GEM Global Interactions Campaign Report
2006 Snowmass Meeting

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This year's meeting of the Global Interactions (GI) Campaign in Snowmass, Colorado was divided into 8 sessions:

(1) Inherent and Upstream-Induced Time-Dependent Reconnection at the Magnetopause (Omidi)
(2) Inner-Outer Magnetosphere Coupling (organized jointly with the Inner Magnetosphere Campaign, led by M. Chen, and summarized elsewhere)
(3) Component Versus Antiparallel Reconnection (Berchem)
(4) The Cusp (Trattner)
(5) Heavy Ion Effects on Tail Dynamics and Magnetic Reconnection (joint with the Magnetosphere-Ionosphere Campaign, led by R. Winglee, and summarized elsewhere)
(6) Mechanisms and Efficiencies for Solar Wind Plasma Entry {Lavraud and Otto)
(7) Transport Paths and Time Scales to the Plasma Sheet (Onsager and Wing)
(8) Magnetotail Event Selection and Near-Term Goals (Wing, Lavraud, Onsager, and Otto)

The campaign invited two speakers to give plenary review talks: K. Trattner from Lockheed-Martin and Tom Moore from GSFC. Attendance was generally high and lively discussions persisted throughout all the GI sessions. This document summarizes the presentations and discussions in each session, as well as the invited talks.

1. Time-Dependent Reconnection (Omidi)

(Monday morning)

Omidi began the session by presenting his own talk plus results from T. Phan, J. Drake and J. Huba who could not attend the meeting.

Phan et al. [2004] examined Cluster observations of the magnetopause and boundary layer during steady southward IMF conditions. Even during intervals of steady solar wind parameters, plasma blobs generated on the low latitude magnetopause move poleward to high latitudes. Accelerated flows in the boundary layer exhibit the characteristics expected for steady state reconnection at the magnetopause. Phan et al. suggested that the plasma blobs result from time-dependent reconnection rates.

Omidi showed results from 2.5-D global hybrid simulations during periods of steadily (and purely) southward IMF. FTEs marked by density enhancements and considerable variations in size and speed form on the low latitude dayside magnetopause and move poleward. When they reach the cusp, the density enhancements diminish and the events ultimately disappear. The interaction of FTEs with the cusp involves secondary reconnection and is quite complex. It may be an important means by which solar wind plasma enters the magnetosphere. The reasons for time-dependent reconnection at the simulated magnetopause remain to be established. Using local hybrid simulations, Omidi showed that the interaction of a magnetosonic pulse with a current sheet can initiate reconnection and therefore it is conceivable that some of the time dependency is tied to magnetosheath turbulence.

Drake and colleagues have used full particle 2-D simulations to examine the nature of time-dependent reconnection. They find that when a guide field is not present both the location of the x-line and the reconnection rate remain steady. However, when a guide field is present the location of the original x-line no longer remains steady and secondary magnetic islands form. According to these results, antiparallel reconnection should be steady state, but component reconnection should be time-dependent.

Huba obtained results from the first fully three-dimensional Hall MHD simulation of forced magnetic reconnection. In the absence of a guide field, reconnection extended along the current direction with asymmetric accelerated flows. Although the current layer shows some dynamic behavior, the overall reconnection process seems steady state with no FTE formation.

Gosling discussed observations of magnetic reconnection in the solar wind and its exhaust region. Observations show that reconnection events tend to occur for low solar wind thermal plasma β (typically less than 0.1). Their properties are consistent with some but not all predictions of Petschek's steady state reconnection model. Specifically, the plasma exhaust or jet occurs behind a boundary with properties similar to slow shocks where density and temperature increase and the magnetic field decreases. Examination of ion velocity distribution functions shows that the increase in temperature results from the presence of cold counter-streaming, ion beams. Nor are the electrons heated as they cross the boundary. The absence of dissipation and heating means that event boundaries are not true slow shocks. Observations provide no evidence for plasmoids or time-dependent reconnection.

