SM12A-0492 1330h POSTER

Role of field-aligned current closure via the Pedersen, Hall, and atmospheric displacement current in the formation of ionospheric current system

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To consider the transmission process of electromagnetic disturbances carried by field-aligned current (FAC) into the ionospheric and atmospheric loading region, we construct a simplified model for the ionosphere-atmosphere-Earth electromagnetically coupled system. The ionospheric slab (conductor) separated by Earthfs ground plane by the atmospheric region forms a capacitor. Outgoing current flows in the ionospheric slab and return current flows in the ground plane, forming an inductor. Thus, the ionospheric slab acts as if it has a capacitor in parallel to a ground inductor in series. Electric energy is stored in the dielectric atmospheric region due to the electric field between ionospheric slab and ground plane. Charge present in the ionospheric slab and induced in the ground plane creates a shunt self-capacitance. Magnetic energy associated to currents is stored in the ionospheric slab. The magnetic field links the loop formed by the conductor and ground plane and creates a series self-inductance.

This model clarifies the roles of the FAC closure via the currents in the ionosphere-atmosphere-Earth electromagnetically coupled system. Electromagnetic energy associated with FACs is dissipated in the ionosphere through Joule dissipation of the ionospheric divergent Pedersen current carried by ions. On the other hand, the FAC closure via the divergent Hall current carried by electrons increases the energy of the rotational Hall current, causing it to radiate Poynting fluxes that lead to the growth of a poloidal-type magnetic field in the magnetosphere and atmosphere. Furthermore, the FAC closure via the atmospheric displacement current provides Poynting fluxes for the generation of a non-local ionospheric current system. In this study, we will show the physical details of the redistribution process of the FACfs momentum and energy into current in the ionosphere-atmosphere loading region.

SM12A-0493 1330h POSTER

The Response of the Tail to Extended Intervals of Bz < 0: Periodic Unloading Versus Steady Magnetospheric Convection

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The purpose of this study is to examine magnetospheric responses to periods of relatively steady negative Bz component of the interplanetary magnetic field (IMF). In particular, we wish to determine whether these intervals result in periodic tail loading-unloading or a transition, at some low value of negative Bz to steady magnetospheric convection. Magnetic cloud events during 1995 – 2002 identified by the WIND/MFI team were searched for intervals when IMF Bz was southward more than five hours with a standard deviation less than 20% of the average Bz. We will present an overview of the 7 events meeting these criteria for which Geotail, IMP8, or Interball data were available. Examples of both steady magnetospheric convection and periodic loading-unloading were found. Conditions leading to the development of these magnetospheric states will be discussed.

SM12A-0494 1330h POSTER

Spatial distribution and variation of narrow L-shell bands in the plasmasphere supporting field-aligned propagating modes as observed by the RPI/IMAGE satellite

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Field-aligned propagating (FAP) modes have been a regular characteristic of the RPI/IMAGE plasmagrams from the beginning of the experiment. LF/MF (in the range of 3 kHz to 3 MHz) transmitted radio signals from the satellite propagate in the magnetic meridian plane along the magnetic field line passing through the satellite position to both the northern and southern hemispheres where they reflect at a level that depends on the sounding frequency. This analysis has shown that these hemispherical reflections occur on about 20% of the plasmagrams while the IMAGE satellite is between L = 2.5 and L = 4.5. Occurrences of these FAP plasmagrams were consistently organized into two L-shell bands. The first band was found at L = 3.2± 0.2 moving in and out slowly over a period of a few days. This band, with a width of DL $\gg$ 0.2, is always present. The second observed band also supports hemispherical propagation and was found at higher L-shells, ranging from L = 3.5 under quiet magnetic conditions, moving to L = 4.0 as the level of magnetic activity increases. During high magnetic activity conditions this outer band disappears. When RPI/IMAGE passed through the inner band the probability of the appearance of FAP modes was 98

SM12A-0495 1330h POSTER

April 2000 Geomagnetic Storm: Ionospheric Drivers of Large Geomagnetically Induced Currents

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Geomagnetically induced currents (GIC) flowing in technological systems on the ground are a manifestation of space weather. Due to the proximity of very dynamic ionospheric current systems, GIC are of special interest at high latitudes where they are known to cause harm e.g. for normal operation of power transmission systems and buried pipelines.

