(IMF) with two events:November 17, 1996 and March 26, 1998. DP2 magnetic field perturbations instantaneously begin from the polar cap to the dip-equator on the dayside indicating development of the global ionospheric currents that connect to the Region-1 Field-aligned currents (FACs). During the events, the SuperDARN measurements in the polar region showed dramatic changes in the ionospheric plasma flow from the multi-cell convection pattern associated with the northward IMF to the large scale two-cell pattern associated with the southward IMF. The dusk cell in the two-cell convection emerged and developed around a center of 15 MLT at 78 degrees magnetic latitude, as the reverse cells in the multi-cell pattern disappeared. We found that the reverse convection cells remained in the polar cap for the first six minutes while the DP2 current were developing. The observational results suggest that it takes about six minutes for the potential electric field of the Region-1 FACs to surpass that of the NBZ FACs in the polar cap when the IMF turns southward.

SM52D-04 1435h

Electrodynamics of Storm Time Auroral Disturbances

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The electrodynamics of magnetic storm-time auroral disturbances is contrasted with the electrodynamics of isolated, classical bulge-type auroral substorms. Global auroral images are used to organize in-situ electrodynamic data from satellites and ground magnetic data from a large array of stations. The distribution of onset locations, the conductance distribution, convection electric field, and the electrojet topology are all analyzed during the development of the main phase magnetic storm. It is found that the onset locations of auroral disturbances are generally later in local time during magnetic storms than for substorms. The convection electrojet throughout the post-midnight region into dawn dominates over the more classical premidnight wedge electrojet of substorms and continues over the long period of main phase development. Specific examples and statistical results will be presented, with dominant attention on the electrojet configuration and it relationship to the evolution of the Dst.

SM52D-05 1450h INVITED

What Features of Field Aligned Currents Might Global Scale Fits Miss?

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Much of the nomenclature for field aligned current systems is based on analyses of satellite magnetometer data consisting of visual inspection of time series traces. Recent statistical analyses take advantage of digital data processing and nearly continuous solar wind data coverage. These advances allow more mathematically sophisticated techniques using multiple parameter regression with upstream parameters and various global fitting techniques. For several reasons the new methods do not necessarily provide a better basis for understanding the current systems. First, because of dynamics in both solar wind/IMF and the magnetosphere itself statistical analysis over many passes, will suffer from temporal and spatial smoothing even when binned by solar wind/IMF conditions. Second, the solar wind/IMF measurements do not provide a perfect system state monitor due to variability in the solar wind and the associated time history effects on the magnetosphere, uncertainties in the convection time from L1 and dynamics in conditions actually imposed on the magnetosphere resulting from phenomena at the bow shock. Third, global fitting procedures have inherent limitations in spatial resolution determined by the spatial density of the input data which in turn is related to the resolution with which the governing' parameters are binned. By using data from the Iridium constellation we obtain a global snapshot' representation of the FAC system during stable IMF conditions to minimize problems with the first two effects. By comparing these results with Oersted we identify the features that are most likely to be missed in similar global-scale fit analyses. We find that currents near or at the polar cap boundary, often near the cusp, are the most likely to suffer from poor fidelity in large scale fitting analyses. These currents have densities typically ten times larger than the nominal large scale currents and comparable net current. These results illustrate the need to make sure that any new nomenclature reflects both the results of large-scale fitting analyses and the finer spatial resolution afforded by the time series data used historically to characterize the current systems.