Russell reviewed the history of reconnection theory and spacecraft observations. He then discussed the motion of FTEs along the magnetopause surface and how multiple spacecraft observations can be used to determine the nature of this motion. Observations indicate that FTEs generally move away from local noon. Russell concluded that neutral points and not current sheets are the key to understanding reconnection. Reconnection enables (but does not guarantee) rapid energy release. Reconnection through topology changes enables momentum coupling between flowing plasma and obstacles. Coupling is not necessarily steady: flux transfer events and bursty bulk flows recur without obvious triggers. Geometry is important in determining event size and occurrence frequency. A large statistical scatter and the strength of By effects suggest that an interpretation in terms of a single subsolar merging line is not correct. The guide field appears to control onset of collisionless reconnection. This controls where reconnection occurs, results in a half-wave rectifier effect and dipole tilt control, and enhances the semi-annual variation of geomagnetic activity.

Fear used Cluster observations to present an analysis of FTE motion during northward IMF. The emphasis was on post-terminator FTEs, which can result from a tilted equatorial x-line or from magnetic reconnection near the cusp. The observations were more consistent with reconnection near the cusp. Observed velocities generally agree with the model of Cooling et al., [2001]. It was also suggested that the locations, polarities and velocities of the observed FTEs are in general agreement with a long, component merging x-line originating from a region of high magnetic shear on the lobe. Although the events could be mapped back to high shear regions, not all the observed velocities were consistent with a near 180^{o} shear.

(Tuesday morning)

Wang used Cluster observations and global MHD simulations to study the dependence of FTEs on geophysical parameters and solar wind conditions. He reported that FTE occurrence may depend upon dipole tilt, that FTE amplitudes may increase with magnetic latitude, that there is solar wind trigger (e.g. north/south fluctuations), and that more events occur for IMF Bx > 0. Combining the Kawano and Wang data bases may provide more statistically significant information about FTEs and transient magnetopause reconnection. Without simultaneous observations in the magnetosheath, it is hard to identify the effects (if any) of magnetosheath fluctuations on FTEs.

Raeder used a global MHD model to simulate an event in which both Cluster and DS1 observed FTEs during an interval of strongly dawnward IMF orientation. At Cluster, deep within the magnetosphere, nearly monopolar magnetic field signatures normal to the magnetopause and density pulses were observed. Raeder noted that global MHD simulations do not predict FTE formation unless the resolution suffices to suppress diffusion. The objective of the study was to establish model limits and parameter dependencies and to investigate FTE formation and evolution. The simulation generally predicted the characteristics of the observed FTEs, suggested a subsolar origin, but more detailed analysis of the simulation data and comparisons with spacecraft data is planned for future (in particular speed, size, origin, recurrence times).

Dorelli, used the same global MHD simulation to look at FTE formation. He also stressed the need for sufficient grid resolution in order to see FTEs to form, and noted that there was no dependence of occurrence rates on dipole tilt. His results indicate the formation of poleward-moving FTEs at low latitudes during periods of steady southward IMF orientation. When they encounter the exterior cusps, the FTEs generate pressure enhancements that move along field line into the interior cusp. This suggests that FTE interaction with the cusp is important for solar wind plasma transport into the magnetosphere. During periods of northward IMF orientation, the simulation provided evidence for steady reconnection.

Winglee showed results from global multi-fluid simulations during southward IMF. Concentrating on the dayside magnetopause, he demonstrated the ability of the model to produce current layer thicknesses as low as about ion skin depth. The results show no evidence for time-dependent reconnection or the formation of FTEs, while the accelerated flows are consistent with steady state reconnection. Only a small amount of the plasma entering the dayside LLBL enters via the cusp.

Kuznetsova showed results from the BATS-R-US MHD code during southward IMF. She demonstrated that when the resolution of the simulations is high enough, FTEs form at the low latitude magnetopause and travel to high latitudes. The FTEs are associated with an enhancement in pressure similar to the results shown by Dorelli. Upon encountering the cusp the pressure enhancements travel into the interior cusp. On the flanks, she found tailward-propagating vortices and both strong velocity and magnetic shears.

