National Oceanographic and Atmospheric Administration (NOAA) satellites, and the Fast Auroral SnapshoT (FAST) spacecraft. Changes in the open flux content of the magnetosphere are related to the rate of magnetic reconnection occurring at the magnetopause and in the magnetotail, allowing us to estimate the day- and nightside reconnection voltages associated with different IMF orientations and the occurrence of substorms. In addition, we discuss the ramifications for the magnetotail of changes in open flux content of the magnetosphere.

SM51D-04 1115h

Interhemispheric conjugate observations of ionospheric convection flows in the dayside high-latitude regions

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Interhemispheric conjugate observations of ionospheric convection flows are essential for understanding the electrodynamics in the dayside high-latitude regions, particularly in the cusp and the open/closed field line boundary region. We investigate the SuperDARN data for this purpose. Merged vectors obtained from pairs of radars are calculated using the common program data during the 8-year period of 1995-2002. We select 29 events in which a large number of merged vectors are obtained by coverage of pairs of conjugate radars. Most events occurred near equinox under the southward IMF conditions. This is consistent with a fact that the generation of ionospheric irregularities is affected by daylight high diffusion rates and enhancements of convection electric field. Interhemispheric convection patterns are consistent with the Heppner-Maynard pattern when the IMF is stable for >30 min. It is found that convection flows and vorticities tend to be weak in the sunlit region in the vicinity of the open/closed field line boundary. This may reflect an asymmetry of the cusp properties in the northern and southern hemispheres due to ionospheric conductivity differences. Considering these result, we discuss the three dimensional current system producing the interhemispheric convection patterns in the dayside high-latitude region.

SM51D-05 1130h

Does the IMF High Latitude Convection?

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One of the paradigms of present day magnetospheric physics is that the interplanetary magnetic field at the dayside magnetopause controls the shape of the high-latitude convection pattern and the magnitude of the cross polar cap potential. From this viewpoint, IMF-derived statistical models of high-latitude convection can readily be used to carry out studies of plasma transport and evolution in both the ionosphere and magnetosphere. While there appears to be underlying structure to the convection patterns that is well represented by IMF orientation, studies being carried out with the SuperDARN radar network indicate that the IMF magnitude and orientation does not provide a good measure of the instantaneous cross polar cap potential. Rather the cross polar cap potential exhibits sharp transient increases in a manner discussed by Lockwood and Cowley in the early 1990s. The effects are most apparent in the vicinity of the cusp, but can be observed at other local times. Transient latitudianlly-confined regions of strong convection are the most obvious feature of these potential enhancements. In this paper, we present examples of this phenomena as observed with SuperDARN and discuss its implications.

SM51D-06 1145h INVITED

Numerical modelling of observed cusp characteristics for spatial and temporal variations in magnetopause reconnection rate

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Using the Cowley-Lockwood theory of ionospheric flow excitation, a numerical model of the response to generalised variations of the magnetopause reconnection rate, in both space and time, has been developed for times when the Y-component of the IMF is small. This model allows the motion of all reconnected field lines to be monitored and maps of time-elapsed since reconnection can be generated. Because the characteristics of the ion precipitation spectrum can be characterised as a function of this elapsed time and the site of the reconnection, we can use this model to generate time series of maps of parameters such as the sheath ion flux, the mean energy, the low-energy cut-off, and the proton aurora intensity, as well as the convection patterns and maps of the consequent ion heating. Comparison with observations shows very good agreement with observations by the IMAGE spacecraft and the SuperDARN network of HF radars. The model reproduces observed stepped and sawtooth signatures, depending on satellite altitude and pass orientation, as predicted for pulsed reconnection. Using the maintenance of quasi-neutrality, first-order predictions of features produced by sheath electron precipitation can also be modelled. For example, we show how poleward-moving 630 nm auroral transients and patches of enhanced plasma concentration can also result from the pulsed reconnection.