SM52D-06 1510h

New Terminology for the High-Latitude Field-Aligned Current Systems

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Since pioneering works of Iijima and Potemra in mid-1970s, the lexical meaning of terms Region 1 and Region 2 have formulated a definitive lexicon for describing the field-aligned currents systems linking the outer and inner magnetosphere with both the northern and southern polar ionospheres. However, the Region 0 system remains problematic in its clear detection or definition; at the same time, the NBZ FAC system has been easily accepted for describing of reverse (to R1) currents at the near-pole dayside developed during the northward IMF. The separate IMF B_Y-related FAC configurations were either observed by satellites or reconstructed from ground-based data for the dayside cusp region; multi-sheet current systems were proposed for the nightside polar area. Although it seems that these lexical elements were sufficient in describing various components of the global 3-D FAC systems, a number of recent studies utilized high-precision satellite magnetic field measurements for deriving detailed FAC polar maps as a function of the IMF strength and direction. The basic R1/R2 and NBZ patterns are seen, but the maps show structures that are more complex and evolving as the IMF vector rotates. In addition, a potentially new FAC system is detected from statistical maps for IMF ~ 0, having the same current directions as NBZ. This system might be considered as a part of the R0 system; from the other hand, what might be considered as a R1 current footprint often wraps around, through noon or midnight, connecting with either R2 or R0 currents (when IMF By is either negative or positive, respectively) without any obvious boundary line. Interestingly, the new statistical maps show features resembling the "upward current spiral" and "downward current spiral" introduced by *Siscoe and Maynard* [JGRA, *96*, 21,071, 1991] from combining two theoretical models of R1 and R2 currents. These spirals "rotate" over the polar cap showing R0, R1, and R2 segments at the corresponding MLT hours. We will discuss new terms that might be needed for the existing lexicon - to extend its old terminology in describing the modern understanding of morphology and evolution of the high-latitude field-aligned current systems.

URL: http://maggy.engin.umich.edu/mist/limie.html

SM52D-07 1525h

Mapping the Field-Aligned Currents During a Superstorm

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During the superstorm of April 2000 four DMSP satellites crossed 1A/m sheets of field-aligned current (FAC) that were widely distributed in local time and centered at magnetic latitudes less than 60°. FAC positions relative to particle precipitation boundaries (B2e, B2i), described by Newell et al., [1996], mandate generation sources in the central plasma sheet. The phenomenon repeated four times near the storm's maximum epoch, on each occasion after the AE index indicated a pseudo breakup event. As the evening-sector system decayed, an upward FAC sheet formed near the equatorward boundary of auroral electron precipitation. This requires a westward ion pressure gradient in the inner plasma sheet near 21:00 MLT, consistent with radially differential gradient-curvature drifts subsequent to substorm-like plasma injections into a ring-current inflated inner magnetosphere. Net Poynting fluxes, estimated from measured magnetic and electric field perturbations, indicate that these FACs carry several percent of the total ring-current energy into the mid latitude ionosphere where it dissipates as Joule heat.

SM52E MCC: 2002-2004 Friday 1600h

The Role of the Plasmasphere in Ionospheric and Magnetospheric Dynamics III *(joint with SA, AE)*

Presiding: **M Moldwin,** University of California, Los Angeles**; J Foster,** Millstone Hill Observatory

SM52E-01 1600h

Stormtime Refilling of the Slot Between the Inner and Outer Radiation Belts

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During geomagnetically quiet periods a pronounced slot develops between the inner and outer energetic electron radiation belts, due to wave induced scattering by whistler-mode waves inside the plasmapause. This slot can be rapidly filled during strong magnetic storms, when the plasmapause is compressed towards the location of the inner zone. The stormtime refilling of the slot at energies above several hundred keV cannot be explained by convective injection from the plasmasheet since the Alfven layer for high-energy electrons lies much further out than the plasmapause, which demarcates the convection boundary for thermal plasma. Instead we demonstrate that the refilling is due to local acceleration during resonant interactions with intense whistler-mode chorus, which is generated in the region exterior to the plasmapause during storms. The characteristic time-scale for acceleration ranges between a few hours at 100 keV to a day at 1 MeV. Refilling of the slot is consequently most effective at lower energy and is limited by the outward expansion of the plasmapause during the storm recovery.

