## SM22A-0578 1330h POSTER

### Ionospheric Outflow and Ring Current Composition During 2001 Geomagnetic Storms

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We will examine compositional changes in the near-Earth neutral H and O emissions detected with the Low & High Energy Neutral Atom imagers (LENA & HENA) aboard the Imager for Magnetosphere-to-Aurora Global Exploration (IMAGE) satellite during magnetic storm periods in 2001. In comparison with in situ ion composition measurements from the CLUSTER Ion Spectrometry (CIS) experiment on three of the CLUSTER spacecraft, remote neutral atom measurements from IMAGE will be used to probe the global behavior of upflowing and ring current ions, whose interaction with the neutral H geocorona produces energetic neutral atoms. By analyzing temporal and spatial variations in the composition of neutral atoms measured with LENA that are associated with upflowing ions, ring current ions deduced from HENA data, and direct ion observations from CIS, and by making comparisons between individual storm periods, we will investigate the possible transport of upflowing ionospheric ions to the ring current region.

## SM22A-0579 1330h POSTER

### Guiding-Center Simulations of Stormtime Ring Current Electrons

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We examine the stormtime injection of electrons to the stormtime ring current by simulating the drift and loss of electrons from the plasma sheet to the inner magnetosphere. We use a similar method and magnetic and electric field model that *Chen et al.* [*JGR, 99*, 5745-5759, 1994] used previously to account for the stormtime injection of ring current ions to determine the extent to which that model can also account for observed stormtime electron injections. The model traces the guiding-center motion of representative particles, having selected first adiabatic invariants $\mu$. The magnetic field model is a dipole field plus constant southward IMF, and we impose corotation and a 25-kV quiescent Stern-Volland cross polar cap potential. We simulate two real storms (August 27, 1990, and October 10, 1990) by applying additional storm-associated enhancements in the convection electric field that are less well shielded than the Stern-Volland field. The enhancements in the cross-polar cap potential are obtained by linearly interpolating DMSP measurements of the cross polar cap potential minus an assumed 25-kV quiescent potential. We perform simulations for representative equatorially-mirroring electrons for $\mu = 1$ MeV/G to 200 MeV/G. Using the simulation results, we map stormtime phase space distributions by invoking Liouvilles Theorem modified by losses. We consider electron loss due to precipitation via a model in which there is strong diffusion far in the plasma sheet ($L > \sim 8$) and weak diffusion within the plasmasphere. The loss rates in the region $L \sim 8$ to the plasmapause boundary are based on diffusion rates calculated by *Lyons* [*JGR, 79*, 575-580, 1974]. We apply a boundary spectrum at geosynchronous orbit that is based on averaging 12 years of geosynchronous LANL/MPA electron data and is parameterized by Kp and binned in 0.5 hr MLT increments. The initial quiescent electron distribution for trapped electrons is taken from the steady-state balance between radial diffusion and weak-pitch-angle-scattering losses. From the simulation results, we find significant stormtime enhancements of ring current electrons at equatorial radial distance r = 2.6 to 6.6 $R_E$ for energies from tens of keV up to 180 keV. We compare features of our stormtime electron flux distribution with CRRES/LEPA and CRRES/MEA data. We find good agreement between simulated and observed electron flux profiles at low energies ($\leq$ 20 keV). Measurements are not available from $\sim$20 keV to 150 keV. However, our model does not reproduce stormtime enhancements of electron flux at high energies ($\geq$ 150 keV) at $L \sim 3$ to 4, suggesting that a local energization may be responsible for these enhancements.

## SM22A-0580 1330h POSTER

### Solar Wind Driving of the Stormtime Ring Current

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We present results describing the solar wind driving of the ring current. Results have shown that much of the behavior of the ring current is related to conditions in the solar wind, and in particular, shows reasonable agreement with the epsilon parameter. Recent results suggest that during times of more intense driving by the solar wind, the kinetic energy flux from the solar wind may have a stonger effect than previously believed. Other work shows a relationship between the type of solar wind driver and the energy deposited in the auroral ionosphere. In this study we examine several storms of various intensities to determine the response of the stormtime ring current to different driving conditions and different coupling mechanisms from the solar wind.

