near Earth. This requires modeling the non-uniform, ambient solar wind and tracking the propagation of interplanetary shocks and coronal mass ejections through the heliosphere. The mapping the IMF lines connecting the traveling shock region to the Earth is also required for predictions of solar energetic particles (SEP) and predictions based upon SEPs. Our group is developing an observation-driven, hybrid, kinematic/3D-MHD solar wind modeling system (H3DM) in order to simulate realistic solar wind conditions, including the time-dependent IMF vector (including Bz) direction and magnitude at Earth. This system couples two mature solar wind codes: the Hakamada-Akasofu-Fry (HAF) model and the Interplanetary Global Model, Vectorized (IGMV). Scientifically, this effort seeks to improve the understanding of the role various drivers of interplanetary disturbances play throughout the solar cycle. Operationally, we are working toward providing a capability to predict, shortly after the launch of large-scale structures at the Sun, their evolution and propagation to Earth. We will describe the H3DM modeling system and provide a project status report.

SH51A-05 0905h INVITED

Cosmic Rays, Solar Energetic Particles, and Climate: Where are the Links?

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The correlation of Earth's climate with the 11 year solar sunspot cycle is difficult to explain with variations of the solar radiative output alone. Recently it has been argued that such climate variations may be due to a modulation of the galactic cosmic ray flux impinging on Earth or due to a modulation of the less energetic solar energetic particles. Such mechanisms are suggested by the surprisingly strong correlation between sunspot numbers and climatic parameters, such as cloudiness. Correlations are of course no proof of causality as long as the detailed mechanisms are not understood. Several mechanisms have been proposed, for example the modulation of the global electric circuit and the modulation of the generation of cloud condensation nuclei (CCNs). Such mechanisms require a sequence of processes to occur, from the modulation of the cosmic ray flux, through the air showers of the atmospheric interaction, the formation of ion pairs, the formation of CCNs, and to the formation of cloud droplets. We are far from understanding these processes, let alone how they interact with each other. In this talk we will outline the beginnings of a interdisciplinary research program that addresses these processes and some initial results.

SH51A-06 0925h

Ion Mediated Nucleation: how is it Influenced by Changes in the Solar Activity?

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Recently it has been pointed out that tropospheric cloudiness can be correlated with the galactic cosmic rays (GCRs) intensity [*Svensmark and Friis-Christensen*, 1997]. A possible explanation for such a correlation relies on the fact that GCRs are the main ionization source in the upper troposphere, hence, throughout ionic mediated nucleation, they could possibly influence the global cloud condensation nuclei (CCN) formation [*e.g.*, *Yu*, 2001; *Dickinson*, 1975]. Because the GCRs are modulated by the interaction between the solar wind and the Earth's magnetosphere and their intensity generally decreases with increasing solar activity, subtle changes in the solar activity could indirectly affect the Earth's climate. We have been studying the very first steps of ionic nucleation considering the molecular species of atmospheric interest (*e.g.*,water, nitric acid, sulfuric acid, ammonia *etc.*). In our approach the formation and evolution of ionic clusters is followed by resolving the time dependent kinetic aggregation process and considering the ions sources (ultimately the atmospheric ionization of neutral species) and sinks. We show how in typical atmospheric conditions stable populations of molecular ions forms. The novelty of our work consists in the determination of the kinetic parameters that govern the molecular ions growth (*i.e.*, the forward and reverse clustering reaction constants for each cluster type and size) at a microscopic level. In fact a thermochemistry data base is built for the species of interest by integrating laboratory measurements, quantum mechanical calculations and, when appropriate, results from the macroscopic liquid droplet model [*Thomson*, 1928]. Such database is than used to retrieve the reverse clustering reaction coefficients for the molecular ion type and size and for the environmental conditions (pressure and temperature) of interest. The forward reaction is instead determined by calculating the ionic-neutral collisional rate or is assumed from laboratory determinations. Here we discuss the methodology and some of the results from sensitivity tests in which the ionization rate is changed so to reflect natural variation of the GCRs as modulated by the Sun. References: Dickinson, R. E., Solar variability and the lower atmosphere, *Bull. Am. Meterol. Soc., 56*, 1240-1248, 1975. Svensmark, H., and E. Friis-Christensen, Variation of cosmic ray flux and global cloud coverage A missing link in solar-climate relationships, *J. Atmos. Sol. Terr. Phys., 59*, 1225-1232, 1997. Thomson, J. J and G. P. Thomson, Conduction of electricity through gases, *Cambridge University Press*, 1928. Yu, F., Altitude variations of cosmic ray induced production of aerosols: Implications for global cloudiness and climate, *J. Geophys. Res., 107*, 10.1029/2001JA000248, 2001.

