SM22A MCC: Level 1 Tuesday 1330h

Sun-Earth Connections: Linked Models III Posters *(joint with SA, SH, NG)*

Presiding: **D Baker,** Laboratory for Atmospheric and Space Physics, University of Colorado**; M Wiltberger,** National Center for Atmospheric Research, High Altitude Observatory

SM22A-0218 1330h POSTER

Implications of Multipoint Solar Wind Observations for MHD Predictions of Magnetospheric Dynamics

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Traditionally event oriented MHD modeling is based on observations from a single upstream monitor (e.g., Wind, ACE) extrapolated as a boundary condition over the entire upstream edge of the simulation domain. Occasionally more than one spacecraft is observing the solar wind in the upstream region during a disturbed interval. In those cases data from the different satellites can be used to evaluate spatial structures in the solar wind and the sensitivity of the MHD simulations to uncertainties in the solar wind parameters can be determined. An event that meets this criteria occurred during a magnetic storm on May 24, 2000 when solar wind observations from four spacecraft (Wind, ACE, IMP-8 and Geotail) were available. After taking into account the different spatial locations of the satellites and shifting the observations by the solar wind velocity, it was found that the time series of the observed magnetic field and plasma bulk parameters did not coincide. An analysis was carried out by calculating cross correlation coefficients between parameters taken at each pair of spacecraft. Then the solar wind parameters from each of these spacecraft were used to drive global MHD simulations of the magnetosphere. The power deposited in the ionosphere for each simulation was calculated and compared with that observed by the VIS instrument on Polar. Cross correlation coefficients of the ionospheric power and the cross polar cap potential difference from the simulation output from each pair of solar wind inputs were calculated. Finally the simulation output cross correlations with the input cross correlations were compared. Implications for the use of such an analysis to determine the reliability of forecasts of magnetospheric activity based on observations at a few points in the solar wind will be discussed.

SM22A-0219 1330h POSTER

Global heliospheric disturbances near 1 AU caused by the launch of solar transients on January 1 and September 23, 1978.

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We revisit the transient events of January and September 1978. In the January event the ejecta (an interplanetary magnetic cloud, IMC) was studied using multiple spacecraft observations [Burlaga et al., 1981]. In the September event Reames et al., 1997 studied the spectral characteristics of the energetic particles of this big particle event with a driven shock passage observed at longitudes nearly 180° apart. Here we present a combined analysis of the overall solar wind and energetic particles (EP) features of the shock and the driver, observed at different locations in longitude. We further evaluate the Rankine-Hugoniot properties of the shock at the locations its passage is observed and add modeling of the driven shock using a three dimensional MHD code which, at this stage of the analysis, does not include the magnetic structure of the ejecta. For the study of the shock velocity we use remote type II radio burst observations from near Earth (the September event), and at different longitude locations we examine: (a) flux intensity of the energetic particles, (b) shock strength, (c) timing of the shock structure and the driver passage at each spacecraft to infer the possible location of the nose of the shock. A preliminary assessment on the connection between the global nature of the shock and the observed level of energetic particle flux will be presented. The data sets include the kilometric radio measurements on ISEE3, and the 3 to 80 MeV energetic proton flux data from IMP-8, and a similar energy range from Helios at wide longitudinal locations relative to Earth. For the solar wind parameters we use magnetic field and plasma parameters from instruments at Helios 1, and 2, and ISEE3 and IMP-8. The data set is completed with the Dst index (Kyoto). We acknowledge partial support from NSF and NASA grants, and the NSSDC for on-line access to their space science data archives. Burlaga LF, E. Sittler, F. Mariani, and R. Schwenn, Magnetic loop behind an interplanetary shock: Voyager, Helios, and IMP-8 observations, J. Geophys. Res., 86, 6673, 1981. Reames, DV, SW Kahler, , and CK Ng, Spatial and temporal invariance in the spectra of gradual particles in gradual solar events, Astrophys. J., 491, 414, 1997.

