TheGEMstone

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NOTES FROM THE NSF PROGRAM DIRECTOR

GEM is a Real NSF Program

One of the big changes in GEM for this year is the fact that for the first time, there is an official Program Solicitation for GEM. As most of you probably realized, in the past, GEM was only an unofficial part of the Magnetospheric Physics Program. If you were submitting a proposal for GEM, you designated the general announcement for unsolicited proposals as the NSF program, and then directed your proposal to the Magnetospheric Physics Program. This approach had some advantages. By being unofficial, we had a little more flexibility in the way we handled the program. But the disadvantage was a lack of visibility within NSF. All this is now changed. From now on, when you submit a proposal to the GEM program you will need to reference the Program Solicitation, NSF-02-122. You can download the full text of the Program Solicitation from the NSF web site.
The URL is:
http://www.nsf.gov/pubsys/ods/getpub.cfm?ods_key=nsf02122.
As in the past, the target date for GEM research proposals is October 15 every year.

Speaking of proposals, it is important for anyone submitting proposals to NSF to be aware that there have been some important changes to the requirements for proposals. There is a new version of the NSF Grant Proposal Guide that all PIs and prospective PIs should look at. *Proposals that are not compliant with the new requirements will be returned without being reviewed.* As with all public NSF documents, you can download the GPG from the NSF website. The URL for the Grant Proposal Guide is: http://www.nsf.gov/pubsys/ods/getpub.cfm?gpg.

GEM Postdocs

The Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) program in Aeronomy has been providing for a special type of proposal whose purpose was to support a recent Ph.D. in a postdoctoral position. At the GEM steering committee meeting held during last year's Fall AGU meeting, a recommendation was made to begin a similar effort in GEM. The new GEM postdoctoral awards are described in the new GEM Program Solicitation. These are 2-year awards and provide a stipend of $40,000 for the postdoctoral candidate and appropriate additional costs for benefits, travel, publication costs, and indirect costs. NSF expects to fund at least one postdoctoral award each year and if NSF budgets increase over the next few years, it is likely that we will be able to eventually fund two such awards each year.

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GEM Homepage URL
http://www-ssc.igpp.ucla.edu/gem/

In order to accommodate the academic calendar, the GEM postdoc proposals have a target date of May 1 of each year, with the awards to be made at the beginning of the next fiscal year. Please do not submit postdoc proposals as part of the regular GEM research proposal competition.

The first round of GEM postdoc proposals were submitted this past May. Because the formal GEM Program Solicitation could not be published in time for the May 1 deadline in 2002, that first round of postdoc proposals was handled through the CEDAR program. In that first round we received four proposals. I want to thank the proposers for their submissions and I want to also thank the three anonymous reviewers who read and commented on each of the proposals. The competition was very close and all of them were meritorious.
Unfortunately, we have limited funding and good proposals have to be declined. At this point I am not permitted to give out the name of the one successful candidate (awards cannnot be made public until they are actually made official by the Division of Grants and Agreements), but I want to take this opportunity to congratulate the winning candidate and to wish all the proposers future success in their scientific careers.

Cooperation with CEDAR – M-I Coupling

Funding for the Magnetosphere-Ionosphere Coupling campaign was initiated in the GEM 2001 competition. That campaign was given a kick-start by making a cooperative effort with the CEDAR program to increase the initial funding. The CEDAR program committed $250,000 for M-I coupling proposals that were submitted to the GEM program in October 2000. Thus, in FY 2001 we actually had a total of $500,000 just for M-I coupling proposals. Last year (FY 2002) there was no additional funding for new awards from the CEDAR program, and the same is true this year (FY 2003). However, for FY 2004, the CEDAR money committed to M-I coupling will be freed up and we expect to have that money available for new awards.

Since the first round of M-I coupling was handled through the GEM program, it seemed only fair to have the second round be handled through the CEDAR program. You should be aware that the CEDAR proposals for FY 2004 are due in May of 2003 (less than a year away). So, within the next 12 months you will have two opportunities to submit proposals on M-I coupling, first in October of this year and then again next May.

What Should the Next GEM Campaign Be?

With the Tail/Substorm Campaign winding down it is time for the GEM community to give serious consideration to what the next GEM campaign should be. This issue will be considered at the GEM Steering Committee meeting that will take place just prior to the Fall AGU meeting. If you have any thoughts or suggestions for the next campaign, please feel free to communicate them to me or to anyone on the GEM Steering Committee. You'll find the names of the Steering Committee members on the GEM homepage (http://www-ssc.igpp.ucla.edu/gem/steering.html).

Budget Outlook

The Magnetospheric Physics Program benefited last year from a 10% increase and much of that increase was directed to the GEM program. As I write this, Congress has not passed the NSF appropriations bill and it appears likely that Fiscal Year 2003 will start out with us operating on a Continuing Resolution. Hopefully, the upward trend in NSF budgets will continue. My goal is to increase the GEM funding to the point where we have approximately $750K available for competition in each year while at the same time increasing the average duration of the GEM awards.
And speaking of award duration, NSF is urging all programs to move toward

longer awards. The GEM Program Solicitation states that awards will typically be made for three years, but “applicants may request from one to five years…provided the requested duration is adequately justified.” So if you have a GEM project that would justifiably take four or five years, don’t be inhibited in asking for the extra time.

Summation

GEM continues to be the flagship for magnetospheric physics research at NSF. Our summer workshop continues to be one of the most scientifically stimulating meetings in all of space physics research, and it has been particularly gratifying to see that the student participation in the GEM workshop has grown. The budget situation looks good; the GEM meetings are a great success; the information about GEM continues to be widely disseminated through the GEM web pages, the GEM electronic newsletter and the GEMstone paper newsletter; and most importantly, great research is being done and published by the members of the GEM community. I look forward to many more years of great success for the GEM program.

Dr. Kile Baker
Program Director,
Magnetospheric Physics
Tel: (703) 292-5819, Fax: (703) 292-9023
kbaker@nsf.gov

Notes from the Steering Committee Chair

The Next Campaign

The Steering Committee is now soliciting suggestions for the next campaign. GEM began with the Boundary Layer Campaign, followed by Tail-Substorm which will convene for the last time at next year's Snowmass meeting. Continuing campaigns include: Inner Magnetosphere-Storms, GGCM and M-I Coupling, the newest. Several suggestions were mentioned at the June Steering Committee meeting in Telluride, and it was decided that time would be set aside at our Mini-Workshop on the afternoon of December 5, preceeding the Fall AGU Meeting in San Francisco, to discuss proposals. From those presented, we will select two for full consideration at the June workshop, including tutorial speakers. Several suggestions which have surfaced include: geospace transport, perhaps focusing on the interaction between the solar wind and the plasma sheet, or more generally solar wind-magnetosphere coupling to tie in with the SHINE program, as M-I Coupling does with CEDAR. Please communicate your interest in making a presentation at the Mini-Workshop to myself and Frank Toffoletto (maryk@dartmouth.edu, toffo@rice.edu), who will be scheduling rooms for the Dec 5 Mini-Workshop. Organizers of other sessions at the Mini-Workshop will be posting information on the GEM Messenger.

Mary Hudson
Chair, GEM Steering Committee
maryk@dartmouth.edu

Next GEM
Snowmass
Workshop
June 22-27, 2003

Telluride, Colorado, June 24-28, 2002

WORKING GROUP REPORTS

Magnetosphere ionosphere coupling campaign

Working Group 1 Mass exchange:

WG 1 on mass exchanges invited a tutorial speaker, organized three sessions and participated in two others. A summary of these sessions is given below.

Perhaps the most significant outcomes of the discussions during the week were:

1) The intense interest in all participants in unraveling the role played by mass outflow from the magnetosphere to the ionosphere.

2) The variety and quality of new data and reanalysis of old

data that are now available: Perhaps the best examples of reanalysis of old data were the solar cycle summaries of outflow obtained from the SMS instrument on Akebono presented by Drs. Yau and Abe which are discussed below. The best examples of new data were the Cluster data obtained in the tail and the plasmaspheric images. Some of the best examples of empirical results ready for application to global simulations were reported from the FAST data set by Bob Strangeway.

3) The difficulty of achieving a consensus on a way to organize a challenge to bring observations and modeling together (see below).

In view of point 3, we propose to select a small number of intervals for which we will ask for observers and modelers to characterize as completely as possible:

a) Energy transfer from the magnetosphere to the ionosphere, in all forms.
b) The state of the topside ionosphere, plasmasphere, and plasma sheet.
c) The outflow of ionospheric plasma in response to the inputs.
d) System behavior as modeled with/without the ionospheric mass transfer.

We plan to organize a discussion to pick at least two intervals in a pre-Fall AGU GEM session and challenge observers to come to the 2003 GEM meeting prepared to characterize the ionosphere and it's contribution to the magnetosphere. The best ion mass spectrometer data from FAST, Polar, and Akebono are available in 1997, suggesting that one of the intervals should be in 1997. The recent launch of TIMED and availability of data from IMAGE and Cluster suggests that one of the intervals should be after February, 2002.

Session Summaries

Tutorial: Prof. Andrew Yau, University of Calgary, Canada, presented an overview of the current state of our understanding of the processes responsible for mass outflow and the consequences in the magnetosphere that follow. He made a clear distinction between thermal (i.e. polar wind) and energetic ion outflow. He presented the results of analysis of more than a solar cycle's data on the flux of ion outflow from the Canadian SMS instrument on the Japanese Akebono (Exos -D) satellite. In particular he presented the results of a statistical study showing significant positive correlation between O^+ ion outflow and Solar Activity as paramerized by the F10.7 Index. The H^+ correlation with F10.7 was slightly negative, i.e. more H^+ outflow during periods of low F10.7. He also showed a stronger correlation between ion outflow and the solar wind pressure than with magnetic activity as parameterized by the Kp index. The results of this study will appear soon in a JGR paper by Cully et al. Dr. Yau also presented results of simple models of the transport of ionospheric ions to the plasma sheet showing how changes in the large-scale electric field dramatically affect the transport of ionospheric plasma to the plasma sheet.

***Plasmaspheric Plumes*:**Dr. Yi-Jiun Su presented an overview of her work with a solar cycles worth of plasmaspheric observations derived from low energy LANL ion data. She also showed that observations made by the Millstone radar observations agree with the LANL geosynchronous observations. In particular she noted that the both the plasmaspheric refilling rate and speed of convection increase with magnetic activity (i.e. with Kp).

Dr. Jerry Goldstein presented various examples of imaging and motions of plasmasphere obtained from the EUV instrument on the IMAGE satellite. He noted both the creation of plasmaspheric plumes and their dynamics. He demonstrated that Kp=5 is enough to get a nice plume. If convection continues the EUV images clearly show the plasmasphere wrapping up.

Dr. Maria Spasojevic also presented images of the plasma-phere from the EUV imager on IMAGE. She made same points much more clearly because she explicitly presented and compared with in-situ density observations from the IMAGE RPI instrument.

Dr. Dennis Gallagher presented a compilation of movies of time histories of images from the EUV imager data. These movies showed that density rises at low L when it drops off at high L. At the time of geomagnetic activity the moves show that the entire plasmasphere is compressed, rather than displaced, or pushed down into ionosphere. Dr. Peterson commented that the movies would have been much more informative if they included index plots showing geomagnetic activity and estimates of the convection electric field derived from the data.

Dr. John Foster presented a comprehensive series of observations of enhanced density features in the topside ionosphere extending from low latitutes into the polar cap. He showed that these features are the direct signature the stripping off the plasmaspheric plumes at the onset of strongly enhanced convection. He showed examples of density enhancements extending from Florida to Alberta when plumes are created. He also presented evidence of plasma enhancements in the polar cap associated with these events.

Dr. Mark Engebretson presented ULF Wave observations made from the Antarctic and the Polar satellite. He showed that there was a class of waves occurring on isolated L shells that energize thermal He and H up into 100 eV range where they are detected by the TIMAS energetic ion mass spectrometer on Polar. He identified a potential source of free energy for the ULF waves in the keV ion data.

