SM51C-06 1000h

Laboratory Observation of Fast Collision-less Magnetic Reconnection

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Plasma dynamics around a magnetic X-point and magnetic reconnection in the collisionless regime are studied on the Versatile Toroidal Facility. Ar and H plasmas are created by ECRH with densities and temperatures in the range of 10^{17} m^{-3} and 20 eV. The magnetic configuration is based on a magnetic cusp forming an X-line at the center of the device and a toroidal magnetic field. Reconnection is driven by inducing a toroidal electric field using an ohmic transformer.

The response of the plasma is measured in terms of poloidal distribution and time evolution of plasma density, flows, magnetic flux and currents. Fast collisionless reconnection is observed experimentally. The detailed evolution of the profiles of plasma density, current density, and electrostatic potential at the onset of driven reconnection is reconstructed experimentally in the collisionless regime, for the first time. Despite a constant, externally imposed reconnection drive, we show that the reconnection does not proceed in a steady-state manner. The formation and decay of the current is shown to be related to the evolution of the electrostatic potential and the associated ion polarization currents.

The size of the diffusion region is inferred from the detailed knowledge of the electrostatic potential, and is shown to be insensitive to the ion mass and plasma density. Within the limit of two fluid theories it is shown that electron momentum balance can only be fulfilled with the inclusion of off diagonal terms in the electron pressure tensor.

SM51C-07 1035h

Unraveling the Nature of Steady Magnetopause Reconnection Versus Flux Transfer Events

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Magnetic reconnection is a fundamental mode of energy and momentum transfer from the solar wind to the magnetosphere. It is known to occur in different forms depending on solar wind and magnetospheric conditions. In particular, steady reconnection can be distinguished from pulse-like reconnection events which are also known as Flux Transfer Events (FTEs). The formation mechanism of FTEs and their contolling factors remain controversial.

We use global MHD simulations of Earth's magnetosphere to show that for southward IMF conditions: a) steady reconnection preferentially occurs without FTEs when the stagnation flow line nearly coincides with the X-line location, which requires small dipole tilt and nearly due southward IMF, b) FTEs occur when the flow/field symmetry is broken, which requires either a large dipole tilt and/or a substantial east-west component of the IMF, c) the predicted spacecraft signature and the repetition frequency of FTEs in the simulations agrees very well with typical observations, lending credibility to the the model, d) the fundamental process that leads to FTE formation is multiple X-line formation caused by the flow and field patterns in the magnetosheath and requires no intrinsic plasma property variations like variable resistivity, e) if the dipole tilt breaks the symmetry FTEs occur only in the winter hemisphere whereas the reconnection signatures in the summer hemisphere are steady with no bipolar FTE-like signatures, f) if the IMF east-west field component breaks the symmetry FTEs occur in both hemispheres, and g) FTE formation depends on sufficient resolution and low diffusion in the model – coarse resolution and/or high diffusivity lead to flow-through reconnection signatures that appear unphysical given the frequent observation of FTEs.

SM51C-08 1050h INVITED

Comparison of Concepts and Simulations of the Sub-solar Magnetopause With Measurements

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The Polar Satellite experienced more than 1000 sub-solar magnetopause crossings during three spring months in 2001 and 2002. Features of these crossings that both agree with and differ from the static, two-dimensional, picture of the magnetopause will be discussed. In particular, the simple flow of plasma and Poynting flux into the magnetopause in the plus and minus x-directions and out along the plus and minus z-directions will be contrasted with an actual, much more complex, flow. Also, the measured current distributions and power dissipation will be compared with models.

SM51C-09 1110h INVITED

Magnetic reconnection in the magnetotail

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Observations with the spacecraft Geotail have added significantly to our knowledge of magnetic reconnection in the magnetotail. The structure and dynamics of magnetic reconnection have been studied at the MHD level. Detailed characteristics of ion and electron behaviors have been revealed with measurements of distribution functions with a high time resolution. An intriguing characteristic for ions is counterstreaming ions on the field lines that have a convection motion with a high speed. For these ions, one component moves parallel to the magnetic field and the other component moves anti-parallel to the magnetic field, and both have the same speed. These features are well reproduced in simulations for magnetic reconnection in hybrid and full particle codes. An unexpected characteristic for electrons is seen in the tail lobe-plasma sheet boundary near the reconnection site. High-energy electrons flow out of the reconnection site, while low-energy electrons flow into the reconnection site. These electrons are found to form part of the Hall current system. Furthermore, ions and electrons show motions to different directions, indicating the ion-electron decoupling. This is what is expected in the immediate vicinity of the magnetic reconnection site. Hence, various characteristics of magnetic reconnection have emerged at the kinetic level.

SM51C-10 1130h

CLUSTER Observation of Magnetic Reconnection in the Magnetotail: Comparison with Hall Physics Effects.

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During the August 17, 2001 ~16:20 substorm event, CLUSTER S/C were at apogee (~20 R_E) in the midnight region (~0100 MLT) and very close to the reconnection site. High velocity (~1000 km/s) tailward ion field aligned and ExB flows were observed while the B_Z component of the magnetic field was negative. These tailward flows were followed by two Earthward reversals. Low energy O^+ was observed in the inflow region with a dawnward direction while energetic O^+ was observed tailward of the reconnection site. The plasma sheet was very thin, ~1100 km, very variable in thickness and tilted in the Y-Z plane due to a strong B_y component of the IMF. Due to this very thin plasma sheet CLUSTER S/C probed almost simultaneously all regions, from the neutral sheet to the lobes. Variations in the magnetic field are consistent with the quadrupole structure produced by the Hall current system while the presence of electron beams towards the reconnection site indicate that we are observing the Hall current carriers. Electric field data show very strong low frequency fields. These observations will be compared to the theoretical models of collisionless magnetic reconnection and more specifically to the Hall physics effects.