SH51A-07 0940h

Simulated Radial and Azimuthal Structure of Proton Ring-Current Field

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We simulate the radial and azimuthal structure of the proton ring-current magnetic field by tracing the guiding centers of representative ions from the plasma sheet as they drift within a model magnetosphere. The ambient magnetic field model we use for this study is the Dungey model, which consists of a dipole field plus a uniform southward "tail" field. We map a spatially analytical expansion of the AMIE ionospheric electric potential, expressed as a function of magnetic latitude and magnetic local time, along magnetic field lines (for $L \geq 2$) throughout this model magnetosphere. We trace the bounce-averaged drift for ions conserving the first two adiabatic invariants μ and J (with values that correspond to energies of $\sim 10-300$ keV at $L = 3$). Using these simulation results, we map proton phase space densities according to Liouville's theorem but taking into account losses due to charge exchange. We specify an "initial" proton ring current distribution by solving the steady-state transport equation that balances quiescent radial diffusion against charge exchange. To obtain MLT-dependent and UT-dependent boundary values for our phase space density distribution, we map geosynchronous LANL ion data to the boundary of our model magnetosphere as boundary conditions. From the simulated phase-space density, we calculate the proton pressure and energy density distributions. From the pressure distributions, we compute the separate contributions of the magnetic field perturbation from the gradient-curvature drift currents, magnetization currents, and field-aligned currents needed to satisfy Ampere's law. We add these contributions together to obtain the total ring current magnetic field. We perform simulations for a few storm events including the 19 October 1998 storm. We find that during the 19 October 1998 storm the large AMIE electric field in the evening sector would have led to rapid (~ 20 minutes) inward transport of ions from the plasma sheet to the dusk meridian at $L \sim 3$. We can thus account for the observed rapid formation of the partial ring current there and its subsequent symmetrization to a wider range of MLT. In regions where the ring current is especially intense, the ring current magnetic field can be a significant fraction of the Earth's magnetic field. This suggests a need for eventually calculating the particle transport in a magnetically self-consistent model in the future.

SH51B MCC: 2008 Friday 1020h

Space Science Research With Societal Consequences III *(joint with SA, SM, AE)*

Presiding: **V Papitashvili,** Space Physics Research Laboratory, University of Michigan**; J Foster,** Millstone Hill Observatory

SH51B-01 1020h

Space as Humanosphere: Role of space physics for human activities in the near-Earth Space

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We are entering a new era of utilization of space as Human territory (Humanosphere) for sustainable human society. From this point of view, a comprehensive academic study of the space environment could provide fundamental knowledge for developing space infrastructure such as huge power station (Solar Power Satellite :SPS). Such study should cover not only the solar terrestrial relations but also possible nonlinear effects of space plasma onto large space structures. Since we have reached a state of understanding the framework of solar-terrestrial relations, we need to proceed our research for more practical objectives, which are directly related to the human activity in space. In the preset paper, we review the state of art of our knowledge of the space as Humanosphere from a view point of space plasma physics. I will then discuss the trend and perspectives of the role of space plasma physics, especially space plasma simulations in the coming new era of space civilization (utilization and beyond). The International Space Station is one of the human space activities at the ionospheric altitude level in the very near future. However, beyond the ISS era, much higher space activities will follow towards higher space civilization based on a very large structure such as Solar Power Station (SPS). I will discuss first the need of large scale space development such as the SPS to avoid a possible catastrophe of human life on Earth by the end of this century. Then I will touch upon possible plasma physics problems emerging from such large scale space development. The huge structure and the high voltage power supply for the microwave power transmission from the SPS definitely electromagnetically interact with space plasmas. Also much higher level artificial ion injection from the electric propulsion engine to carry such large structure into the GEO will create a large modification of the natural magnetosphere. These issues will demand the contribution by space physicists and simulationists.