SM52E-02 1615h

Long-period Magnetic Pulsations Associated with Detached Proton Auroral Arcs

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One remarkable discovery of the NASA-IMAGE mission is the occurrence of detached proton auroral arcs. These are fairly long lived (>30 minutes) relative to other subauroral phenomena, are found separated by hundreds of kilometers from the main dusk-sector auroral oval, and generally occur several hours into a period of heightened geomagnetic activity. Interaction of 10-50 keV ring-current protons with a cold plasmaspheric population drawn outward and sunward by enhanced magnetospheric convection is generally believed to be the source of the phenomenon. The cold-hot plasma interaction is prone to the growth of the ion-cyclotron instability, which subsequently scatters hot ions into the loss cone, which are then seen as precipitation of energetic protons in detached arcs by the SI-12 proton auroral imaging instrument on IMAGE. It has now been noted that most, if not all, of the detached

proton arcs are associated with a strong pulsation signature with a period in the range of 300-600 seconds (Pc5), as observed by ground-based magnetometers in the vicinity of the arcs. It is not yet clear whether the Pc5 pulsations are generated at the magnetopause by solar wind disturbances, or rather within the magnetosphere by the energetic protons themselves, possibly through a bounce resonance mechanism. Whether the Pc5 waves are somehow causative in producing the precipitation, simply a result of the hot-cold plasma interactions which otherwise scatter the ring current particles, or just coincidentally present during these events is the question this investigation seeks to answer.

SM52E-03 1630h

Hot-cold plasma interactions and the generation of transient dayside sub-auroral proton precipitation

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The IMAGE spacecraft obtained the first global images of the proton aurora. One of the discoveries from these images was proton precipitation equatorward of the nominal auroral oval. This precipitation can be observed for approximately 10 minutes immediately following a large solar wind pressure pulse. Various mechanisms have been proposed for producing this precipitation. Here, precipitation due to scattering from electromagnetic ion cyclotron (EMIC) waves is investigated using data from the IMAGE FUV and EUV imagers and in situ data from the Los Alamos geosynchronous spacecraft. In the proposed EMIC wave mechanism, the compression of the dayside magnetosphere enhances the growth rate of the wave instability. These waves scatter hot, ring current protons into the atmospheric loss cone, reducing the proton temperature anisotropy (the free energy source of the waves). Two features of the proton precipitation from these waves require explanation. First, the precipitation pattern may peak at any local time on the dayside between about 09 and 15. Second, the precipitation pattern has limited latitudinal extent (typically less than about 10 degrees) and is often separated from the main auroral oval. The local time peak in the precipitation pattern is related to the characteristics of the solar wind pressure pulse that causes EMIC wave growth. The separation of the precipitation pattern from the main auroral oval is related to properties of the hot and cold plasma within the magnetosphere that enhance EMIC wave growth.

SM52E-04 1645h

Plasmaspheric Loss Estimates

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A significant amount of material can be removed from the plasmasphere during periods of enhanced geomagnetic activity. Magnetospheric convection acts to strip away the outer layers of the plasmasphere, and flux tubes in the inner plasmasphere may be significantly depleted as well. Using global images of the He^+ distribution in the inner magnetosphere, we calculate the amount of He^+ removed from a volume extending from 1.5 to 5.5 R_E during a set of five moderate disturbance periods. For each of the events, approximately 1 to 3×10^{30} He^+ ions were removed, which constituted between 20 and 42 % of the initial He^+ distribution, in a period of 15 hours or less. The loss percentage is correlated with the number of hours of strongly southward IMF ($B_z < -5$ nT). Between 25 and 40 % of the He^+ loss appears to occur from within the newly established plasmapause boundary. The total mass removed for each of the events is estimated to be in the range of 50 to 100 metric tons with variations on the order of tens of metric tons depending on the assumed value of the He^+ to H^+ density ratio.

SM52E-05 1700h

Global plasmaspheric dynamics and L-shell dependent rotations from inverted data from the IMAGE EUV plasmaspheric imager

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The IMAGE EUV plasmaspheric imager allows, for the first time, the dynamics of the plasmasphere to be viewed on a global scale. Inversions of the EUV data produce geomagnetic equatorial density maps of the plasmaspheric He+ ions which form the basis of this study. One of the most intriguing events looked at so far has been the plasmasphere erosion event of 10 July 2000. The erosion event when looked at as a function of LT vs MLT for various fixed L-Shells yields some interesting results. The plots indicate a definite switch in rotation direction of plasmaspheric features with the rotation being in the co-rotation direction for low L-Shells and in the opposite direction for high L-shells. At about 4 - 4.5 Re there is no apparent rotation consistent with the concept of a plasmapause as defined by the 0V equipotential contour line formed in the overlap of the co-rotational and the cross tail electric fields.