SM51C-11 1145h

Formation, Characteristics, and Diagnostic Usage of Energetic Ions in the Near and Mid Tail

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The interaction of the solar wind with the Earth's magnetosphere results in global changes of the magnetic field topology and alters many plasma properties, with pronounced effects on both thermal and energetic particle populations. In our work, we investigate the energetics and dynamics of the magnetotail during active times. We have studied the ion-kinetic physics surrounding substorm onset and the development of near-Earth reconnection using large-scale, three-dimensional hybrid simulations (kinetic ions, electron fluid), in conjunction with models that describe the interaction with the ionosphere. Here, we concentrate on characterizing the origin, location, and timing of energetic ion fluxes. These particles are self-consistently energized in the simulations, reaching fluxes that significantly affect the energy and momentum balance of the system. When the ions reach geostationary orbit or low altitudes, their localization and timing serve as an excellent means of mapping and linking the respective magnetospheric and ionospheric regions and processes. We show how this linkage is in many ways more directly tied to relevant tail processes than that provided by alternative ionospheric signatures. Observationally, the presence of energetic ions is detectable not only in situ, but also remotely from the ground and by spacecraft (such as the IMAGE satellite) via characteristic emissions. We discuss our results in the framework of such observations.

SM52A MCC: Hall D Friday 1330h

ULF Waves and Their Role in Diagnosing the Plasmasphere I Posters *(joint with SA)*

Presiding: **B J Fraser,** University of Newcastle**; D L Gallagher,** NASA Marshall Space Flight Center

SM

SM52A-0528 1330h POSTER

Measurements of the Mass Density Dependence Along Field Lines Using Toroidal Alfvén Frequencies Observed by the CRRES Spacecraft

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It is sometimes possible to measure several harmonics of the toroidal Alfvén wave for a particular field line. Because of the difference in parallel structure for these harmonics, they react differently to density at different points along a field line. Using this fact, it is possible to use the frequencies to remotely sense the mass density at different points along a field line. Here we examine some new techniques for calculating the mass density based on the toroidal frequencies. Using toroidal harmonics measured by the magnetic field instrument on the CRRES spacecraft, we compare the inferred mass density at the spacecraft location to the electron density measured locally using plasma wave data.

SM52A-0529 1330h POSTER

Estimation of Plasma Mass Density Using Toroidal Oscillations Observed by CRRES

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Plasma mass density is a quantity that is difficult to determine using particle instruments. However, with proper models of the ambient magnetic field and density variation along the field lines, one can relate the frequency of observed field line eigenoscillations to the density [Denton et al., JGR, page 29,925, 2001]. In the present study we estimate the density using the toroidal oscillations detected by the magnetic (B) and electric (E) field experiments on the CRRES spacecraft. A period including the geomagnetic storm of October 9,1990, is chosen for analysis because the spacecraft was located on the dawn sector where toroidal waves are routinely excited. Dynamic spectra of the B and E fields are generated for each CRRES orbit for identification of the presence and harmonic mode of the toroidal oscillations. The fundamental mode is found to the easiest to identify when the spacecraft was at magnetic latitude higher than 15 degrees. Consequently, we follow the frequency of this mode for the selected storm period. At L = 7, the frequency was 6 mHz before the storm and it decreased to 3 mHz a few days after the main phase of the storm. This frequency change corresponds to an increase of mass density by a factor of four. The electron number density at the same L shell, determined from the CRRES plasma wave spectra, did not show a similar change. This result suggests that heavy ions increased during the storm. We use the Denton et al. [2001] technique to estimate the mass density, and then combine the mass density and electron density to obtain the effective ion mass/charge ratio.

SM52A-0530 1330h POSTER

Simulation Study of Ionospheric Damping of Pi2 Pulsations

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Pi2 pulsations observed in the plasmasphere indicate the presence of the toroidal components, radial electric field and azimuthal magnetic field, of field line oscillations. According to an Akebono spacecraft observation made at 24-40 degree magnetic latitude, the oscillations carried a large Poynting flux directed toward the ionosphere and it has been suggested that the cavity mode oscillation is quickly damped by this loss mechanism [Osaki et al., JGR, 17,605, 1998]. However, a recent Polar observation at 10-14 degree magnetic latitude showed a small Poynting flux [Keiling et al., JGR, page 25,8981, 2001]. These conflicting observations motivated us to run the simulation code developed in a previous study of plasmaspheric Pi2 pulsations [Lee and Lysak, 1999]. The simulation incorporated a nightside impulsive source, a plasmapause density gradient, energy loss from the magnetopause, and ionospheric damping. The cross phase between the electric and magnetic fields of the toroidal mode was near 90 degrees near the equator but it became smaller as latitude increased. This is consistent with the behavior of the Poynting flux observed from spacecraft. The cross phase changes because the electric field is required to gradually become in phase with the magnetic field as the ionosphere approaches. The simulation also produced compressional poloidal oscillations exhibiting the properties of virtual plasmaspheric resonance (cavity mode). The decay time scale differed between the toroidal and poloidal modes, and we conclude that the duration of the virtual resonance is not much affected by the ionospheric damping of the toroidal mode.

SM52A-0531 1330h POSTER

Multipoint Observations of a Pi2 Pulsation on Dayside

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Previous studies have shown that the plasmaspheric cavity mode resonance is a plausible mechanism for Pi2 pulsations. Fast mode waves emitted from a substorm onset region will bounce back and forth between two boundaries (the ionosphere and the plasmapause) and will be radially trapped, if the wave normal is nearly perpendicular to the boundaries. This is likely to occur near the midnight meridian where substorms are thought to initiate. It is expected that waves would not be trapped effectively on the flanks where the waves make oblique incident on the boundaries, resulting in no appearance of Pi2 pulsations. However, Pi2 pulsations are global phenomena observed at local times far from local midnight. The longitudinal structure of the cavity mode resonance is yet to be investigated.