## SM22A-0581 1330h POSTER

### Observations of Storm-Time Ion Injection and Loss Processes in the Ring Current

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Measurement of 20 keV ions pitch-angle distributions in the ring current during the magnetic storms of January 10,1997 and, May 15, 1997 show evidence of injection, pitch angle scattering and, precipitation. The observations were made with the IPS detectors of CEPPAD on the Polar spacecraft while intercepting the radiation belts at L-shells between 3 and 7 Earth radii, and at magnetic latitudes which span +/- 55 degrees. The magnetic local times (MLT) coverage of the Jan 10, 1997 measurements were confined to dawn and dusk. For the May15 storm the coverage was near noon and midnight. The progression of both storms was observed from onset through the main phase and early and late recovery phases. The main phase and early recovery of both storms exhibited elevated flux levels - indicating particle injection into the ring current over all L-shells. Very isotropic pitch-angle distributions were observed on the night side and at dusk local times, and over L-shells greater than 4, throughout main phase and early recovery - indicating strong pitch angle diffusion. In many cases these flat distributions extended over the loss cone regions - signifying enhanced precipitation. The observed enhanced precipitation, associated with strong diffusion into the loss cones at dusk and /or night local magnetic times, cannot be explained by recent modeling efforts that incorporate wave particle interaction scattering losses. Instead this precipitation has the signature of current sheet scattering of ions associated with distortions of the near geomagnetic tail, that cause a violation of the Measurement of 20 keV ions pitch-angle distributions in the ring current during the magnetic storms of January 10,1997 and, May 15, 1997 show evidence of injection, pitch angle scattering and, precipitation. The observations were made with the IPS detectors of CEPPAD on the Polar spacecraft while intercepting the radiation belts at L-shells between 3 and 7 Earth radii, and at magnetic latitudes which span +/- 55 degrees. The magnetic local times (MLT) coverage of the Jan 10, 1997 measurements were confined to dawn and dusk. For the May15 storm the coverage was near noon and midnight. The progression of both storms was observed from onset through the main phase and early and late recovery phases. The main phase and early recovery of both storms exhibited elevated flux levels - indicating particle injection into the ring current over all L-shells. Very isotropic pitch-angle distributions were observed on the night side and at dusk local times, and over L-shells greater than 4, throughout main phase and early recovery - indicating strong pitch angle diffusion. In many cases these flat distributions extended over the loss cone regions - signifying enhanced precipitation. The observed enhanced precipitation, associated with strong diffusion into the loss cones at dusk and /or night local magnetic times, cannot be explained by recent modeling efforts that incorporate wave particle interaction scattering losses. Instead this precipitation has the signature of current sheet scattering of ions associated with distortions of the near geomagnetic tail, that cause a violation guiding center approximation

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# SM22B MCC: 131 Tuesday 1330h

## Dipole Tilt Effects on Sun-Earth Connections II *(joint with SA, SH)*

***Presiding:*** **R L McPherron,** University of California, Los Angeles**; E W Cliver,** Air Force Research Laboratory

## SM22B-01 1330h INVITED

### Internal or External? What MHD Simulation Can Say about the Cause of Semiannual Variation in Geomagnetic Activity

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To what degree does the semiannual variation of geomagnetic activity result from external causes (e.g., heliographic latitude of the earth or tilt between heliographic and geographic equators) versus internal causes (e.g., north-south asymmetry of ionospheric conductances during solstices)? MHD simulation is well suited to explore the degree of an internal cause since one can vary conductances at will in the two hemisphere separately to see the effect these variations have on indicators of geomagnetic activity such as convection potential. This talk will give the MHD-simulation answer to the question, "Does the convection potential, as measured in the ionosphere, increase or decrease during solstice compared to equinox for the same solar wind conditions (in the GSM coordinate system)?" Moreover, it will compare storm-time activity against moderate activity to show how interhemispheric comparisons of ionospheric electrodynamic parameters can test theories of transpolar potential saturation.