SM52E-06 1715h

Cluster Observations of Channels of Enhanced Convection Velocity in the Ring Current Region

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For decades, spacecraft-borne instruments have detected enhanced convection features in the duskside and premidnight subauroral region, variously known as polarization jet [Galperin et al., 1973] or subauroral ion drifts (SAID) [Spiro et al., 1979]. We report Cluster observations of this phenomenon, detected with the electron drift instrument (EDI) which uses a novel particle-detection method to measure electric fields in the plane perpendicular to the magnetic field. We have identified enhanced convection velocity striations within the dusk-side ring current region. Such striations with durations 1-5 minutes were observed in AMPTE/IRM data [LaBelle et al., 1988] and also may be the source of fine features observed recently in ground-based radar observations of SAID [Erickson et al., 2002]. Cluster, due to its more polar orbit, finds them on time scales of tens of minutes implying that the channels are extended along magnetic flux tubes. A survey of Cluster/EDI data from February, 2001 until July, 2003 was performed, using data from 14 to 24 hours local time, from 60-69 degrees invariant latitude, and for Kp > 4. Enhanced electric fields were defined as those in the anti-corotation direction (westward) with amplitude exceeding twice the corotation speed. The data show a tendency for the enhanced electric fields to occur at lower latitudes in premidnight/midnight local time than on the duskside, consistent with previous observations. Many previous observations report widths as narrow as 0.1 degrees for SAID events, and for example the 1-5 minute crossing times at IRM imply striation widths on the order of 1000-2000 km. The variable separations of the Cluster spacecraft over the multi-year data set provides a unique opportunity to improve the determination of this width. In this paper, we elaborate about statistical properties, theoretical implications, and association with the SAPS (sub-auroral polarization streams) and SAID phenomena. Erickson, P.J., et al., Inferred electric field variability in the polarization jet from Millstone Hill E-region coherent scatter observations, Radio Sci., 37, 10.1029/2000RS002531, 2002. Galperin, Yu., et al., Direct measurements of ion drift velocity in the upper ionosphere during a magnetic storm, Cosmicheskie Issled., 11, 273, 1973. LaBelle, J., et al., The duskside plasmapause/ring current interface: Convection and plasma wave observations, J. Geophys. Res., 93, 2573, 1988. Spiro, R.W., et al., Rapid subauroral ion drifts observed by Atmosphere Explorer C, Geophys. Res. Lett., 6, 660, 1979.

SM52E-07 1730h

Multipoint Observations of Ionic Structures in the Plasmasphere by CLUSTER-CIS and Comparisons With IMAGE-EUV Observations

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The 4 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. Data provided by the Cluster Ion Spectrometry (CIS) instruments are used to analyse Cluster crossings of the plasmasphere. CIS is capable of obtaining full three-dimensional ion distributions (about 0 to 40 keV) with a time resolution of one spacecraft spin (4 sec) and with mass-per-charge composition determination. In addition the CIS Retarding Potential Analyser (RPA) allows more accurate measurements in the about 0 - 25 eV energy range, covering the plasmasphere energy domain. The low-energy ion distribution functions, obtained by CIS-RPA during the perigee passes, allow to reconstruct statistically the plasmapause morphology and dynamics, but they also reveal new and interesting features. 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 > 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 CIS local ion measurements have also been correlated with global images of the plasmasphere, obtained by the EUV instrument onboard Image, for an event where the Cluster spacecraft were within the field-of-view of EUV. The EUV images show, for this event, that the difference observed between two Cluster spacecraft was temporal (boundary motion): the radial density profile of the plasmasphere varies with MLT, and a more extended radial profile "rotated" into between the two Cluster spacecraft perigee passes. They thus show the necessity for correlating local measurements with global images, and the complementarity of the two approaches, local measurements giving the "ground truth" (including plasma composition, distribution functions etc.) and global images allowing to put local measurements into a global context, and to deconvolve spatial from temporal effects.

