Dynamic changes in the geomagnetic field provide useful information about the coupled earth-sun system. They also produce ground induced currents (GIC) that can have a profound impact on artificial systems such as pipelines, communications networks, and power transmission grids. Recent work has established that the time derivative of the horizontal magnetic field (dH/dt) is a good proxy for GIC. For this study we analyzed 15 years of data from the CANOPUS magnetometer array, which has 13 sites located primarily in the auroral zone. Most results (ie. weak 11-year and 27-day dependencies, strong latitudinal and local time dependence) are similar to those obtained in other studies. However, we also found a strong quasi- periodic variation in dH/dt with time scales of 7-14 days. This led to the discovery of a strong correlation between dH/dt and solar wind speed. We will present these results, and show how they can be used to predict GIC risks.

SM32B-1162 1330h POSTER

Ground induced currents incorporated to the model for direct and simultaneous simulations of the heliosphere-magnetosphere-ionosphere interactions

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The performance of the modern supercomuters allows us to simulate the space weather phenomena and/or the distinct events in the heliosphere-magnetosphere-ionosphere interaction. More and more complicated and extensive models may be incorporated into the global simulation system (framework) to simulate the more complicated in interesting physical phenomena, on one hand, as well as achieve the predictive features of the space weather framework. Among the new features which are being added to the Space Weather Model Framework (University of Michigan) now is the ground induced current model. Being based on more or les detailed information about the ground condictivity, this tool allows us to predict the inductive voltage between any pair of the (grid) points at the Earth surface, on one hand, and estimate the effect the ground induced currents on the ionospheric electric currents and electric fields as well as on the measurements of the magnetic feild variations

SM32B-1163 1330h POSTER

The Effect of Joule Heating on Neutral Density

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The amount of Joule heating in the upper atmosphere is known to be affected by solar radiation and geomagnetic activity. This heating can lead to an expansion of the upper atmosphere and increase the drag on low-earth orbiting satellites. Currently, the ap index is used as a geomagnetic proxy for neutral density. However, recent studies have shown that Joule heating in the upper atmosphere, and presumably neutral density, can be estimated fairly well by the polar cap (PC) and Dst indices. In this study, we present correlations of neutral density data from the CHAMP satellite to Joule heating spatial distributions from the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) as parameterized by the polar cap index. The CHAMP densities are from days 134 to 182 for the year 2001 at a normalized altitude of 450 km. Preliminary results have shown that in regions of enhanced Joule heating, the neutral density at 450 km as determined from CHAMP data also increases. Further analysis will focus on identifying a temporal relationship between neutral density and Joule heating.

SM32B-1164 1330h POSTER

Global Thermosphere Density Response During the May 27 - June 4, 2003 Storm Interval From CHAMP Accelerometer Measurements

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Measurements of atmospheric density from the CHAMP satellite near 410 km are used to illustrate the dependence of seasonal, latitudinal, and day/night response of the thermospheric region to elevated levels of magnetic activity. The latitude vs. time evolutions of total mass density at local times near 03:00 and 15:00 hours are elucidated from accelerometer measurements on the CHAMP satellite. These results are compared with density predictions from the NRLMSISE-00 empirical density model. Zonal winds near the equator along with polar north/south winds are analyzed using cross-track accelerometer measurements from CHAMP. The time period considered includes a significant geomagnetic storm from May 27 to June 4, 2003, which exhibits elevated magnetic activity of approximately Kp $\sim$ 5-8. Response during this storm is compared to typical quiet-time behavior during May and June (Kp $\sim$ 1-2). This time interval provides an opportunity to examine the equatorward penetration of storm-induced disturbances under conditions where the mean solar-driven summer-to-winter solstitial circulation, and the circulations driven by high-latitude heating, reinforce and oppose each other in opposite hemispheres. We find a number of orbits to be characterized by 100-1000 km-scale structures, suggesting the presence of aurorally-generated waves. Day/night differences in the equatorward penetration of both global-scale and small-scale density perturbations are also examined in terms of diurnal variations in the solar-driven meridional flow.

SM32B-1165 1330h POSTER

The ISR World-Day Campaign: Review of the April 2002 Geomagnetic Storm With Comparisons to the TIMEGCM/ASPEN Model

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In this presentation, the results of the April 2002 world-day campaign are reviewed. Initiated by the Haystack Observatory, this campaign unites the efforts of eight incoherent scatter radars to collect ionospheric data during a major geomagnetic storm beginning on April 17, 2002. The participating ISRs are located along latitudinal and longitudinal sectors making this campaign unique and invaluable for studying spatial and temporal effects of ionospheric storms. Emphasis is given to describing pre-storm electron density depletions, storm-time ionospheric structure, and comparisons between the ISRs and TIMEGCM/ASPEN, a first principle physical model.