SH51B-02 1035h

The Three Modes of Magnetospheric Behavior Observed During Magnetic Storms

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Understanding geomagnetic storms is a paramount space weather problem as well as a fundamental scientific challenge. The processes that operate during magnetic storms have been areas of active investigation and significant discussion for many years. We believe that it is possible now to identify three distinct modes of magnetospheric operation during various geomagnetic storms. One mode consists of periods of enhanced steady magnetospheric convection (SMC)

punctuated by isolated magnetospheric substorm expansions. A second mode of operation consists of periodic substorm expansions. The third mode of operation is characterized by global sawtooth oscillations in the magnetic field tilt and particle fluxes measured at geostationary orbit. We will report on the means to identiry and distinguish these three modes of operation. The conditions under which each mode appears to become dominant during a particular storm appears to lie both in the solar wind driving conditions as well as in some internal magnetospheric conditions.

SH51B-03 1050h

Forecasting High-Latitude Ionospheric Electric Potentials and Currents

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Improvements are being made to an empirical model of the high-latitude ionospheric electric potential, and its twin model of the ionospheric field-aligned currents (FAC). These models show the two-dimensional electric potential or FAC distribution as a function of the solar wind and interplanetary magnetic field (IMF). The FAC model, which is based on magnetic Euler potentials, can be used to predict geomagnetic perturbations on the ground. The two models together can also be used to produce maps of ionospheric Joule heating, or total integrated Joule heating, as a function of the IMF. The techniques used to obtain the recent improvements to these empirical models will be discussed. These models have been incorporated into a prototype computer program, which uses the real time, upstream IMF/solar wind measurements from the ACE spacecraft, to display predictive maps of various ionospheric electrodynamic parameters. This real-time program also uses the "minimum variance" technique to derive the tilt angle of the IMF phase fronts, and thus improve the timing accuracy of the predictions.

SH51B-04 1105h

Refining and understanding the auroral electrojet index AL

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A large number of ground based magnetometer stations and images are used to investigate a possible separation of the auroral electrojet index AL. Based on the two-component electrojet concept, the AL index is a measure of either the directly driven convection electrojet activity or the substorm current wedge electrojet activity. We presents results of a separation of the auroral electrojet index AL into two parts each monitoring these fundamentally different processes. Classical auroral substorms are selected using global auroral images and case studies as well as statistical results from more than 100 substorms will be presented. The statistical MLT distribution of the AL station location before and after the substorm onset was found by Gjerloev et al. [EOS, SM52B-05, F1179, 2002] to be well separated, thereby enabling a separation of the AL into ALw (wedge) and ALc (convection) using a simple MLT binning. The suggested separation of AL enables a simultaneous monitoring of the two westward electrojet components, thereby improving our ability to specify the space weather conditions as well as increasing our understanding of the temporal variability of these two electrojet components.

SH51B-05 1120h

Global MHD Simulation Study of Joule Heating in the Polar Ionosphere

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Energy from the solar wind is transferred to the magnetosphere and drives currents in the polar ionosphere. The resistive or Joule heating produced by these currents can be on the order of a terrawatt during an intense geomagnetic disturbance. Joule heating can change the scale height of the upper atmosphere affecting spacecraft orbits. We use a global, 3D, MHD magnetosphere model to study this process. We will show the dependence of the magnitude and spatial distribution of Joule heating on the strength and direction of the interplanetary field, the season of the year, the solar wind ram pressure, and the solar output. Work supported by the NASA LWS program and the NAVO HPC center.