In the present study we focus on a Pi2 pulsation that occurred at 0538 UT on September 20, 1995, because two satellites (ETS-VI and EXOS-D) and ground stations located from low-latitude (L$\sim$1.5) to high-latitude (L$\sim$12) made observations at 07-10 MLT. Magnetic field data from equatorial and low-latitude stations (L<1.5) at 02 MLT and 15 MLT were also available. This data set provided us with a unique opportunity to investigate the Pi2 pulsation on the morning side in great detail and to examine its longitudinal structure.

We found that all ground stations observed a Pi2 pulsation. The ETS-VI satellite at L=6.3 observed a Pi2 pulsation that had nearly the same period and waveform as the ground Pi2 pulsation. The Pi2 pulsation detected by the ETS-VI satellite was dominated by the parallel and radial components, indicating a fast mode wave. Plasma wave observations by the EXOS-D satellite places the plasmapause at L=6.8. From these results, we suggest that the plasmaspheric cavity mode resonance can be established even on the morning side and is a plausible mechanism for the Pi2 pulsation. It was also found that low-latitude Pi2 pulsations were observed globally and showed no phase differences among stations, indicating that the plasmaspheric cavity mode is rather uniform in longitude.

SM52A-0532 1330h POSTER

Solar Wind Activity Dependence of the Occurrence of Field-Line Resonance at low Latitudes (L$\sim$1.3)

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It is known that the field line resonance (FLR below) is caused by hydromagnetic waves in the magnetosphere. The fundamental field line eigenfrequency can be expressed by the magnetic field line length, the magnetic field intensity, and the plasma density at the magnetic field line. We can measure the fundamental field line eigenfrequency by ground-based observation. The field line length and the magnetic field intensity can be calculated from some magnetic field model (such as the IGRF model) of the magnetosphere. Then, it is possible that the plasma density at the magnetic field line is determined by these factors.

The final aim of this study is to monitor and study time-dependent changes in the plasmaspheric plasma distributions by using ground magnetic field observations. For this purpose, we are working in the following three research phases. The first phase is to confirm the possibility of identifying FLR at low-latitudes (L$\sim$1.3). The second phase is to examine the correlation between FLR and solar wind parameters. The third phase is to estimate the plasma density from the FLR data, and monitor the density in a continuous manner. We are now in the third phase, and we report here the results of the first two phase.

In the first phase, in order to investigate features of FLR close to the Earth, we installed three magnetometers in Japan at L$\sim$1.3 (at Kawatabi, Zaou, and Iitate), and started observing ULF geomagnetic pulsations. Each adjacent stations are separated in latitude by 50 to 100 km. The magnetic field data from these stations and Kakioka geomagnetic observatory, Japan, were analyzed by using the amplitude-ratio method and the cross-phase method. As a result, we identified FLR events whose frequency decreased with decreasing geomagnetic latitude; we infer that this feature was caused by heavy ion mass loading to low-L field lines.

In the second phase, we studied the dependence of the occurrence probability of the above-identified FLR events on solar wind parameters: To investigate the dependence, we used every 20-min of ground data to judge if FLR took place in the 20-min interval. For the same intervals, we recorded maximum values of solar wind parameters such as the dynamic pressure and the IMF (Interplanetary Magnetic Field) intensity. We then studied the dependence of the FLR occurrence on each solar wind parameters (normalized by its background distribution). As a result, we found that the occurrence probability is large at very large values of the IMF intensity and the solar wind dynamic pressure (Psw below), which suggests the following scenario for the generation of FLRs at L$\sim$1.3: When the IMF intensity and Psw suddenly increase (in a step-like manner, as in sudden commencements), such a change in the solar wind hits the magnetopause and generates hydromagnetic waves at all frequencies, including the field line eigenfrequency at L$\sim$1.3; some of them travel in the magnetosphere to the Earth and cause FLRs.

Acknowledgment. Solar wind parameters used in this study were obtained from the Coordinated Data Analysis Web (http://rumba.gsfc.nasa.gov/cdaweb/istp_public/).

SM52A-0533 1330h POSTER

Hodograph Method to Restore the Radial Profile of Magnetospheric Plasma Density From Data of Ground-Based ULF Observations

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A new method to restore the radial profile of resonant magnetospheric frequencies from the data of ground-based ULF measurements is presented. In contrast with the standard gradient method, the approach of this paper is based on simultaneous use of both amplitude and phase information. It is implemented via analysis of the hodograph (in the complex plane) of the ratio between complex spectra at two stations. This geometrical method with the use of the hodograph enables one to extract more information about the magnetospheric resonator parameters: For example, it provides not only the resonant frequency at the position midway between the two stations but also its continuous latitudinal distribution; it also provides the Q-factor of the resonator. An interactive program is elaborated that makes it possible in an easy way to control the match of the gradient observations data to the resonance model, and to find the least-squares-fit approximation of the hodograph. The possibility to restore a continuous radial profile of plasma density in the magnetosphere is demonstrated with the data of Pc4 observations along the Great Britain magnetometer array.

SM52A-0534 1330h POSTER

Determining the Mass Composition of the Outer Plasmasphere During Large-Amplitude Pc5 Oscillations

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The magnetosphere often rings in the Pc5 frequency range (few minutes) in response to the sudden impulse imparted by an interplanetary shock, as well as to other less-obvious stimuli. At geosynchronous orbit, this ringing is manifested in largely-azimuthal flow oscillations of the outer plasmasphere, as observed by Los Alamos MPA instruments on several satellites. If the amplitude of these Pc5 pulsations is large enough, the different mass species of the plasmasphere (H+, He+, and O+) can be separated by E/q in the MPA analyzer, enabling the determination of the composition of the plasmaspheric material. For example, Pc5 oscillations on 25 Sep 2001, stimulated by the passage of an interplanetary shock at 2026 UT, reveal the presence of a substantial population of He+ and O+ in the duskside outer plasmasphere, whereas simultaneous observations by a different satellite near dawn show a smaller proportion of heavy ions. The results of a search for such events will be presented.