SM22A-0220 1330h POSTER

Substorms in the ionosphere: LFM and GUMICS-4 global MHD simulations compared

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We simulate a substorm that occurred on March 28-29, 1998, using two state-of-the-art global MHD simulation codes. The substorm evolution in the ionosphere is investigated in three simulation runs. In the first two runs we use the usual setup of the two codes, in which the ionospheric potential is determined from the field-aligned currents and magnetospheric particle precipitation. In the third run the ionospheric module of the LFM simulation is replaced by the Thermosphere Ionosphere Nested Grid (TING) model. In particular, the global ionospheric energy deposition during the substorm is evaluated by comparing the spatial and temporal variation of Joule heating and particle precipitation in the three simulation runs. Furthermore, the open-closed field line boundary and the polar cap potential are compared in the two codes in order to investigate the global convection structure. The performance of the two codes is further quantified by comparing the simulation results with global measurements (e.g., SuperDARN, DMSP, AMIE). We investigate the details of the ionospheric modules in order to identify the reasons for similarities and differences between the simulation results and their agreement with the global observations. Ultimately, we consider the impact of this comparison on the ionospheric dynamics of the substorm.

SM22A-0221 1330h POSTER

Development of Real-Time Earth's Magnetosphere Simulator with 3-Dimensional MHD Code

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The super computing system is a powerful equipment to realize physical models of the Sun-Earth connection system for Space Weather forecast. Adopting the three-dimensional (3D) magneto-hydrodynamical (MHD) simulation code developed by Tanaka, we have constructed the real-time numerical simulator of interplanetary space-magnetosphere-ionosphere coupling system. By using the real-time one-minute solar wind data of a density, a flow speed and interplanetary magnetic field (IMF) from the ACE spacecraft as boundary conditions, this MHD simulation system can reproduced numerically the global structure of magnetosphere at the same time with the real world. Our real-time MHD simulator can calculate the dynamical response of the magnetosphere and can predict the timing when the geomagnetic disturbances occur and how they develop. The real-time MHD simulator have been developed by using the super computer system (SX-6) in Communications Research Labortory (CRL). To realize a real-time speed in simulations, 8 CPUs are being used adapting the newly developed HPF (High Performance Fortran) language that is an appropriate language for the calculations in multiprocessor parallel system. By now we have achieved a real-time speed in a 3D simulation of interplanetary space-magnetosphere-ionosphere coupling system with the 44x56x60 mesh size. Visualization of dynamical response of the Earth's magnetosphere is also done at the same time to numerical calculations by using RVSLIB (Real Time Visualization System Library), which is developed by NEC. This real-time MHD simulator will be run routinely on the CRL's super computer system. In this paper, we will explain the system configuration in detail and some examples will be presented to show how the geomagnetic disturbances occur responding to a solar wind change. This project will be one of the essential approaches to perform Space Weather forecast.

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SM22A-0222 1330h POSTER

A General Code Coupling Framework and the Dissection of the LFM Code

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One of the challenges of producing an end-to-end model for Space Weather is the coupling together of disparate codes. Most often, very sophisticated simulation models have been developed that treat regions or physical regimes in isolation. With funding from the NSF Center for Integrated Space Weather Modeling and the NASA Living With a Star Program, we have been developing a coupling technology that will allow coupling of such models together with a minimum of modification to those codes. Our approach is built on the following ideas:
1. The modification to the original code(s) should, to the extent possible, only deal with the output or input of necessary information.
2. Necessary transformations and translations of variables from one code to another should be handled in a separate code module.
These criteria allow us to use object oriented code concepts for maximum modularity and reusability without throwing away the huge amounts of effort invested in existing codes. For example, the translation modules in 2. can easily be designed do that replacement of one existing MHD code by another is a simple task. While these design criteria will not lead to a real “plug and play” modularity, we believe that they will provide a very useable framework in which different simulation codes can be added to or used as replacements in an end-to-end Space Weather model. We will discuss the software elements that undergird these ideas. The communication between codes is being handled by the interCom meta-library (the successor to the MetaChaos library). This meta-library is designed to provide transparent and efficient data transfer between different parallel processes in both homogeneous and heterogeneous environments. With the advent of grid computing and with the possibility that specific codes need to run at specific locations, the heterogeneous aspect becomes particularly important. We are also using the Overture package to help with the writing of the connector modules. Overture is a C++ class library devloped for doing computational fluid dynamics on overlapping grids. As such, it has built in functions for handling grid transformations and interpolations, as well as a Fortran 90-like array syntax. As an example of these techniques, we discuss the dissection of the LFM global magnetosphere/ionosphere simulation code into separate magnetospheric (MHD) and ionospheric (height integrated potential solution) modules linked via the interCom meta-libraries. We will show how the new coupled pair compares with the old integrated model in terms of simplicity and efficiency. In addition, we will discuss the operation of the new model in a heterogeneous computing environment and the use of heterogeneous tools to provide a real-time monitoring capability for code runs.