Dr. Bill Peterson presented observations of energized thermal plasmaspheric He^+ inside and outside of the dayside magnetopause obtained from the Polar satellite in March 2002. In one case both the TIMAS and CAMMICE instruments saw He^+ in the keV energy range. In another case, TIDE data was presented that clearly resolved the density and temperature of the energized He^+ component. Dr. Peterson noted that the combination of motion of the magnetic field in response to ULF pulsations and compress-ion of the magnetosphere make the routine detection of very low (i.e. ~ 2 or 3 cm^{-3}) He^+ ion densities possible) He noted that these data can be used to complement and extend the global images presented by Drs. Goldstein, Spasojevic, and Gallagher

Dr. Tom Moore extended the discussion of low energy ions observations at the subsolar magnetopause most all the time. He pointed out they vary tremendously in density, corresponding to the variation from partially to fully filled flux tubes.

Discussion - There was a vigorous discussion of all sorts of implications of dense ionospheric plasma being at the dayside magnetopause routinely, especially if variable in density. We are looking forward to more quantitative presentations on this topic at future meetings.

***Auroral Outflow Contributions to Magnetospheric Plasma*:**

Dr. Robert Winglee discussed the implications of some recent simulations made with this unique multi-fluid MHD code. He noted that most nightside and flank H^+ from the ionosphere enter the plasma sheet in the event modeled, which had conditions of very strong activity characteristic of a large storm. In this case, O^+ from the dayside cusp region is energized so much that it is lost downstream without entering the plasmasheet. He also noted that the cross polar cap potential and associated cross tail electric field results in significant energization in his codes.

Dr. Steve Mende presented observations of the substorm surge and associated ion outflow. The images were obtained from the MAGE/WIC camera and the ion observations from FAST. He suggests that the surge region is associated with intense H^+ outflow. He emphasized that the images put the location of the surge well equatorward of the poleward edge of auroral emissions. These observations and suggestions were amplified in the Tutorial talk given the following day by Dr. Robert McFadden. The suggestion made by Dr. Mende, McFadden and others at the conference is that the ions in the surge are accelerated by an Alvenic process that is different from the processes associated with the downward and upward current regions.

Dr. Lila Andersson presented preliminary results from a study to cast ion outflow observations in auroral zone boundary coordinates. She gave an overview of a poster describing how the boundaries are identified. She also presented results from the first 300 orbits analyzed. Specifically she showed the occurrence of ion beams and conics as a function of magnetic local time and auroral zone coordinates. The auroral zone coordinates went from 0 at the equatorward boundary to 1 at the polar boundary. The results presented were confusing, as the cusp region did not show the usual signature of intense conic activity. Several modelers present at the session encouraged Dr. Andersson to continue working on this project.

Dr. Gang Lu presented an overview of EISCAT observations of isolated and intense outflow events. Some of these events were associated with electron precipitation and some not. The events seem to be correlated with the region of convection reversal.

Dr. Chris Mouikis presented mass resolved, energetic ion composition observations from the Cluster/CIS instruments in midnight tail region near 19 Re. He is aiming to resolve the effect of O^+ on tail dynamics and storms. The data he presented for 17 Aug 01 - 10-17 UT, showed double beams showing bouncing ion streams, with energies dispersed. He also reported Energetic O^+ tailward of the reconnection site in this event. The data appear very good. We are looking forward to seeing a quantitative analyses of the data at future meetings.

Dr. Simon Wing presented analysis of dayside cusp ion distributions observed on the DMSP satellite in the frame-work of a model he and his colleagues have developed. The model predicts the magnitude of an electric field at the magnetopause.

Dr. Pontus Brandt presented results from the low energy neutral mass spectrometer that flew on the Swedish Astrid satellite. He showed low energy (~100 eV) Oxygen neutrals originating on field lines well inside the polar cap. These data were obtained before the IMAGE/LENA observations and are in the process of being compared with them.

Ms. Karen Remick presented Incoherent Scatter Radar (ISR) observations she interprets as the signature of ion outflows. She showed that most of the ISR data points were not associated with ion outflow. She concluded that heating by electrons in the topside ionosphere is associated with many ion outflows. It was not clear how these observations extend the statistical analysis of ion outflows in the less than 1000 km region obtained from DE -2 by Loranc, Heelis, and their coworkers.

Dr. Tom Moore discussed auroral and Lobal Winds. One chart showed the types of distributions seen over the poles, in the lobes, and into the plasma sheet during Fall 2001 Polar equatorial period. Hot auroral flows are embedded within pervasive cold lobal winds. Neutral sheet is either bi-directional streaming for thick NS, or isotropic hot for thin NS. The identification of bistreaming with the PSBL as being of ionospheric bihemispheric origin was somewhat controversial.

***Polar Wind Contribution to Magnetospheric Plasmas*:**
Dr. Peterson's introduction on

the polar wind and the difficulty of obtaining synoptic measurements of its properties precipitated a discussion about how the polar wind can be distinguished between ion outflows on auroral field lines. The general consensus was that the polar wind is a seed population that can and is energized by many other processes.

Dr. Takume Abe presented detailed movies of primarily polar wind velocity obtained from more than a solar cycle of observations from the Canadian SMS instrument on the Japanese Akebono (EXOS-D) satellite. He showed that the velocity of the polar wind decreases with increasing solar activity. Polar wind velocity increases with magnetic activity (Kp >3). His movies of the data sorted into geo-magnetic coordinates as a function of solar and geo-magnetic activity show that the region of outflow expands significantly with increasing solar and geomagnetic activity. Many of the variations of polar wind plasma properties presented were counterintuitive which initiated a lively discussion. It is hoped that Dr. Abe and the SMS analysis team will make these results available in a useful form for the modeling community.

Dr. Pat Newell noted that there should be a direct relation between polar rain and polar wind. He suggested that the presence of polar rain electrons should modify the ambipolar field accelerating the polar wind. Evidence supporting this was cited by Tom Moore, from Polar experience

Dr. Mark Hairston presented analysis of DMSP ion drift data obtained during an over flight of an EISCAT radar during an active period. He had been asked by Drs. Gang Lu and Bill Peterson if the ion drift observations were capable of identifying thermal molecular ion outflow (i.e. $N2^+$, $O2^+$ or NO^+) He discussed the limitations of the DMSP instrument package ---temporal resolution, energy range, and assumption of a thermal plasma. He noted that the next generation of DMSP ion drift instruments will have significantly higher temporal resolution than the current 4-s. The bottom line was that the event of interest probably did contain significant upwelling thermal molecular ions, but the temporal resolution of the instrument precluded resolution of the most interesting part of the data.

Dr. Bill Peterson presented a re-sorting of published energetic ion outflows flows above 15 eV from three years of Polar perigee passes. The data were binned by solar zenith angle (SZA), Kp, INVL, and MLT. Complete coverage was limited to the dawn/dusk region because complete SZA coverage is not available for the cusp and mid-night regions of the auroral oval. He showed that, during geo-magnetically quiet times, the flux of energetic H^+ and He^+ decreases with increasing solar illumination. He suggested that charge exchange with thermal O^+ component of the polar wind in sunlight is the cause of this unexpected variation.

Dr. Tom Moore presented arguments that the polar wind should be regarded as a continuous outflow that is unresponsive (in flux) to magnetospheric inputs, though it does respond in velocity as shown by Dr. Abe. He asserted that the polar wind flux should be regarded as a given for all global simulations, and that they should endeavor to form a plasmasphere by trapping this flux on low latitude flux tubes. Changing magnetospheric convection would then make that outflow available at higher latitudes.

Dr. Jim McFadden reported observations of cold ion streams in the plasma sheet at 19 Re observed by the Cluster CIS plasma instrument package. He suggested that this was the observation of energized polar wind in the tail. He also noted that cold ions are also often seen above the Cluster spacecraft potential near the magnetopause, apparently reflecting either plasmaspheric or polar outflows.

Joint WG1/2 session on Ionospheric Outflow Response to Imposed AuroralEnergy Inputs: Dr. Jay Johnson presented detailed analysis of a FAST He^+ ion outflow event. He used the observed wave spectrum (in the BBF frequency range) on FAST, propagated it to lower altitudes and showed that the observed flux of energized upflowing He+ was consistent with its being energized below FAST by the broad band wave spectrum observed at FAST, assuming it was prorogating downward. The subsequent discussion compared and contrasted his analysis with previous, reports and supports the conclusion that a significant fraction of heavy ions are energized by broad-band waves in the altitude region below a few 1000 km.

Dr. Yi-Jiun Su presented an overview of her recent work on identifying ion and electron acceleration events in the so-called Alfvenic region of the auroral oval. The FAST team has determined that there are three different types of auroral acceleration regions sorted in latitude. The upward and downward current regions and the Alfvenic region. This region is characterized by intense, low frequency, fluctuating electric fields. Dr. Su showed that separation of the Alvenic region is not always easy. She presented a comparison of ion outflow vs. pointing flux from various regions and illustrated a strong correlation between them in the Alfvenic region.

Dr. Steven Mende expanded on the observations (discussed above) he presented in the WG 1 Session on Auroral Outflow Contributions to Magneto-spheric Plasma. In particular he noted that the intense optical emissions assoicated with proton precipitation at substorm onset move systematically dawnward, contrary to expectation.

Dr. Bill Lotko outlined the basic basic theoretical concepts involved in auroral acceleration of ionospheric ions (FAC system, auroral density cavity, Knight relation, Bohm Criterion) and discussed their relationship to the problem of the ionospheric response. He noted that a treatment of field aligned potential drops is an essential part of simulating the overall MI-interaction, since these regulate outflow energy or velocity, thereby influencing convection paths. There was some discussion about whether E_{11} should be covered by the ionospheric boundary condition or within a global simulation.

Joint WG1/2 session on implementing a MI Coupling Challenge: The spirited discussion during this well-attended session revealed considerable interest among observers, modelers and theoreticians in three general problem areas: 1) distributions of energy and energy flux of electron precipitation (more generally electron parallel energization); 2)distributions of the mass flux and composition of outflowing ions, the processes determining them, and the impacts of ionospheric mass outflow on magnetospheric processes; and 3) distribution and length-scale dependence of ionospheric Joule heating. Global, regional and local distributions in space and time are of interest.

The discussion also revealed different expectations in the outcome of a MI coupling challenge. Global models require large data sets for code validation and the formulation of reduced models and/or parameterizations of the fluxes and transport that define MI coupling and boundary conditions in terms of MHD or macro variables, e.g., mass outflow rate in response to ionospheric energy deposition rates, if simple relations of this type exist. Modelers therefore expressed a need for relatively simple physical reductions from theoreticians and empirical relations from observers in order to implement appropriate ionospheric outflow boundary conditions and to improve existing electron precipitation models, together with appropriate data needed to validate the performance of such relations in large-scale codes. Alter-natively, the interpretation of data is facilitated by results from theory and models that quantitatively address the impacts of mass exchange and energy deposition on magneto-spheric circulation, including feedback loops. Observers therefore want quantitative theoretical and model results that can be tested against data and that will serve to organize and interpret the data and facilitate understanding of causal relations. Given the current state-of-the-science, we seem to be confronting a chicken and egg problem. It also appears that a productive MI coupling challenge will likely require a joint effort of CEDAR and GEM.

In view of the different expectations, needs and scope of a MI coupling challenge, the working group co-chairs and campaign coordinators propose to use event studies to encourage the development of the tools needed to make further progress, in particular, to assess the physical-empirical outflow relationship to energy input on the ionospheric end, and the modeling methods to accommodate corresponding ionospheric plasma inflow into the global simulation models.

The first task will involve the identification of several intervals or events that can be characterized as completely as possible by both observers and modelers given the current state-of-the-science. Special attention should be devoted to the following processes:

a) energy transfer from the magnetosphere to the iono-sphere, in all forms;
b) the state of the topside ionosphere, plasmasphere, and plasma sheet;
c) the outflow of ionospheric plasma in response to the inputs;
d) system behavior as modeled with/without the ionospheric mass transfer.