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SM52E-08 1745h

Wave Contributions to Coupling Between the Ring Current/Plasmasphere and Subauroral Ionosphere

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It has long been established that strong electric fields at subauroral latitudes in the post-sunset sector enable ionospheric closure of field-aligned currents generated in the stormtime ring current. Recent observations by the DMSP satellites of ∼10-km scale plasma density and electromagnetic oscillations, within the region of strong electric fields, indicate efficient M-I coupling in the ring current-plasmasphere overlap. It is demonstrated that a feedback instability may develop, analogous to that found in the auroral ionosphere. Enhanced electric fields and large-scale density troughs are the necessary conditions for the feedback to develop. Usually density troughs collocated with strong electric fields are viewed as consequences of frictional ion heating causing plasma outflow and increased rates of recombination stemming from charge exchange/transfer. This paper reports observations from DMSP satellites that are not fully described by this conventional model. During some strong subauroral wave-structure events, density troughs coincide with electron temperature enhancements, while the electric fields and ion temperatures are barely perturbed from background values. No significant ion outflows occur. Our observations suggest additional requirements for describing these subauroral dynamics. In addition to the conventional model, we account for strong electron heating in the ring current-plasmasphere overlap region. Resultant electron heat fluxes lead to the vibrational excitation of molecular nitrogen and support enhanced rates of charge exchange/transfer and recombination.

SM52F MCC: 2006 Friday 1600h

Magnetospheric Convection at Polar Latitudes *(joint with SA, AE)*

Presiding: **L Andersson,** Laboratory for Atmospheric and Space Physics, University of Colorado**; M W Dunlop,** Rutherford Appleton Laboratory

SM52F-01 1600h

Cusp Structures and the Location of the Reconnection Site

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Ground-based observations (SuperDARN) together with multi-spacecraft observations (Polar, FAST, Interball and the Cluster satellites) reveal that structures observed in the cusp are both temporal and spatial phenomenon. While temporal cusp structures maybe the result of variations in the reconnection rate at the magnetopause, spatial cusp structures are thought to be due to spatially separated flux tubes emenating from multiple reconnection regions at the magnetopause. In this study we analyze a double cusp structure observed by the Cluster satellites. The analysis of the double cusp together with ionospheric convection information by the SuperDARN radar arrays show that these structures are associated with different convection cells, consistent with a spatial phenomenon. The distance to the reconnection line for both structures was calculated using the proven method of 3D cuts of the Cluster proton distribution function in the cusp to identify the low energy cutoffs of precipitating and mirrored ion populations. The calculated distance to the reconnection line is determined by tracing along the geomagnetic field to the reconnection site, where the draped IMF is used to estimate the magnetic field shear angle across the magnetopause. We find that double cusp precipitation originates in the anti-parallel reconnection regions in the northern and southern hemispheres, confirming the multiple reconnection line scenario.

SM52F-02 1615h

Semi-Global SuperDARN–Magnetometer Determinations of the Ionospheric Hall Conductance

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The conductivity of the ionosphere plays a vitally important role in the electrodynamic coupling between the magnetosphere and ionosphere. The primary mode of coupling between these two regions is through field-aligned currents, which depend on spatial gradients in the conductivity. Despite its importance, values of ionospheric conductivity are not readily available, due mostly to the difficulty in measuring it, particularly over widespread regions. No technique exists to directly measure the conductivity over large regions of the high-latitude ionosphere. Using combined SuperDARN measurements of the ionospheric electric field and magnetometer measurements of the ground magnetic perturbation, it is possible to infer the height-integrated Hall conductivity (Hall conductance) in the localized region of the measurements. By using the extended nature of the SuperDARN and magnetometer networks it is possible to make localized inferences of the Hall conductance over a widespread region. Several periods with collocated measurements extending over many hours of local time are analyzed to determine the Hall conductance for varying geomagnetic conditions. The results are compared to other techniques and models commonly used to infer this quantity.