SM32C MCC: 2002-2004 Wednesday 1340h

Magnetotail and Plasma Sheet III

Presiding: **N E Turner,** University of Texas at El Paso**; J Buechner,** Max-Planck-Institut für Aeronomie

SM32C-01 1340h

Numerical Simulations of the Interchange Instability in the Plasma Sheet

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Although the plasma sheet of the Earth is usually stable with respect to interchange motion, it has been long known that, under appropriate conditions, interchange-like instabilities are possible even in the ideal MHD approximation. For example, such conditions may exist during periods of strong sunward convection when there are sharp and significant decreases in the plasma sheet density. Previously, we have used numerical simulations to show that the inner (L<6) magnetosphere can be interchange-unstable if we take particle fluxes measured by LANL geosynchronous spacecraft as inputs to the Rice Convection Model (RCM). In this paper, we present new results from RCM numerical simulations with the modeling region expanded to 20-25 Re in the magnetotail, to include the central plasma sheet region. In these simulations, a global time-dependent magnetic field model, as well as a time-dependent distribution of particle fluxes in the plasma sheet, are used as inputs to the model. First, we analyze under what geomagnetic conditions the plasma sheet may be interchange-unstable by using a number of different empirical models of the plasma sheet plasma distribution and several magnetic field configurations (both theoretical and data-based). We then present time-dependent simulations of magnetospheric global particle fluxes, field-aligned currents, and electric fields computed self-consistently with the RCM that show growth and evolution of the interchange instability. Based on these results, we address the previously-published idea that interchange-instability motions in the plasma sheet may be related to the formation of auroral arc structures.

SM32C-02 1355h

Probability Distribution Functions for Magnetic Field Fluctuations Inferred From Cluster Measurements: Evidence for Intermittent Turbulence in the Plasma Sheet.

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Cluster fluxgate magnetometer data and ion spectroscopic data are employed to construct and interpret the probability distribution functions (PDFs) of magnetic field fluctuations. This technique, often used in analysis of laboratory plasmas, is used to look for intermittent plasma turbulence. We examined the distribution of the magnetic field fluctuations for a single spacecraft, and between pairs of highly correlated Cluster times series magnetometer data in both the plasma sheet and lobe regions. Because there are four Cluster spacecraft, one can examine up to 6 spacecraft pairs and because the separations change yearly, it is possible to examine for three different scale sizes (about 150 km, 1000 km, and 5000 km) relative to the turbulent eddy scales during Cluster's passages through the magnetotail regions in the summers of 2001, 2002, and 2003. The PDFs in the plasma sheet fall off more slowly for increasingly large fluctuations than do normal distributions. Furthermore, the distribution function for

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temporal fluctuations observed by a single spacecraft is nearly the same as the distribution function determined with two spacecraft and the kurtosis of the distribution decreases with increasing scale sizes. The lobe PDFs of the magnetic field times series difference, however, more closely resemble a normal distribution as would be expected for random fluctuations. These results suggest that magnetic turbulence is occurring within the plasma sheet resulting in turbulent energy dissipation. Our results also suggest that that spatial and temporal fluctuations are similarly distributed within the plasma sheet, as would be the case if the Taylor Hypothesis were valid.

URL: http://www.igpp.ucla.edu/jweygand

SM32C-03 1410h

Static Pressure Distribution in the Distant Tail Lobe and Compressional Variations Observed by Geotail

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In order to study the dynamics of the magnetosphere, it is important to know the temporal variation and spatial distribution of the static pressure. The static pressure in the magnetotail basically depends on the distance from the earth and also on the solar wind condition. We have statistically analyzed the static pressure measured by GEOTAIL in the magnetotail (X < -40 RE) and extracted an empirical equation to express the static pressure in the tail lobe by the solar wind parameters. In the calm magnetosphere, the total pressure in the tail lobe is often smaller than the static pressure in the solar wind (<74%). For more than 90 % of the 30-minutes averaged data, the deviation of the measured pressure from the expected one is found to be within 50 %. On the other hand, substantial deviations of the measured static pressure from the expected one are often caused by the passage of plasmoids. An example of the static pressure variation in the distant magnetotail lobe caused by the passage of a plasmoid is investigated in detail. The traveling speed of the plasmoid is estimated to have been faster than the concurrent magnetosonic speed in the lobe. The magnetic field variation along the maximum variance direction was linearly related to the variation in the field strength, which suggests that a magneto-hydrodynamic compressional mode might have occurred. The propagation direction of the variation is determined from the background field direction and the maximum variance direction of the field. Shortly after the passage of the plasmoid, the relation between the field and velocity variations is consistent with the fast mode. Pressure variation in the fast mode was possibly generated in the trail of the plasmoid to restore equilibrium.