SM51D-07 1205h

Plasma Dynamics in the Vicinity of a Cusp-Like Magnetic Configuration

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The magnetospheric cusps are an important structural element of the Earth's magnetosphere. Magnetic flux from the magnetospheric boundaries converges into the cusps and the magnetic field in the vicinity of the cusps rotates by 360 degrees. The magnetic field and plasma flow configuration allows for magnetic reconnection and Kelvin Helmholtz instabilities in the vicinity of the cusps. In addition plasma flow can become turbulent due to boundary layer separation as a result of the plasma flow over the cusp indentation. However, there are very few models based on first principles and with good numerical resolution which address the cusp physics. Here we will present first results based on MHD simulations with an initial condition which includes a cusp-like magnetic field indentation. The initial conditions particularly address cases with a magnetic field and plasma flow aligned and perpendicular to each other. The results consider a variation of the velocity on the magnetosheath side as well as the influence of viscosity on the the flow structure in and adjacent to the cusp.

SM51E MCC: 3014 Friday 1020h

Radiation Belts and the Inner Magnetosphere III

Presiding: **T P O"Brien,** The Aerospace Corporation**; A A Chan,** Rice University

SM51E-01 1020h

SAMPEX Observations of the Inner Radiation Belt Over a Complete Solar Cycle

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The Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) satellite was launched into low Earth orbit in July 1992, and has been measuring energetic protons and heavy hydrogen isotopes during several traversals of the inner radiation belt each day since then. We have now accumulated a data set covering a full 11-year cycle of solar activity (from declining phase of Cycle 22 to the declining phase of the current Cycle 23), and have assembled it into time-varying maps of several parameters of the radiation belt. We will describe the variations of energy spectra, pitch-angle distributions, scale height, and isotopic composition as the solar activity level changed during the mission. The scale height (measured through gradient anisotropy, the "East-West effect") at the lower edge of the radiation belt responds to changes in the upper atmosphere over the solar cycle. Varying isotopic composition, especially considering the 12-year half-life of tritium, reflects the differing sources and losses for the CRAND protons and secondary deuterium and tritium. Time variations at the upper edge of the radiation belt at energies of tens of MeV respond to geomagnetic injections of these high-energy particles as well as to the relatively steady CRAND source and atmospheric losses. This data set is being incorporated into models of the low-altitude inner zone that seek to improve on the two-state (solar max, solar min) AP8 model by including continuous response to changes in solar activity.

SM51E-02 1035h

Coordinated Energetic Particle Measurements Using Chandra, Cluster, and Polar

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It is not well known in the magnetospheric physics community that the Chandra spacecraft carries a multi-element energetic particle telescope called EPHIN (Electron Proton Helium Instrument) fielded by the University of Kiel. For present purposes we are interested in electrons that are measured from greater than 30 keV to greater than 10 MeV. Chandra is in a highly elliptical orbit with a perigee of 16000 km, and apogee of 133,000 km and an inclination of 28 degrees. Fortuitously the line of apsides is relatively close to that of the Cluster constellation. A first use of the Chandra data has been a further examination of a substorm onset that occurred = 0408 UT on 27 August 2001, discussed in a publication by Baker et al. (2002). At that time the s/c coordinates in GSM were Chandra (-6.64, 16.15, 12.82); Cluster 3 (-19.15, -1.40, 1.54); Polar (-7.71, -4.50, 3.32). It can be seen that whereas Cluster and Polar were a bit post midnight and roughly radially aligned, Chandra was well pre-midnight at around 20 hrs. Yet the onset time of energetic electrons at Chandra was very close to that observed at Cluster and Polar. Furthermore, some pre-substorm bursts were also seen to be closely time coincident at Chandra and the other spacecraft. These observations give additional evidence about the scale size of the phenomena and will be discussed in detail along with other coordinated measurements. Baker et al. GRL 29, no. 24, 2190, 2002

SM51E-03 1050h

Global flux isotropization and in-situ Pitch angle evolution during relativistic electron energization in the outer zone.

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Energization of outer zone electrons to relativistic energies in the Earth's magnetosphere is fundamentally caused by high solar wind velocity and the southward turning of the interplanetary magnetic field. However, details of all the physical processes involved, are ill

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understood. Relativistic electron fluxes in the outer zone are highly dynamic and vary over several orders of magnitude on time scales of a few days. Energization models invoke processes ranging from radial diffusion to in-situ acceleration mechanisms. Important characteristics of electron energization such as electron pitch angle distribution and isotropization enable identification of separate energization mechanisms. We report on the measurements of in-situ pitch angle evolution at geosynchronous altitude and global isotropization of relativistic electrons during recent electron energization events.We use data from energetic particle sensors onboard SAMPEX and the recently developed pitch angle data from the SOPA and the ESP sensors onboard LANL spacecraft. The latter provide an in-situ view of the electron pitch angle distribution at geosynchronous altitudes. Comparison of electron fluxes measured by SAMPEX which is in low earth orbit, with LANL geosynchronous data provides a global view of the flux isotrpization time scales.