This discussion will be continued at the GEM Fall AGU mini-workshop where we hope to identify at least two intervals for further study, with the intention of challenging obser-vers to return to the 2003 GEM summer workshop prepared to characterize the ionosphere and its contribution to the magnetosphere. The best ion mass spectrometer data from FAST, Polar, and Akebono are available in 1997, suggesting that one of the intervals should be in 1997. The recent launch of TIMED and availability of data from IMAGE and Cluster suggests that one of the intervals should be after February, 2002.

Bill Peterson, Co-Chair
Pete@willow.colorado.edu

Tom Moore, Co-Chair
Thomas.E.Moore.1@gsfc.nasa.gov

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Working Group 2 Electrodynamics

MI Coupling WG2 held three open forums, each devoted to a key problem area in the electro-dynamics of MI coupling (summarized below) and one joint forum with WG1 dealing with the interplay between inertial and electrodynamic MI coupling (see WG1 Report). A lively challenge discussion involving WG1, WG2 and the GGCM working group was also held. Brief summaries of each session are given below.

How does MI coupling regulate field-aligned particle acceleration? The discussion focused mainly on microphysics of parallel electric fields and Alfvén wave processes leading to and regulating electron acceleration.

The microphysics of "quasi-static" MI coupling and associated field-aligned particle acceleration differs significantly in regions of upward versus downward field-aligned current (R. Ergun). Quasi-static models predict the formation of multiple "double-layer" sheaths in upward current regions, but the occurrence of a single potential structure or multiple sheaths with the same integrated potential drop has little influence on the current-voltage relation, e.g., the often used Knight relation. The parallel electric field sometimes forms coherent microstructures in downward current regions where the current-voltage relation is still rather poorly understood, if such a relation is even meaningful in such regions.

When MI coupling is mediated by Alfvén waves, coherent wave-particle interactions involving nonlocal Landau damping promote field-aligned electron acceleration in Alfvénic structures with transverse length scales less than about 10 km (referenced to the iono-spheric altitude), in regions where the ambient electron temperature exceeds about 100 eV (R. Lysak). When the large field-aligned currents carried by Alfvén waves exceed a critical threshold for the onset of current-driven microinstabilities, they can also deposit substantial energy in the lower magnetosphere, but the ability of the region to absorb such energy is highly dependent on the transverse length scale of the Alfvén wave (A. Streltsov). The reflectance of the associated dissipative layer approaches unity at kilometer length scales, making the lower magneto-sphere rather opaque at small transverse length scales. Nonlinear processes involving ponderomotive driven density cavities boost the parallel electric field, and presumably particle acceler-ation, at the edges of such cavities (M. Prakash). Magnetospheric dynamos are dynamically modified by Alfvén waves that are reflected at the ionosphere and/or in acceleration regions in the lower magnetosphere (Y. Song), which in turn modifies the conditions sustaining lower magnetospheric energy de-position and particle acceler-ation and, therefore, the acceleration process itself.

How do scale-interactive processes influence the electrodynamics of MI coupling and transport between the magnetosphere and ionosphere? Most of the discussion focused on scale-interactive aspects of ionospheric Joule dissipation.

Examination of the average electric field in the ionosphere and its variance derived from radar measurements suggests that large scale models do need to "sweat the small scales" (J. Thayer), but the effective roll-off in the wavenumber spectrum of "sub-grid" dissipation is still uncertain. Observations of phase variations in the optical and conductivity signatures of auroral precipitation structures (J. Semeter) may provide a quantitative means of identify- ing specific mechanisms that regulate or facilitate cross-scale energy transfer, such as the Atkinson-Sato feedback in-stability that redirects energy from Joule dissipation and stores it in the magnetosphere in the form of reactive Alfvénic power that may be released via some of the collisionless dissipation processes discussed above (D. Pokhotelov).

Does MI coupling regulate (or how does it regulate) magnetospheric convection, magnetotail dynamics and solar wind-magnetosphere coupling? The discussion concentrated mainly on the time scales of dynamic MI coupling and some consequences of the ionosphere as a plasma source and momentum sink.

The dynamics of convection in the vicinity of the plasmapause inferred from IMAGE data suggests that the magnetosphere requires about 30 minutes to establish a new convection state (J. Goldstein). The possibility of reconfiguring magnetospheric convection more rapidly by propagating signals first to the incompressible ionosphere, where fast mode waves could presum-ably signal changes on time scales of minutes, is deemed unlikely because fast wave propagation is very diffusive when the distributed nature of the finite ionospheric conductivity is considered (R. Strangeway). When the magneto-sphere in a global MHD model is allowed to acquire mass from a low-altitude source, the response time of the magnetosphere is found to increase measurably (A. Ridley). The development of large geodesic curvature of the geo-magnetic field lines, which arises, for example, with intensification of the field-aligned currents, increases the field line eigen-periods of such field lines and, therefore, the time scale for communication between the ionosphere and magnetosphere (J. Johnson).

Simulation studies of structures resembling plasmasheet reconnection bubbles in a global MHD model suggest that ionospheric plasma sources may suppress their formation (J. Lyon). Observational studies of solar wind-driven coherent structures on the dayside-so-called traveling convection vortices-seem to be relatively unaffected by the ionosphere, as evidenced by conjugate studies of the upward current filament of the TCV under solstice conditions (D. Murr).

Joint WG1/2, GGCM Session: Posing a MI Coupling Challenge. The spirited discussion during this well-attended session revealed considerable interest among observers, modelers and theoreticians in three general problem areas: 1) distributions of energy and energy flux of electron precipitation (more generally electron parallel energization); 2) distributions of the mass flux and composition of outflowing ions, the processes determining them, and the impacts of ionospheric mass outflow on magnetospheric processes; and 3) distribution and length-scale dependence of ionospheric Joule heating. Global, regional and local distributions in space and time at some reference altitude are of interest.

The discussion also revealed different expectations in the outcome of a MI coupling challenge. Global models require large data sets for code validation and the formulation of reduced models and/or parameterizations of the fluxes and transport that define MI coupling and boundary conditions in terms of MHD or macro variables, e.g., mass outflow rate in response to ionospheric energy deposition rates, if simple relations of this type exist. Modelers therefore expressed a need for relatively simple physical reductions from theoreticians and empirical relations from observers in order to implement appropriate ionospheric outflow boundary conditions and to improve existing electron precipitation models, together with appropriate data needed to validate the performance of such relations in large-scale codes. Alternatively, the interpretation of data is facilitated by results from theory and models that quantitatively address the impacts of mass exchange and energy deposition on magneto-spheric circulation, including feedback loops. Observers therefore want quantitative theoretical and model results that can be tested against data and that will serve to organize and interpret the data and facilitate understanding of causal relations.

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a) energy transfer from the magnetosphere to the ionosphere, in all forms;
b) the state of the topside ionosphere, plasmasphere, and plasma sheet;
c) the outflow of ionospheric plasma in response to the

inputs;
d) system behavior as modeled with/without the ionospheric mass transfer.
This discussion will be continued at the GEM Fall AGU mini-workshop where we hope to identify at least two intervals for further study, with the intention of challenging observers to return to the 2003 GEM summer workshop prepared to characterize the ionosphere and its contribution to the magneto-phere. The best ion mass spectro-eter data from FAST, Polar, and Akebono are available in 1997, suggesting that one of the intervals should be in 1997. The recent launch of TIMED and availability of data from IMAGE and Cluster suggests that one of the intervals should be after February, 2002.

Brian Anderson, Co-Chair
Brian.Anderson@jhuapl.edu

Bill Lotko, Co-Chair
william.lotko@dartmouth.edu

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Inner Magnetosphere and Storms Campaign

The Inner Magnetosphere-Storms (IMS) Campaign held a very active three day program at the 2002 GEM Summer Workshop. Two tutorials, a poster session, and 14 breakout sessions were held, including two sessions joint with the GGCM and MI-Coupling campaigns on "The Magneto-sphere and Ionosphere under Extreme conditions: Points of Contact between Global MHD Simulations, IMS Modeling, and Data". In addition, the GEM Student-Sponsored Tutorial "Radiation Belt Ups and Downs: Acceleration, Transport, and Loss of Relativistic Electrons" was given by Geoff Reeves of Los Alamos National Laboratory.

The joint GGCM-IMS-MIC sessions have been reviewed by George Siscoe (see The GEM Messenger, Volume 12, Number 24, July 29, 2002). The remaining IMS activities are summarized below.

Anthony Chan (aac@rice.edu),
IMS Campaign Convener

Working Group 1

PLASMASPHERE AND RING CURRENT REPORT

The Inner Magnetosphere Storms Working Group 1 (IMS/WG1) held six independent and joint sessions during the June 2002 GEM, as well as an invited tutorial presentation. The sessions focused on new work regarding inner magnetospheric electric and magnetic fields, on the new techniques that have become available for deriving the distributions of thermal plasma and results from their application, and on the obser-vations and modeling of ionospheric, plasmaspheric, and ring current interactions in the inner magnetosphere. The tutorial, given by Prof. Dick Wolf of Rice University,gave a lucid description of why inner magnetospheric dynamics are important to the global stormtime scenario: low and midlatitude ionospheric effects, primarily driven by the asymmetric ring current, are presently one of the biggest space weather concerns. Changes in upper atmospheric flow patterns and total electron content impact GPS and communication systems, resulting in adverse societal impacts. Prof. Wolf detailed this connection and the history of our understanding of it.

***Inner Magnetospheric Electric and Magnetic Fields*:** Presentations on inner magnetospheric magnetic and electric fields discussed newly observed properties and modeling. Several empirical/ physical B-field models exist for the inner magnetosphere. Some use up-stream conditions for the para-meterization, while others use magnetospheric parameters. These models are indicating that, for intense storms, most of the inner magnetospheric B-field perturbation (and also Dst) is from the ring current. Determinations of partial-versus-symmetric ring current contributions are also becoming incorporated into these models. In small storms, the tail current plays a much larger role. It was discussed that modular, event-oriented B-field models are more flexible than statistical models and may be the best option for the strongest storms. However, with the collection of more data, statistical models are becoming better at very disturbed times. B-fields from field-aligned currents (FACs) are the hardest to include because the FACs that flow along B also modify B. Subauroral FACs are often carried by soft electrons, so they close in the F region, with little or no ground magneto-meter signature.

The biggest E-fields in the inner magnetosphere occur inside of L=5 (evening/nightside), opposite of the standard picture. Over shielding requires an inward penetration of the plasma sheet followed by a northward turning of the IMF Bz. There is a 30-minute time delay between changes in the IMF and the reconfiguration of inner magnetospheric electric fields, probably because the inner magnetospheric electric fields depend on the build up and decay of ring current pressure. The inner magnetospheric convection electric field extends at least through the early storm recovery phase. Comparisons between various electric field descriptions shows that the E-field is quite complicated and the simple field models used up until now are probably inadequate to truly describe the stormtime features. Fresh injections appear common throughout storms, including the recovery phase. New online DMSP derived products will soon become in support of these studies e.g. integrated precipitating energy flux, ion drifts, ion composition, and satellite tracks. A new SIMEF electric field model is being developed as spherical harmonic fits to the RCM. It is intended to be both easy to use and capable of reproducing physically interesting features, e.g. SAPS. For this meeting, MSM was used to explore the range of storm-time magnetotail depolarization effects. The analysis found distortions reaching into L=5 at midnight and found quiet-time geosynchronous field lines stretching to L=25 in the tail during storm-times.