SM32C-04 1425h

Magnetotail Bubbles, Current Sheets, and Auroral Arcs

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Using two-dimensional steady-state Vlasov theory, we investigate properties of thin current sheets that result from exact particle motion. The self-consistent quasi-neutral structure of such current sheets generally requires the presence of an electric potential, which is constant along field lines. We explore the possible association with the perpendicular electric fields that are part of the U-shaped potential structures above auroral arcs. For sufficiently small scales, the converging perpendicular electric field corresponds to two oppositely directed thin Hall current sheets. We construct such double current sheet models and confirm that they result in potentials with the postulated shape and, for sufficiently small scales, in potential differences of up to the ion thermal potential. The formation of such thin double current sheets is found in simulations of an earthward collapsing entropy-depleted magnetic flux tube (“bubble”), This may provide a further link between bursty bulk flows, bubbles, and auroral features.

SM32C-05 1440h

Bifurcated Thin Current Sheets in the Magnetotail: Comparison of Model and Spacecraft Observations

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The evolution of the Earth's magnetotail current sheet through different stages is studied using a self-consistent theory of thin current sheets. The model solves a Grad-Shafranov type equation for the current sheet under quasi-adiabatic approximation. Quasi-adiabaticity allows the construction of an average equilibrium, assuming the conservation of quasi-adiabatic invariant of motion Iz. However the adiabatic invariant evolves in time and this is represented as a diffusion process, leading to a slow change of the equilibrium. This diffusion leads to a gradual trapping of transient and unbounded (or the so called Speiser orbit) particles into orbits trapped in the vicinity of the sheet midplane. It is found that the cross-tail current of such newly trapped population is opposite to the one from transient Speiser orbits and eventually flattens the profile of the magnetic field near the midplane. As a result profile Bx(z) acquires a complex concave shape instead of a simple linear one, a characteristic of Harris equilibrium. The corresponding cross-tail current profile attains a "double humped" shape, which can be a typical characteristic of a thin current sheet during a major part of its "life cycle". This process of current sheet deterioration by quasi-trapped plasma may finally lead to the disruption of the current sheet. The results of numerical modeling are compared with Geotail and Cluster observations of bifurcated or double-humped current sheets in the Earth's magnetotail. The role of electron currents under these conditions are studied. The observables predicted by our model and the conditions under which they are expected to be observed by Geotail, Cluster and other spacecraft will be discussed.

SM32C-06 1455h

Setting Up a Thin Current Sheet and Its Bifurcation

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In most studies on magnetic reconnection, Harris equilibrium or its modified versions are initialized. The current in the sheet is primarily carried by ions with peak current occurring in the neutral sheet. However, recent particle simulations of reconnection with initialized perturbations in the magnetic field show that soon after the start, an electron current dominates the neutral sheet. This current is set up by the induction electric field associated with the initial magnetic perturbations and plays a crucial role in further evolution of the reconnection. In nature the magnetic field perturbations of the Harris type of equilibrium must be a rule and not exception. For strong enough perturbations in the lobe magnetic field, the electron current density may exceed threshold for Buneman and/or acoustic instabilities. The anomalous resistivity created by such instabilities may trigger spontaneous reconnection. We report 3-D PIC simulation of (1) setting up of thin current sheet with strong electron current, (2) generation of instabilities and (3) magnetic reconnection. The onset of reconnection is accompanied by (1) electron and ion acceleration, (2) plasma evacuation in the central current sheet, (3) disruption of current in the neutral sheet, and (4) bifurcation of the original current sheet. In the region of low current between the two large currents, strong plasma turbulence ensues.