(Wednesday morning)

Newell examined the ability of 19 solar wind-magnetosphere coupling functions to predict geomagnetic activity (including storms), as measured by 10 characterizations of the magnetosphere (Dst, AE, Kp,…). The two coupling functions that consistently work the best are based on the "intermediate" coupling function described by Wygant, Akasofu and Vasyliunas (E_{WAV}) with the best corresponding to $(E_{WAV})^{2/3}$. Newell concluded that the global merging rate can be approximated reasonably well by vB_T times a function of the IMF clock angle. Also, the dependence of global merging on magnetic shear is intermediate between a half-wave rectifier and the Kan-Lee electric field.

Borovsky discussed the effects of plasma from plasmaspheric drainage plumes reaching the dayside magnetopause. He argued that this plasma could reduce the rate of reconnection at the subsolar magnetopause. The reason for this reduction is due to change in the local Alfven speed caused by the presence of heavier magnetospheric ions. MHD simulations indicate rate reductions up to 50%. The effect can only occur following a southward IMF turning in which the IMF then remains strongly southward.

Birn used local MHD simulations to examine the effects of asymmetries on the reconnection rate. The asymmetry considered was due to the presence of heavier plasma (reduced Alfven speed) on one side of the current layer. This is similar to the effect discussed by Borovsky due the presence of plasmaspheric plumes at the magnetopause. The results of the simulations show a reduction in the reconnection rate. The high speed flows occur on the low density side.

Reiff showed results from Cluster observations of an x-line at the high latitude magnetopause. Using data from the 4 Cluster spacecraft, the inflow and outflow of electrons and ions at the x-line was examined and compared to the currents calculated from the magnetometer data. The x-line seems to be in a steady state, however, some of the flow patterns observed at the x-line seem more complex than a simple inflow-outflow. The y-component was enhanced at the X-line, and the derived current sheet was thicker than that drawn by Birn.

Singh showed results from 3-D, full particle, electromagnetic simulations that examined the stability of a current sheet. The magnetic field geometry corresponded to anti-parallel configuration, i.e. no guide field. No initial perturbations were introduced to generate an x-line. The results of the simulations show that current sheet evolution is associated with the formation of substructures (many islands) in the current sheet profile. Similarly, spiky electric fields with length scales of the order of electron Debye length are generated which were compared to Mozer's observations of electric field by Cluster. The results also show electron acceleration associated with the reconnection process.

3. Component Versus Antiparallel Reconnection (Berchem)

The program for this session resulted from discussions at the mini GEM meeting held just before the last Fall AGU in San Francisco. There a small group of modelers agreed to focus on large-scale properties of 3D dayside reconnection. One of the targeted themes was to revisit the "component versus antiparallel merging" issue, though the participants acknowledged that it might not be the best way to describe the problem. Two sets of comparisons were planned. First, a comparison of code results for idealized inputs for fixed solar wind input (n = 7 cm^{-3}; V = 400 km s^{-1}; B = 5 nT; P = 4 nP) for three generic clock angles (45°, 90° and 135°) and no dipole tilt, leaving the other parameters (e.g., resolution, simulation domain size, resistivity model) free. Second, there would be comparisons of model output with actual events. Proposed events to simulate were a) 03/18/2002 originally discussed by *Phan et al.* for which *Wendel et al.* [PRL, in press, 2005] claim that Cluster passed through the ion diffusion region and skirted the edge of the electron diffusion region; b) 07/25/2001 studied by *Trattner et al*. [2005] who used ion velocity distributions, the T95 model, and a time-of-flight analysis to calculate the location of the reconnection site on the magnetopause and thereby discriminate between component and antiparallel merging.