New Density-Deriving Techniques for the Inner Magnetosphere: The past few years have seen the emergence of new techniques which are capable of delivering much more global descriptions of ionospheric and plasmaspheric density distributions. Ground magnetometer observations of ULF waves are used to measure Eigen modes of field oscillations. Frequencies are related to magnetic field strength, field line length, and mass loading. The analyses of observed resonances yield field line mass densities. The technique assumes a smooth, monotonic variation of Alfven velocity versus location along an L-shell. Resonances occurring directly over an observing station are found to be difficult to interpret. The technique also assumes a purely toroidal mode and that sufficient broadband noise exists to excite all modes and latitudes of interest. Resonance analysis is simple and easy to perform and can provide mass density estimates from L<2 to L<12. It can also be used to provide continuous measurements over most of the dayside with 30 min resolution time resolution. Magnetoseismology makes use of propagation times for subsolar origin ULF waves that propagate to the ground. By analyzing the time of arrival and wave phase, mass densities can be inferred over large regions of the magnetosphere. More extensive placement of ground stations and improved inversion techniques are needed. GPS TEC is becoming mainstream for obtaining total electron densities. The technique uses Faraday rotation of trans-ionospheric signals, which depend on the frequency and line-of-sight integrated electron column density. Typically 50% if TEC is below 1000km and the rest from the plasmasphere. There are about 500 GPS stations across the north American continent making these measurements for the last 5-years continuously. A density map is made every 5 minutes, derived from over 150 measuring stations. This processing extends out to L=4. Processing is expected to be automated in the next year. IMAGE Extreme Ultraviolet imager (EUV) observations can be used directly to obtain the (L& MLT) equatorial projected locations of observed edge features, primarily the plasmapause. Densities are just beginning to be obtained using a variety of techniques: forward modeling, genetic algorithm inversion, and arithmetic reconstruction technique inversion. These techniques remain to be broadly applied to EUV observations, although this can now be expected soon. The observations are of 30.4nm solar ultraviolet light scattered by He+ in the inner magnetosphere; presenting an optically thin medium. Inversions depend to varying degrees on a priori assumptions and are capable of varying spatial resolutions in derived density. IMAGE Radio Plasma Imager (RPI) measurements directly sample remote densities. Group index of refraction for X and Z mode waves (primarily) are used to determine group velocity transit times for transmitted wave pulses, which are directly measured. Simultaneous fitting of multiple-mode echo traces yields unique identification that echoes often follow field-aligned paths.

Inner Magnetospheric Density Results:In situ measurements of plasmaspheric plasma have a long rich history, from the ground and from space. As part of a review, the suggestion was made to use d(Dst)/dt in future statistical correlations. It was also noted that few observational missions have measured both ion populations and waves at the same time and that more of these measurements are needed. In situ and remote techniques are yielding new information about field aligned density distributions. ULF waves together with in situ and remote IMAGE RPI observations can be used to explore storm-time mass loading of field lines. It was also noted that there might be some value in consolidating the differing mathematical approaches currently being employed to describe derived plasma density distributions. Initial interpretation of IMAGE global EUV images suggest that midnight eroded plasmaspheric plasma may be pushed inward to lower L-shell, while evening plasmas can be seen to directly convect toward the dayside magnetopause. A clear determination of midnight plasma transport remains to be accomplished. Field aligned plasmaspheric densities are often found not to follow diffusive equilibrium. In one case this was true even after 3 or more days of quite conditions at L=5. The question was posed as to when collisional and collisionless treatments are appropriate for describing field-aligned distributions and how do distributions transition between these treatments? New models for polar cap thermal densities and plasmaspheric densities are becoming available from the IMAGE RPI. Global observations from the IMAGE EUV are showing that plasmaspheric structures include the convection tail, as previously anticipated, but also strikingly include many types of azimuthal structures. Some azimuthal structures have been successfully related to under/over shielding of the convection electric field. Some show evidence of large-scale standing waves, perhaps externally driven by the solar wind and not locally resonant. Plasmapause behavior is still not well understood. Observational techniques are now available which should be capable of addressing this issue, which include GPS TEC measurements that were used to find a hole in the plasmasphere/ionosphere over the magnetic equator with TEC=20.

Inner-System Coupling: Observations: Sub-Auroral Polarization Streams (SAPS) are driven by a polarization electric field that forms in the low conductivity region between the inner edge of plasma sheet precipitation and the plasma-sphere. SAPS are found between dusk and midnight, and have flow speeds of about 1 km/s. They appear to be driven by a ring current pressure gradient. The inner edge of SAPS penetrate the outer plasmasphere, participating in plasmaspheric convective tail formation. Meso-scale inward and outward motions of the outer plasmasphere are interpreted as the result of a westward electric field resulting from over or under shielding of the externally driven convection electric field. 30-minute delays are found between changes in the IMF Bz and the reconfiguration of electric fields in the inner magneto-sphere. Remote plasmasphere, ring current, and auroral observations were presented that suggest coupled interactions between these regions. An overlap between the plasmasphere and ring current appears to result in a significant reduction in plasmaspheric densities in the overlap region. This region also appears connected to a localized equatorward extension of the auroral zone. Evidence suggests that these interactions occur during storm and recovery times. Observat-ions were presented of the build up of the ring current in response to changes in IMF Bz, suggesting that the 30-minute time delay in the transmission of convection electric field to the inner magnetosphere results from the time required for ring current build up. The implication is that the inner magnetospheric electric field is purely pressure driven. Ring current asymmetry is found to persist well into storm-time recovery, based on Dst. It was suggested that IMF driven convection should be examined to determine whether injection continues beyond early storm times, which would explain persistent asymmetry. The convection electric field as represented by VB-south does not appear to control the rapid initial recovery of Dst. If flow-out is the primary loss process in the initial recovery, then the plasma sheet density is a likely influence. Examination of the AMPTE/CCE database reveals that there is a lot of low-energy O+ at low L-shells during storms.

Inter-System Coupling: Modeling: Several new and near-new plasmasphere models were presented. H^+, He^+, and $O^+$are modeled in these physics-based models. Ionospheric inflow/outflow and convection are uniformly included in these models. Simulations of the storm-time diffuse auroral using AMIE electric field were compared to PIXIE and UVI. Flux dependent diffusion is found to be the most realistic regarding precipitating flux and local time variation. It has been possible to account for some, but not all, features. A next step is to include a more realistic time dependent magnetic field configuration. RCM modeling results were presented, which capture most of SAPS events: double peak structure of SAPS electric field, MLT extent, and variation of SAPS location with MLT. Modeling does not include changes in ionospheric conductance in the midnight sector. Modeling also does not have changes in charge exchange in strong flow regions. Future work requires coupling an ionospheric model with RCM. Results from Michigan MHD and RCM modeling were presented. The MHD code directly drives RCM inputs, but RCM products are applied with a different time-scale to MHD code operation. This coupling results in a different pressure distribution. It also results in a change in the magnetic field configuration and clearly gets the development of a region 2 current system. Pressure pushes the reconnection site further down the tail. Differences in grid resolution that result in some computational diffusion have yet to be dealt with. In the future, comparison will be made between potentials and Birkeland currents computed by RCM with those computed from MHD and RCM will be further extended into the nightside, simulating a magnetic storm.

WG1 Plans for the future: This last year has been one of transitions. Important new observational techniques have been developed, which now make possible much more global representations of ionospheric, plasmaspheric, and ring current plasmas. At the same time, new efforts to couple plasma population models have successfully advanced physical modeling. In this context, this year's IMS/WG1 sessions made it possible to share many of these advances.

WG1 sessions for June 2003 will consequently refocus on

GEM storms, both old and new, for the purpose of encouraging the application of new observational and modeling techniques. GEM storm times will be revisited at the mini-GEM meeting at Fall AGU 2002. At that meeting, participants are invited to argue for including specific storms for discussion in the following June 2003 Workshop. The following storm times have been proposed so far as candidates:

Previously-chosen storms:
January 10, 1997
May 15, 1997
September 25, 1998
October 19, 1998
October 4-7, 2000
March 31-April 2, 2001
Newly-suggested storms:
April 6, 2000
September 17, 2000
April 11, 2001
October 21, 2001
November 6, 2001
April 17-24, 2002

You will note that the list includes storms from the previous GEM list and new storms. Participants at the mini-GEM in December will down-select to a shorter list of storm-times for community-wide examination. It is encouraged for those interested in promoting a particular storm to send data, model results, and explanations to the GEM-Storms webmaster (go to http://leadbelly.lanl.gov/GEM_Storms/GEMstorms.html).

Following the mini-GEM, providers of data products will be invited to contribute data relevant to these down-selected storm-times for posting to the GEM web pages. These data products will then be available for model comparison. Modelers are solicited to quantify the important features of their models, which will be used for modeling the selected events for GEM 2003, through submission of Model Vitas. Web posted vitas need to be submitted prior to the June 2003 meeting along with "key parameters" that summarize modeling results.

The current plan is for the first WG1 session to consist of presentations by data product providers who will summarize their data by storm. Subsequent sessions will focus, storm by storm, on modeling results. Some of these sessions are likely to be jointly held with other working groups. Vita and key parameter results will be used to facilitate the comparison of modeling results and the identification of modeling technique strengths and weaknesses.

The proposed Model Vita format contains:
* A list of relevant inputs, processes, and calculational methods :
- So others can reproduce results
- So others can understand
- strengths and weaknesses
  So others can contrast and compare various model results

* A vita for each storm event simulation run

Model presenters are further encouraged to identify key parameters of the physical system that result from their modeling efforts. Discussions at the June meeting will make it possible for the community to select among these provided parameters to identify common community parameters for future work.

Dennis Gallagher, Co-Chair
Dennis.Gallagher@msfc.nasa.gov

Mike Liemohn, Co-Chair
liemohn@umich.edu

Working Group 2

(RADIATION BELTS)

At the 2002 GEM summer workshop the Inner Magnetosphere-Storms Working Group 2 (IMS WG2) held several oral and poster sessions.

Inner Magnetospheric Magnetic and Electric Fields (joint with WG1)
Recent Theory and Modeling of Radiation Belt Acceleration
Radiation Belt Electron Loss Processes
The Magnetosphere and Ionosphere under Extreme conditions: Points of Contact between Global MHD Simulations, IMS Modeling, and Data (joint with GGCM and MIC)
Observations of the Radiation Belts and the Radiation Belt-

Storm connection
Solar Wind Drivers of Radiation Belt events
End-to-end Models and "Cartoons" of Radiation Belt Events
Wrap-Up/Future Plans session (which was also joint with W.G.1)

A report on the sessions on "The Magnetosphere and Ionosphere under Extreme conditions: Points of Contact between Global MHD Simulations, IMS Modeling, and Data" has been published in THE GEM MESSENGER, Volume 12, Number 24.

The Working Group 2 tutorial was by Richard Horne of the British Antarctic Survey who spoke about the contribution of wave particle interactions to acceleration and loss of radiation belt electrons.
There were also approximately 20 posters presented on radiation belt dynamics, theory, modeling, and related processes. This year the poster presentations sessions were notably well-attended and rich in content.

Several important areas of consensus emerged from the discussion of the oral and poster presentations.

There is now wide-spread appreciation of the delicate balance between loss processes and acceleration processes, both of which appear to be enhanced during storms. One result is that any given storm can produce either an enhancement or a reduction in relativistic electron fluxes throughout the radiation belts. This has several important implications, one of which is that the amount of acceleration cannot be quantified without having a simultaneous quantitative understanding of electron loss. Models of electron acceleration without losses will underestimate the amount of acceleration. Estimates of electron precipitation rates as well as theoretical calculations of pitch angle diffusion suggest that loss processes could essentially empty the radiation belts in a matter of days under storm-time conditions (and if simultaneous acceleration/transport processes were not acting simultaneously.)

The investigation of acceleration and transport processes (both observational and theoretical) continued at this workshop but the emphasis has changed from evaluating the possibility of certain mechanisms to developing quantitative calculations of the amount of acceleration and transport.

Drift resonance with ULF waves has been shown to produce enhanced radial diffusion leading to radiation belt enhancements. Several papers therefore looked more closely at the ULF wave fields during geomagnetic storms. It was shown, for example, that ULF wave power is significantly higher during storms than at other times and such enhancements are seen both in ground magneto-meter data and in MHD simulations. It was also shown that the location of the ULF wave fields as a function of L-shell is also highly variable with ULF wave power geometrically increasing with higher L-shell. Evidence was also shown for a minimum L with significant wave power with that cut-off related to the auroral boundary index. These ULF wave fields were used in particle simulations to demonstrate that the particle dynamics and diffusion rates obtained from the drift resonances can account for relativistic electron enhancements.

