The GEMstone

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NOTES FROM THE NSF PROGRAM DIRECTOR

The Flagship of the Magnetospheric Physics Program

The GEM program continues to be the flagship of the Magnetospheric Physics Program at NSF. The summer workshop has continued to grow in attendance and it is common for new attendees to comment that the GEM workshop is the best scientific meeting they have attended. The workshop atmosphere and the focused nature of the GEM campaign combine to produce a week that is both highly productive and yet relaxed and collegial. It seems that we have an ever proliferating set of meetings to attract our attention, but for me, GEM remains the highlight of the year.

Last year (Fiscal Year 2003) 25 regular GEM proposals were submitted to NSF and 7 of those proposals were funded. The average award size was about $80,000/yr and the average award duration was 3 years. In addition to the normal GEM proposals, we also received 4 proposals for the first GEM postdoc competition and one 2-year award was made, again for about $80K/yr. A new competition for FY2004 GEM postdocs has already begun (proposal deadline was May 1, 2003), and by the time you read this introduction the review process will be complete. For this second round of the GEM postdocs NSF received 6 proposals.

The M-I Coupling campaign is now going full blast. This campaign was given a jump-start in 2001 by having a joint announcement with the CEDAR program in Aeronomy for the first M-I coupling proposals. This provided an initial funding level of $500K/yr. The funding for most of those initial M-I coupling proposals comes to an end in FY2003 and we therefore had another joint CEDAR/GEM competition. The proposals deadline was May 1, 2003. NSF received a total of 20 M-I coupling proposals and we expect to make 7-8 awards at a level of about $80K/yr.

I would remind everyone that the regular GEM deadline for proposals is Oct. 15. For FY2004 there will be approximately $350K available. Since the M-I coupling proposals for FY2004 are being handled through the CEDAR/GEM joint competition, no M-I coupling proposals will be $80K/yr – up from $70K/yr in FY2002.

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GEM Homepage URL

http://www-ssc.igpp.ucla.edu/gem/

Future Directions for GEM

Although the Geospace General Circulation Model (GGCM) is the primary goal of the GEM program, there was a feeling at the last Steering Committee meeting that the GGCM campaign was not as vital as it should be. A small working group has been formed to try to give the GGCM campaign some new direction and the recommendations of that working group will be considered at the Steering Committee meeting to be held just prior to the Fall AGU meeting.

The other major question for the Steering Committee will be the campaign that will follow the Tail/Substorm campaign, which has now come to an end. Another working group has been given the task of trying to formulate a new campaign from the suggestions that were presented during the last summer workshop in Snowmass. Details on the new campaign will be made available as soon as possible after the December Steering Committee meeting.

Postdoc Awards

There is one other change to the GEM program that young scientists considering submitting a GEM Postdoc proposal should be aware of. NSF plans to remove the postdoc portions from the CEDAR, GEM and SHINE Program. Solicitations and consolidate them into a single CEDAR/GEM/SHINE Postdoc program. We expect the Program Solicitation to be available by November 1 with a proposal deadline of early February. By advancing the deadline for the postdoc proposals from May to February, the proposers will know the fates of their proposals enough in advance of the academic year to make reasonable plans, including relocating to a new institution during the summer.

Connections to other programs

The GEM program, with its emphasis on the eventual production of a GGCM has obvious relevance to research related to space weather. The National Science Foundation continues to provide funding for research in support of the National Space Weather Program (see NSF 03-500 for the Program Solicitation). Details on the NSWP can be found in the NSWP Implementation plan, available from the Office of the Federal Coordinator for Meteorology (http://www.ofcm.gov). Space weather researchers should also be aware of the interest of the NASA Targeted Research and Technology (TR&T) program in this area.

In addition to the connections to the CEDAR (Aeronomy Program) and SHINE (Solar-Terrestrial Research Program), the GEM community has a great deal of interest in NSF's Information Technology Research Program (ITR). ITR is a cross-directorate program with almost $300M/year of funding. In this past year there were over 1500 proposals submitted to the ITR program, requesting over $3.5B. Because of the large number of proposals submitted, the success rate was very low (~8%), but the space physics community did very well in the competition. The ITR program expects to fund three proposals in space physics with funding of about $700K/yr for each of the three proposals (total of over $2M/yr) for 4 years. Of those three space physics proposals, two come from members of the GEM community! This is new money coming into the GEM community and the PI's are to be heartily congratulated on their excellent proposals.