SM32C-07 1510h

Storm-time convection in the near-Earth plasma sheet

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The mechanism of particle injection and associated field variation is one of the most fundamental issues regarding magnetic storm. Several recent modeling studies on the storm-time ring current suggest that enhanced convection electric field in the magnetosphere, which is induced by continuous southward IMF, is responsible for steady particle transport into the inner magnetosphere during the storm main phase. On the other hand, the enhanced convection weakens, or ceases after the main phase in response to the decrease of southward IMF, leading to the formation of a relatively symmetric ring current around the Earth during the recovery phase. Although these modeling studies have been employing some electric field models that apply a somewhat strong ($\sim$ 1 mV/m), large scale electric field to the region from the near-Earth plasma sheet to the inner magnetosphere on the night side, systematic observational studies have not been made yet to investigate such a large electric field by using in situ measurement performed in the near-Earth plasma sheet. We have examined particle and field observations made by the Geotail spacecraft during magnetic storms to study enhanced convection and the associated electric field that is thought to be a key to govern the particle injection into the ring current. Surprisingly, our preliminary study found no clear evidence for the existence of such a large, steady earthward convection during either the storm main phase or the recovery phase. The observed particle and field properties in the near-Earth plasma sheet are basically classified into the two categories of time intervals: One is governed by stagnant plasmas with small, fluctuating electric fields, and the rest of intervals are dominated by intermittent flow bursts and associated large spikes of the dawn-dusk component of the electric field accompanied by significant increases in the north-south component of the magnetic field. Thus it appears to be nothing but a typical sequence of particle and field variations associated with substorms. These results imply that a continuous earthward particle transport driven by the enhanced convection is not likely to take place from the near-Earth plasma sheet to the ring current region, and that particle injection associated with substorms still plays a major role in the ring current development during storm main phase.

SM32C-08 1525h

Modeling the Earthward Penetration of Plasma Sheet Protons Under Enhanced Convection

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In order to understand the evolution of protons and magnetic fields in the inner plasma sheet as increasing convection electric field brings protons earthward to regions of strong dipole field, we use a modified version of the Magnetospheric Specification Model to simulate proton electric and magnetic drifts and obtain proton distributions. The magnetic field is provided by a modified version of the Tsyganenko 96 model with two-dimensional force balance maintained along the midnight meridian. The convection electric field is determined mainly by the cross polar-cap potential drop ($\Delta\Phi$) and the equatorward edge of the convection

electric field (shielding latitude θ). The local-time dependent proton differential fluxes assigned to the model boundary are a mixture of hot plasma from the mantle and cooler plasma from the low latitude boundary layer. We previously used this model to simulate the inner plasma sheet under weak convection corresponding to $\Delta\Phi$ and θ equal to 26 kV and 66°, and obtained two-dimensional quiet time equilibrium that agrees well with observations. In the current simulation, we start with the quiet time equilibrium and boundary particle sources and enhance convection by increasing $\Delta\Phi$ steadily from 26 to 146 kV and lowering θ from 66° to 52° in 5 hours while keeping the boundary sources time independent. The inner edge of the plasma sheet at midnight, mapped to the equatorial plane using the self-consistent magnetic field, moves from 10 R_E for $\Delta\Phi$ = 26 kV to 4 R_E for 146 kV. This earthward penetration to regions of dipole field results in strong plasma pressure increase, which significantly stretches the original dipole field lines. Proton pressure at r = 6.6 R_E increases from 1 to 6 nPa as $\Delta\Phi$ increases from 26 to 146 kV, while the magnetic field strength decreases from 80 to 10 nT. The simulated pressure and magnetic field strength, their radial variations at midnight, and their changes with convection strength in the inner plasma sheet in general agree with observations. Protons undergo enhanced earthward electric drift but are significantly diverted toward dusk by azimuthal magnetic drift around midnight. The enhanced magnetic drift, responding to enhanced particle energy, changes particles' trajectories and magnetic field configuration in a way that restrains particle energization, thus plays an important role in plasma sheet dynamics. Simulations are also run to a steady state under constant $\Delta\Phi$ = 98 kV and θ = 57.6°, which indicates the inner plasma sheet can remain steady under moderate and constant convection. A scale analysis of our results suggests that using the frozen-in condition E = -v×B in MHD can lead to an inconsistency with Faraday's law in the inner plasma sheet because of neglect of the Hall term in the generalized term.

SM32D MCC: 2002-2004 Wednesday 1600h

Bow Shock, Magnetosheath, and Magnetopause I *(joint with SH)*

Presiding: **X Blanco-Cano,** Instituto de Geofisica, Universidada Nacional Autónoma de México**; S A Fuselier,** Lockheed Martin Advanced Technology Center

SM32D-01 1600h

Coupling of Solar Wind Energy to the Magnetosphere via ULF Waves

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The solar wind flow ultimately provides energy to the magnetosphere through a variety of different processes. One of these energy transfer paths is via the excitation of magnetospheric ULF waves. Recent studies (Kepko et al., 2002; Kepko and Spence, 2003) have identified a subset of global ULF waves (multiple, discrete-frequency <3 mHz), driven directly by density structures in the solar wind. In this paper, we examine this mechanism through model-data comparison. We use the Lyon-Fedder-Mobarry MHD model to simulate the global magnetospheric response under a variety of solar wind ram pressure drivers (both idealized and as observed) and compare these results with observations to explore and quantify such characteristics as coupling efficiency and frequency response.