Wave particle interactions with VLF and EMIC waves were also investigated in more quantitative detail than in previous years. A prominent feature of this class of interactions is that it integrates acceleration and loss processes into a single physical model with both processes driven by the same wave fields. Another key difference between this class of interactions, compared to the ULF interactions, is the importance of continued substorm activity during the recovery phase of a storm. Substorm injections produce the substorm-associated VLF chorus emissions that are responsible for the electron gyro-resonance and energy and pitch angle diffusion process.

Quantitative modeling of this scenario showed that, with continued enhanced wave fields, the electron spectrum could continually harden at L=4 over at least a week, even with significant losses occurring simultaneously.

Analytic treatments of wave-particle interactions (both ULF and VLF) have developed considerably in the past year. Those studies show promise for developing better physical understanding and numerical simulation of particle acceleration and losses.

Solar wind-magnetospheric electron interactions were discussed in the context of radiation belt events. Those interactions were discussed in the context of semi-empirical models of electron fluxes that can be used for space weather applications as well as in the context of physical interactions between the solar wind and magnetosphere which could, for instance, produce the observed wave fields. The role of high solar wind velocity and enhanced dayside reconnection were joined by the role of intrinsic fluctuations in the solar wind in capturing the attention of the working group. Efforts to disentangle these potential drivers (which tend to occur together) by statistical analysis and by modeling of hypothetical conditions is leading to a tantalizing clues about which conditions are necessary and/or sufficient to produce relativistic electron events.

While these topics define some of the dominant themes of the meeting there were numerous and significant presentations that are not mentioned here. Many of those were in the nature of raising interesting observations for which clear explanations do not yet exist. In the course of our discussions we developed broad consensus on several questions that the campaign will focus on between now and the 2003 summer workshop. A partial list includes:

While the largest changes in relativistic electrons occur during storms can the same processes occur during non-storm times? These might include "small storms", high solar wind velocities with little or no Dst, intervals of strong solar wind ULF wave power with little or no geomagnetic activity. These events may be rare but would provide a sensitive test of which conditions are necessary and/or sufficient. What are the IMF and magnetospheric conditions during storm recovery phase? How do they relate to the ultimate flux levels of radiation belt electrons and what do they tell us about the acceleration and transport mechanisms? How do they influence the spectral, spatial, and temporal structure of the belts?

What is the role of the plasmasheet source population? What are its characteristics? How are they different during efficient and inefficient electron acceleration events? How are they trapped?

What is the phase space density gradient as a function of L-shell and storm phase? How often and when are peaks observed? Are the peaks produced by localized acceleration or localized losses? What does the gradient look like at or outside the trapping boundary?

What are the statistical properties of the various relevant parameters for quantitative modeling of the radiation belts? Those properties include at least, wave fields (power and distribution) of ULF, VLF chorus, and EMIC waves, the rate and intensity (?) of substorms, the phase space density of the plasma sheet source population, the pitch angle distribution of radiation belt particles, the energy spectrum, etc. In particular we identified the need to compare MHD wave power calculations with ground-based observations.

Are there different processes for acceleration and loss that can have different magnitudes during storms? Or, are acceleration and loss intimately related by the same physical processes?

What determines the inner boundary of the radiation belts? Is the boundary primarily set by loss processes, by the location of an internal acceleration process, or the depth of penetration of the radial transport in a given event.

How do we quantify the relative magnitudes of acceleration and loss and the balance between the two?

In the summary session we reviewed the objectives of the campaign set in 1999. Those continue to be appropriate guides for our continued efforts. A small change recognizing the importance of loss as well as acceleration was incorporated so the objectives now read:

1) To evaluate the relative contribution of various proposed acceleration and loss processes through theory, modeling, and comparison with data.

2) To create time-dependent phase space density profiles of the radiation belts that will more accurately represent their structure and dynamics than fixed-energy profiles.

The evidence of published work on these topics shows that the campaign has been highly successful. The number and importance of outstanding questions shows that there is still considerable opportunity for improved scientific understanding.

Geoff Reeves, Co-Chair
reeves@lanl.gov

Richard Thorne, Co-Chair
rmt@atmos.ucla.edu

Global Geospace Circulation Model Campaign

Working group 1 models

The GEM GGCM campaign held a session focusing on the current status of the GGCM campaign and related GGCM issues at this year's Telluride summer workshop. This session provided a forum for both the providers of models and their users. Two specific topics were brought up:

a) Current community-accessible models: What is available, how is it working, what is needed, and what could be improved? Several speakers addressed these questions. Dan Weimer announced that his data-derived models of the ionospheric potential and FAC models are now available at the CCMC via a web nterface which allows for quick access without having to obtain and install the model. Kile Baker discussed the current structure and operations of the CCMC. Two working groups have been established to advise the CMC: one focusing on the science and one that focuses on the operations. The CCMC Science Working Group is the primary contact point for the community regarding issues and concerns as to what the CCMC offers and how. Of the 7 members of this working group David Sibeck, Chuck Goodrich, and Tamas Gombosi represent the magnetospheric community. Marsha Kusnetzova presented new features and new models now available at the CCMC which may be accessed via the CCMC web site (http://ccmc.gsfc.nasa.gov). She also reported that there is substantial demand for magnetosphere model runs. Jimmy Raeder announced that model runs on demand with the UCLA/NOAA GGCM are now also available from a web site at UCLA (http://www-ggcm2.igpp.ucla.edu), and continue to be offered by the CCMC. John Freeman gave a user's perspective, noting the usefulness of the models available at the CCMC, while also pointing out that there are still a number of glitches in the plotting interface (Mike Heinemann chimed in). Sorin Zaharia reported results from pressure balance calculations using the Tsyganenko model that point to spurious currents when the Vasyliunas equation is used to obtain the currents.

b) What should the role of the GEM community be in the emerging world of community-accessible models? This question led to an animated discussion. It was generally agreed upon that the GEM community continues to play an important role in the GGCM development and dissemination. In particular, the GEM community provides models, conducts research with the models, organizes challenges to valididate and intercompare models, recommends inclusion of models into the CCMC, recommends metrics to test the models, and provides data for metrics and model validation. In discussing these issues the consensus was that there is no specific need to institutionalize such efforts but that close collaboration with the CCMC Science Working Group should be sought.

Jimmy Raeder, Co-Chair
jraeder@igpp.ucla.edu
Terry Onsager, Co-Chair
Terry.Onsager@noaa.gov

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Joint GGCM-IMS-MIC Session: The Magnetosphere and Ionosphere under Extreme conditions: Points of Contact between Global MHD Simulations, IMS Modeling, and Data

A pair of sessions on modeling and observations focused on two aspects of the solar wind-magnetosphere-ionosphere system that recent observations and modeling suggest might characterize the storm state as distinct from the non-storm state. The two aspects are transpolar potential saturation (TPS) and differential convection. TPS refers to an apparent upper limit on the transpolar potential (a.k.a. the cross-polar-cap potential CPCP) which sets in when the storm-driving component of the solar wind motional electric field (called here the IEF) exceeds about 5 to 10 mV/m. Differential convection refers to a condition in which the trans-magnetospheric potential exceeds the transpolar potential when the latter is saturated. A necessary consequence of differential convection is the appearance of parallel potentials comparable to the difference between the potentials across the polar cap and magneto-sphere. In the first session representatives of the modeling community were solicited to interrogate their models to address the following issues:

Does transpolar potential saturation occur in the model?

If so what causes it?
1. Ionospheric limit on current
2. Reconnection limit on potential
3. Ram-pressure limit on region 1 current
4. Mass loading by ionospheric outflow

What observables distinguish the answer to this question?
Do storm-level parallel potentials develop in the model?
If so what causes them?
1. Differential convection
2. Resistivity and parallel currents
3. Other

What observables distinguish the answer to this question?

In the second session representatives from the observing community were solicited to interrogate their data to address the following issues:

Does transpolar potential saturation occur in the data?
If so does it vary with parameters?
1. Ram Pressure
2. Season (conductance)
3. other

Do storm-level parallel potentials develop in the data? If so do they vary with parameters?
1. IEF
2. Ram pressure
3. Season (conductance)

The following summarizes the presentations.

Models: George Siscoe opened the session with a review of issues to be addressed then illustrated them with results from the global MHD code developed by Mission Research Corporation (the ISM code, which stands for Integrated Space Weather Prediction Model). The ISM code develops TPS at observed levels of IEFs and CPCPs. Siscoe associated the saturation phenomenon with the usurpation as the IEF increases into the saturation domain of the Chapman-Ferraro current system by the region 1 current system, which then must perform the function of providing the JxB force to stop and deflect the solar wind. According to this idea, once the stopping and deflecting function fully devolves onto the region 1 current system the current has reached an upper limit and the current system, which in the ionosphere sets the CPCP, reaches saturation. This "ram-pressure model" predicts that the level at which the region 1 current system (and hence the CPCP) saturates should be higher the greater the ram pressure, a property seen in the output of the ISM code. The ISM code also develops parallel potentials in the outer magnetosphere in the dawn and dusk local-time sectors as a consequence of differential convection, i.e., as the IEF increases the transmagnetospheric potential continues to rise after the CPCP has saturated.

Aaron Ridley presented results from the University of Michigan global MHD code called BATS-R-US. A plot of the CPCP from the output of a series of BATS-R-US runs as a function of IMF strength for southward IMF nicely displayed saturation of the CPCP. At an IMF Bz of -40 nT (corresponding to an IEF of 16 mV/m) the CPCP was fully saturated at 230 kV. These values generally accord with observations. Rather than ram-pressure limiting the CPCP, Ridley preferred to attribute the phenomenon of saturation to a change of the magnetosphere's shape, which might limit access of the IMF to the reconnection site. A change in shape that could indicate the action of such a process shows up in the profile of the nose of magnetopause in the noon meridian plane. As the IEF increases the nose profile goes from convex outward (the usual case) to concave outward (i.e., a dimple) in the saturation domain. Regarding dependence on ram pressure, the code returned saturated CPCP values that increased approximately as the ½ power of ram pressure. For comparison, the Hill model of TPS (as formulated by Siscoe et al.) predicts a 1/3 power dependence on ram pressure in the saturation domain. The BATS-R-US code also generates parallel potentials approximately of the same magnitude and location as the ISM code.

Jimmy Raeder used a simulation by the UCLA global MHD code of the Bastille Day storm to demonstrate TPS in the form of a moderate CPCP (~250 kV) despite a very strong IEF (~ 20 mV/m). He made other runs also to test for dependence of the saturated value of the CPCP on ram pressure. He found a positive but weak dependence. Like Ridley, Raeder prefers a geometrical to a dynamical explanation of TPS. He suggests that saturation is a result of the effective length of the reconnection line shrinking as the IEF increases, a behavior that in part results from the dayside "erosion" of the magnetosphere that reconnection causes. The UCLA code also generates parallel potentials approximately of the same magnitude and location as the ISM code; Raeder, however, thinks that such potentials could be numerical artifacts.

John Lyon used the LFM (Lyon, Fedder, Mobarry) global MHD code (developed at NRL and Dartmouth) to address TPS and parallel-potential issues of the session. The LFM code displays TPS although at higher potentials than the other codes. Lyon attributes the TPS phenomenon to a feed back to the magnetopause from the ionosphere of the electric field that is generated by currents in the ionosphere, which are in turn driven by reconnection at the magnetopause. According to this idea, the feedback distorts the electric field at the magnetopause in a way that limits magnetic reconnection there. He found that the value of the potential at saturation decreases as the ionospheric conductance increases, which was also found to hold for the other codes. Lyon finds no evidence of significant parallel electric potentials in LFM runs designed to reveal them. In this respect LFM results differ from results of the other MHD codes.

Dennis Papadopoulos supplemented Lyon's presentation by directing attention to a possible feedback instability in the ionosphere itself which might account for TPS. He noted that if the convection speed in the ionosphere driven by solar wind coupling exceeds the local sound speed a two-stream type of instability can occur, which might change ionospheric conductance. He suggested that it is important to incorporate such a mechanism in global MHD codes.