SM52A-0535 1330h POSTER

Forward Modeling of Travel-time Magnetoseismology: Tamao's Approximation vs. MHD Simulation

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The travel-time magnetoseismology is one of the two major methods remotely sensing the plasma mass density of the magnetosphere from the ground. This method measures the differentiation of the arrival time of impulsive waves-including the preliminary impulses of sudden commencements and impulsive pulsations-and infers the plasma density that determines the propagation speeds. Previous observations find that these impulsive signals propagate to the ground mainly by means of MHD waves. Tamao's approximation of MHD wave propagation has been used to provide the first-order model for inversion. This model enables the calculation of wave propagation time along simple travel routes, which are composed by the closest path between the impact location and the field line of interest and the field-aligned propagation to the ground.

In this paper we examine if Tamao's approximation can be repeated by numerical calculation as a step to examine its accuracy and to assess the validity of its use in inversion. We examine the propagation of preliminary impulses to the low-altitude boundary in MHD simulation in 3-D dipole geometry. This numerical simulation is a useful reference because it has a better quantitative assessment on the coupling between fast mode and Alfven waves and on the wave refraction in a realistic geometry. We find that Tamao's approximation is in good agreement with the simulation results in the outer magnetosphere: The wave energy reaches low altitude boundary first at latitude outside the plasmapause. However, the simulation shows characteristics of signal's arrival time deviated from Tamao's approximation at plasmaspheric latitudes. The arrival time is slightly earlier than predicted and is less differentiated across different L-values. The sharp gradient of Alfven velocity near the plasmapause yields a rather degenerated step function of latitude in arrival time. These simulation results imply that the plasmasphere significantly distorts impulsive waves when they propagate to low latitudes. The implications arising from this comparative study on the inversion problem of magnetoseismology will be discussed.

SM52A-0536 1330h POSTER

Local Time Dependence of Preliminary Impulse Propagation and the Implications on Density Distribution in the Magnetosphere

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The preliminary impulse of sudden commencements is a unique phenomenon in the interaction between the solar wind and the magnetosphere in which the impact of an enhanced solar wind pressure produces a strong pulse propagating throughout the magnetosphere. This propagation provides an opportunity for ground observers both to study the fundamental process of wave propagation in the magnetosphere and to understand the state of the magnetosphere. Recently, observations have provided tangible evidence that preliminary impulses propagate to the ground mainly by means of MHD waves. Clear discontinuity of the arrival time of preliminary impulses is found at the plasmapause latitude, where the plasma density varies significantly. The propagation velocities and patterns are also likely to vary across the noon-dusk sector because the plasma density is also a function of local time. Our study is aimed to catalog a number of preliminary reverse impulse (PRI) events for varying local times in hopes to confirming the process by which the wave signal propagates.

We have examined several PRI events in ground records at a variety of local times. The PRI arrival time for local times close to noon is in good agreement with the estimation of arrival time from MHD wave propagation and in contradiction to the prediction by the Earth-ionosphere waveguide model. The polarization pattern is also found to vary consistently with local time, a direct result of the station's location with respect to the Hall current vortex. We further apply travel-time magnetoseismology to find that density distribution implied by these observations. A larger variation in arrival time for local times closer to dusk implies that the density inversion can be complicated by the existence of the plasmatail or drainage plumes.

SM52A-0537 1330h POSTER

Dynamics of the Plasmapause Location After SSC

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We study the radial motion of the plasmapause in response to an SSC. The plasmapause is identified as the inner most steep radial density gradient using the CRRES plasma wave receiver data. CRRES data from thirty SSC intervals are used in this statistical study. The 10-hour CRRES orbit allows us to determine the plasmapause dynamics at two local time sectors every 10 hours. We find that the plasmapause location generally moves both inward and outward on average ± 1 Re prior to an SSC on this timescale. In the dawn local time sector, a systematic inward shift of about 1 Re is observed within the first 10 hours following the SSC. The motion then returns to pre-SSC variability. In the dusk sector a systematic outward shift of nearly 2 Re is observed within the first 10 hours following an SSC before it returns to pre-SSC variability.

SM52A-0538 1330h POSTER

ULF Waves - Pc5 range - from the solar wind to the ground during high speed solar wind streams

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We show a clear correlation between the power in ULF waves (Pc5 range) inside and outside Earth's magnetospere during high speed streams in 1995. We find that the peak power in high speed streams is in the 0-10 mHz range, particularly below 2 mHz, where the Pc5 range is defined as 1-10 mHz. We trace the waves beginning 200 R_E upstream using Wind data to waves just upstream from Earth's bow shock and in the magnetosheath using Geotail data to waves on the ground at the Kilpisjarvi ground station. We compare the total power in the Pc5 frequency from the upstream waves to the total power from Pc5 pulsations at the Kilpisjarvi ground station. We find that the pattern of increases and decreases in ULF wave power at Pc5 frequencies correlates in all regions; between the solar wind and the ground the correlation coefficient is 0.61. The total power in the solar wind is about a factor of 10 less than that on the ground, but the total power increases in the magnetosheath to values comparable to the ground. This suggests that solar wind waves may provide a ready source for the magnetosphere. In agreement with earlier studies we find that the ULF waves in the central region of the high speed streams are Alfvénic and in the compression region at the leading edges have higher amplitudes but are not purely Alfvénic. In contrast to earlier studies we find that the trailing edges are not purely Alfvénic. In the magnetosheath the Alfvén mode is less pure in the central region of streams, and is most likely mixed with other modes due to turbulence.

SM52A-0539 1330h POSTER

Dusk-sector Pc6 Pulsation Activity Related to Magnetopause Oscillations During a High Solar Wind Speed Event.