Summary

GEM has had another very successful year. Interest (and funding) for GEM has continued to grow. With the problems in the middle east and the worsening Federal budget deficits, the crystal ball for the future is cloudy. I hope to be able to continue the increase in the funding for GEM but that will depend on the budget decisions being made in Congress. But whatever happens to the funding levels, I expect GEM to continue play a vital role in the Magnetospheric Physics 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

Farewell

It has been my pleasure serving as chair of the GEM Steering Committee these last three years. I participated in the development of the Inner Magnetosphere-Storms campaign, which I was happy to see grow to maturity during my term as chair, thanks to a lot of hard work from campaign coordinator Anthony Chan and enthusiastic working group co-chairs. I was also happy to see the M-I Coupling campaign get off to such a good start, with Jeff Hughes serving as campaign coordinator and an active group of co-chairs. The strong showing from the GEM community in the first joint proposal round with CEDAR is to their credit.

I look forward to continued collaborative meetings with our SHINE and CEDAR partners. The '01 Snowmass meeting held contiguously with SHINE, with two joint sessions and the banquet overlap, provided an opportunity for discussing topics of mutual interest which I hope will be repeated next year with an overlapping day. We have benefited from the arrival of some CEDAR regulars joining in the MI-Coupling campaign studies, and I hope that the jointly located '05 meeting in Santa Fe will facilitate collaborations between our two groups.

I have not missed an annual GEM Workshop since we started having them in Colorado back when Bill Lotko was chair, and I share community pride in what outstanding meetings these have become, engaging our colleagues in the development of new research ideas and development of data-model comparison metrics, and important model-model comparisons like the GEM Reconnection Challenge. The best part has been the participation of students, some of whom have grown up, like our children, in the GEM era. Thanks to all of you for your hard work. You have an able and enthusiastic new chair in Bob Strangeway, but as always, GEM's success comes from the community's effort.

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

Notes from the Incoming Chair

The Next Campaign

As incoming GEM Steering Committee Chair I wanted to pass on my impressions of the recent GEM meeting, and describe some of the future activities as decided by the GEM Steering Committee.

First, the GEM meeting was held from June 22-27 at Snowmass Village, Colorado, with over 200 participants, a quarter of whom were students. The GEM meeting as usual consisted of a series of topical lectures and scientific sessions tied to the various campaigns carried out by the GEM community. The high quality of the review lectures and the liveliness of the scientific sessions are both directly related to the efforts of the campaign and working group coordinators, and they are to be commended for their efforts.

The annual GEM meeting continues to be one of the highlights of the year. Plans are being made to hold the GEM meeting in conjunction with SHINE in 2004, and CEDAR in 2005.

As noted above GEM consists of several campaigns, and their associated working groups. The current campaigns are the Inner

Magnetosphere/Storms (IMS) Campaign, the Magnetosphere-Ionosphere Coupling (M-I Coupling) Campaign, the Magnetotail/Substorms Campaign, and the Geospace General Circulation Model (GGCM) Campaign. The Magnetotail/Substorms Campaign is coming to a close, and the GEM steering committee is in the process of defining a new campaign to replace this one. The M-I Coupling and IMS Campaigns are in full swing, and significant progress is being made in these campaigns. The GGCM Campaign, on the other hand, appears to be in need of redefinition.

The two major activities to come out of the GEM Steering Committee are therefore the following: First a task force is to be formed that will redefine the goals and activities of the GGCM Campaign. A second task force will also be formed to define a new campaign that will be a hybrid of the two previously proposed campaigns ("Solar Wind Interactions with the Magnetosphere" and "Geospace Transport"). These two task forces will present reports at the Fall GEM mini-workshop.

GEM continues to grow, and is a strong driving force for progress in magnetospheric research. The Campaign definitions that will result from the task force activities will further strengthen GEM research. I am looking forward to following GEM's growth over the next three years during my tenure as GEM Steering Committee Chair.

Robert J. Strangeway
Chair, GEM Steering Committee
strange@igpp.ucla.edu

AGU GEM Mini workshop
December 7, 2003

This years fall AGU GEM mini-workshop will be held on the afternoon of Sunday December 7, 2003. Details will be posted on the GEM workshop website at http://gem.rice.edu/~gem

Next GEM Workshop
June 20-25, 2004
Snowmass, Colorado,

Tutorial Talks

It is traditional to collect the tutorial presentations from the GEM tutorial speakers and make them available on the web. This year is no exception and you may access these presentations (generally in power point or pdf files) at

http://www-ssc.igpp.ucla.edu/gem/tutorial/index.html .

Tutorials from previous years are also available at this site.