The session started with two presentations of recent kinetic simulations. Michael Hesse examined whether macroscopic conditions impact microscopic reconnection. He showed that the presence of a guide field (or component merging) slightly favors the formation of islands, however he noted results from Huba indicating that the guide field reduces the reconnection rate because it makes the system less compressible. He also presented recent results from M. Swisdak showing that pressure asymmetries result in diamagnetic drifts on the magnetopause that suppress reconnection. A recent study with Joe Borovsky found that the reconnection rate depends on a hybrid Alfven speed when such asymmetries are present. He also pointed out studies by Horiuchi, which indicate that kinetic reconnection can be highly time dependent for a wide range of driver profiles. Homa Karimabadi presented some results of kinetic simulations showing the linear and nonlinear evolution of the tearing mode as a function of the guide field. He found that guide field tearing is competitive with anti-parallel merging at the magnetopause. There is a continuum of solutions ranging from component to antiparallel. He showed also some results from a related study (Daughton and Karimabadi, 2005) that indicate that a new regime, which he called the intermediate regime, forms with mode properties that are a mixture between anti-parallel and strong guide field. This regime occurs at relatively small values of guide field (~7%). From these results, he suggested that one should expect to observe reconnection at various guide field strengths at the magnetopause, and that this would generally take the form of component reconnection for most conditions. Homa criticized the concept of a single stable x line, noted that multiple lines eventually become unstable, and remarked that the electron diffusion region is small and doesn't control the overall configuration. He was examining island coalescence and jets perpendicular to the current sheet.

The session continued with presentations of results from global models. Jean Berchem started by showing results from global MHD simulations using idealized inputs. He showed that for a 135° shear angle, the simulation indicated simultaneous antiparallel merging at high latitudes and component merging in the subsolar region. However he pointed out that isosurfaces of non-vanishing parallel electric field indicated that the component reconnection was patchy and limited to a relatively small region of the subsolar magnetopause, and that he could not identify a clear merging line as predicted by simple geometrical constructions.

Dorelli investigated the dependence of dayside magnetopause reconnection topology on the IMF clock angle. He considered two cases: a) clock angle = 45° and b) clock angle 135°. For case a), he found that the reconnection topology was consistent with steady state separator reconnection; for case b) that reconnection was time dependent, with flux ropes forming at the subsolar magnetopause and propagating into the cusps.

Wiltberger et al. used LFM simulations of the magnetosphere to study the reconnection configuration during IMF clock angles of 45, 90, 135, 180. By combining pathline traces with magnetic field lines they were able to track the motion of flux tubes into reconnection sites. While the analysis is still ongoing its clear that the reconfiguration of the magnetic field is significantly more complicated than the classic 2-D pictures of x lines.

Aaron Ridley showed BATS-R-US MHD results for conditions on October 24-25, 2003, when the IMF pointed strongly northward. The model results compared quite well with observations by many different spacecraft, implying that the model had captured the essential physics. The model predicts the times and characteristics of magnetopause crossings well, and the trends but not the magnitude of Dst (pressure variations), but did not predict the degree of stretching that was observed in the magnetotail. Wind missed seeing the magnetotail, perhaps because it was short and torqued or compressed and deflected. There was a strong indication that the reconnection site was poleward from the cusp, with no reconnection occurring in the equatorial region. This indicated that the model favored anti-parallel rather than component reconnection. Because the only resistivity in the model is numerical resistivity, there is a need to examine how results might change for different resistivity models.

Tom Moore explored simulations of steady NBz, EBy, and SBz conditions, examining flow streamlines that would radiate from the subsolar point in the absence of Maxwell stresses produced by reconnection. Moore concluded that the LFM simulations contain an extended Z or S shaped "X curve" that crosses the subsolar equator (with active component reconnection) and loops up around each cusp (crossing the antiparallel reconnection region), as suggested by himself and coauthors [Moore, Fok, and Chandler, 2002 JGR].