SM22A-0223 1330h POSTER

Doing It In The SWMF Way: From Separate Space Physics Simulation Programs To The Framework For Space Weather Simulation.

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The NASA-funded Space Weather Modeling Framework (SWMF) is developed to provide “plug and play” type Sun-to-Earth simulation capabilities serving the space physics modeling community. In its fully developed form, the SWMF will comprise a series of interoperating models of physics domains, ranging from the surface of the Sun to the upper atmosphere of the Earth. In its current form the SWMF links together five models: Global Magnetosphere, Inner Heliosphere, Ionosphere Electrodynamics, Upper Atmosphere, and Inner Magnetosphere. The framework permits to switch models of any type. The SWMF is a structured collection of software building blocks that can be used or customized to develop Sun-Earth system modeling components, and to assemble them into application. The SWMF consist of utilities and data structures for creating model components and coupling them. The SWMF contains Control Model, which controls initialization and execution of the components. It is responsible for component registration, processor layout for each component and coupling schedules. A component is created from the user-supplied physics code by adding a wrapper, which provides the control functions and coupling interface to perform the data exchange with other components. Both the wrapper and coupling interface are constructed from the building blocks provided by the framework itself. The current SWMF implementation is based on the latest component technology and uses many important concepts of Object-Oriented Programming emulated in Fortran 90. Currently it works on Linux Beowulf clusters, SGI Origin 2000 and Compaq ES45 machines.

SM22A-0224 1330h POSTER

The Space Weather Reanalysis

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The objective of this project is to generate a complete 11 year space weather representation using physically consistent data-driven space weather models. The project will create a consistent, integrated historical record of the near Earth space environment by coupling observational data from space environmental monitoring system archives with data-driven, physically based numerical models. The resulting product will be an enhanced look at the space environment on consistent grids, time resolution, coordinate systems and containing key fields allowing a research customer to quickly and easily incorporate the impact of the near-Earth space climate in environmentally sensitive models. Currently there are no long term climate archives available for the space-weather environment. Just as with terrestrial weather it is crucial to understand both daily weather forecasts as well as long term climate changes, so this project will demonstrate the ability to generate a meaningful and physically derived space weather climatology. We will present a status report for the project concentrating on new data, new models and new web based access added in 2003. In particular we will present results from the Global Ionosphere Thermosphere Model (GITM) run for 1997-1998, AMIE run for 1999-2001 and the new SWR website available at the National Geophysical Data Center.

URL: http://swr.ngdc.noaa.gov

SM22A-0225 1330h POSTER

RCM meets LFM: Initial results of one-way coupling

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It is well known that ideal single-fluid MHD does not reasonably represent the physics of the inner magnetosphere where energy dependent gradient and curvature drifts become important. As part of the space environment modeling activities of the Center for Integrated Space Weather Modeling (CISM), we have been working to merge the Rice Convection Model (RCM) into the Lyon-Fedder-Mobary (LFM) global MHD model of the magnetosphere. We present initial results of using LFM-computed magnetic and electric fields, ionospheric conductivity, and plasma distributions to drive the RCM. We describe and discuss the inner magnetosphere effects of this coupling, including the formation of region-2 field aligned currents and ring current.

SM22A-0226 1330h POSTER

Inner Magnetosphere Results from Coupled MHD-RDM Modeling

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The Michigan MHD model (BATSRUS) and the Rice Convection Model (RCM) have been successfully coupled to more accurately simulate the physics in the inner and outer magnetosphere. This self-consistent combined model has been applied to several idealized solar wind input conditions. Results will be presented for a number of magnetic field reversals and magnitude changes. Analysis will include inner magnetospheric shielding, partial and symmetric ring currents, pressure distribution, and particularly 3D global current configurations.

SM22A-0227 1330h POSTER

Performance Analysis of a Ring Current Model Driven by Global MHD

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Effectively modeling the high-energy particles in Earth's inner magnetosphere has the potential to improve safety in both manned and unmanned spacecraft. One model of this environment is the Fok Ring Current Model. This model can utilize as inputs both solar wind data, and empirical ionospheric electric field and magnetic field models. Alternatively, we have a procedure which allows the model to be driven by outputs from the BATS-R-US global MHD model. By using in-situ satellite data we will compare the predictive capability of this model in its original stand-alone form, to that of the model when driven by the BATS-R-US Global Magnetosphere Model. As a basis for comparison we use the April 2002 and May 2003 storms where suitable LANL geosynchronous data are available.