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We present an interval of long-lasting Pc6 pulsations following an extremely active day, which may shed light on the communication between ULF waves and high-energy electrons. Virtually monochromatic large amplitude highly-polarised pulsations were observed by the CANOPUS magnetometer chain at dusk for many hours, during which the Cluster spacecraft constellation traversed the dusk magnetopause. The solar wind conditions are very steady, the solar wind speed is fast, and time series analysis of the solar wind data shows no significant power concentrated in the Pc6 band. Many radars of the SuperDARN HF network observed clear pulsations of similar frequencies as these radars rotated into the dusk sector ionosphere. The pulsations are observed in geosynchronous LANL SOPA data at all local times. While Cluster is in the vicinity of the magnetopause, it provides clear evidence of boundary oscillations with essentially the same periodicity as the ground and geosynchronous observed pulsations. This event is an excellent example of global ULF activity driven by compressional waves which are in turn driven by magnetopause oscillations. These oscillations are

clearly not present in the solar wind, and the frequency is clearly selected by the magnetopheric characteristics. The fact that these oscillations are observed globally in the magnetosphere, but only in the dusk sector in the ionsphere, supports the idea that local time distribution of ground-observed ULF pulsations is at least partly due to the ionospheric response to ULF waves.

SM52A-0540 1330h POSTER

Comparison of ULF Plasma and Magnetic Field Waves Inside the Foreshock and Magnetosheath.

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Large amplitude plasma and magnetic field ULF waves are typical features in the foreshock and in the magnetosheath but the relationship between the waves in each region is not understood. We investigated ULF plasma and magnetic field waves using simultaneous measurements from the solar wind near the bow shock and from the magnetosheath using the INTERBALL-1, IMP 8 and GEOTAIL spacecraft. Plasma and magnetic field data with time resolution up to 1/16 s were used. We have found significant difference in the properties of ULF waves in the foreshock and magnetosheath. Ion flux and magnetic field magnitude variations in the foreshock are strongly positive correlated (consistent with fast magnetosonic waves) whereas in the magnetosheath such correlations are weak and sometimes negative. Power spectra of the ion flux and magnetic field variations in the range from 0.0002 to 5 Hz in the foreshock are very similar and their slope (especially in the high frequency part of this range) is significantly steeper than power spectra of magnetosheath data. Both case studies and statistical studies show that the amplitude of ULF waves in the magnetosheath strongly depends on the type of the bow shock. The amplitudes of the plasma and magnetic field variations behind quasi-parallel bow shocks are on average about two times larger than those behind quasi-perpendicular shocks.

SM52A-0541 1330h POSTER

What is the Correlation Length of ULF Pulsations in the Magnetosphere?

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A combination of simultaneous measurements from high-altitude, low-altitude and ground-based instruments is used to explore the large-scale coherence of ULF pulsations in the magnetosphere. Periodogram analysis of the time series measured at various regions of the magnetosphere reveals that the energy in the pulsations is consistently concentrated in a few discrete peaks. These peaks are found simultaneously in the electrojet intensifications, geosynchronous dipolarizations and energetic particle injections, plasma and magnetic field oscillations in the plasma sheet, and magnetic field oscillations in the tail lobes. The evolution of the large-scale correlation of the magnetosphere is tracked by examining the correlation matrix of the time series filtered into various frequency bands, over successive time intervals. We define a measure of coherence at each time interval as the correlation length that gives the best fit to an exponential decay of correlation with increasing separation. When the correlation length is examined over a range of geomagnetic activity levels, it becomes apparent that substorm expansion onsets establish a high level of coherence (long correlation lengths) in the magnetosphere at all ULF frequencies considered (0.5-6.0 mHz). However, as the substorm progresses into a state of expanded oval and plasma sheet, long correlation lengths are observed only at certain discrete frequency bands. In the example analyzed, there was one band extending between 1.5 and 2.0 mHz. The discrete frequency bands of long correlation length appear to be dependent of the solar wind forcing, which was observed at a lower frequency (below 1.0 mHz).

SM52A-0542 1330h POSTER

Relation between Field Aligned Currents, Electrons and ULF Waves

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ULF waves at frequencies of the order of the proton gyrofrequency have been identified as Current Driven Alfvén Waves (CDAW) resulting from a coupling between the Shear Alfvén (SA) and Fast MagnetoSonic modes via a parallel drift of the electrons with respect to the ions. These waves are systematically observed just at substorm onset at the geostationary orbit, as well as further in the Earth magnetic tail, and in the auroral region. Magnetic measurements (DC and waves) at four separate CLUSTER locations allow us to identify the free energy source of these waves by measuring the current density near CLUSTER apogee, and to study their propagation along the field lines. When the waves propagate along the field lines, they undergo a conversion mode into SA waves. CDA and SA waves have a parallel electric field component which is > 2 % of the perpendicular component. This parallel electric field component leads (via Landau damping), to strong parallel diffusion of the electrons along closed field lines, as evidenced by the electron distribution. The diffusion time is much shorter than the bounce period of electrons, thus it is a very efficient process to reduce the parallel current.

SM52A-0543 1330h POSTER

Energy Transport in the Terrestrial Polar Cap Regions by Alfvén Waves as Observed by the Electron Drift Instrument (EDI) Aboard the CLUSTER Spacecrafts

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We present analysis of low frequency, magnetohydrodynamic (Alfvén) waves observed during multiple passes of the CLUSTER satellites over both the northern and southern polar cap regions. Electron Drift Instrument (EDI) measurments of the wave electric field, combined with Fluxgate Magnetometer (FGM) measurments of the wave magnetic field are used to characterize wave mode, strength, polarization, and energy and propagation direction. Presently, our survey of these wave events reveals predominantly transverse waves with energy transport during northern (southern) passes directed largely into the northern (southern) ionosphere. Although this preferential direction exists, many of our cases have very strong standing components, resulting in virtually no preferred direction for energy transport. This poses an interesting problem in light of the fact that these polar cap field lines are presumed to be open. We will also discuss possible solar-terrestrial energy transfer mechanisms and magnetopause configurations which make the existence and characteristics of these waves possible.