Despite numerous studies on GIC, there still exists no well established picture of the detailed structure of the ionospheric currents driving large GIC. Although some rough estimations of large-scale electrojet intensities and structures during GIC events have been carried out, no rigorous study of the ionospheric source currents has been made so far.

In this study, a single intense geomagnetic storm event on April 6-7, 2000 is investigated. During the event, large GIC were measured in technological systems both in Finland and in Great Britain, providing a basis for a detailed GIC study over quite a large spatial scale. By using these GIC data and geomagnetic data from north European magnetometer networks, the ionospheric drivers of the large GIC during the event were identified and analyzed.

URL: http://www.geo.fmi.fi/MAGN/GIC

SM12A-0496 1330h POSTER

Relativistic electron loss investigation from multiple LANL GPS and GEO, HEO and NOAA Spacecraft

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Losses are the most dominant feature during the onset-phase of geomagnetic storms, and strong wave-particle interactions are as part of many of the proposed acceleration mechanism, which often leads to losses of particles.

From existing measurements in the drift-loss cone at low altitude it is known that energetic electron precipitation increases during active times, but it is not known whether this increase is due to increased loss rates or simply an overall increase in the radiation belt population. Furthermore, several of the wave particle interaction processes that may be responsible for both losses and acceleration of are thought to exhibit strong local time preferences - dawn to midnight for whistler chorus, afternoon to dusk for EMIC waves, and are active during different phases of a geomagnetic storm. We can test these hypotheses directly.

Here we intend to use low altitude data from the recent NOAA spacecraft that sample the radiation belts 14 times a day at 4 different local times separated roughly by 6 hours. These spacecraft sample the local electron population in two directions, which for most regions yields a measurement close to the loss cone and one close to the locally mirroring population. By investigating the RATIO of these two detectors we can determine the times during which there are more precipitating versus trapped particles. We intend to compare our results to the in-situ equatorial observations from HEO (near L=2), LANL GPS (near L=4) and LANL GEO (near L=6.6), which can sample the full trapped distribution.

SM12B MCC: 124 Monday 1330h

Discontinuous Cusp and Magnetospheric Boundary Layers II

Presiding: **S Wing,** Applied Physics Laboratory**; K J Trattner,** Lockheed Martin ATC**; H E Spence,** Boston University

SM12B-01 1330h INVITED

Radar and Particle Observations of the Double Cusp: Resolving Spatiotemporal Ambiguities

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The role of radar observations in resolving the ambiguities between spatial and temporal interpretations of the double cusp will be outlined, and related to the wider context of understanding the large-scale physics of reconnection. Our recent work has established that dayside reconnection under conditions of significant IMF y-component can lead to a split reconnection x-line on the magnetopause, which is observable in the polar ionosphere when the geometry of field-line mapping to the ionosphere is favourable. In this presentation, simultaneous DMSP particle data and SuperDARN radar data will be shown from a split x-line

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event, demonstrating the connection between split x-line radar signatures and double-cusp particle signatures. Separated reconnection sites will in general have different histories and velocity filter characteristics: the observable consequences of this in the double cusp signature will be discussed. Both temporal and spatial variability in the reconnection site can give rise to a particle cusp discontinuity, and the utility of ground-based data in determining which of these is more important in any particular case will be assessed.

SM12B-02 1345h INVITED

Multiple Cusps: Temporal and Spatial Injections

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The high-altitude cusp is the region of principal particle entry into the magnetosphere. However, that entry can be quite turbulent and time-dependent, especially when observed at high altitudes. A clean single ion energy-versus-latitude dispersion is observed at low-to-mid-altitudes when the interplanetary magnetic field (IMF) is steady and southward; however, changes in the magnetic field direction or particle pressure can result in multiple injection signatures when observed from low altitudes. In addition, during times with the IMF has a strong dawn-dusk component, a single hemisphere can observe precipitation from merging sites in both hemispheres simultaneously, but at different locations. A spacecraft traveling through these precipitation regions could measure either a double dispersion, a V-shaped dispersion, or a "stairstep" ion dispersion, depending on the spacecraft travel direction and the flow directions. V-shaped dispersions can arise from simultaneous low- and high-latitude reconnection.