There was not enough time left to present results from the simulations of actual events. The session concluded with a general discussion between the participants. It appeared that a small (but vocal) fraction of the audience was skeptical about determining the three-dimensional configuration of reconnection at the magnetopause using global MHD models and that kinetic models were needed. It was agreed that pursuing kinetic studies was fundamental to understanding the physics of magnetic reconnection at the magnetopause, however it was clear that local simulations are too dependent on boundary conditions to provide reliable macroscopic predictions. To resolve this issue it was proposed that the group should check consistency between global and kinetic, Hall-MHD etc models. The following iterative approach was suggested:

1) Run generic kinetic simulations to determine the response to

various parameters (e.g., pressure asymmetry)

2) Run global MHD simulations for a set of different IMF conditions
3) Identify dayside reconnection sites
4) Determine, from global models, MHD parameters in neighborhood of reconnection site(s)
5) Use these conditions as input/initial conditions for Hall-MHD, and kinetic models
6) Compare MHD reconnection with results from Hall-MHD, kinetic models

4. The Cusp
(Trattner)

The cusp breakout session discussed several simulations dealing with plasma transport into and out of the cusp. Particles with specific energies are launched in the cusp and followed backward in time to determine the origin of these ions with specific energies. In a separate presentation, a simulation scenario for a future study of a possible cusp particle acceleration mechanism was introduced.

Observations focused on four pre-selected Polar events in the northern cusp for which cusp boundaries and the origin of energetic ions where discussed. The Polar cusp events where presented side by side in an effort to highlight the differences in the interpretation about the origin of energetic particles for the audience. With strong audience participation, the cusp breakout session discussed diamagnetic cavities, the influence of waves in the cusp observed at Cluster, and event times which showed sudden changes in the flux of energetic ions. The pre-selected events contained periods that exhibited continuous variations in the flux of energetic ions in addition to sudden appearances and disappearances that were linked to sudden changes in the IMF direction and connection/disconnection to the quasi-parallel shock. By contrast, several cusp events observed by ISEE 1 and 2 showed strong upward ion outflow from the cusp with no significant simultaneous ion inflow in the same energy range. This was interpreted as an indication of an acceleration mechanism in the cusp.

Future plans include a broader understanding of the particle and wave environment in the cusp. It was agreed to widen the perspective of the investigation to include general particle access, heating, and acceleration of magnetosheath ions in the cusp.

6. Mechanisms and Efficiencies for Solar Wind Plasma Entry (Lavraud and Otto)

The PATM session on solar wind entry had 8 presentations covering all of the entry mechanisms and core properties for northward IMF (Double cusp reconnection, diffusion, Kelvin-Helmholtz modes). The session afforded an opportunity to discuss important new insights and progress concerning

- The various processes that enable plasma entry
- The dependence of these processes on solar wind conditions,
- time scales and rates for the plasma entry,
- small-scale properties of the entry and boundary layers
- quantitative/modeling/statistical results for plasma entry and magnetotail filling

The presentations and constructive discussion demonstrated progress with respect to the goals of this campaign and the session provided a clear focus for the important unresolved issues of the plasma entry.

Chih-Ping Wang reported a statistical survey showing how the properties of the plasma sheet depend upon solar wind conditions. During northward IMF intervals, the plasma sheet becomes colder and denser. Increases in the solar wind velocity greatly enhance plasma sheet temperatures, but have little impact upon densities. By contrast, increases in the solar wind density enhance plasma sheet densities particularly on the flanks, but have little effect on temperatures.

Simon Wing used Geotail plasma observations to track the plasma sheet's response to a prolonged period of northward IMF on February 4, 1998. The cold component of the plasma sheet plasma exhibited a strong dawn-dusk temperature asymmetry and a time-dependent response to IMF variations (3 hours). The temperature of the hot component decreased as IMF changed from southward to northward. Jay Johnson applied theoretical considerations to the same event. He reported that both diffusion and reconnection entry rates would result in comparable filling rates, which are similar to observed values.

Vahe Peroomian traced the motion of ions entering the magnetosphere during geomagnetic storms. Nykirii compared MHD simulation results with Cluster observations of the Kelvin-Helmholtz instability on the dawn magnetotail flank. The simulation predicted the observed quasi-periodic bipolar magnetic field signatures normal to the nominal magnetopause.

