SM52A MCC: Level 1 Friday 1300h

Ring Current and Geomagnetic Storms Posters

Presiding: **R A Wolf,** Rice University; **V Peroomian,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles

SM52A-0559 1300h POSTER

Two different approaches for the inner magnetosphere currents estimation: ion pressure measurements and the curlometer technique, using CLUSTER CIS and FGM data.

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The inner magnetosphere's electric currents configuration and mapping is one of the keys for understanding current loop closure inside the whole magnetosphere. Development of the ring current as a function of geomagnetic activity is still one of the most interesting aspects about this region. Analyzing thus data from the four CLUSTER spacecraft while passing in the inner magnetosphere (perigee situated at about 4 RE, inclination 90°), we have been using two different methods to quantify currents in this region. First, based on Maxwell's laws application, the curlometer technique is applied. It is based on four point measurements of the magnetic field, as measured by the four Fluxgate magnetometer instruments onboard Cluster. This allows to determine the current density vector crossing the tetrahedron formed by the spacecraft. Second, based on the general MHD momentum equation, and under simplifying assumptions (static conditions, isotropic distribution,...), we experimentally deduced the perpendicular component of the current density by calculating the pressure gradient between spacecraft. This was done by using the Cluster Ion Spectrometer experiment, which provides full three-dimensional ion distributions (from about 5eV/q to 40 keV/q) with one spacecraft spin time resolution (4 sec) and with mass-per-charge composition determination. Both methods reveal very clear and interesting structures of the current. Filamentations' of the current are observed in the plasma sheet within the field-aligned currents system, and they appear to be extremely well correlated with low energy protons up-flowing from the ionosphere. Smooth and isotropic structures inside the ring current during low geomagnetic activity are also shown, with a large latitudinal extent. Nevertheless, some unexpected signatures are also observed, such as the inversion of the XGSM current density component during perigee passes, even if not fully understood yet. The comparative study of both methods should allow for the first time to better quantify the offsets induced on the current estimation, and to get a more precise image of the current systems in the inner magnetosphere.

SM52A-0560 1300h POSTER

STORM-TIME PLASMA BEHAVIOUR AT GEOSYNCHRONOUS ORBIT

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Plasma at geosynchronous orbit is known to have access to the inner-magnetosphere, particularly during geomagnetic storms when plasma from the tail plasma sheet may be driven deep into the inner magnetosphere, boosting the strength of the ring current. The set of Magnetospheric Plasma Analyzer (MPA) data from seven Los Alamos geosynchronous satellites now covers an entire solar cycle. This very extensive database has been used to explore the statistical behaviour of a number of plasma properties as a function of local time and various measures of magnetospheric activity. In this report we focus on three such analyses: 1) the variation of plasma properties with Dst, 2) the variation with storm phase, and 3) the variation with solar cycle. These statistical analyses provide clues to the storm-time sources and transport of inner-magnetospheric plasma populations, as well as a foundation for comparison with global energetic neutral-atom images.

SM52A-0561 1300h POSTER

A Statistical Study of the Global Structure of the Ring Current

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In this paper we derive the average configuration of the ring current as a function of the state of the magnetosphere as indicated by the Dst index. We sort magnetic field data from the Combined Release and Radiation Effects Satellite (CRRES) by spatial location and by the Dst index in order to produce magnetic field maps. From these maps we calculate local current systems by taking the curl of the magnetic field. We find both the westward (outer) and the eastward (inner) components of the ring current. We find that the ring current intensity varies linearly with Dst as expected, and that the ring current is asymmetric for all Dst values. The azimuthal peak of the ring current is located in the afternoon sector for quiet conditions, and near midnight for disturbed conditions. The ring current also moves closer to the Earth during disturbed conditions. We attempt to recreate the Dst index by integrating the magnetic perturbations caused by the ring current. We find that we need to multiply our computed disturbance by a factor of 1.88 ± 0.27 and add an offset of $3.84 \pm 4.33\,nT$ in order to get optimal agreement with Dst. When taking into account a tail current contribution of roughly 25% [Turner et al., 2002], this agree well with our expectation of a factor of 1.3 to 1.5 based on a partially conducting Earth. The offset does not agree well with an offset of approximately $20\,nT$ based on solar wind pressure.