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## SM22B-02 1350h INVITED

### The Seasonal and Diurnal Variation of Dst Dynamics

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In recent years the debate over the causes of seasonal and diurnal variations in magnetic activity has been revived. Popular explanations rely primarily on the orientation of the terrestrial magnetic dipole relative to heliospheric topology. We investigate the signatures of this geometry in the dynamics of $Dst$, the ring current index. We show that the Russell-McPherron is present; however, enhancements in $Dst$, as measured by the $Dst$ index, exhibit a seasonal and diurnal pattern that is significantly different from the Russell-McPherron (RM) effect. Specifically the dynamics of $Dst$, which accommodate the RM effect, demonstrate seasonal and diurnal variations associated with $\psi$ the magnetic colatitude of the subsolar point. Specifically, it is primarily the diurnal signature that distinguishes between various mechanisms for semiannual variations. We suggest that these variations are most consistent with the hypothesis that $\psi$ modulates the depth of penetration of the magnetosheath field into the magnetopause, and thereby the amount of magnetic merging and the strength and orientation of magnetopause currents.

## SM22B-03 1410h

### Dipole Tilt Effects on the Dst index

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The Dst index shows a large variation with season with larger negative values occurring at the equinoxes. As is well known, larger magnetic storms occur more often near the equinoxes but the average baseline value of Dst also shows the same seasonal periodicity. We have been able to model Dst using the solar wind as an input. The modeled Dst index is sum of several driver terms with different decay constants and a pressure term. All terms have a significant equinoctial variation. The equinoctial terms were introduced into the model with arbitrary phases and best phase was found through minimizing the least square error. The phase agrees with and thus confirms the equinoctial effect. Much of the baseline seasonal variation in Dst is the result of the varying effect of the pressure term. The diurnal variation in Dst is substantially smaller than one would expect given the seasonal variation. This may be due to the removal of the diurnal variation from the Dst index. Some of the diurnal variation, which is mostly due to the Sq ionospheric current, is in fact due to magnetospheric currents and may also be removed in forming the Dst index. The removal of the Sq current system in not perfect and there is on average 9 nT peak-to-peak residual diurnal signal of varying phase remaining in the Dst index. The modeled Dst confirms the dominance of the equinoctial effect on the seasonal dependence of Dst index and thus on magnetospheric activity despite many minor inconsistencies in the behavior of the individual terms that make up the modeled Dst.

## SM22B-04 1425h

### Stormtime and Non-stormtime Drivers of Dst Variability

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In this presentation we examine systematic diurnal and seasonal variation of the Dst index. A part of this variation arises from geometrical differences in the Earth's and its magnetosphere's position in the heliosphere. Three such effects have been identified: the heliographic latitude of the Earth, the equinoctial effect and the Russell-McPherron effect. Besides these three external drivers a part of the observed variability arises from factors that are not directly related to magnetospheric activity. The locations of the Dst stations are one such factor. Differences in individual station properties, such as local ground conductivity structures resulting in differences in induction contributions, may lead to apparent diurnal variations in the Dst index. The asymmetric north-south distribution of the stations affects the seasonal variation pattern of the Dst index. To remove the internal effects and to estimate the relative importance of the three external drivers we have studied data from many magnetic observatories (including those used to compute the Dst index) over several solar cycles. From the Dst data for 1957-1999 we have identified more than 2000 magnetic storms and divided our data set into storm main phases, recovery phases and non-storm periods and examined the diurnal and seasonal variability of each of these data sets separately. The results indicate that the three external effects account for only about 50% of all daily and seasonal variation of the Dst index with Russell-McPherron effect as the leading external driver. For storm periods the Russell-McPherron effect is again the dominant effect while for non-storm periods all three effects are equally significant.