Robert Winglee presented results from a global multifluid code developed at the University of Washington. This code differs from standard MHD codes in significant respects, one of which is its ability to investigate ionospheric outflow and its effect on global dynamics. His code manifests a TPS-like behavior, which he attributes to loading of convecting open field lines by outflowing material from the ionosphere. This mechanism is basically different than any that the other codes produced since the other codes have no ionospheric outflow (at least as yet). A limitation of the Winglee code compared to the others is its rigid prescription for the electric field, E = - VxB. Thus the code is mathematically incapable of generating parallel electric fields, and so had to remain silent regarding the session's parallel-potential issue.

Vahe Peroomian applied the Large-Scale Kinetic model (LSK) developed at UCLA to investigate the behavior of ions moving under magnetic and electric fields specified from the output of an MHD code that produces significant parallel potentials (the ISM code). The idea he pursued was to discover signatures in particle data that are diagnostic of such potentials. The absence of such signatures would then testify against the predicted potentials whereas the presence of the signatures would tend to confirm them. He found that particles initiated in the outer magnetosphere in the dawn meridian plane—a place well situated to be influenced by the questionable potentials—took a variety of trajectories. Some particles drifted to the dusk side of the magnetosphere then precipitated into the ionosphere, but most precipitated directly into the dawnside ionosphere, picking up tens of kilovolts in the process. The result suggests that a good test of the reality of the predicted parallel potentials would be to confirm the presence or absence of energetic ions (tens of kilovolts) precipitating into the high-latitude, dawnside ionosphere during the main phase of a magnetic storm. This work is continuing.

Masha Kuznetsova showed pertinent results obtained from varying ionospheric conductance in several codes now installed at the Community Coordinated Modeling Center (CCMC) located at Goddard Space Flight Center (http://ccmc.gsfc.nasa.gov/). She investigated cases in which the conductance was held constant as the IEF changed and cases in which the conductance depended on current into the ionosphere. Most of the runs were made in the non-saturated domain of small solar wind electric fields. She found that as conductance is increased, total field-aligned current increases and the cross polar cap potential decreases, which is what one expects in this domain. One new piece of information emerged, however, from the study in cases of current-dependent ionospheric conductance (the new region of parameter space explored in this study). It is that the cases of current-dependent conductances behaved qualitatively similar to the cases of constant conductances except that the cross polar cap potential tended to be greater in the current dependent cases.

Observations relating to transpolar potential saturation: Marc Hairston, using DMSP data to measure the transpolar potential, added events to the March 31, 2002 storm that he had presented at earlier meetings. The total number of points on his plot of transpolar potential versus IEF now totals 26, which taken together fall within the range of potentials that the Hill model of TPS (as formulated by Siscoe et al.) predicts for ionospheric conductances of 5 S and 10 S and nominal ram pressure. He anticipates being able to add more points by using lower latitude passes and correcting for the offset. There were four cases in his plot that fell above the predicted range based on 5 S to 10 S range of conductances. These had unusually high ram pressures, which would be consistent with the Hill model since in the saturation domain the Hill model predicts that the saturation potential increases as the 1/3 power of ram pressure. The average transpolar potential for the 26 points was about 170 kV with a range from 140 kV to 250 kV.

Ray Greenwald presented results based on data taken by the SuperDARN coherent radar array. The data were processed to infer the transpolar potential from derived ionospheric convection velocities. His plot of transpolar potentials versus IEF contained hundreds of points, which clearly defined a curve that rose linearly for small IEFs then saturated at high IEFs. For IEF = 0 the curve intersected the potential axis at about 20 kV, suggesting that this is the potential associated with convection driven by non-reconnection processes. At high IEFs, the curve leveled off at about 80 kV with a range from 40 kV to 110 kV. Greenwald stressed that the scatter in the data, which is evident also from measurement to measurement, probably reflects a real property of the potential. Fitting the Hill model to these points, after adding the 20 kV offset at IEF = 0, requires that the ionospheric conductance be around 23 S, which is probably unphysically high. This result differs from that of Hairston—which agreed with the Hill model with conductances between 5 S and 10 S—in part because the DMSP-derived potentials are about twice those of the radar-derived potentials (170 kV for DMSP versus 80 kV for SuperDARN). Since in the Hill model the transpolar potential at saturation varies inversely with conductance, the factor-of-two difference in the potentials in the Greenwald and Hairston presentations accounts for the factor-of-two difference in conductance in their fits to the Hill model, one being physically realistic (~10 S) and the other possibly not (~20 S).

Gang Lu used HAO's AMIE technique to analyze three storms in detail (May 3-4, 1998; July 15, 2000; and March 30-31, 2001). She also presented a compilation of results from 15 separate events. The storms of May and July showed saturation of the transpolar potential at about 225 kV and 300 kV respectively. The March storm showed no clear saturation even though the IEF reached 32 mV/m, at which one would expect saturation. In the compilations, she plotted the maximum values of Dst, maximum cross polar cap potential (CPCP), maximum AE, and maximum joule heating versus maximum IEF. These plots showed fairly clear saturation for CPCP and AE, saturating around 300 kV and 4000 nT respectively. There was also a tendency for Dst to saturate at around -400 nT. Curiously, joule heating showed no clear tendency to saturate. Lu suggested that the last of these results at least poses a challenge for modelers.

Observations relating to parallel potential drops: The issue here, to repeat, is this: some MHD models find significant parallel potential drops in the outer magnetosphere on closed field lines in the dawn and dusk local-time sector when the transpolar potential is saturated. Is there any observational evidence for such potential drops? Two types of evidence have been suggested that might be used for such a test: Dst versus CPCP and energetic O^+ ions pulled out of the ionosphere by the parallel potentials under investigation. The first of these approaches (Dst versus CPCP) was suggested by C. T. Russell et al. (Nonlinear response of the polar ionosphere to large values of the interplanetary electric field, *J. Geophys. Res., 106,* 18,496-18,504, 2001.) who found that although CPCP saturates Dst appears not to saturate, from which they inferred that the magnetospheric convection potential does not saturate whereas the ionospheric convection potential does. Above we referred to this condition as differential convection. To exploit Russell's method directly, one should plot Dst versus CPCP to see whether the one continues to grow while at the same time the other levels off. The second type of observational test for parallel potentials involves looking for accelerated ionospheric ions in the place and time predicted by the MHD simulations.

Mike Liemohn applied the Dst method to the Bastille Day storm. First he noted that by comparison with empirical models which do not properly capture the saturation behavior of the CPCP (e.g., Weimer), the value of the transpolar potential was definitely below what these models predict, hence the polar cap potential was in the saturation domain. Then he put the observed (and as said saturated) CPCP into the Michigan ring current model (which has no parallel potentials, i.e., it has no differential convection) and obtained the observed Dst. Hence he inferred that magnetospheric convection must have saturated too, which is opposite to the conclusion of Russell et al. The Lu result reported above appears to be in between the Liemohn and Russell results. In her compilation of 15 storms Dst tended toward saturation but not as strongly as did CPCP.

Walter Lennartsson brought his knowledge of particle data to address the problem. He used particle measurements taken by the ISEE spacecraft to look for direct injection of ionosphere ions into the ring current (L < 5.5) during extreme events. These included one on May 3, 1978 that he selected for being ideal to observe such injections since the ring current was possibly completely dominated by ionospheric ions at the time. Looking near midnight and inside of L = 5.5, he found no evidence of direct injection from the ionosphere. There was however much injection at higher L values, such as the MHD codes predict, although at a different local time (around dusk).

Pontus Brandt presented evidence from the IMAGE spacecraft that O+ injections are associated with substorms. Every substorm gives O+ emission at low altitudes. These are high-energy (~150 kV) bursts. He suggested a scenario to populate the ring current with substorm-injected ions: ionosphere -> plasma sheet during growth phase -> inner magnetosphere during expansion phase. In this scenario one does not need parallel potentials from differential convection to pull ions out of the ionosphere.
Bob Strangeway, however, did find evidence for direct injection from the ionosphere into the outer magnetosphere in the dusk sector during the main phase of a magnetic storm—the right place and time to test the peculiar parallel-potential results from the MHD simulations. He presented data from SCATHA/S33 of the CDAW 6 event injection of 32 kV ionospheric oxygen all of which happened in the dusk sector around L = 7. For the storm of February 1979 he showed that the O+ ions were on open trajectories yet they could account for Dst by the DPS relation, thus they must have been continuously injected, such as one might expect from a persistent parallel potential, lasting as long as the polar cap potential is saturated.

General Conclusions and Assessment

1. All models and data able to observe transpolar potential saturation do observe it.
2. Most find saturation vales of the order of 200 kV +/- 100 kV.
3. The saturation value increase with ram pressure in data and (to differing degrees) in models.
4. The saturation value decreases with ionospheric conductance in all models tested.
5. These results are in qualitative agreement with the Hill model.
6. Significant parallel potential drops are seen in three of four MHD codes.
7. Differential convection is not clearly implied in the Dst data as presented.

8. In the one test of particle data that looked in the right place and time, evidence favored the presence of the predicted parallel potential drops.

The exercise carried out in these two sessions was extremely valuable. It established a set of questions (listed in the introduction to this report) that truly challenge both the modelers and the observers. It is not that the question are too hard to answer for every modeler (at least) gave answers to them, but except for the question of the existence of TPS basically no two answers agreed. Thus the deep questions—the cause of TPS and existence and cause of parallel potential drops--remain unanswered. Nonetheless, it seemed clear that many participants felt that the answers could be found. There are some obstacles to progress that must be overcome, however, such as models not agreeing on the values of the saturation potential for the same solar wind conditions, and some models giving parallel potential drops and one not. On the observational side, if different techniques give values for the saturation potential that differ by a factor of two, how can they be used to test the models? A similar comment applies to studies of the Dst versus CPCP relation. The good news is that these are focused and finite questions that are amenable to progressive solution through a coordinated series of steps. To begin making progress, it would be good at the December mini-workshop to plan as the next step a continuation of the study at the next summer workshop.

Stephen Jay Gould in an essay on Antoine Lavoisier made an observation that is pertinent to the motivation behind this project: “All fundamental scientific innovation must marry new ways of thinking with better styles of seeing.” The advent of global MHD simulations has provided magnetospheric physics with a better style of seeing. If we are to find a fundamental innovation with this new style of seeing we must be willing to try and test new ways of thinking.

George Siscoe, Co-Chair
siscoe@bu.edu
Gang Lu, Co-Chair
Ganglu@hao.ucar.edu

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Tail/Substorm Campaign

Working Group 1 Tail/Substorm Observations

The Tail/Substorm Observations working group held one session at GEM 2002 in Telluride CO. In previous years the working group has attempted to identify the relative timing between substorm signatures in the near-Earth tail and in the mid-tail. Currently the two dominate models of substorms place the initiation of the substorm sequence in one or the other of these two locations. Unfortunately, the ability to time onset signatures (auroral brightenings, Pi 2 pulsations, energetic particle injections etc.) all have uncertainties of about 2 minutes (due to either the cadence of the instrument, the difficulty of identifying the beginning of a long period wave, and the apparent localized nature of many plasma sheet phenomena associated with substorms). This is also the approximate fast mode travel time between the mid-tail and the near-Earth magnetosphere. Hence current measurements are not sufficient to distinguish between the two models.

This year we concentrated on results from energetic neutral atom imaging (ENA) observations that have the promise of addressing this issue since they can provide global perspective of the energetic particle population. Therefore, these images in combination with other in situ measurements can be used to provide new insights into the spatial and temporal structure of substorms and the substorm-storm relationship.

Geoff Reeves (LANL) presented work from Jorg-Micha Jahn (SwRI) that demonstrated that it was possible to quantify azimuthal propagation of energetic particles on the nightside of the Earth but it is more difficult to discern quantitatively radial motion. Geoff also presented simultaneous observations from MENA and the Los Alamos geosynchronous orbit satellites. The datasets were inter-compared to give a global context for in situ observations of the plasmasphere and plasmasheet and to directly compare the ion fluxes inferred from ENA image inversion with direct local measurements of those fluxes. Mike Henderson (LANL) also utilized simultaneous observations of ENA and in situ particle data but also incorporated auroral imaging data in an effort to understand the difference between isolated substorms and those that occur associated with storms. Mike concludes that the substorm signatures are identical for both types of substorms however there is continuous substorm activity driven by solar wind-driven convection during storm-time substorms. Pontus C:son Brandt (JHU/APL) presented ring current observations (between L<6 out to L=13) from HENA for periods of southward IMF when the geomagnetic field is stretched. During dipolarization the ENA flux from the L<8 region decreased rapidly. Pontus postulates that the flux decrease during dipolarization is caused by the dipolarization induced E-field, which brings ions to lower L-shells faster than they can be replenished by the overall convection, creating a void of particles in the plasma sheet. This scenario implies that the acceleration region must be localized to, from L=8 out to, at least L=13.