SM32D-02 1615h

Cluster Observations of Magnetic Structures at Quasi-Parallel bow Shocks

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Collisionless quasi-parallel shocks are thought to be composed of a patchwork of short, large-amplitude magnetic structures (SLAMS) which act to thermalise the plasma, giving rise to a spatially extended and time varying shock transition. With the launch of Cluster, new observations of the three-dimensional shape and size of shock structures are available. We present SLAMS observations made when the spacecraft were separated by about 100 km. The SLAMS enhancement in $|B|$ is typically well correlated between spacecraft on this scale, consistent with previous observations showing that the overall SLAMS extent exceeded about 600 km, but small differences are still observed. The statistical characteristics of these differences contain information on the typical gradients of magnetic field changes within the SLAM structure which, in the cases studied here, occur on scales of 100-150 km.

SM32D-03 1630h

Time and Length Scales of Magnetic Field Variations in the Quasi-Perpendicular Terrestrial Bowshock

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The terrestrial bowshock is an example of a moderate Mach number collisionless shock which can be studied in detail. Despite decades of study of the quasi-perpendicular shock, several questions remain, such as the scales of various parts of the shock transition and in particular the time and length scales of its variability. Recent measurements using the four Cluster spacecraft make it possible to measure the orientation and motion of the quasi-perpendicular bowshock surface and also, by comparing profiles measured by different spacecraft, its variability. We present estimates of the variation with Mach number of the ramp, overshoot and undershoot scales and compare these with earlier work. We also discuss the variability of shock structures, such as the peak magnetic field and the ramp itself, and demonstrate that the shock ramp varies on scales of a few seconds, but appears to be stable over scales of hundreds of km.

SM32D-04 1645h

Energetic Ion Observations at the Cusp and Bow Shock

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Previous studies have shown that solar wind ions are accelerated up to ∼150 keV/e at the quasi-parallel bow shock via the first order Fermi mechanism. It has been suggested that shock accelerated ions can directly enter the cusp when cusp and quasi-parallel shock are magnetically connected through the merging of IMF and geomagnetic field lines. Results from global hybrid simulations for a northward and antisunward IMF are consistent with the ion acceleration and transport processes. We present simultaneous observations of energetic ions from Interball and Polar in the foreshock and cusp region, respectively. Ion fluxes at the quasi-parallel bow shock agree with those in the cusp. Furthermore, energetic ions at both places demonstrate similar spectral characteristics. These results are consistent with the shock acceleration and ion transport processes.

SM32D-05 1700h

Cluster Observations of the Flank Boundary Layer Under Northward IMF Conditions

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The four Cluster spacecraft made observations near the dusk flank boundary layer during a north-to-south passage at a location near X=-5 Re on November 20-21, 2001. The IMF remained quite steady and northward while a decreasing solar wind kinetic pressure moved the boundary outward and kept it near Cluster for almost 20 hours. Magnetic field and plasma measurements revealed repeated traversals between a higher-density tailward-flowing magnetosheath plasma with cool isotropic 30 eV electrons and a lower density, lower-tailward-velocity boundary layer plasma with anisotropic field aligned electrons nearer 80 eV. Transitions from the boundary layer to the magnetosheath were characterized by rotations to a more northward external magnetic field. These outbound crossings were invariably better defined than those in the opposite direction. For these outbound crossings, boundary normals were determined from a minimum variance analysis on the magnetic field; these normals generally agreed within 5 degrees at the 4 spacecraft and showed tilting of the normal toward the sunward direction as is typical for waves on the boundary. Individual transitions were seen successively at the four spacecraft with 5-20 s delays at spacecraft separation distances up to 2000 km. The transitions back to the boundary layer occurred gradually over a period of several minutes until the next abrupt entry to the magnetosheath. This recurrence periodicity of a few minutes is that often seen for Kelvin-Helmholtz waves in this boundary region. Determinations of Kelvin-Helmholtz instability criteria will be compared with these observations.

SM32D-06 1715h

Low Frequency Waves in the Magnetosheath as Seen by Cluster

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The distribution of plasma waves encountered during one complete traversal of the magnetosheath from the bow shock to the magnetopause is studied using data from the four Cluster satellites . It is shown that in the region adjacent to the magnetopause mirror waves dominate plasma turbulence. As the Cluster spacecraft move away from the magnetopause other plasma modes replace the mirror waves.