Benoit Lavraud discussed double reconnection at the cusps. It results in a structured boundary layer at the magnetopause during periods of northward IMF orientation. Within this boundary layer, one can sometimes observe bidirectional streaming electrons, taken to be the result of double reconnection. He discussed Wenhui Li and Joachim Raeder's MHD simulation results describing the entry window as a function of solar wind conditions, and in particular the dependence on IMF clock angle which is compatible with Cluster observations. Antonius Otto noted that the Kelvin-Helmholtz instability periodically compresses the magnetopause current sheet, setting up conditions for reconnection to occur.

7. Transport Paths and Time-Scales to the Plasma Sheet (Onsager and Wing)

Larry Lyons reviewed the importance of the magnetic drift, which leads to a dawn-dusk pressure asymmetry in the inner edge of the plasma sheet and the formation of the partial ring current. Model calculations with Wang show that PV^{γ} is not constant along the streamlines.

Joe Borovsky reviewed many past studies performed at LANL in quick succession. His presentation included a discussion of:
a. the entropy density of the plasma sheet populations
b. adiabatic curves in the plasma sheet. Ions at geosynchronous, in the mid- and distant- tail are on the same adiabatic curve, but not those in the cold dense plasma sheet and the magnetosheath.
c. The missing mass problem [Elphic, 1997]. The plasmasphere is thought to be eroded/lost after plumes are involved in dayside reconnection. But plasmaspheric material has rarely been observed in the cusp and other high-latitude regions.
d. The calm before the storm. The presence of a cold dense plasma is effective in building up the ring current. Storms preceded by long periods of northward IMF are stronger than those without such preconditioning.

Mike Wiltberger (for Tim Guild) showed comparisons between LFM and Geotail observations over 2 months (although the Geotail observations included periods when the spacecraft was in the solar wind). MHD does not capture high speed Vperp, but seems to do better when using higher resolution grids.

Tom Moore described simulations of O+ outflow from the ionosphere to the magnetosphere for various IMF configurations. The simulations appear to preferentially populate the duskside with O+.

Mikhail Sitnov presented a new theory of plasma bubbles that explained Cluster observations of BBFs. Unlike reconnection-based models, it involved a change in continuity and the appearance of bifurcated and embedded current sheets, but there was no change in topology.

Wenhui Li presented several slides that compared Open GGCM simulations with observations of the super-dense plasma sheet event on 9/14/2001. He tracked the time required for solar wind plasma to reach the Earth's magnetotail (1.5 hours to reach the plasma sheet 20 RE down the magnetotail).

Lynn Kistler presented observations of O+ in the midtail region, about 20 Re down the magnetotail. Some O+ appears to originate from nightside aurora and some from cusp. She presented a superposed epoch analysis of O+ during storms and non-storm substorms. There is a dropout of O+ after substorms. O+ is present at all local times on the nightside.

Vahe Peroomian traced the motion of particles originating in the dayside ion fountain. He found the O+ population density to be a factor of 2 less than that of the solar wind H+, contradicting previous simulations that show the O+ densities exceeding those for H+.

Daisuke Nagata presented 2D distributions of plasma sheet density and pressure profiles constructed from Geotail observations. He found a thin plasma sheet near midnight with depressed densities. The total thermal pressure was symmetric about midnight. There were differences in the equatorial versus off equatorial profiles. He planned to study the effects of IMF Bz.