SM52A-0544 1330h POSTER

Quasi-linear Diffusion Coefficients for EMIC Waves in a Multi-species Plasma

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EMIC waves, with frequencies below the local proton gyrofrequency, are believed to play an important role in the dynamics of ring current ions and outer zone electrons, especially during disturbed conditions. Their properties are complicated by the presence of heavy ions, He^{+} and O^{+}. Considerable work has been done on their generation and propagation, but their effect on test particles is less well studied. Here it is shown that analytical/computational techniques developed for the efficient calculation of quasi-linear diffusion by whistler waves can be applied to left-hand polarized EMIC waves. Bounce-averaged pitch angle and energy diffusion coefficients for electrons and ions will be presented.

SM52A-0545 1330h POSTER

Finite Element Modeling of Nonlinear Evolution of Dispersive Field Line Resonances in Stretched Magnetic Fields

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Using a two-dimensional finite element code, we investigate the nonlinear interaction of shear Alfvén wave (SAW) field line resonances (FLRs) and ion acoustic waves on stretched magnetic field lines in Earth's magnetosphere. Previous calculations on stretched field lines were based on a set of linearized equations or a quasi linear form of the equations with an envelope approximation. Here, we account for a consistent set of reduced non linear MHD equations. Our model also includes the effect of electron inertia, finite ion Larmor radius and electron thermal pressure. Three representative magnetic field configurations are considered, corresponding to a pure dipolar, weakly and strongly stretched field lines. It is shown that the eigenmode frequency in the stretched case considered is in the 1-4 mHz range, in agreement with observations near midnight. A significant nonlinear evolution of the wave is seen in vicinity of the resonance. The strong nonlinearity and dispersion can cause SAW to be self-trapped inside density cavities when electron inertial dominates. Double density structures are seen, however, if finite ion gyroradius and electron thermal pressure dominates. Finally, the stretched geometry results in a larger density cavities and parallel electric current.

URL: http://www.space.ualberta.ca/~jlu

SM52A-0546 1330h POSTER

Three Dimensional Modelling of Magnetospheric Plasmas

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Preliminary results are presented from a three dimensional simulation model of magnetized plasmas in the magnetosphere, in the ideal and resistive MHD

approximation. The model is based on a finite element discretisation of the mass, momentum and energy equations using an unstructured tetrahedral mesh. The advantages of this approach, compared with the more familiar approaches using structured meshes or unstructured meshes with a fixed orientation, is discussed. In particular, it is shown that the mesh may be aligned along the magnetic field lines, thus preventing or greatly reducing unphysical diffusion in the direction perpendicular to the magnetic field. Example results are presented for the propagation of Shear Alfvn waves in the magnetosphere.

SM52A-0547 1330h POSTER

Hybrid Simulations of Nonlinear Magnetospheric Alfven Waves

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A two-dimensional magnetohydrodynamic-gyrokinetic hybrid particle-in-cell initial-value code has been developed to simulate the nonlinear evolution of Alfven-ballooning modes destabilized by the drift-bounce resonance of energetic particles in the Earth's magnetosphere. The physical model is based on the analytical formulation developed for two-component (core and energetic) plasmas by Chen and Hasegawa [1991]. In the conditions of interest, the core component supports the magnetohydrodynamic Alfven oscillations, while the energetic component provides the instability drive. Recent one-dimensional linear investigations have numerically demonstrated the energetic particle resonant excitation along a single field line [Dettrick, Chen, Zheng, 2002]. In such linear studies, the energetic particles are taken to follow the unperturbed equilibrium phase-space trajectories. As the unstable modes evolve into the nonlinear state, the finite-amplitude perturbations may significantly alter the phase-space trajectories of the resonant particles. In particular, there will be perturbed radial drifts of particles, resulting in the spatial detuning of the wave-particle resonant condition and, hence, possible nonlinear saturation. The relevant features and theoretical results will be discussed in details.

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SM52A-0548 1330h POSTER

IMAGE-EUV Observation of Large Scale Standing Wave Pattern in the Nightside Plasmasphere

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We present analyses of a nightside plasmaspheric pattern of bifurcated, filamentary He^+ 30.4-nm emission enhancements observed by IMAGE EUV between ∼19:40-22:13 UT on 28 June 2000 that indicate the presence of a large-scale, global ULF standing wave pattern. Analysis of coincident IMAGE magnetometer chain data reveals that these ULF waves extend across the magnetic latitude-longitude range of the chain and possess multiple spectral features between 0.6-5.0-mHz (3-30 minute period). Additionally, analysis of ACE SWEPAM data reveals similarly structured spectral components in the solar wind. Collectively, these analyses lead to the conclusion that the observed large-scale ULF wave pattern is the result of solar wind pressure pulses ringing the inner-magnetosphere.

SM52A-0549 1330h POSTER

Altitude Profiles of Plasma Density in the Trough Region derived from Radio Plasma Imager Observations on the Image Spacecraft

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One of the main objectives of the Radio Plasma Imager (RPI) on the IMAGE spacecraft is the observation of the Earth's magnetized plasma from the satellite's polar orbit, with apogee of approximately 8 Earth radii and perigee near 1200 km altitude. During perigee passes in the trough region just poleward of the plasmapause, RPI echoes indicate 200 - 300 kHz HF sounding pulses are often ducted to higher altitudes by irregularites near the plasmapause surface. The echoes appear in an HF frequency range just above the Z mode cutoff at the spacecraft location. Multiple reflections occur within these ducts from reflection points below and above the spacecraft, resulting in multiple echoes received on IMAGE. Because the multiple echoes allow enhanced time resolution, the apparent range of the duct upper reflection point can be determined to a high degree of accuracy. Using the range information in conjunction with ray tracing calculations, we derive altitude profiles of the cold plasma density in the trough region, a region where the characteristics of the cold plasma density are poorly known.