New data from the Cluster mission can be used to help distinguish among various models of the double cusp. Sequential identical ion dispersions indicate predominantly spatial structures, whereas changeable structures indicate temporal variability. Electron pitch angle distributions can also be used to distinguish among the various options, since electrons exhibit an energy-versus-pitch angle dispersion only when an active X-line is crossed.

SM12B-03 1405h

The Location of the Reconnection line for Northward IMF

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The interconnection of magnetic fields through magnetic reconnection at the magnetopause is the dominant process for mass, energy and momentum transfer from the Earth's magnetosheath to the magnetosphere. Earlier studies on the location of the reconnection line during northward IMF conditions and high solar wind dynamic pressure revealed an approximately equal probability for anti-parallel and component reconnection between the interplanetary magnetic field (IMF) and the geomagnetic field. Using data from the Toroidal Imaging Mass Angle Spectrograph (TIMAS) on the Polar spacecraft we have increased our survey over the entire cusp data base, selecting events with northward IMF but no restrictions on the solar wind dynamic pressure. The distance to the reconnection line is calculated by using the proven method of 3D cuts of the proton distribution function in the cusp to identify the low energy cut-off of precipitating ions. Anti-parallel or component reconnection is identified by tracing the distance to the reconnection line along the geomagnetic field line to the reconnection site. We find that both reconnection scenarios, antiparallel and component reconnection, occur for the same IMF conditions. The observation of either antiparallel or component reconnection depends entirely on the location of the observing spacecraft.

SM12B-04 1420h

Cluster Observations of the appearance of a double cusp

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The polar cusp is moving in latitude according to the interplanetary magnetic field (IMF) orientation, from about 75 deg. ILAT for Bz negative to about 82 deg. ILAT for Bz positive. This is explained by the magnetic reconnection, between the solar wind and the magnetosphere, taking place at the subsolar point for Bz negative and in the tail lobes for Bz positive. For the first time we can measure, in-situ, the motion of the polar cusp with the Cluster spacecraft. The four Cluster spacecraft are crossing the mid-altitude polar cusp, in a "string of pearl" configuration, and are therefore the ideal tool to study the motion and evolution of the cusp on time scale of a few minutes up to 45 min. On 30 August 2001, the four Cluster spacecraft crossed the mid-altitude polar cusp (4-6 Re) around 12.5 H local time with SC4 entering the cusp at 1532 UT, SC2 following 1.5 min later, SC1, 3 min later and finally SC3, 45 min later. SC4 and SC1 observed a typical poleward ion dispersion associated with Bz negative. SC3 observed first the same dispersion starting at about 74 deg. ILAT, however at 81 deg. ILAT a second dispersion was observed. The IMF was southward during the dispersion and became slightly positive during the second dispersion. DMSP satellites data, SuperDarn and global MHD simulation model, all support a motion of the cusp poleward which would explain the cusp encountered twice by Cluster. In addition, burst of high energy ions are observed by Cluster near the equatorial boundary of the cusp which could be explained by the cusp motion.

SM12B-05 1435h INVITED

Dynamics of the Cusp - Signature of Spatial and Temporal Variability

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The cusp is the region in the high-latitude dayside magnetosphere where the magnetosheath plasma has direct access to the magnetosphere and ionosphere along open field lines. Because of this direct connection to the dayside magnetopause, the cusp is expected to vary temporally and spatially with changes in the rate and location of reconnection on the magnetopause. Indeed, variability of the cusp properties is commonly observed. An important challenge is to use the cusp observations to study the reconnection process; however, it is often difficult to determine if the observed cusp structure is due to spatial or temporal variations in magnetopause reconnection. In this presentation, we will review the basic properties of the cusp and describe the expected cusp structure resulting from temporally and spatially varying reconnection. Observational evidence for both types of variability will be shown, and the implications for reconnection structure and dynamics will be discussed.

SM12B-06 1455h

Comparison of Dayside Magnetic Separatrix Signatures in HF and Incoherent Scatter Radar Data

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Remote sensing of dayside magnetospheric reconnection by ground-based radar relies on accurate identification of the open-closed magnetic field separatrix. In one technique - using incoherent scatter (IS) radar - the signature of the separatrix is the poleward edge of dayside boundary plasma sheet (BPS) electron precipitation, where the precipitation regime is inferred from the measured ionization profile versus altitude. In another technique - using high frequency (HF) radar -the signature of the separatrix is the equatorward edge of high spectral width coherent backscatter.