SM52F-03 1630h

The Effects of High Frequency ULF Wave Activity on the Spectral Characteristics of Coherent HF Radar Returns

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It is now a common practice to employ ground-based radars in order to distinguish between those regions of the Earth's upper atmosphere which are magnetically conjugate to open and closed field lines. Radar returns from ionospheric irregularities inside the polar cap and cusp regions generally exhibit large spectral widths in contrast to those which exist on closed field lines at lower latitudes. It has been suggested that the so-called Spectral Width Boundary (SWB) might act as a proxy for the open-closed field line boundary (OCFLB), which would then be an invaluable tool for investigating reconnection rates in the magnetosphere. The exact cause of the increased spectral widths observed at very high latitudes is still subject to considerable debate. Several mechanisms have been proposed. This paper compares a dusk-sector interval of coherent HF radar data with measurements made by an induction coil magnetometer located at Tromso, Norway (66° N geomagnetic). On this occasion, a series of transient regions of radar backscatter exhibiting large spectral widths are accompanied by increases in spectral power of ULF waves in the Pc1-2 frequency band. These observations would then, seem to support the possibility that high frequency magnetospheric wave activity at least contribute to the observed spectral characteristics and that such wave activity might play a significant role in the cusp and polar cap ionospheres.

SM52F-04 1645h

Determining the Relative Importance of Ionospheric Parameters to Ion Upwelling using Multivariate Analysis

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The O+ content in the magnetospheric plasma sheet varies highly with magnetic activity. Because of the mass difference between H+ and O+, the plasma parameters that determine the behavior of the plasma in the magnetosphere, will also be highly variable. This O+ can only come from the earth's ionosphere. In order for the O+ to reach the magnetosphere from the ionosphere it must undergo heating in 2 different regimes: first bulk upwelling in the ionosphere, then filamentary heating at altitudes close to the auroral acceleration region. While H+ ions are light enough to easily boil off, O+ ions reside lower in the ionosphere and need to over come gravity and make it through the charge exchange region located at 800 Km. This study uses incoherent scatter radar and multivariate statistical analysis to look at the first step; the bulk upwelling in the ionosphere. It uses field-aligned data from 3 radar facilities to look at the 400-800 km altitude region, and multivariate analysis to determine the ionospheric parameters most associated with variation in upward ion flux. There are a whole zoo of mechanisms that could be responsible for the upwelling ions, each with their own effects on the ionospheric parameters. By determining which parameters are associated with upward ion flux, we can narrow down which mechanisms are dominant in each region. This is an important step in understanding both the mechanics of the ionosphere, and the ionospheric input into the magnetosphere.

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Magnetospheric Compression Signatures of Traveling Convection Vortex Events

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Most dayside, high-latitude ionospheric traveling convection vortices (TCVs), as observed in ground based magnetometer measurements, are accompanied by variations in the magnetic field strength at geosynchronous orbit. Similar compressional signatures in Equatorial ground-based magnetic observations have also been reported for many cases. A comprehensive understanding of these signatures and their relation to the TCV events, however, is still lacking. We present here the results of a systematic analysis of these relationships. The geosynchronous and low-latitude ground-based magnetic signatures for more than 40 TCV events identified in the Greenland and MACCS magnetometer data during 1998 have been analyzed. The results are compared to theoretical predictions for the relationships based on field aligned current generation by propagating localized compressions at the magnetopause. Further, the upstream solar wind conditions for the events are analyzed and interpreted in terms of predictions for occurrence, propagation direction and speed of magnetopause oscillations.

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MHD Simulations of SIs observed by Polar

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We use the UCLA MHD Geospace General Circulation Model (GGCM) to simulate Sudden Impulses (SI) observed by the Magnetic Field Experiment (MFE) onboard Polar. SI's are observable on the surface of the Earth as abrupt changes in the magnetic field magnitude caused by thin solar wind discontinuities across which the solar wind dynamic pressure abruptly and significantly increases. They compress the magnetosphere as they move past the Earth. The empirical T89 and T96 models developed by N. Tsyganenko can be used to predict the steady state changes in field magnitude but an MHD model can also resolve the temporal evolution of the SI signal. Since the rise time of an SI is used to determine the distance a shock travels along the length of the magnetosphere the MHD model is more useful for predicting such an occurrence. By varying the speed of a shock, and other solar wind parameters, we investigate the respective effect that various parameters have on the rise time and magnitude of an SI.