URL: http://nis-www.lanl.gov/~ajorg/papers/crerc.pdf

SM52A-0562 1300h POSTER

The Dependence of Ring Current Asymmetry on the Phase of Magnetic Storms

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We utilize the 1-minute resolution Asym and Sym indices for the horizontal component H to study the dependence of ring current asymmetry on the phase of magnetic storms. We find that the ratio Sym-H/Asym-H decreases during the recovery phase suggesting that the ring current is becoming relatively more asymmetric. This result contradicts theoretical expectations and previous experimental results. It suggests that there may be problems with the current operational definition of these quantities. We have examined the possibility that dynamic pressure effects in Sym-H or a constant bias in Asym-H can explain these results. Neither correction can account for our observations. In this paper we will use the original magnetograms and alternative definitions of asymmetry to see if the problem lies in the current procedure for calculating the index. We will illustrate our results using storms from the NSF GEM campaigns that have been numerically modeled.

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

SM52A-0563 1300h POSTER

Oxygen Injections Into the Ring Current: Tail and Ring Current Observations Combined

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We are investigating the circulation of O+ in the magnetosphere by using a combination of POALR/TIMAS in situ oxygen plasma and IMAGE/HENA neutral oxygen remote sensing measurements during the Fall months of 2001 and 2002. HENA observations of the inner magnetosphere / ring current show that significant quantities of oxygen are typically only observed during geomagnetic storms, and that they are delivered in bursts by substorm activity. It also appears, that the first substorm of a storm is not necessarily rich in oxygen. Isolated non-storm substorms, on the other hand, typically show little contribution of oxygen. With TIMAS located in the tail lobe and the plasma sheet for extended amounts of time we can locally determine the oxygen content and oxygen dynamics associated with those storm-time substorms. This gives us a better understanding and correlation between the observed ring current content and the associated tail content and dynamics.

SM52A-0564 1300h POSTER

The Contribution of Ionospheric O^+ Ions to the Storm-time Ring Current

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We have investigated the population of the near-Earth plasma sheet and ring current by ionospheric O^+ ions by tracing particle orbits in time-dependent electric and magnetic fields obtained from a three-dimensional global magnetohydrodynamic (MHD) simulation of a geomagnetic storm that occurred on September 24 - 25, 1998 (Dst = -225). During this storm, which began with the impact of a 13 nPa pressure pulse on Earth's magnetosphere shortly before midnight on September 24, 1998, the POLAR spacecraft observed significant outflows of O^+ ions in response to the pressure pulse. We developed a time-dependent empirical map of the ionospheric O^+ ion outflow for this event and calibrated the outflow rate to that observed by the POLAR spacecraft. Ions from the auroral zone were launched in a broad energy range from 500 eV to 10 keV to simulate outflowing ion beams

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and conics. Since the inner boundary of the MHD simulation is at a radial distance of 4 R_E, the ions were launched with the energies typical of those found after acceleration by the auroral parallel electric fields. Dayside ions were launched with energies similar to those found on POLAR/TIDE and POLAR/TIMAS for this event, in the range 100 eV to 1.2 keV. Ions were launched at 10 key times during the storm. We will present time-dependent maps of O^+ plasma moments in the equatorial plane, including density, pressure, temperature, energy density, and current density for this event.

SM52A-0565 1300h POSTER

Contribution of ion flow-out and charge exchange processes to the decay of the storm-time ring current

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The decay of the ring current during the storm recovery phase can be attributed mainly to loss of energetic ions. Its mechanisms, however, are still open problems. Although ion flow-out and charge exchange processes are the most probable causes of such loss, it is yet to be identified how much these processes contribute to the loss. In this study we evaluate the contribution of each process to the decay of the ring current, using energetic ion data acquired by the EPIC instrument onboard Geotail and energetic neutral atom (ENA) data acquired by the HENA imager onboard IMAGE. The HENA imager observes ENAs ($\geq$ 10 keV) that are produced when energetic ring current ions experience charge exchange collisions with cold neutral atoms and molecules. We can calculate the rate of energy loss due to the charge exchange process. The Geotail spacecraft is frequently located in the magnetosheath and upstream of the Earth's bow shock, where the Geotail/EPIC instrument observes energetic ions flowing out from the magnetosphere. Because the instrument provides charge state information of $9 - 210$ keV/e ions, it can distinguish the leaking ions from solar wind ions accelerated at the Earth's bow shock. From this data we can calculate the energy density of leaking ions. In order to evaluate total energy loss via the ion flow-out process, we investigate if it is possible from HENA images to determine the leakage area. The area can also be estimated from statistical studies on energetic ions outside the magnetosphere. We will present two interesting storms (September 23, 2001 and April 22, 2001). During the recovery phase of these storms, Geotail/EPIC observed energetic protons and singly-charged oxygen ions outside the magnetosphere on the dusk side, and IMAGE was located in a vantage point in the northern hemisphere. We will estimate contributions of the two processes to the decay of the storm-time ring current.