Stephen Mende (UCB/SSL) presented observations from the FUV and HENA instruments on IMAGE. Proton aurora expands dawnward following a sub-storm onset, which is accompanied by the expansion of the region of intensified ENA fluxes. Mende interprets it in terms of the dawnward skewing of a plasma convection pattern in the inner magnetosphere. Such a convection pattern was also presented in the tutorial talk given by Dick Wolf earlier at the workshop, and it can be regarded as a combined effect of the closure of region-2 currents in the ionosphere and the corotation electric field. As the Tail-Substorm campaign winds down next year, the Observations: Working group is exploring the idea of having a session on multi-perspective studies of substorms. Currently data from Polar, IMAGE, Cluster and a large number of operational satellites are making simultaneous multi-point and global imaging observations of substorm dynamics. If you are interested in participating in such a session please contact one of the co-chairs.

Mark Moldwin, Co-Chair
mmoldwin@igpp.ucla.edu

Shin Ohtani, Co-Chair
ohtani@fluxgate.jhuapl.edu

Working Group 2 Substorm Triggering

The substorm triggering session held one session this year, which was focused on three questions: 1) What databases of substorms are available for large statistical studies? 2) What are ongoing studies of substorm onset? 3) How can we use such studies to reach a consensus on substorm triggering?

Several presenters described databases of substorm onsets identified by various signatures: energetic particle injections, auroral images, magnetic signatures, and magnetic pulsations. Some of these databases contain several hundred substorm events. The compiled database will be published online at: http://csem.engin.umich.edu/substorms.

Ongoing studies presented included a study of the recurrence frequency of northward turning in the IMF which shows a distribution that compares well with the recurrence frequency of substorms. A second study showed that in the several cases examined, the auroral arc that is the first to break up at substorm onset forms just 4 minutes before onset, at the same time as dayside convection reduced in each case. Another study that used an energy storage and transport model of the magnetosphere to relate VBs to AL showed that 40% of the substorm events required a northward turning trigger, in 40% of the cases the unloading was triggered internally, and 20% of the cases were directly driven by the solar wind. Finally, two studies of individual substorms showed events that were apparently internally triggered, although the internal triggering mechanism was in dispute between the two studies.

All interested parties are invited to use the assembled database of substorm onset times for studies of substorm onset triggering.

Larry Kepko, Co-Chair
lkepko@bu.edu

Aaron Ridley, Co-Chair
ridley@mho.engin.umich.edu

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Working Group 3 Steady Magnetospheric Convection

The Steady Magnetospheric Convection (SMC) working group hosted three sessions at the 23-28 June GEM Telluride Workshop:

1. IMF Conditions for SMCs
2. The role of the ionosphere in regulating SMCs
3. Comparative studies of SMCs

P. O'Brien presented results of a statistical analysis of IMF conditions leading to SMC conditions. Starting with a definition of SMC as a period of sustained stable AE >200 nT, it becomes apparent that SMCs are more likely for moderate solar wind velocity and relatively weak southward Bz (~ -3 nT). It is also apparent that SMC duration is sub-exponential (the longer steady convection lasts, the lower the probability of onset) and that very steady Bz is not necessary for SMC occurrence.

J. Borovsky's statistical analysis of solar wind data compared the contribution of two drivers of convection: reconnection and viscosity and established that for mild Bz south conditions both drivers are comparable and posed the question of whether SMCs are shutting off the viscous driver. A crucial element in determining how the magnetosphere responds to solar wind input is the configuration of the magnetotail. Joachim Birn is exploring the role of thin current sheets in the magnetotail as mediators between solar wind driver, tail activity and auroral activity. Also of critical importance is the determination of the magnetopause in the time-dependent case. Parameters that can be influential for the establishment of equilibrium in the magnetotail include total magnetic flux change, maximum strength and duration of the electric field and the relationship between tail flaring and total pressure in the magnetotail. Mass and entropy conservation arguments can be used to isolate constraints on magnetospheric convection. A. Otto applied these concepts to suggest that average entropy of newly closed flux tubes could be larger for SMCs relative to substorms. He also suggested that the average reconnection rate might be smaller for SMCs and pointed out that observations of plasmasphere erosion should establish a measure of the strength of convection that could be used to identify differences with respect to substorm convection. IMAGE EUV observations of the plasmapshere, presented by M. Spasojevic and J. Goldstein, show the formation of a plume and a steady, smooth plasmasphere during SMCs. By comparison, non-SMC conditions usually show a highly structured plasmasphere. Furthermore, the end of Bz south conditions trigger a rotation of the plasmasphere tail. A systematic analysis of EUV measurements for SMCs is planned to quantify fundamental plasmaspheric parameters, such as the rate of erosion and plume formation, for SMCs and compare them to their values for non-SMC periods. In discussing the role of the ionosphere as a regulator of SMCs, B. Strangeway noted that an initial overview of FAST observations suggests little qualitative difference in SMC particle precipitation relative to non-SMC situations. SuperDARN measurements (N. Fox) suggest a stable two-cell convection pattern as a distinguishing characteristic of SMCs. Temporally and

spatially stable aurora, as seen by POLAR VIS (J. Sigwarth), appears to be a concurrent characteristic of SMCs. It was suggested (B. Strangeway) that steady ionospheric convection conditions characteristic of SMCs are likely to produce strong neutral winds that can have significant impact on M-I coupling by reducing electric current demand from the ionosphere. Another parameter of significance for M-I coupling is the thickness of the ionosphere because it introduces, for instance, dependence of the electric current vector direction with altitude. Altitude-dependence of M-I coupling is apparent also in tall F-region arcs in the polar cap boundary intensifications that form after long periods of southward IMF (J. Semeter.)
S. Ohtani, B. Anderson and C. Goodrich presented intercalibrations of IRIDIUM measurements of magnetic field deflection with field-aligned current (f.a.c.) distributions from the Fedder-Lyon-Mobarry MHD computer simulation during long periods of steady southward IMF conditions. Three examples representing different magnetospheric responses were discussed: one response was characterized by sawtooth geosynchronous dipolarizations (11 August, 2000). SMC response was apparent at other times (23 November, 1999) and periods of SMC-like response alternated with isolated injections was observed in other cases (e.g., 13 August, 1999). As the full depth of this rich data-simulation continues to be mined, several fundamental questions regarding SMCs should find an answer. Sawtooth oscillations with a 2-hour periodicity were resolved by AMIE during a southward IMF period on 17-21 April, 2002 in which ionospheric convection was largely stable (G. Lu). Sawtooth oscillations were also observed in the magnetic field of the magnetotail for the same period by GEOTAIL (D. Fairfield and T. Moore). Sawtooth oscillations represent themselves a separate class of response of a strongly driven magnetosphere and comparative studies with SMC periods will help answer the question of what kind of threshold separates the different responses of the magnetosphere to solar wind forcing.

One response commonly found in SMCs consists of large amplitude ULF pulsations (~30 min period) that can be measured simultaneously by ground-based magnetometers and by field and particle detectors at geo-synchronous and mid- to far tail altitudes (L. Lyons). This property suggests a large-scale coherence of the magnetosphere-ionosphere system.

G. Erickson posed that, although it has been established that SMCs represent a state distinct from quiet times, storms or substorms, it has not been established whether there are other conditions that define SMCs uniquely. Erickson also pointed out certain key questions about the tail configuration that allows SMCs. For instance:
-Is it dominated by flow channels of Pontius-Wolf bubbles? Or,
-How steady-state is the tail configuration?
-Is there a middling X-line? (unless the X-line is near the inner edge of the sunward convection region, there will still be a PV^gamma crisis.) Relating to this problem, an important question is: Does convection not get close to Earth?

Relevant to tail configuration Erickson the following posed question: Given that SMCs do appear to dissipate energy at substorm levels but in a steady rather than impulsive fashion, can the rate of dissipation be large enough to solve the PV^gamma problem? This question opens up related questions such as: Do thin current sheets play a particularly important role in creating magnetic-field-parallel electric field potentials and ionospheric dissipation as well as non-frozen plasma transport?

Erickson pointed out how SMCs provide important constraints for the substorm problem by answering, for instance, the question of whether pseudobreakups occur along the inner edge of the oval during SMCs. If the answer is no, then the NGO model is viable and then one must ask why there is no ballooning: Is it because convection doesn't generate a significant pressure gradient and there are no drift waves present or is it because convection is too strong to allow drift wave reversal of the electric field? If pseudobreakups do occur, then one must ask why ballooning doesn't trigger substorms: Is it that ballooning was never going to trigger a substorm in the first place or that the tail is not susceptible to develop any instability because of the configuration it has settled into?

These questions constitute the heart of the research thrust envisioned for the GEM-SMC working group in the year to come. An electronic workshop has been created to post and archive these questions and their answers, as they become available. The electronic workshop also contains survey plots of IMF and POLAR UVI and VIS data for all periods of steady southward IMF between January 1996 and December 2000, to facilitate comparative and statistical studies. The GEM-SMC working group electronic workshop is accessible at (http://isr.sri.com/iono/SMC/HomePageForWorktools.html).

Joe Borovsky, Co-Chair
jborovsky@lanl.gov
Ennio Sanchez, Co-Chair
ennio.sanchez@sri.com

Magnetometer Session

Special Session on Ground-based Magnetometry

At the 2002 Telluride meeting a special effort was made to convene a special session not only of importance to the on-going campaigns (Inner Magnetosphere/ Storms, M-I Coupling, and Tail/Substorms) but also of interest to the ground-based magnetometer community that has much to offer to the GEM Program. This special session on ground-based magnetometry is a sequel to the successful event organized by Chris Russell in the 1999 Snowmass Workshop. In the last few years new magnetometers have been installed and instrument capabilities enhanced, and therefore the session provided a timely status review. The need to make better use of all possible data from various ground magnetometer arrays was also a major motivation in organizing the magnetometry session.

The special session was well attended by the magnetometer community. Several overseas magnetometer groups sent their delegates to GEM for this event. The participation by the USGS Geomagnetism Group also helped enhance the interaction between the geomagnetism and space physics disciplines in which magnetometers are used extensively. Two breakout sessions were arranged on Thursday, June 27 under the Tail/Substorm Campaign. There were twelve presentations that cover global magnetometer arrays as well as regional arrays in North and South Americas, Antarctica, Europe, Asia, and Australia.

Among the magnetometer arrays presented in the session, new arrays such as MEASURE and SAMBA started operation in the last few years. Some other magnetometer arrays have also expanded their observational coverage by installing more stations. For example, British Antarctic Survey (BAS) deployed 6 low-power magnetometers in Antarctica last year. In the last few years, many magnetometer groups also developed web servers distributing their data (see the minutes for details). As to instrument design/ capability, GPS has become a standard method of timing for many magnetometer systems. Some stations have upgraded or are planning to upgrade the timing resolution to 1-sec. One of the welcome developments is that upgrading to 1-sec systems has been included in INTERMAGNET's future plans.

It was clear from the presentations that sounding the magnetosphere by magnetoseismic methods became a major scientific objective for many magnetometer groups. The plasma mass density can be estimated by applying the gradient method that detects the signatures of field line resonance on magnetometer data. The role of the magnetometer community is well suited in this regard because most magnetometer experimenters are also active players in ULF waves research. Continuous efforts have been made in monitoring the mass density of plasma by the magnetometers in North America, Australia, Europe, and Japan. Several groups attended the magnetometry session also presented their observations of plasmaspheric density in the Plasmasphere and Ring Current Working Group sessions of the Inner Magnetosphere/Storms Campaign. The gradient method requires closely spaced stations on the same meridian, and it was found that future deployment of stations, especially in North America, would be crucial to fill in the observational gaps that exist now.