2003 WORKING GROUP REPORTS

Magnetosphere Ionosphere Coupling Campaign

Working Group 1: Plasma outflow

WG-1 sponsored the tutorial talk by Prof. Robert Winglee of the University of Washington on "Magnetosphere-Ionosphere Coupling Determined by Multifluid Magnetodynamic Global Simulations." One of the most interesting results of the simulations and discussions presented was the demonstration that outflowing heavy ions act to limit the cross polar cap potential, by absorbing energy at altitude and reducing the amount transmitted to the bulk ionosphere. Another aspect of the Winglee multifluid approach, which generated discussion, is that some drift physics is included in the formulation of the transport equations.

Bob Strangeway chaired a session entitled "Energy Inputs to the Ionosphere." In this session, Gang Lu looked at Joule heating processes using the AMIE method. She demonstrated that its possible to track Joule heating effectively with AMIE. Yi-Jiun Su discussed her work using FAST data on energy transfer to soft electrons produced by Alfven waves in the cusp. Barbara Giles presented an overview of ion outflow morphology and influences in solar wind derived from DE/RIMS and Polar/TIDE data. She emphasized that IMF Bz had little effect on the magnitude of ion outflow in the cusp region and that the solar wind dynamic pressure had a very direct correlation with ion outflow in the cusp region. Laila Andersson presented the results of casting mass resolved ion outflow, electron precipitation, and conic occurrence observations from FAST in dynamic, boundary oriented, coordinates. She demonstrated that the dynamic coordinates organize the data better than the standard, static, invariant latitude magnetic local time coordinates and that these coordinates are more appropriate for use with large-scale magnetospheric models.

Bill Peterson chaired a session titled "Ionospheric outflows, April 2002 focus." In this session, Mehdi Bouhram presented Cluster observations of ion outflow from the cusp region. He noted the coherence in the response of O+ to increases in the solar wind dynamic pressure. Laila Anderson presented the altitude distribution of outflowing H+ and O+ from 1997 FAST observations in boundary-oriented coordinates. She showed three altitude bins covering the altitude range from 1500 to 4000 km and two levels of activity. Hot spots for O+ outflow were seen near the midnight polar boundary, the 0900 MLT polar cap boundary and near noon. She noted some expected and unexpected features in the altitude distribution that she is working on resolving. Robin Coley presented DMSP observations of vertical flows of ionization in coordinates normalized to the convection reversal location. These coordinates could, with work, be made compatible with the boundary-oriented coordinates used by Andersson and her co-workers. He noted that the thermal (i.e. Non escaping) fluxes are upward in the auroral zone and downward in the polar cap. The magnitude of the thermal fluxes (both upward and downward) reported from DMSP are quite large compared with total ion outflows reported from DE, Akebono, FAST, and Polar. Takumi Abe presented a long-term variation of average polar wind velocity profiles obtained from 10 years of Akebono observations and discussed its solar activity and seasonal dependence. He did not stress the variability of the average data, rather the averages. He did not report the variability of the average data, which resulted some confusion in comparison to the DMSP data presented by Coley. The Akebono observations do, indeed, include many intervals of significant downflow in the low altitude polar cap. The average polar wind data presented suggest that 1) There is an unexpected solar cycle dependence in the H+ and O+ components of the polar wind outflow, 2) The solar cycle dependence appears to be different in its characteristics below and above 3500-4000 km, suggesting that the ion acceleration is dominated by different process depending on the altitude. 3) Seasonal dependence of the polar wind velocity was more clearly seen at solar maximum than at solar minimum. Hina Khan presented observations from IMAGE/LENA on cleft ion fountain as seen in neutral atom emission. Tom Moore presented Polar/TIDE data "DC' Poynting flux and kinetic energy flux effects on ion outflow. "DC" Poynting flux and precipitating electron density were shown to be well correlated with ion outflow. Other measures, such as IMF Bz, were more poorly correlated. Tom was encouraged to look at AC Poynting flux which has been seen to be important in the FAST data presented by Strangeway and Su. Gang Lu was the only participant to present data from the

April 2002 storm interval. She presented Sondrestromfjord and Millstone Hill radar data as well as AMIE potential and joule heating patterns for the period.