## SM22B-05 1440h

### How the Tilt of the Dipole Could Affect the Rate of Reconnection at the Earth's Magnetopause

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The semiannual variation of geomagnetic activity was attributed by Russell and McPherron (1973) to reconnection modulated by the varying angle of the magnetic field at the nose of the magnetosphere to the statistically Parker-spiral-oriented IMF. The division of the semiannual variation of geomagnetic activity into two annual variations according to the polarity of the IMF clearly demonstrates that reconnection is the cause of the semiannual variation. The so-called Russell-McPherron mechanism does not explain the diurnal variation of geomagnetic indices, albeit it does explain the annual variation of this diurnal variation. O'Brien and McPherron (2002) have recently demonstrated that if the reconnection rate depends on the tilt of the dipole an improved prediction of both the semiannual and diurnal variation results, but they do not provide a credible explanation for tilt dependence. Nevertheless, a very simple explanation does exist based on simple geometric arguments following those of Crooker (1979) and Luhmann et al (1984) who predicted the sites of reconnection for a dipole perpendicular to the solar wind flow. If reconnection is initiated where the IMF is antiparallel to the magnetospheric field and if the rate of reconnection depends on the solar wind pressure normal to the magnetopause, then the rate maximizes for the 0 deg. tilt (0 deg. magnetic latitude of the subsolar point) and lessens as either pole of the dipole tilts toward the Sun. In short, the simple merging law used by Russell and McPherron may need tuning, but the basic mechanism is valid as proposed.

## SM22B-06 1455h INVITED

### The Semi-annual Variation of Geomagnetic Activity.

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This problem of long standing has had three classes of explanation: 1) the Axial mechanisms, 2) the Equinoctial mechanisms, and 3) the Russell-McPherron effect. Proponents of each mechanism have usual claimed exclusivity. It is becoming clear that they all have a grain of the truth. Mechanisms from all three classes seem to be operating at all times, the relative importance of each mechanism ever-changing, roughly regulated by the solar cycle. Typical average values being of the order of 10%, 70%, and 20% for the three classes, with the Equinoctial mechanisms clearly dominant. At any time the relative importance may shift so that any of the three classes may dominate. Our understanding of the influence of each class is improving to the extent that we can generally untangle the various contributions (although the physical processes behind the Equinoctial mechanisms remain obscure)

## SM22B-07 1535h INVITED

### Seasonal, Solar Cycle and Universal Time Variations of the Auroral Electrojets

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It has been reported that magnetic activity shows pronounced seasonal and universal time (UT) variations. Various attempts have been made to explain the reasons. As one of such attempts we analyze the hourly mean auroral electroject indices obtained during the last 20 years. Recognizing that the AU and AL indices play different roles in the solar wind-magnetosphere coupling, we examine the two indices separately instead of examining their combined index, AE. The AU and AL indices maximize during summer and equinoctial months, respectively. By normalizing the solar conductivity contribution to the AU index, we are able to estimate the electric field contribution to the AU index. It is found that the AU and AL exhibit the same semiannual variation pattern, indicating that the semiannual magnetic variations are controlled by the electric field. The variation pattern of the yearly mean AL index follows the mirror image of the AU index, providing another indication that the electric field is the main modulator of magnetic disturbances. We also confirm that the Dst index shows the same seasonal variation pattern. The pronounced UT variations of the auroral electrojet indices are also examined. To determine the variations as functions of the electrojet intensity, the probability of observing a given level of the indices during each hour of UT, or the number of occurrence of a given level of AU and AL during each UT, is obtained. The probability distribution of the AL index is characterized by a maximum appearing around 12-18 UT and a minimum around 00-08 UT, while the AU shows two peaks. This feature is particularly clear during disturbed periods, indicating that the latitudinal "mismatch" between the AE stations and the auroral electrojet belt is its main cause. It is also confirmed that the seasonal change of the ionospheric conductivity due to the solar EUV radiation contributes to the UT variation, particularly of the AL index during winter. Thus, the combined effect resulting from the unfavorable distribution of the AE stations and the seasonal change of the ionospheric conductivity seems to contribute more effectively to the UT variation of the auroral elctrojet indices during disturbed periods than any physical reason, for example, such as either the Russell-McPherron effect or the equinoctial effect.