After the presentations from various groups, some time was reserved for discussing the needs of the GEM community. A focal point of the discussion was the generation of ULF wave indices that are pressingly needed by the Radiation Belt Working Group of the Inner Magnetosphere/ Storms Campaign. This task has also been one of the key issues for IAGA's ULF Waves Working Group, and suggestions on collaboration between GEM participants and the IAGA Working Group were raised. Also discussed was the single web portal that facilitates the requests of data from multiple magnetometer arrays, a concept similar to "one-stop shopping" in the business world. Some preliminary work has been done in this direction, and the development may ultimately bring us very useful tools for accessing magnetometer data.

In summary, the session was both well attended and very interactive. The material gathered from the various presenters will be assembled and posted on the web to facilitate collaboration and data exchange. We recommend that a regular working group be established in the GEM Program to work with the IAGA ULF Waves Working Group for achieving scientific goals that would directly benefit the GEM community in the future.

Peter Chi, Co-Chair
pchi@igpp.ucla.edu
Mark Moldwin, Co-Chair
mmoldwin@igpp.ucla.edu

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Student Tutorials

2002 GEM Student Tutorials

GEM sponsored 40 students from 16 different institutions to attend the 2002 workshop. Student tutorials were held on Sunday, June 23. Student interest breakdown was: 50% Inner Magnetosphere/Storms, 20% Magnetosphere/Ionosphere Coupling, 20% GGCM, and 10% Tail/Substorms.
On a scale of 1 to 5, the tutorials were on average rated a 4 for usefulness, and 85% of the student felt the tutorials should remain at the same level next year.

Yongli Wang, UCLA, will be the new student representative for 2003.

Student Tutorial Schedule

I. Introduction to GEM (Maria Spasojevic)
II. Introduction to the Magnetosphere (Chelle Reno)
III. Inner Magnetosphere / Storms
A. Inner Magnetospheric Shielding, Penetration Electric Field, and the Plasmasphere (Jerry Goldstein)
B. A Radiation Belt Tutorial (Jacob Bortnik)
C. Ring Current (Paul O'Brien)
D. Wave Particle Interactions (Maria Spasojevic)
IV. Magnetosphere-Ionosphere Coupling
A. An Overview of Magnetosphere Ionosphere Interaction (Karen Remick)
B. Electrodynamics of M-I coupling (Sorin Zaharia)
C. Ion Outflow (Philip Valek)
V. Tail / Substorms
A. Substorms (David Murr)

B. Steady Magnetospheric Convection (SMC) (Scott Thompson)
VI. Geospace General Circulation Model (GGCM)
A. The Global MHD Simulation: Basics, Challenges, and Its Future
(Yongli Wang)
B. The Rice Convection Model & Magnetic Field Models
(Colby Lemon)

Maria Spasojevic, Student Representative
mystical@stanford.edu

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Gem Steering Committee Minutes

June 22, 2002, Telluride, Colorado

Present: Mary Hudson, Dartmouth College (chair), Anthony Chan, Rice University, Brian Fraser, University of Newcastle, Chris Russell, UCLA, Deloras Knipp, USAF (CEDAR), Ennio Sanchez, SRI, Frank Toffoletto, Rice University, Gang Lu, NCAR, Hedi Kawano, ISAS, Howard Singer, NOAA, Janet Luhmann, UC Berkeley, (SHINE) Jeff Hughes, Boston University, Jimmy Raeder, UCLA, Joachim Birn, LANL, John Lyon, Dartmouth College, Kile Baker, NSF, Larry Lyons, UCLA, Maria Spasojevic, Stanford University, (student representative), Mark Moldwin, UCLA

Plans for future GEM campaigns

Some discussion of future GEM campaign suggestions was initiated, with the conclusion that broader GEM community discussion is in order at the December mini-workshop, narrowing suggestions down to two which will be pursued at the following June meeting, in campaign planning mode, i.e. with tutorial speakers and working group breakout sessions. Those with suggestions should plan to make a presentation at the December 5 GEM mini-workshop the afternoon before the Fall AGU meeting in San Francisco.

Plans for future GEM work-shops

Frank Toffoletto outlined plans for future GEM workshops. Current plans are to have the 2003 and 2004 workshops in Snowmass, Co. The 2003 meeting will be held the week of June 22, 2003 and plans call for having the 2004 meeting that same week in June. The 2002 Fall workshop will be held before the AGU meeting on the afternoon of December 5, 2002 followed by the steering committee meeting that following evening. There was some discussion of alternative locations for future GEM workshops such as Crested Butte, Breckenridge, Lake Tahoe, and Banff.

Agency Reports

Kile Baker (NSF) reported that there should be about 750k of money for new FY03 awards. There have been 4 applications for GEM postdocs positions, awards will be announced a couple of weeks after the end of August. To address the problem of the lack of tenure-track positions in space physics, NSF is considering a plan to fund teaching positions in Space physics. It would be a 5 year award plus if the person gets tenure there will be a further 5 years of support at ~$250k/year. NSF hopes to have an announcement for this new type of award out in time for FY2004 funding.

Howard Singer (NOAA SEC) reported that Space Weather Week is planned for May 19-22, 2003. The 2002 meeting was the largest ever and the Research to Operations portion, co-organized with NSF, NASA, and AFRL was another major success. He also mentioned that there is one NOAA NRC opportunity each year at SEC and that this year Janet Green is the recipient of the award. Starting in September, she will be working with Terry Onsager on MeV electrons.

International liaison reports

Brian Fraser (University of Newcastle) reported on the situation for space physics research activities in Australia and New Zealand. The 58-kg FedSat microsat is slated for a November 2002, launch by Japan. There are also plans for build a SuperDARN radar in New Zealand, discussions are underway with the funding agencies for a possible 2004-5 installation. This radar will complement the current radar facility in Tasmania that has been operating for 2 years. The effort is led by Peter Dyson at La Trobe University with assistance from the Ionospheric prediction Service. He reported on the status of Australian Antarctic research stations with plasmapause, auroral zone, cusp and polar cap stations, located at Mawson, Davis and Casey respectively. He also reported on the upcoming meetings in Australasia including the Western Pacific meeting in Wellington, New Zealand (July 9-12), the International Conference on Plasma Physics in Sydney (July 15-19) and 2 conferences in Adelaide, Australia (The World Space Environment Forum, July 22-25 and an associated workshop on advanced computing, July 29-August 2). This latter series of conferences is led by Abraham Chian who has plans to set up a expand the WSEF into an international consortium called the World Institute for Space Environment Research (WISER) based at the University of Adelaide.

Hedi Kawano (Japan, ISAS) reported that ISAS would be merged with NASDA.

Campaign reports

Jeff Hughes (MI-coupling). Plans for the 2003 workshop are at this point similar to 2002. However, ways to involve the CEDAR community more heavily in the campaign and workshop are being explored. Brian Anderson wishes to be replaced as a working group chair (due to over ommitments). The intention is to replace him with someone more connected with the CEDAR community. The campaign is discussed various forms of a Campaign challenge. This will be decided at the December mini-workshop.

Anthony Chan (Inner Magnetosphere/Storms). The IMS campaign had a very active program at this years workshop and it has plans to continue 2-4 more years, in order to take advantage of the momentum gained recently in GEM and GEM-related IMS projects and to enhance GEM IMS activities during the upcoming declining phase of the solar cycle. The campaign plans to revisit the list of GEM storms in December 2002, where there could be a possible connection with SHINE and CEDAR.

Larry Lyons (Tail/substorms). This campaign is winding down but there are plans for 4-5 sessions in 2003 including sessions on multi-satellite studies, steady magnetospheric convection and triggering. Next year is the last year of the campaign.

Jimmy Raeder (GGCM). This campaign plans to continue coordinating with the other ongoing campaigns as well as acting as a forum for modelers. There was some discussion of the possibility of organizing a Chapman conference on Modeling.

CEDAR/SHINE COORDINATION

Janet Luhmann (who was representing SHINE in place of Dave Webb). The new SHINE chair is John Linker of SAIC. This year SHINE will meeting 8/18 - 8/22 in Banff, Canada. SHINE would like to interact with GEM and CEDAR to what level is mutually beneficial.

Deloras Knipp (CEDAR). Most of the MI coupling activities at CEDAR seem to be related to high latitude variability, plasmasphere and ion outflows. There is a new focus area associated with TIMED mission and data. Next year's CEDAR meeting will be held in Longmont, Colorado during the 3rd week in June. She mentioned the possibility of a future GEM/CEDAR meeting or even the possibility of a separate MI-coupling meeting. There was a suggested that one way to further facilitate CEDAR/GEM/SHINE interaction is to bring tutorial speakers from the other campaigns. An example of this was Bob Strangeway who gave an MI-coupling tutorial at this years CEDAR meeting.

Communications

Chris Russell urges all speakers to place copies of their tutorials on the web and that all WG chairs turn in their reports as soon as possible.

For the GEM Messenger send any news items to editor @igpp.ucla.edu

GEM Contact List

Contact	E-mail Address	Contact	E-mail Address
Brian Anderson	Brian.Anderson@jhuapl.edu	Mark Moldwin	mmoldwin@igpp.ucla.edu
Kile Baker	kbaker@nsf.gov	Tom Moore	Thomas.E.Moore.1@gsfc.nasa.gov
Joachim Birn	jbirn@lanl.gov	Shin Ohtani	Shin.Ohtani@jhuapl.edu
Joe Borovsky	jborovsky@lanl.gov	Terry Onsager	Terry.Onsager@noaa.gov
Anthony Chan	anthony-chan@rice.edu	Bill Peterson	pete@willow.colorado.edu
Dennis Gallagher	Dennis.Gallagher@msfc.nasa.gov	Jimmy Raeder	jraeder@igpp.ucla.edu
Ray Greenwald	ray.greenwald@jhuapl.edu	Geoff Reeves	reeves@lanl.gov
Mary Hudson	Mary.K.Hudson@dartmouth.edu	Aaron Ridley	ridley@umich.edu
Jeffrey Hughes	Hughes@bu.edu	Chris Russell	ctrussel@igpp.ucla.edu
Larry Kepko	lkepko@bu.edu	Ennio Sanchez	ennio.sanchez@sri.com
Mike Liemohn	liemohn@umich.edu	George Siscoe	siscoe@bu.edu
Bill Lotko	william.lotko@dartmouth.edu	Maria Spasojevic	mystical@Stanford.edu
Gang Lu	Ganglu@hao.ucar.edu	Frank Toffoletto	toffo@rice.edu
John Lyon	John.G.Lyon@dartmouth.edu	Richard Thorne	rmt@atmos.ucla.edu
Larry Lyons	larry@atmos.ucla.edu	Yongli Wang	ylwang@igpp.ucla.edu

Current GEM Structure

GEM Steering Committee Chair: Mary Hudson	
GEM Workshop Coordinator: Frank Toffoletto	
GEM Communications Coordinator: Chris Russell	
Tail/Substorm Campaign:	**Convener**: Larry Lyons
Working Groups:	**Tail/Substorm Observations** - Mark Moldwin and Shin Ohtani
	Substorm Triggering - Larry Kepko and Aaron Ridley
	Steady Magnetospheric Convection - Joe Borovsky and Ennio Sanchez
Inner Magnetosphere/Storm Campaign:	**Convener:** Anthony Chan
Working Groups:	**Plasmasphere and Ring Current** - Dennis Gallagher and Mike Liemohn
	Radiation Belts - Geoff Reeves and Richard Thorne
GGCM Campaign:	**Conveners:** Jimmy Raeder and Joachim Birn
Working Groups:	**Models** - Jimmy Raeder and Terry Onsager
Magnetosphere-Ionosphere Coupling Campaign	**Conveners**: Ray Greenwald and Jeffrey Hughes
Working Groups:	**Mass Exchange** - Tom Moore and Bill Peterson
	Electrodynamics - Brian Anderson and Bill Lotko

UCLA/IGPP
C.T. RUSSELL - GY-79
THE GEMSTONE
BOX 951567
LOS ANGELES, CA 90095-1567

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