8. Magnetotail Event Selection and Near-Term Goals (Wing/Onsager/Lavraud/Otto)

The PATM discussion session held on Friday June 30th was meant to address the future directions of the group by involving all attendees in the discussion. Both attendees and conveners suggested actions to prepare for the December mini-GEM and next year's June meeting. The points discussed and potential consensuses are:

- The goals of the PATM group would be clearer if the current state of knowledge and the need for future studies were described in a review paper (to be "published" for next year's meeting).
- Jonathan Eastwood expressed interest in preparing such a review. There may be a review tutorial next year.
- Additional/specific campaign goals ought to be defined based on the capabilities of the THEMIS mission (to be launched in late 2006). V. Angelopoulos may be invited for a tutorial next year.
- A lack of involvement from the ground-based community was noted. This is not specific to the PATM group but rather to GEM as a whole. In the Themis – ground based context, Eric Donovan may also be contacted and invited.
- Although substorms are undoubtedly important for plasma transport in the magnetotail, the group was reminded that substorm physics has been excluded from the GI campaign. A question then arises as to whether it should be?
- Bursty Bulk Flows (BBFs) are important in plasma transport, but were barely mentioned at this meeting.
- Doubt has been cast upon the assumption that internal transport in the magnetotail is better understood than the processes that enable solar wind plasma access to the magnetotail.
- Many of the PATM presentations focused on statistical studies, so there is a need to identify interesting events for case studies. Input is welcome.

- The group should construct a list of observational facts (asymmetries, ion-electron temperature ratio in various regions, etc.) for modelers to address.
- Similarly, modelers should prepare a list of model predictions for observationalists. These two lists should be completed and advertised before the mini-GEM in December.
- The PATM group should characterize and understand the plasma sheet and magnetotail as outer boundaries for the inner magnetosphere and modellers.
- PATM welcomes inclusion of an "Inner-outer magnetosphere coupling" focus group as a new GI sub-group. This would ensure integration of results form the inner magnetospheric campaign.
- Doubt was expressed concerning the utility of identifying the KH instability in global MHD simulations to determine its significance with respect to reconnection during periods of northward IMF. The concerns focuses on insufficient diffusion in the models, even those with greater resolution, as the resolution is never large enough.
- It was observed that global MHD simulations typically predict accurate pressures, but temperatures that are too low and densities that are too high at geosynchronous orbit. When the results of MHD models are used as boundary conditions for ring current models, the results are not realistic. There was a proposal to use the MHD results scaled to local geosynchronous measurements. Data-assimilation may be a tool for that purpose.
- The discussions during this session were very interesting and helpful. The number of attendees, owing to various reasons, was however limited and the diversity of the comments may not reflect that of the entire PATM-GI community.
- The group representatives should send out general conclusions and other outputs/inputs after they have captured what came out of the discussions.

Plenary Talk (Trattner)

Karlheinz Trattner described the relationship of the cusps to magnetic reconnection. One of the most important issues concerns whether changes in the signatures seen within the cusp result form temporal or spatial effects. He used combined radar and spacecraft observations to show that some changes result from spacecraft crossing convection boundaries but that others result from these boundaries moving. He used the particle dispersion signatures seen by Cluster to demonstrate that reconnection occurs along the locus of the maximum shear between magnetosheath and magnetospheric magnetic field lines. Whenever there is a large IMF Bx or the clock angle lies further than 20° from due south, antiparallel merging predominates. There are seasonal effects in the location of the merging line.

Plenary Talk (Moore)

Tom Moore described ionospheric plasma in the Earth's magnetotail. Reconnection at distant and near-Earth lines removes trapped plasma from the magnetotail. Inspection of results from the LFM model reveals that southward IMF turnings clear out plasma from the magnetotail lobes, while northward IMF turnings facilitate the formation of a cold dense plasma sheet via entry through the LLBL. During periods of southward IMF orientation, the outflow of ionospheric O+ increases and this constituent fills up the void lobes. The pressure of O+ ions can be significant in the magnetotail and must not be neglected. To obtain observed values of Dst during geomagnetic storms, it is essential to couple the LFM to the CRCM model, using the LFM model alone gives values for Dst that are only ~25% those obtained from the coupled models. To summarize: the ionosphere is important - it provides plasma directly to the magnetosphere, this supply continues throughout all periods of geomagnetic activity, and moves radially. The ionospheric plasma serves as a load on the magnetospheric generator. The ionospheric plasma is heated, pumped up, compressed, and ultimately escapes.