## SM22B-08 1555h

### Dipole Tilt Effects on Radiation Belt Electrons and Dst Index

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Long term measurements of MeV electrons by the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) and also by LANL sensors at geostationary orbit clearly show seasonal variations: enhanced electron fluxes occur around the equinoxes. The same variation can be seen for geomagnetic activity such as the Dst index. Recently developed models for predicting MeV electron at geostationary orbit [Li et al., 2001] and the Dst index [Temerin and Li, 2002] based on solar wind measurements are used to examine the cause of the prominent semiannual variations of outer belt electrons and the Dst index. We found that the equinoctial effect (the angle between the Earth's dipole and the flow direction of the solar wind) contributes most to the semiannual variation of the Dst and MeV electrons deep in the inner magnetosphere (L<5). The semiannual variation of MeV electrons at geostationary orbit (1995-2000) is attributed mostly to the semiannual variation of solar wind velocity itself.

[Li et al., 2001] Li, X., M. Temerin, D. N. Baker, G. D. Reeves, and D. Larson, Quantitative Prediction of Radiation Belt Electrons at Geostationary Orbit Based on Solar Wind Measurements, Geophysical Research Lett., Vol. 28, 1887, 2001.

[Temerin and Li, 2002] Temerin, M., and X. Li, A New Model for the Prediction of Dst on the Basis of the Solar Wind, J. of Geophysical Research, in press, 2002.

## SM22B-09 1610h INVITED

### What role does the high latitude ionosphere play in the magnetosphere-ionosphere (MI) coupling?

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The high-latitude ionosphere is a conducting boundary of the magnetosphere that closes global magnetospheric current systems. It is also a significant mass source of the plasmasheet. At times the auroral ionosphere is expected to control magnetospheric processes and the magnetospheric particle population. However, its role in the particle interchanges (magnetospheric particle precipitation, ionospheric particle outflow) and in the induced aurora is still being debated. The tilt of the Earths rotation axis to the ecliptic and the tilt of the Earths magnetic dipole to the rotation axis result in seasonal asymmetry and variations of auroral phenomenology. An approach to address the role of the ionosphere in the MI coupling is to appeal to statistical studies classifying particle or optical data by magnetic locations, solar zenith angles, and solar activity. Correlations between auroral brightness and precipitating electron flux (causing intense aurora) with solar EUV-related parameters (solar index, Pedersen conductance) have been reported. In the premidnight sector, the intense aurora is suppressed in sunlit conditions as compared with darkness. Seasonal statistical studies of ion beams, auroral kilometric radiations, and auroral electromagnetic ion cyclotron waves support the finding of this sunlit/dark hemispheric asymmetry. These observations reinforce the assertion that the background density of ionospheric plasma, which is controlled by the solar EUV flux, controls the extent to which intense auroral acceleration processes can operate. Nevertheless, there is still no consensus on what generators power the electric currents. Simultaneous observations of magnetically conjugate auroral regions can offer the unique opportunity to study the MI coupling under different illumination, that is, ionospheric, conditions, for given geomagnetic and interplanetary activities. Unlike the observations of one hemisphere over several seasons, such conjugate observations eliminate other causes of seasonal variations, such as the heliographic and Russell-McPherron effects. We will discuss the need for global, simultaneous observations of both hemispheres of MI coupling, in particular during substorm and storm periods. We will present a possible space mission which can assess the role of the ionosphere, in the MI coupling.