In this study, we compare the latitude of these two signatures in simultaneous HF- and IS radar measurements on 20 January 1999, and show that the consistency between these signatures depends on the local reconnection electric field. The two signatures yield a consistent identification of the separatrix at local times where the reconnection electric field is low. In the merging gap, however, where the reconnection electric field is high, the signature in the HF radar data moves several degrees equatorward of the signature in the IS radar.

Investigation of the HF radar backscatter autocorrelation functions reveals no significant difference in the two regions. Investigation of the ionization profiles calculated from the IS radar data, however, indicates that the precipitation is distinctly softer in the merging gap than elsewhere. These observations are backed up by DMSP precipitating particle observations, which indicate that the IS radar technique is properly identifying the poleward edge of the dayside BPS precipitation, but also that there is an abrupt transition in the BPS character at exactly the latitude indicated by the HF radar signature. These observations are consistent with the theory that a portion of the dayside BPS is on open magnetic field lines. The latitudinal width of the dayside BPS on open field lines is given by $\Delta\Lambda = 0.14E_{rec}$.

SM12B-07 1530h

Accelerated Plasma Flows in the Cusp Boundary Layer: A CLUSTER-FAST-Ground Conjunction Stud

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Observations during a triple magnetic conjunction CLUSTER-FAST-Sondestrom are examined. CLUSTER was on an outbound pass through the exterior cusp. The IMF pointed south-west throughout. A solar wind dynamic pressure release, whose arrival at CLUSTER can be very well timed, shifted CLUSTER into the cusp boundary layer at the poleward edge of the cusp (geomagnetic $B_z < 0$, $B_x > 0$). There it observed 5 flow bursts and magnetic perturbations which are Alfvenic in nature. We interpret these flow events as being due to a sequence of reconnected flux tubes passing over CLUSTER (i.e., flux transfer events, FTEs). This interpretation is further supported by (i) the observation at FAST of a staircase cusp signature on magnetic field lines nominally connected to CLUSTER; (ii) the observation by the Sondestrom and CUTLASS radars of a sequence of pulsed poleward enhancements of ionospheric flows (PIFs) which are (a) in one-to-one correspondence with the flow bursts at CLUSTER and which (b) are well known from previous work to be an ionospheric signature of FTEs; and (iii) Observations of the ion flow bursts at Polar, situated in the magnetosphere further downstream of CLUSTER, whose directional characteristics are consistent with the interpretation proposed above. The work extends previous studies of signatures of FTEs by showing flow bursts associated with reconnection at sub-cusp latitudes but which are seen behind the cusp.

Acknowledgements: This work is supported by NASA Grants NAG 5-10883, NAG5 - 11803, NAG 5-11676, and NAS5-31283.

SM12B-08 1545h INVITED

Cluster Observations of Reconnection at the Magnetopause and in the Cusp: Implications for the Large-Scale Nature of Reconnection

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We survey the occurrence of reconnection at the magnetopause and in the cusp using measurements from the CIS and FGM experiments. We present evidence for reconnection occurring both equatorward and poleward of the cusp for different IMF orientations. The multi-spacecraft measurements reveal that under steady IMF conditions, reconnection is large scale and occurs continuously over an extended period of time, but the reconnection rate may be modulated.

SM12B-09 1605h INVITED

The Discontinuous IMF-Dependent Entry of Solar Wind Ions into the Magnetosphere

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We have investigated the entry of solar wind ions into the magnetosphere by tracing particle orbits in time-dependent electric and magnetic fields obtained from a three-dimensional global magnetohydrodynamic (MHD) simulation of the magnetosphere. The MHD simulation begins with a 2-hour period of northward interplanetary magnetic field (IMF). The IMF then rotates by 45^o every two hours. The final four hours of the simulation has southward IMF. Ions were launched in the solar wind at time intervals corresponding to the midpoint of each IMF interval and collected after crossing the magnetopause current layer. We found that the region of the upstream solar wind that mapped to the magnetopause entry regions was parallel to the y z orientation of the IMF. Moreover, ions generally entered into the magnetosphere through the cusps and through the reconnection regions for that IMF orientation. In the cases with a finite IMF B_y, the cusp entry region was stretched toward lower latitudes and had a larger longitudinal extent than the northward or southward IMF cases and showed similarities to the double cusp feature observed by the DMSP spacecraft. The characteristics of ion entry for each IMF orientation as well as the acceleration of ions in the cusp and reconnection entry regions will be compared and analyzed.