SM22A-0228 1330h POSTER

Simulations of Steady Magnetospheric Convection

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Steady Magnetospheric Convection in the Earth's magnetosphere is typically defined as a period of several hours of enhanced solar wind driving of the magnetosphere (i.e. the Interplanetary Magnetic Field is southward) during which the magnetosphere is nonetheless devoid of substorm signatures. We present and discuss model results of generic Steady Magnetospheric Convection (SMC) events using the Self-consistent Rice Convection Model. The SRCM consists of two coupled models that are used to separately compute the plasma and magnetic field evolution. The Rice Convection Model (RCM) is a multi-fluid guiding-center plasma drift code used to simulate plasma dynamics under the assumption that convection can be modeled quasi-statically as a sequence of force-balanced states. The RCM has been coupled to an equilibrium solver that computes a magnetic field

that is in force-balance (and is therefore self-consistent) with the RCM's plasma distribution. Various levels of steady external driving conditions are imposed in order to contrast the ability of the model magnetosphere to respond to differing rates of energy input and form a steady-state convection pattern. Model results will be compared with empirical SMC morphology.

SM22A-0229 1330h POSTER

Modeling System Earth During Geomagnetic Polarity Transitions

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During a geomagnetic polarity transition, the configuration and strength of the Earth's geomagnetic field can differ very much from the current state. This has consequences not only for the large-scale current systems, but also for the distribution of high-energy particle precipitation into the middle atmosphere, and therefore, for the composition of the middle atmosphere during and after large energetic particle events. Observations of the Earth's magnetic field during the last century show an increase of variability and a decrease of magnetic field strength. It has been argued that this might imply that a new polarity transition of the Earth's magnetic field is preparing to occur. This work is a multi-institutional collaboration aiming at modeling the magnetosphere during polarity transitions, the resulting energetic particle fluxes, and their effect on the middle atmospheric ozone concentration. We use MHD simulations and parametric modeling of the paleomagnetosphere to determine the geomagnetic field configuration for different transition scenarios. Particle orbits are traced and the resulting particle fluxes are used as input parameters in Monte-Carlo simulations of the mesospheric and stratospheric energy deposition and ionization. The effects on the composition of the middle atmosphere are investigated by means of a two-dimensional photochemistry and transport model. Although these models describe very different physical processes, links can be established through well-defined interfaces, and the chain of models allows us to study the global consequences of geomagnetic field reversals on system Earth.

SM22A-0230 1330h POSTER

Investigation of Shabansky Orbit Accessibility by Using 3D Particle Tracing in the Global MHD Simulations

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Due to the existence of the magnetic field strength minimum in the outer cusp region, energetic particles (a few hundred keV protons and MeV electrons) approaching the dayside magnetic field lines with a minimum field off-equator will experience large scale transport toward high latitude, being trapped at high latitude, and then being scattered back through Shabansky orbit [Shabansky, 1971]. The particle trajectories inside the magnetosphere can be grouped into three classes: (a) bouncing around the Equator (trapped); (b) going through Shabansky Orbit or being elevated at dayside (pseudo-trapped); (c) lost. Characterizing these three regions of particles and understanding their dependence on the solar wind condition can help understand the energization and loss of energetic particles in the radiation belt. Recently, we developed a 3D particle tracing code to simulate particle transport in transient global MHD (LFM model) simulation output. The protons are traced with full-motion and electrons are traced with guiding-center approximation. By launching energetic electrons and protons with different pitch angle and from various location along the tail in the model magnetosphere, recording and averaging the latitude the particle experiences at the dayside, we derive the Shabansky Orbit Accessibility Map (SOAMap) to visualize the three regions (trapped, pseudo-trapped, and lost) and their dependence on the initial launching position and pitch angle. We derived the SOAMaps for both electrons and protons inside steady state magnetosphere under different solar wind conditions. We also studied the evolution of the SOAMaps during a simulated magnetospheric substorm triggered by the turning of the solar wind IMF from northward to southward. Combining 3D particle tracing and global MHD simulation provides an integrated view of 3D energetic particle transport inside the Earth's magnetosphere. Shabansky, V. P., Some processes in the magnetosphere, Space Sci. Rev., 12, 299, 1971.