SM52A-0550 1330h POSTER

A Simple Approach to Reproducing IMAGE/RPI-Derived Field-Aligned Electron Density Profiles During Plasmaspheric Refilling

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Magnetic field-aligned electron-density (Ne) profiles can be calculated from active soundings using the Radio Plasma Imager (RPI) on the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite. By observing these profiles under different geomagnetic conditions, the underlying physics that control the Ne distribution can be investigated.

In this presentation RPI observations will be used to show that a magnetic field line depleted of plasma has an Ne distribution approximating a collisionless (CL) profile, while a saturated field line has a diffusive equilibrium (DE) profile. Furthermore, by using the RPI-derived profiles it is possible to observe the transition from the depleted CL profile to the saturated DE profile. Using computationally simple CL and DE models as upper and lower boundaries respectively, methods to vary the distribution between these two extremes that reproduces the refilling of the field-aligned Ne profiles observed by RPI will be presented. Furthermore, the results of this approach will be compared with the Multi-Species Kinetic Plasmasphere Model (MSKPM), a kinetic field-aligned model that simulates the plasmaspheric refilling by single particles from the underlying exosphere.

Comparisons of the Global Plasmasphere Ionosphere Density (GPID) model with IMAGE Ne observations from passive and active RPI operations will demonstrate the increased accuracy of GPID when the improved CL-DE field-aligned Ne distribution is included in the model.

SM52A-0551 1330h POSTER

Density irregularities observed near the plasmapause by the CRRES satellite at the onset of magnetic disturbances

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High resolution (8-sec) cold plasma density data derived from plasma wave observations is available for over 1000 orbits of the CRRES satellite (1990-1991). We will present the results of a study of density irregularities near the plasmapause with special emphasis on the midnight to dawn local time sectors during the onset of magnetic disturbances. We will examine where and under what geophysical conditions irregularities occur in an attempt to understand the role they may play in the shedding of plasma by the plasmasphere.

SM52A-0552 1330h POSTER

Ionic Structures Observed in the Plasmasphere by CLUSTER

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Data provided by the Cluster Ion Spectrometry (CIS) instruments are used to analyze Cluster crossings of the plasmasphere. The Cluster spacecraft orbit the Earth in a highly eccentric polar orbit at 4 Re perigee, and this permits them to sample the ring current, the radiation belts and the outer plasmasphere. CIS is capable of obtaining full three-dimensional ion distributions (about 0 to 40 keV/q) with a time resolution of one spacecraft spin (4 sec) and with mass-per-charge composition determination. In addition the CIS Retarding Potential Analyzer (RPA) allows more accurate measurements in the about 0 - 25 eV/q energy range, covering the plasmasphere energy domain.

The low-energy ion distribution functions, obtained by CIS-RPA during the perigee passes, reveal new and interesting features, not reported by previous missions. The ion discrimination capability of CIS reveals how the density profile is different for each of the main ion species (H+, He+, O+): H+ and He+ present mostly similar profiles; O+, however, is not observed as trapped plasmaspheric population at the Cluster orbit altitudes (R greater than 4 Re). Low-energy O+ is observed only as upwelling ion, on auroral field lines.

Detached plasmasphere events, that are observed by CIS during some of the passes at about 0.5 Re outside the plasmapause, are also present. The bi-directional distribution functions of these detached plasmaspheric populations allow us to distinguish them from upwelling ion populations.

The final new results we show concern the structure of the plasmasphere. The CIS multi-spacecraft measurements reveal very sharp boundaries at the plasmapause, less than 200 km thickness structures.

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SM52A-0553 1330h POSTER

Observations and Analysis of Discrete and Diffuse Whistler Mode Echoes Received by RPI on IMAGE

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We report on observations and analysis of discrete and diffuse whistler mode echoes received by RPI on IMAGE. Discrete whistler mode echoes have been identified on a number of days during the period when IMAGE was at low altitude (< 2000-6000 km) near its perigee in the southern hemisphere. The echoes are in the frequency range ∼13-300 kHz and show time delays of a fraction of a second, and longer time delays at lower frequencies, typical of whistler mode propagation. Out of the ∼300 cases examined, discrete echoes were detected in 24 cases. Ray tracing simulations performed in a limited number of cases indicate that these echoes are the result of reflections of RPI signals from the Earth-ionosphere boundary. By comparing measured time delays of RPI signals with those from ray tracing simulations it is possible to determine (1) nature of propagation, i.e., ducted or nonducted, and (2) the electron density along the ray paths. The diffuse whistler echoes have frequencies below local electron cyclotron frequency and are characterized by an apparent spread in their time delays. The echoes are in the frequency range ∼10-300 kHz and show well defined lower and upper cutoff frequencies. Out of 35 cases examined, diffuse echoes were observed in 16 cases, with 11 of them identified during the period when IMAGE was at low altitude (<1500 - 5000 km) near its perigee in the southern hemisphere, and five when IMAGE was at relatively high altitude (∼10,000-15,000 km) and mostly at geomagnetic latitudes ranging between 40-50°. In several instances, the diffuse echoes were accompanied by z-mode radiation and in some cases by free space mode echoes. The Z-mode radiation upper and lower cutoff are used to obtain local electron plasma frequency and gyrofrequency. We propose that diffuse whistler mode echoes are the result of scattering of RPI signals by field aligned small-scale (∼10-100 m) plasma density irregularities, commonly found in the low altitude magnetosphere. Preliminary analysis indicates that the small scale irregularities responsible for diffuse echoes are located within ∼1000 km of the satellite. A linear mode conversion mechanism, first proposed to explain spectral broadening of ground transmitter signals observed on satellites, can account for many observed features of these echoes including the diffuse nature and cutoff frequencies. The lower and upper cutoff frequencies and the time delay and its spread as a function of frequency can be used to determine the location and nature of plasma irregularities responsible for wave scattering.