SM51E-04 1105h

Multi-satellite measurements of electron phase space density gradients in the Earth's magnetotail and their relation to geomagnetic activity and solar wind conditions

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The variability of the intensity of energetic (MeV) killer' electrons in the Earth's radiation belts has been a renewed area of interest in recent years, yet a major outstanding question is the origin of these particles. In this study we investigate whether the plasma sheet contains a sufficient population of energetic electrons to supply relativistic electron enhancements in the Earth's radiation belts by radial transport alone, or whether one needs to invoke other more localized acceleration processes. We have ordered the equatorial / central plasmasheet electron data from several satellites (GPS ($\sim$ 4 R_E), LANL geosynchronous (GEO) ($\sim$ 6.6 R_E),6 POLAR ($\sim$ 8 R_E) and CLUSTER ($\sim$ 18 R_E)) in phase space density (PSD). By combining these measurements at a particular value of the first adiabatic invariant we are able to examine the radial profile of PSD. In a recent study, POLAR data has been examined over a range of L and a peak in PSD at $\sim$ 4-6 R_E has indicated the possibility of a localized source region. This result has been repeated in a study by the current authors, which also suggested a sufficient population at CLUSTER radial distances to supply the inner magnetosphere by radial transport, agreeing well with particle tracing models. In this current study we extend previous work by utilizing a large number of equatorial measurements by all 4 sets of satellites to examine the statistical nature of the PSD profile under a variety of geomagnetic and solar wind conditions.

SM51E-05 1120h

Examining Relativistic Electron Loss in the Outer Radiation Belt

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Since the discovery of earth's radiation belts researchers have sought to identify the mechanisms that dictate the seemingly erratic relativistic electron flux levels in the outer belt. Contrary to intuition, relativistic electron flux levels do not always increase during geomagnetic storms even though these storms signify enhanced energy input from the solar wind to the magnetosphere [*Reeves et al.*, 2003; *O'Brien et al.*, 2001]. The fickle response of the radiation belt electrons to geomagnetic activity suggests that flux levels are determined by the outcome of a continuous competition between acceleration and loss. Some progress has been made developing and testing acceleration mechanisms but little is known about how relativistic electrons are lost. We examine relativistic electron losses in the outer belt focusing our attention on flux decrease events of the type first described by *Onsager et al.* [2002]. The study showed a sudden decrease of geosynchronous >2MeV electron flux occurring simultaneously with local stretching of the magnetic field. The decrease was first observed near 15:00 MLT and progressed to all local times after a period of $\sim$10 hours. Expanding on the work of *Onsager et al.* [2002], we have identified $\sim$ 51 such flux decrease events in the GOES and LANL data and present the results of a superposed epoch analysis of solar wind data, geomagnetic activity indicators, and locally measured magnetic field and plasma data. The analysis shows that flux decreases occur after 1-2 days of quiet condition. They begin when either the solar wind dynamic pressure increases or Bz turns southward pushing hot dense plasma earthward to form a partial ring current and stretched magnetic field at dusk. Adiabatic electron motion in response to the stretched magnetic field may explain the initial flux reduction; however, often the flux does not recover with the magnetic field recovery, indicating that true loss from the magnetosphere is occurring. Using Polar and SAMPEX data, we examine whether precipitation to the atmosphere or magnetopause encounters can account for the additional loss.

SM51E-06 1135h

Characterization of the global ULF environment during the 09/24/1998 geomagnetic storm, and effect on energetic electron dynamics.