SM22A-0231 1330h POSTER

A Real-time Forecast Model for the Dst Index

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Since the solar wind controls magnetospheric activity, solar wind measurements upstream of the Earth near the L1 libration point can predict geomagnetic activity about one hour in advance. We have developed a prediction model for the Dst index using the solar wind as the sole input. Our current model is operating in real-time, using real-time solar wind data from ACE, which is positioned around the L1 libration point. The structure of solar wind near the L1 libration point and the evolution of solar wind structures from the libration point to the Earth can degrade such predictions. However, we have found that the lack of accurate solar wind measurements is the most important factor limiting accurate Dst forecasts in real time. During the past year neither the real time ACE measurements or the near real time Dst measurements have been accurate and predictions of Dst have been bad. We will show examples of our real-time forecast and the physical basis of our model and the implication of the results will be discussed.

URL: http://lasp.colorado.edu/∼lix/

SM22A-0232 1330h POSTER

The Thermosphere/Ionosphere (TI) Response to Magnetosphere Energy Inputs

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The Thermosphere/Ionosphere Nested Grid (TING) Model has been successfully coupled with the Lyon-Fedder-Mobarry (LFM) global magnetosphere MHD code. This code coupling enables self-consistent studies of the global energy budget of the Ionosphere-Thermosphere-Magnetosphere system to be made. In this paper we will present simulation results of an isolated substorm that occurred on May 20, 1996. It is found that the distribution and magnitude of the high latitude energy deposition in the thermosphere and ionosphere changes greatly when an interactive neutral model is coupled with a magnetospheric model. There is a significant north-south asymmetry in energy flux flowing into the IT system, resulting in hemispheric asymmetries in ionospheric Joule heating and conductivities. It is also found that the global distribution of solar produced ionization plays a significant role in ITM coupling.

SM22A-0233 1330h POSTER

Coupled Model of the Magnetosphere/Ionosphere System

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A major issue in space physics is understanding and quantifying the dynamics of a coupled magnetosphere-ionosphere system. The Naval Research Laboratory is now developing a self-consistent model of the magnetosphere and ionosphere. The two models to be coupled are the LFM magnetosphere model and the SAMI3HL ionosphere model. SAMI3HL is a recently developed high latitude ionosphere model based on the NRL SAMI3 low- to mid-latitude model. SAMI3HL is a fully parallelized 3D ionosphere model that uses a fixed, nonorthogonal grid. The two models will be coupled electrodynamically via the field-aligned currents and the polar cap convection potential. A precipitation model will also be developed to provide a self-consistent ionization source for the high latitude ionosphere model. We will discuss the details of these models, how they will be coupled, and present preliminary results.

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SM22B MCC: Level 1 Tuesday 1330h

Jovian Magnetospheric Environment Science for the Jupiter Icy Moons Orbiter (JIMO) III Posters *(joint with P, SA)*

Presiding: **C Paty,** University of Washington**; R J Walker,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles

SM22B-0234 1330h POSTER

Science and Payload Drivers for the Jupiter Icy Moons Orbiter

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Primary science goals of a mission to the outer three Galilean satellites include the deduction of internal structure and the possible presence of liquid water beneath the ice crusts of these worlds. A liquid-water mantle can provide an explanation of the magnetic characteristics of these moons and also provide a possible site for biological activity, but major unknowns include the possible extent and composition of a sub-surface brine "sea." Using the power re-sources available on the Jupiter Icy Moons Orbiter (JIMO) spacecraft critical data on all of these topics can be re-turned to Earth. A comprehensive payload that can definitely address these goals requires a radar sounder, laser al-timeter, and a suite of fields and particles instruments. An optimized radar sounder for probing beneath the ice should likely be capable of functioning ∼50 MHz at as high a power level as consistent with JIMO resources. A laser altimeter will have a larger mass-to-power ratio and worse power efficiency than a radar sounder. Mass is driven by the optical receiver and alignment requirements. Supporting instrumentation including a magnetometer (magnetic field in situ), imager ("geology" and ice structures), and spectrometers ("mineralogy") are obvious candi-dates for JIMO. Even more important is the inclusion of particle instruments that can measure pickup elements and their isotopes present in the in-situ plasma due to sputtering from the surface of the moons. Such trace elements and isotopes are important for understanding surface processes and adducing the materials present in the ice and impli-cations for subsurface biological activity. Knowledge of these trace elements is also important to understanding the context of the sounder observations. A "wish list" payload combining state-of-the-art instrumentation would com-prise 19 instruments with a mass of 644 kg and requiring 712 W of power, exclusive of a radar sounder. Addition of a 1-kW radar sounder could bring the mass and power totals to nominal values ∼900