SM52A-0566 1300h POSTER

Self-consistent behavior of the ring current development

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A comprehensive ring current simulation has been performed in a self-consistent manner to understand the post-midnight enhancement of tens of keV ion fluxes during the storm main phases. The post-midnight enhancements of the ion fluxes, which are different from a traditional picture, were recently discovered by the IMAGE satellite through energetic neutral atom images, but their mechanism is still debatable. Three possible working hypotheses were suggested and carefully tested. First, skew of the convection electric field is thought to shift the peak of the flux. Second, a decrease in the local magnetic field induced by the ring current itself deflects drift trajectories eastward. Third, local time asymmetry of the distribution function of the near-earth plasma sheet is also a candidate. Two feedback loops were implemented in the calculation to update electric and magnetic fields at each time step. The first loop, electric coupling between the magnetosphere and the ionosphere, is completed by combining Fok's ring current model and the Rice Convection Model. The second loop is newly introduced by constantly updating the magnetic field induced by the calculated ring current. The result shows that the spatial distribution of ion fluxes is significantly modulated by these feedback loops. The post-midnight enhancement is shown to be predominantly produced by the skew of the convection potential modulated by the gradient of the ionospheric conductivity, and shown to depend on the distribution function of plasma sheet ions. The self-consistent magnetic field seems not important for generating the post-midnight enhancement, but is shown to produce a localized enhancement of ion fluxes in L on the dusk side with energy of tens of keV and less. This feature is consistent with measurements made by Polar during the storm main phases.

SM52A-0567 1300h POSTER

Guiding-Center Simulations of Stormtime Ring Current Electrons in a More Realistic Magnetic Field Model

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We examine the consequences of using a more realistic magnetic field for simulating stormtime electron ring current formation. In the past, we have simulated the guiding-center drift of electrons from the plasma sheet to the inner magnetosphere and their loss as they drift in a Dungey magnetic field model consisting of a dipole plus uniform southward field. We improve upon this in the present study by including realistic day-night asymmetry and time variations in the magnetic field by varying the magnitude of the added unidirectional southward field with time (UT) and magnetospheric longitude (MLT) so as to match the modeled polar cap boundary to the auroral poleward boundary provided by the empirically-based OVATION model [*Newell et al.*, JGR, 2002]. Our model electric field consists of corotation, quiescent Stern-Volland convection, and storm-associated enhancements in the convection electric field that are less well shielded than the Stern-Volland field. Our enhancements in the cross-polar-cap potential are based on DMSP measurements. We trace the guiding-center drifts of representative equatorially-mirroring electrons with first adiabatic invariants μ = 1 – 200 MeV/G for the 27 August 1990 storm. Using these simulation results, we map stormtime phase space distributions by invoking Liouville's Theorem modified by losses. Our boundary spectrum at geosynchronous orbit and our initial quiescent distribution are taken from CRRES observations. With both the static Dungey and the more realistic magnetic field model, there are significant stormtime enhancements of ring-current electron fluxes at equatorial radial distance r_0 = 2.6 to 6.6 R_E for energies from tens of keV up to 180 keV. However, the electron drift speed is slower on the dayside than on the nightside in the more realistic asymmetric magnetic field model because the magnetic field intensity is stronger on the dayside than the nightside at a given r_0. This makes the stormtime electron ring current more strongly asymmetric. With the more realistic time-dependent magnetic field model there are also partially adiabatic fluctuations in the flux profiles of $\sim$ 90 to 150 keV electrons at r_0 = 2.5 to 5 R_E due to time variation of the magnetic field.

SM52A-0568 1300h POSTER

Examining the Effects of Including Evening Sector Proton Precipitation in Self-Consistent RCM Modeling of the Stormtime Sub-Auroral Electric Field

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We have used the Rice Convection Model (RCM) to investigate the extent to which the inclusion of evening sector conductivity enhancements caused by proton precipitation equatorward of the diffuse electron aurora affects the location and strength of Sub-Auroral Polarization Streams (SAPS). Typically, during magnetic storms, RCM calculations have indicated that there is a peak in the poleward-directed ionospheric electric field that is located at the transition from the low-conductance sub-auroral ionosphere to the high-conductance auroral ionosphere. Data from polar-orbiting spacecraft frequently show that the electric field peaks not at the low-latitude edge of the electron aurora, but a few degrees equatorward of that boundary. We will compare RCM model results for the March 31, 2001 magnetic storm with DMSP SSIES plasma drift data to evaluate the effects of proton-precipitation-produced conductivity enhancements on the agreement between model results and data.