SM52A-0554 1330h POSTER

Ray-Tracing Modeling of Guided Echoes Detected by Radio Plasma Imager on the IMAGE Satellite

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Using the Radio Plasma Imager (RPI) aboard the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite, radio echo signatures with discrete virtual range-frequency characteristics have been observed at different altitudes and magnetic latitudes varying from the polar cap to the equator. Long-range discrete echoes have also been observed to return from conjugate hemispheres. Such observations, being analogous to very similar past observations made in the ionosphere (at much lower altitudes), strongly suggest that the radio signals have been ducted by field-aligned irregularities, similar to the mechanism generally invoked to explain the ionospheric observations. Reinisch et al [2001] recently suggested another possible signal guiding mechanism due to the presence of field-aligned density gradients, such as might be present over the polar cap regions. In this scenario, field-aligned propagating radio signals can naturally follow the magnetic field lines without the trapping action of a density duct. In order to determine the mechanism responsible for guiding of long-range discrete echoes observed in the magnetosphere by the RPI, we have performed ray-tracing modeling of discrete echo propagation to investigate the plasma conditions needed to support ducting and wave-guiding by a field-aligned density gradient. This paper discusses the plasma models used and presents modeling results.

Reinisch, B. W., et al., Plasma Density Distribution Along the Magnetospheric Field: RPI Observations From IMAGE, Geophys. Res. Lett., 28, 4521-4524, 2001.

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The Transverse Dimensions of Whistler-Mode Chorus Emissions in the Source Region

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High-resolution electric field waveforms from the Wideband Plasma Wave Instrument (WBD) on the four Cluster spacecraft are used to study the spatial scale of whistler-mode chorus emissions. From a variety of measurements it is now known that chorus is generated very close to the magnetic equator, typically within 3 to 5 degrees of the magnetic equator. On April 18, 2002, a nearly continuous series of chorus observations were obtained as the four Cluster spacecraft passed south to north through the source region at about 4.4 Earth radii. The separation distances on this pass were unusually small, less than about 250 km along the magnetic field, and less than about 75 km transverse to the magnetic field. The six transverse baseline distances were also well distributed, from a minimum of 7 km to a maximum of 72 km. By computing the linear correlation coefficient of the chorus intensities across these six transverse baselines, the transverse size of the chorus wave packets can be estimated. A statistical analysis shows that the average transverse half-width of the chorus wave packets, based on a Gaussian fit, is about 35 km. This transverse scale size is quite small, implying that the transverse size of the source is also comparably small, only a few wavelengths. The small size of the chorus source region implies that the waves cannot be emitted in a narrow beam, but rather must be emitted over a substantial range of wave vector directions. The relatively broad beam width has important implications for the subsequent temporal evolution of the wave packet, and may explain why small but easily observable frequency shifts are sometimes observed fin the chorus elements detected by the various spacecraft.

SM52A-0556 1330h POSTER

Fine structure of storm-time chorus

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We discuss the lower band of chorus emissions below one half of the electron cyclotron frequency, measured in the source region by the four Cluster spacecraft during a geomagnetically disturbed period. We analyze the wave vector directions and Poynting flux, and we demonstrate the dynamic character of chorus sources. The electric field waveforms of chorus elements show a fine structure consisting of wave packets with a maximum amplitude above 30 mV/m. We analyze this fine structure using a sine-wave parametric model with a variable amplitude. Simultaneous observations on the four Cluster spacecraft show that the characteristic scale of the fine structure appears to be much smaller than the characteristic scale of the chorus elements. Using delays of time-frequency curves obtained on different spacecraft, we deduce the propagation direction. Our observations show antiparallel propagation directions for two neighboring chorus elements, less than 0.1 s apart.

SM52A-0557 1330h POSTER

Lightning Generated Whistlers Observed With the CLUSTER Satellites Outside the Plasmasphere

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Lightning generated whistlers are ubiquitous within the plasmasphere at both high and low altitudes, and these waves can propagate efficiently in both ducted and non-ducted modes.

On the other hand, in the magnetospheric region outside the plasmasphere,lightning generated whistlers are commonly observed at low altitudes (< 6000km) but only rarely at higher altitudes near the magnetic equatorial plane. The reasons for the lack of these waves at higher altitudes are not well understood. In the present paper we use data from the Wide Band Plasma (WBD) instruments on the 4 CLUSTER spacecraft to study the characteristics of lightning generated whistlers observed on 4 separate days in 2001 at L shells ranging from L = 4 to L = 5, magnetic latitudes ranging from -20° to 10°, and Kp indexes ranging from 3 to 6. The propagation paths of the lightning generated whistlers are determined using a 2D ray-tracing model to calculate the ray paths and group delays from the lower ionosphere to each of the 4 CLUSTER spacecraft over a range of frequencies (1 kHz < f < 8 kHz).

The unprecedented multipoint whistler measurements possible from the 4 CLUSTER spacecraft allow a much more precise determination of the propagation path of the whistlers than was possible in the past using single spacecraft. We compare the characteristics of the CLUSTER whistlers with those commonly observed inside the plasmasphere and delineate the differences in spectra and propagation path. The characteristics of the causative lightning discharges are also compared. On the basis of our study we identify a number of factors that appear to result in the general lack of lightning generated whistler at high altitudes outside the plasmasphere.

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Temporal Signatures of Electron Precipitation Induced by Magnetospherically Reflected Whistlers

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Recent measurements of electron precipitation into the drift loss-cone made by the SAMPEX satellite have shown that lightning generated, magnetospherically reflecting whistler waves can play a significant role in electron precipitation from the radiation belts. Following on from previous work that has only considered the first hop of the whistler wave, or taken into account magnetospheric reflections in a crude way, we use an extensive raytracing and interpolation algorithm, and calculate the detailed frequency-time signatures of a magnetospherically-reflecting whistler wave caused by a single cloud-ground lightning stroke, at all latitude points along a certain L-shell. Using this wave energy distribution, we calculate the flux of precipitating, energetic electrons from the radiation belts, along the specific L-shell under consideration (we use L=3 for illustration), due to wave-particle interactions at every point along the field line.