## SM22B-10 1630h

### The Shape and Location of the Magnetopause: The Tilt Angle Effect

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Recent empirical magnetopause models are bivariate with respect to both solar wind dynamic pressure and Bz component of the interplanetary magnetic field (IMF). Models use various functional forms to represent the shape and location of the magnetopause. Moreover, the various models have different ranges of validity because, among other things, the data set used for their development were usually different. A majority of these models were created for magnetopause crossings regardless of latitude.

We have used a very large set of magnetopause crossings and compared their coordinates with predictions of several magnetopause models with motivation to analyze differences between measurements and models. Our study reveals that the effect of the near-cusp magnetopause indentation that is controlled by the tilt angle can be reflected by an addition of a simple geometrical formula to the generally accepted model. This approach provides a model which describes the whole magnetopause surface with a sufficient accuracy.

## SM22B-11 1645h

### Solar Wind, Interplanetary Magnetic Field, and Geodipole Tilt Control of Central Plasma Sheet Parameters and Magnetotail Geometry as Derived From Geotail's LEP and MGF Data.

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Simple analytical models have been derived for the first time, describing the 2-D distribution (along and across the Earth's magnetotail) of the central plasma sheet (CPS) ion temperature, density, and pressure, as functions of the incoming solar wind and IMF parameters, in the range of distances between 10 and 50 $R_E$. Another result of this effort is a new quantitative model, representing as a function of the dipole tilt angle the shape of the cross-tail current sheet and its response to varying solar wind and IMF conditions. The models are based on a large set of data of the Low-Energy Particle (LEP) and Magnetic Field (MGF) instruments, taken by Geotail spacecraft in 1994-1998 and used in the form of 1-min average values of the CPS parameters and magnetic field components. The concurrent solar wind and IMF data were provided by Wind and IMP 8 spacecraft. The overall quality of the modeling was characterized by the correlation coefficient (c.c.) $R$ between the observed and predicted values of a parameter. The CPS ion density $N$, controlled mostly by the solar wind proton density and by the northward IMF component, is the most unstable characteristic of the CPS, yielding the lowest c.c., $R_N$=0.57. The CPS temperature $T$, controlled mainly by the solar wind speed $V$ and the IMF $B_z$, yielded a higher c.c., $R_T$=0.71. The CPS ion pressure $P$ was found to be most effectively controlled by the solar wind ram pressure $P_{sw}$ and by an IMF-related parameter composed of the perpendicular IMF component $B_\perp$ and the sine of half clock angle $\theta/2$. In a striking contrast with $N$ and $T$, the model pressure $P$ revealed a very high c.c. with the data, $R_P$=0.95, manifesting approximate force balance in the CPS due to its confinement by the external tail lobe magnetic field. The modeling revealed very little dawn-dusk asymmetry of the CPS beyond 10 $R_E$, consistent with the observed symmetry of the tail lobe magnetic field. The plasma ion density $N$ is the lowest at midnight and grows towards the tail's flanks. Larger/smaller solar wind ion densities and northward/southward IMF $B_z$ result in larger/smaller $N$ in the CPS. In contrast to the density $N$, the temperature $T$ peaks at the midnight meridian and falls off towards the CPS flanks (so that the dawn-dusk variation of their product, the CPS pressure, is much smaller). Faster/slower solar wind and southward/northward IMF $B_z$ result in a hotter/cooler CPS. The CPS ion pressure $P$ is nearly constant across the midtail (20-50$R_E$); at closer distances the isobars gradually bend and approximately follow the contours of constant geomagnetic field in the equatorial plane. For northward IMF conditions combined with a slow solar wind, this transition occurs at much larger distances, reflecting a weaker tail current and hence more dipole-like magnetic field. Geodipole tilt and solar wind effects on the shape of the cross-tail current sheet have been modeled in the range of distances 10-50 $R_E$, using the magnetic field data from the entire near-tail phase of the Geotail operation.

URL: http://nssdc.gsfc.nasa.gov/space/model/magnetos/data-based/modeling.html

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