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The dynamics of energetic particle populations in the inner magnetosphere can be quantitatively described by a Fokker-Planck equation written in terms of the invariant quantities M, K, and L. In particular, ULF waves, with frequencies in the range $\sim$1-10 mHz, can lead to efficient diffusive transport in the radial coordinate corresponding to the third invariant, L. The appropriate transport coefficient, D_{LL}, depends not only on the frequency spectrum and power of the waves involved, but also on the global mode structure of the waves as well as the large scale magnetospheric configuration, i.e. the state of magnetospheric compression and stretching due to the effect of the solar wind dynamic pressure and magnetospheric current systems. In this work, we use MHD simulations to model the ULF wave activity occurring during the geomagnetic storm of September 24-26, 1998, and analyze the wave activity both in terms of temporal and frequency characteristics, as well as in terms of the global azimuthal mode structure. By conducting test particle simulations in the MHD fields, we examine the dynamics of the outer zone radiation belts during this geomagnetic storm. Test particle simulations in simple analytic fields which mimic the time-dependent state of magnetospheric compression and MHD wave spectral characteristics are likewise conducted, and the results compared to the results of the full MHD/particle simulations. In this fashion, we show that the global electron response to ULF waves can be described largely in terms of the spectral characteristics of the waves and the state of magnetospheric compression, without necessarily specifying the wave fields in detail. By using these spectral characteristics to quantify appropriate diffusion coefficients, the time-dependent state of the outer zone radiation belts resulting from ULF may thus be specified through solution of the transport equations, rather than through detailed simulation.

SM51E-07 1150h

Why do Some Storms Decrease the Flux of Relativisitic Electrons in the Radiation Belts ?

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An analysis by Reeves et al.(2003) of 276 geomagnetic storms during the period 1989 to 2000 indicates that while about one half of the storms resulted in an increase in the relativistic electron flux in the radiation belts, about one quarter actually decreased the fluxes. In this paper, we demonstrate quantitatively that whether or not storms produce an increase or decrease of relativistic electrons in the inner magnetosphere depends on the competition between the physical processes producing the energization and loss of electrons. We construct a model for the electron energy distribution function incorporating electron energization by cyclotron resonant interaction with whistler-mode chorus, and electron losses due to pitch-angle scattering into the loss cone by combined plasma waves (in particular EMIC waves and plasmaspheric hiss). We then carry out numerical experiments, treating the chorus wave amplitude and electron loss rate as model input variables, and computing the solution for the electron energy distribution function (at a specified time after the storm) as the model output. We find that the extent of the electron flux increase or decrease over the course of the storm is controlled by the magnitudes of the wave amplitude and the particle loss rate. For instance, the results show that if the timescale for particle loss is several days, then a wave amplitude of 10 pT is sufficient to generate a relativistic electron flux increase, while even wave amplitudes as high as 100 pT , if accompanied by a particle loss rate near to that corresponding to strong diffusion, would result in a flux decrease. This study re-enforces the assertion that in order to model the relativistic electron flux variations in the radiation belts over the course of any given geomagnetic storm, a proper accounting must be made of particle losses.

SM51E-08 1205h

MAXIS Balloon Observations of Electron Microburst Precipitation

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Quantifying and understanding losses is an integral part of understanding relativistic electron variability in the radiation belts. SAMPEX observations indicate that electron microburst precipitation is a major loss mechanism during active periods; the loss of relativistic electrons during a six hour period due to microburst precipitation was recently estimated to be comparable to the total number of trapped electrons in the outer zone (Lorentzen et al., 2001). Microburst precipitation was first observed from a balloon (Anderson and Milton, 1964), but these early measurements were only sensitive to <100 keV. The first balloon-based observations of microbursts sensitive to MeV energies were obtained during the MAXIS 2000 long duration balloon campaign. MAXIS was launched from McMurdo Station in Antarctica carrying a germanium spectrometer, a BGO scintillator and two X-ray imagers designed to measure the bremsstrahlung produced by precipitating electrons. The balloon circumnavigated the south pole in 18 days covering magnetic latitudes ranging from $58^\circ - 90^\circ$ South. During the week following a moderate geomagnetic storm (with Dst reaching -91 nT), MAXIS detected a total of over 16 hours of microburst precipitation. We present high resolution spectra obtained with the MAXIS germanium spectrometer which allow us to determine the precipitating electron energy distribution. The precipitating distribution will then be compared to the trapped distribution measured by the GPS and LANL satellites. We also examine the spatial distribution of the precipitation.