SH51B-06 1135h

Pulsed Flows at the High-Altitude Cusp Poleward Boundary, and Associated Ionospheric Convection and Particle Signatures, During a Cluster/FAST/SuperDARN/Sondrestrom Conjunction Under a Southwest IMF

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Observations during a magnetic conjunction Cluster 1-FAST-Sondrestrom within the field of view of SuperDARN radars on January 21, 2001 allow us to draw a comprehensive and self-consistent picture at three heights of signatures of transient reconnection under a steady south-westerly IMF. Cluster 1 was outbound through the high altitude exterior northern cusp when a solar wind dynamic pressure release shifted the spacecraft into a boundary layer at the cusp's poleward edge. Centerpiece of the investigation is a series of flow bursts observed there by the spacecraft, which were accompanied by strong field perturbations and tailward flow deflections, shown to be Alfven waves. We interpret these flow events as being due to a sequence of reconnected flux tubes, with field-aligned currents in the associated Alfven waves carrying stresses to the underlying ionosphere, a view strengthened by the other observations. At the magnetic footprint of the region of Cluster flow bursts, FAST observed an ion energy-latitude dispersion of the stepped cusp type, with individual cusp ion steps corresponding to individual flow bursts. Simultaneously, the SuperDARN radars observed very strong PMRAFs which were conjugate to the flow bursts at Cluster. FAST was traversing these PMRAFs when it observed the cusp ion steps. The Sondrestrom radar observed PIFs just poleward of the convection reversal boundary. As at Cluster, the flow was tailward, implying a coherent tailward motion of the hypothesized open flux tubes. The joint Sondrestrom and FAST observations indicate that the open/closed field line boundary was equatorward of the convection reversal boundary by $\sim 2^\circ$. The unprecedented accuracy of the conjunction leaves no doubt as to the validity of the interpretation of the various signatures as resulting from transient reconnection. In particular, the cusp ion steps arise indubitably on this pass from this origin, in consonance with the original pulsating cusp model. The observations argue in favor of re-establishing the poleward boundary of the cusp as an active site of momentum transfer.

SH51B-07 1150h

Mid-Latitude D-Region Absorption Studies in the Space Weather Context: Modeling Results

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A Data-Driven D-region (DDDR) model has been created to ingest real-time geophysical data streams into a D-region electron density model for improved determinations of D-region specification with respect to HF propagation and absorption characteristics. The model is based on the disturbed D-region model of Swider and Foley ["Steady-State Multi-Ion Disturbed D-Region Model", AFGL-TR-78-0155, June 1978] for quick calculation of the global electron density profile from 60 to 100 km altitude. The model is driven by geophysical indices and ingests x-ray observations and solar wind particle observations (NOAA/GOES 12 satellite) into ionization drivers to the weather-sensitive D region model. The DDDR model and the Ionospheric Forecast Model (IFM) are run for the time period of May 25 to June 25 of 2003 and used to calculate HF signal propagation and strength from WWV, WWVH, and CHU standard time-frequency stations to the HF monitoring stations of the HF Investigation and D region Ionosphere Variation Experiment (HIDAVE). The monitoring sites are at Klamath Falls, OR and Bear Lake Observatory, UT. Day-to-day trends in HF absorption are examined in the data-model comparison as well as the D region response to solar flares from Class C to Class X.

SH51B-08 1205h

MAGNETOTAIL ASSIMILATION MODEL

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Progress in space plasma physics requires coordinated analysis of multi-point observations and hence, many upcoming ionospheric and magnetospheric missions will consist of multiple spacecraft. With the launch dates of these missions only a few years away, there is an urgent need to develop a method that can assimilate the unprecedentedly large multi-point data sets in coherent and unified manner. We have recently developed a technique that integrates low-altitude ionospheric observations to create 2-D/3-D global images of the plasma sheet ion pressure, temperature, and density. This method relies on the plasma sheet plasma isotropy, which has a strong theoretical foundation as well as overwhelming observational support. Previously developed algorithms are used to detect the plasma isotropy boundary and to detect and exclude acceleration events. The plasma properties obtained with this method compare favorably with previous in situ measurements in the magnetotail. The technique can be refined to include mid-altitude and high-altitude observations. Therefore, it can serve as a foundation for building a model that assimilates multipoint plasma observations from multi-spacecraft missions into globally coherent and unified images of the magnetotail tailward of 8-10 Re, which is the region that acts as energy and plasma reservoir. The power this method for magnetotail investigations is illustrated in the study of the dynamics and source of the cold dense plasma in the plasma sheet during periods of northward IMF.

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