SM52A-0569 1300h POSTER

Comparison of LFM Simulation With Tsyganenko Models and GOES Observations

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The physics-based Lyon-Fedder-Mobarry (LFM) model simulates magnetospheric configuration and dynamics, but observational comparisons are needed because they can reveal possible limitations of the model and suggest ways for improvements. Here we present a study that compares the global LFM MHD simulation to two semi-empirical magnetic field models (Tsyganenko 1996 and 2001) and geosynchronous magnetic field measurements from GOES 8, 9 and 10 during storm conditions. Typical magnetic cloud events and moderate storms between 1997 and 2001 were examined. The quantitative comparison of the simulation and model predictions with observations shows very good agreement except during large storm main phases (Dst < -100 nT) and typically on the night side, where the MHD simulation does not have sufficient ring current and the empirical models are poorly constrained.

SM52A-0570 1300h POSTER

Solar wind control of storm and substorm correlations

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The Sym-H index has been used as a higher time resolution measure of the storm intensity, which is associated with the magnetic disturbance caused by the ring

current. The AU and AL indices express the strongest current intensity of the eastward and westward auroral electrojets respectively. In this study both the AU and AL indices are compared with the Sym-H index for storm-time events. The storm-time events are selected for minimal Dst less than - 50nT. It is found that the correlation between the auroral electrojets and ring current changes case by case. These events are then separated by high and low correlation coefficients. Upstream solar wind characteristics related to these events are investigated. Possible causes for changes of the correlation coefficients will be discussed as well.

SM52A-0571 1300h POSTER

Solar Cycle Effects on Different Levels of Geomagnetic Storms

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A yearly check on the correlation between the pressure corrected *Dst* and interplanetary parameters for the whole OMNI data set (1974–1996) reveals that apparently the main controlling parameter producing Dst variations is the solar wind speed v, however it is clear that the driving parameters during the main and recovery phases of approximately 300 magnetic storm events extracted from the OMNI database are the southward IMF B_S and the dawn-dusk component of the interplanetary electric field vB_S. To analyze solar cycle effects the selected set of storm events were separated in two subsets using, as a reference, a baseline given by a sunspot number of ~ 100. We found that the correlation is enhanced for those lying under the baseline and reduced for those events lying over the baseline. Apparently, the correlation is higher for storms occurring near minima of the solar cycle than those surrounding the solar cycle maxima. In a little further analysis we separate the selected data base in four subsets, two for the events occurring on opposite phases of the solar cycle and the other two for those occurring on the ascending and descending parts of the solar cycle. In this case, the correlations between the absolute value of Dst^* and B_S are similar for the opposite phases of the solar cycle ($R = 0.72$, with standard deviations of 30.7 and 40.5, respectively). The best correlation ($R = 0.79$) is found for the ascending phase of the solar cycle marking a significant difference with the descending phase ($R = 0.69$).

SM52B MCC: Level 1 Friday 1330h

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

Presiding: **C T Dum,** Max-Planck-Institut für Extraterrestrische Physik**; H Spence,** Boston University Center for Space Physics

SM52B-0572 1330h POSTER

The upstream boundary of the terrestrial foreshock ULF wave field: Cluster at large separations

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Cluster observations of the terrestrial foreshock made at large (1 Re) and intermediate (600km) spacecraft separations are presented. Case studies are presented where the spacecraft tetrahedron enters and exits the foreshock wave field as a result of changing Interplanetary Magnetic Field orientation. Rapid transitions in and out of the ULF foreshock wave field observed during intervals of stable upstream conditions are presented. The possibility of time dependence in the structure of the wave field is discussed. Two case studies based on observations at large spacecraft separations are also presented where the spacecraft straddle the upstream boundary of the foreshock wave field. It is shown that the spacecraft closest to the shock and connected to the more parallel region of the shock observe the largest amplitude and most prolonged wave activity. The implications of these results are discussed, particularly with reference to the extent of the out-of-ecliptic foreshock.

