will ultimately result in changes in the circulation pattern that provide feedback to the time-varying atmospheric effects. In addition the disturbed wind patterns can affect the distribution of ionospheric density, such as contributing to variations in the Appleton anomaly. As a result, it is anticipated that the extent of the responses will depend on the initial atmospheric condition. For example, the season during which the disturbance(s) occur, at what point in the 11-year solar cycle, and whether the disturbance is an isolated event or part of a series, such as the recent April 2002 storms, will affect the magnitude and structure of the changes in the O/N2 ratio, ionospheric density, etc. In this paper we investigate the response at these various atmospheric conditions using mechanistic runs of first principle general circulation models of the upper atmosphere.

SM42E MCC: 2008 Thursday 1600h

Exploring the Digital Geospace: Modern Methods of Spatial Data Analysis I *(joint with SA, SH, NG)*

Presiding: **L Scherliess,** Utah State University**; R S Weigel,** CISM/KT

SM42E-01 1600h INVITED

Analysing structures and interfaces using spatially-distributed data

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Cluster has provided fully co-ordinated, spatially-distributed data for the first time. A number of multi-spacecraft techniques which measure, for example, boundary orientation, thickness and motion, and deviation from planarity, have been developed. In addition, the data allows the electric current structures, both within the boundary layers and associated with other structure, to be probed. We investigate and compare boundary crossings arising from spacecraft encounters with discontinuities in the solar wind, the bow shock, the magnetopause and the magnetotail, which are observed by Cluster on multiple scales (ranging from 6000-100 km). Behaviour of the interfaces, such as distinguishing strong acceleration and thickness variations, can be made. Knowledge of boundary orientation and motion can accurately scale the plasma and field signatures across the boundary layer.

SM42E-02 1620h

Plasma Wave Identification in Multi-Spacecraft Data Using the Eigenstructure of the Cross Spectral Density Matrix

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Data from multi-spacecraft missions offer the possibility to study plasma processes by means of, both, their temporal and spatial characteristics. This is of particular importance in plasma wave analyses where good frequency and wave vector estimates are needed to test dispersion relations. Here we focus on data from ESA's Cluster-II mission. Analysis methods like the wave telescope or k-filtering technique originally developed for seismic arrays have been generalized and applied to Cluster-II data. This report presents a wave identification method based on the eigendecomposition of the cross spectral density matrix. The method is expected to facilitate the detection of plasma waves and should be well suited for routine analyses of large data sets. Furthermore, the eigenstructure of the cross spectral density matrix allows to compare the method presented here with already existing techniques, and to construct performance measures. Estimation of the complete set of parameters of plane wave sources helps to reconstruct wave fields and to carry out polarization analyses.

SM42E-03 1635h INVITED

Data Assimilation in Ionospheric and Magnetospheric Models

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In this talk we present a review of ionospheric and magnetospheric data assimilation models which are currently in use or under development. This is a very challenging field because of the the sparseness of data and the vastness of the volume. Even though it is challenging, researchers have made tentative steps in the development of region and global data assimilation models. We attempt to discuss a variety of models using different methodologies and complexities. These models cover the ionospheric electrodynamics, radiation belts, ring current, global magnetosphere, thermosphere, and ionosphere.

SM42E-04 1655h

The USU GAIM Data Assimilation Model for the Ionosphere

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Although data assimilation techniques have been successfully used by the meteorologists and oceanographers for several decades, the space physics community has been slow in implementing data assimilation techniques, primarily because of the lack of a sufficient number of measurements. However, this situation is changing rapidly for the ionosphere. Within ten years, it is anticipated that there will be millions of ionospheric measurements per day from a variety of sources, and these data will be available for assimilation into specification and forecast models. A physics-based data assimilation model of the ionosphere is under development as the central part of a DoD MURI funded program called GAIM (Global Assimilation of Ionospheric Measurements). The Utah State University GAIM model will use a physics-based ionosphere-plasmasphere-polar wind model and a Kalman filter as a basis for assimilating a diverse set of real-time (or near real-time) measurements. The new physics-based ionosphere-plasmasphere-polar wind model (IPM/IPWM) includes 6 ion species (O_2^+, N_2^+, NO^+, O^+, H^+ and He^+) and covers the low and mid latitudes from 90 km to about 20,000 km altitude and the high latitudes from 90 km to 10,000 km altitude. The Kalman filter is based on a reduced state approximation combined with a segmentation of the model domain into geographical sectors. These approximations not only lead to a dramatic reduction in the computational requirements but also make the model more easily adaptable for global, regional, or local applications. Several real data types, including in situ electron density measurements from DMSP satellites, bottomside electron density profiles from the Air Force network of digisondes, GPS-TEC from a global network of more than 160 ground stations, and occultation line-of-sight TEC measurements from three low Earth orbiting satellites are currently assimilated into the model. In this paper we will briefly review the Kalman filter technique including the applied approximations and then present results from a 3-day model run using data from the four different data types.

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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