SM12B-10 1625h

Double Cusp: Model Prediction and Observational Verification

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Our open-field line particle precipitation model has successfully simulated the large-scale particle precipitation features in the observed cusp, mantle, polar rain, and open-field line LLBL regions. When IMF is strongly duskward/dawnward and weakly southward, the open-field line particle precipitation model predicts the occurrence of a double cusp near noon: one cusp at lower latitude and one at higher latitude. The lower latitude cusp ions originate from low-latitude magnetosheath whereas the higher latitude ions originate from the high-latitude magnetosheath. The lower latitude cusp is located in the region of weak azimuthal E x B drift, resulting in a dispersionless cusp, as would be observed from a typical meridional trajectory of a polar orbiting satellite. The higher latitude cusp is located in the region of strong azimuthal and poleward E x B drift. Because of a significant poleward drift, the higher latitude cusp dispersion has some resemblance to that of the typical southward IMF cusp. Occasionally, the two cusps have such narrow latitudinal separation that they give the appearance of just one cusp with extended latitudinal width. From the 40 DMSP passes selected during periods of large (positive or negative) IMF By and small negative IMF Bz, 30 of the passes exhibit double cusps or cusps with extended latitudinal width. The double cusp result is consistent with the following new statistical results: (1) the cusp latitudinal width increases with |IMF By| and (2) the cusp equatorward boundary moves to lower latitude with increasing |IMF By|. Other satellites, e.g. POLAR, have also observed this double cusp signature.

SM12B-11 1640h

Cusp Electron and Ion Structures Observed by FAST

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The high-time resolution observations by FAST resolve burst-like electrons and nonmonotonic ion dispersion in the cusp region. The burst-like precipitating electrons are correlated with electric field variations in the frequency range of 0.2-1Hz, which are most easily explained as propagating Alfven waves. Alfven waves cause strong ion heating and outflow in the polar cap boundary acceleration region (dayside polar cusp and near-midnight polar cap boundary). Ion structures are associated with the direction and/or magnitude of the drift velocity which is in the opposite direction of the magnetic field perturbation in the Northern Hemisphere. From this it can be concluded that magnetosheath ion structures are a result of the spacecraft crossing flow streamlines. Each flow channel has its own history of dayside reconnection, therefore, the magnetosheath ion structures contain information of both the spatial and temporal variations of dayside reconnection.

SM12B-12 1655h

Global Observations of Flux Transfer Events and Their Effects on the Magnetosphere-Ionosphere System.

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Multi-instrument observations of the magnetosphere reveal the nature of direct coupling in the solar wind-magnetosphere-ionosphere system, namely dayside reconnection. A case study during which there was a highly favourable conjunction of an extensive array of spacebourne and ground-based instruments offered an excellent opportunity to study magnetic reconnection in situ, as well as its effects on the magnetosphere and ionosphere. Flux transfer events were observed by Geotail during an extended traversal of the dawn magnetopause. Extensive coverage of the entire dayside high-latitude ionosphere was achieved by all of the northern hemisphere SuperDARN radars, and accurate solar wind time delays were possible due to the position of the IMP8 spacecraft immediately upstream of the Earth's bow shock. The SuperDARN radars in the dawn sector, in the vicinity of Geotail's magnetic footprint, measured temporally varying convection velocities. Low-altitude satellites monitored both the size of the auroral oval and particle precipitation in the cusp footprint. Energy-dispersed cusp ions were detected by the DMSP-F11 spacecraft at the same time that an FTE was measured by the magnetically conjugate Geotail. Analysis of the field and plasma data at Geotail reveals details of the structure and motion of the newly reconnected flux tubes as they convected past the spacecraft. The implied location of magnetopause reconnection will be discussed.

SM21A MCC: Hall D Tuesday 0830h

Planetary Magnetospheres II Posters

(joint with P, SA, SH)

Presiding: **B H Mauk,** Applied Physics Laboratory**; R L Mutel,** University of Iowa

SM21A-0520 0830h POSTER

A Global Model of Jupiters Magnetospheric Field

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