SM52B-0573 1330h POSTER

A Comparison of Shock Normals

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An accurate determination of the quasi-perpendicular bow shock orientation is crucial for the understanding of the physics that occurs within this boundary region. Using data collected by the Cluster spacecraft from a number of days during the first half year of operations this paper analyses the shock normal directions determined using three different methods. The first set of normals are derived using several shock models. The second set are computed using the coplanarity method based on FGM magnetic field data from the individual Cluster satellites. The final set are computed using multi-spacecraft timings of the shock crossing based on measurements of the EFW probe potentials. The normals for each shock are compared and the results are also analysed with respect to the upstream values of θ_{Bn} and the shock Mach number.

SM52B-0574 1330h POSTER

Three-Dimensional Global Hybrid Simulation of the Bow Shock

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A 3-D global-scale hybrid code is developed for simulation of the bow shock and the dayside magnetosphere. A spherical, (r, θ, ϕ), coordinate system is utilized in the simulation. The code is developed by generalizing our previous 2-D code [e.g., Swift, *GRL* 22, p.311, 1995; Lin, *PSS* 50, p.577, 2002] to 3-D. In the hybrid code, the solar wind and outer magnetospheric ions are treated as discrete particles, and the electrons are treated as a massless fluid. In the simulation, the bow shock forms by interaction between the supersonic solar wind and the geomagnetic dipole field. The simulation domain contains plasma regions from the geocentric distance of $r = 3R_E$ to $20R_E$. Massively parallel computation is used in the simulation. Our previous 2-D simulations showed the presence of various electromagnetic waves near the quasi-parallel and quasi-perpendicular shocks, and the formation of diamagnetic cavities in the foreshock and downstream regions of parallel and quasi-parallel shocks due to the interaction between backstreaming ion beams and the incoming solar wind plasma. In this presentation, our preliminary 3-D simulations of the kinetic structure of the bow shock will be shown, and the results will be compared with the previous 2-D simulations.

SM52B-0575 1330h POSTER

Macrostructure of the Quasi-Parallel Shock and Magnetosheath: 1. Scale Lengths

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Recently, we have utilized global hybrid (fluid electrons, kinetic ions) simulations of solar wind interaction with magnetic dipoles of various strength to demonstrate the existence of a spectrum of magnetospheric structures. Starting with a simple whistler wake, increasing the dipole strength results in magnetospheric structures which grow in complexity until a terrestrial type magnetosphere is formed. This occurs when the system size is considerably larger than ion gyroradii, specifically when the standoff distance of the magnetopause is at least 20 times the solar wind proton skin depth. In this study, we use a similar approach to understand the macrostructures of the quasi-parallel shock and the magnetosheath and their evolution as a function of system size. These macrostructures are directly tied to ion kinetic processes and microinstabilities which occur in the ion foreshock and the magnetosheath. As a result, the spatial extent of both regions influence the nature of system. Our objective is to establish the spatial scales associated with various kinetic processes in the ion foreshock and the quasi-parallel magnetosheath and determine the spatial scales beyond which the system has a self-similar solution.

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Macrostructure of the Quasi-Parallel Shock and Magnetosheath: 2. Nature of the ULF Waves

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In an accompanying presentation, global hybrid (fluid electrons, kinetic ions) simulations were utilized to demonstrate the existence of spatial scales beyond which quasi-parallel shocks and magnetosheath exhibit self-similar macrostructures. This implies that the results of the simulations should be directly applicable to spacecraft observations at planetary shocks and magnetosheaths. An interesting aspect of the simulation results is that despite the presence of large levels of ULF turbulence in the upstream, at the shock and the downstream regions a macrostructure can be attributed to the system. This macrostructure is associated with large scale, and fairly coherent, density and field fluctuations which populate most of the quasi-parallel magnetosheath. Preliminary analysis of the waves suggest that these fluctuations may be in both mirror (density and magnetic field anti-correlation) and fast magnetosonic (density and field correlation) modes. Here, we present a detailed analysis of the waves observed in the simulations to better understand their mode structure and origin, as well as their influence in modulating the magnetosheath. Comparison between simulation results and observations in the quasi-parallel magnetosheath is also provided.

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Bursty Electron Heating in Nonstationary Shocks

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It is well-known that high-Mach number shocks are nonstationary. The shock front steepens and unsteepens quasiperiodically, and some shocks even reform. It is widely believed that the typical timescale of this process is of the order of the ion gyroperiod, so that electrons feel a quasistationary electric field. Electrons, which cross the shock in the adiabatic regime during the unsteepening phase, may become demagnetized in during the shock steepening. Thus, the electron heating regime may be time dependent in high-Mach number shocks and bursty nonadibatic heating may coexist with adiabatic heating. The downstream electron distribution would be a mixture of nonadiabatically and adiabatically heated electrons.

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