Tom Moore chaired a session entitled "Modeling the sources and impacts of ionospheric outflows, April 2002 focus." In this session Rick Chappell presented a new detailed analysis of polar wind data obtained from Polar/TIDE. He stated that the magnitude of the fluxes observed by Polar/TIDE are significantly higher than those reported from DE, Polar and Akebono data by Yau and his coworkers. He suggested the reason for this difference is the correction for spacecraft potential made in the Polar/TIDE analysis. Bill Peterson pointed out that the Akebono data have also been corrected for the effects of spacecraft potential. Rich Chappell also concluded that the plasma sheet is fed primarily by the dayside outflow region. Tom Moore presented the results of some simulations using only the polar wind to populate the magnetosphere. The energies and pressures seen in the tail and inner magnetosphere in this simulation are realistic. Joel Fedder discussed diagnostics on plasma density in the LFM code plus the Huba ionosphere. In particular he looked at propagation times pressure waves and found that the existing code gets delays close to those observed. He noted this implies that the plasma density inherent in this combination of codes is therefore very good. He also discussed plans for adding a heavy ion component to the outflow to the codes which may be important outside of the inner magnetosphere tested by the pulse propagation time method. Bill White discussed the ISM codes handling of collisional behavior in the E and F regions. He noted that this code resolves the ionosphere rather than treating it in a height integrated approximation. John Foster presented F region observations of plasmaspheric ionization plumes and their association with sub auroral plasma streams (SAPS). He emphasized that these plumes provide a large supply of F region plasma to the polar cap region and eventually to the nightside. Vahe Peroomian presented simulations of solar wind entry based on single particle trajectories in MHD fields. In particular he demonstrated the strong dependence on the entry region and energization with IMF direction.

Ray Greenwald chaired a joint session of working groups 1 and 2 entitled "MIC Challenge Redux." This session was the third attempt of the Magnetosphere Ionosphere Coupling (MIC) campaign to formulate a challenge to the GEM community. Challenges by previous campaigns have served the purpose of focusing efforts. Previous discussions on this topic were held at the Telluride and the Winter AGU meetings in '02. The result of the Winter AGU discussion was to encourage people to present data from the April '02 storm period at this meeting. As noted above, only our tutorial speaker and one other speaker presented data relevant to ion outflow at this meeting. Bill Peterson noted that, during 1997, Akebono, FAST, and the TIDE and TIMAS instruments on Polar were monitoring ion outflow. Currently active monitors are Cluster Polar/TIDE and Akebono with a significant reduction in sensitivity. The cadence of the Polar and Cluster observations are furthermore not ideal for monitoring ion outflow.

Points of view were expressed by Working Group co-chairs Josh Semeter, Bill Lotko, Tom Moore and Bill Peterson, as well as significant comments from Aaron Ridley, David Murr, Vladimir Papitashvili, and others. Points emphasized included: 1) Including the polar wind, Alfvenic aurora, hemispherical asymmetries as well as the typical Eparallel and return current regions in any challenge, in the form of an ionospheric outflow module for use within global simulations. 2) Going beyond the Knight relation, 3) Keeping the challenge simple, 4) Requesting more empirical models. In general modelers wanted simple idealized experiments rather than event studies, while observers preferred event studies.

The conclusion was to find one or more carefully selected event with easily prototyped properties (e.g. simple step in Bz). And have both modelers and observers focus their efforts on these simple, non-traditional, event studies.

After the conferences the Co-Chairs of WG 1 on ion outflow determined to focus at least one breakout session in the '04 Summer Workshop on observations and modeling of the polar wind.

Working Group 1 and 2 and the Inner Magnetosphere/Storms Campaign co-sponsored a joint session entitled "MI-Coupling as a Plasma Source Region." The session was co-chaired by Paul Kintner and Mike Liemohn. Presentations were made by Kintner: The importance of the ionosphere-inner magnetosphere coupling and LWS, J. Makela: Solar wind influences on the midlatitude ionosphere, T. Manucci: GPS analysis for TEC maps, P. C. Brandt: The ring current and the formation of mid-latitude E-fields. J. Goldstein: A quantitative measure of SAPS, R. A. Wolf: A discussion of MI-coupling at midlatitudes, with post-midnight peak and A. Ridley: Using the AMIE model at midlatitudes.

Bill Peterson, Co-Chair
Pete@willow.colorado.edu
Tom Moore, Co-Chair
Thomas.E.Moore.1@gsfc.nasa.gov

Working Group 2: Electrodynamic Coupling

MIC WG-2 hosted a tutorial and three breakout sessions covering various aspects of electrodynamic coupling between the ionosphere and magnetosphere. The tutorial, entitled "MI coupling from the IT perspective: melting the frozen in flux," was presented by Jeff Thayer of SRI International (available at http://www-ssc.igpp.ucla.edu/gem/tutorial/index.html). In his talk, Thayer described three roles played by the ionosphere in MI coupling: (1) as a depository of solar VUV radiation and magnetospheric Poynting flux and kinetic energy flux, (2) as an intermediary in the transition from a collisionless plasma to a collision dominated gas, and (3) as a regulator of MI energy exchange through coupled electrodynamics (e.g., feedback). Roles (1) and (2) are supported through a strong theoretical and experimental foundation, while the significance of role (3) remains an active topic of debate in the GEM community. Follow-up discussions highlighted the need to properly treat reference frame dependencies in measuring and modelling electromagnetic energy deposition, the main issue concerning the proper treatment of the neutral wind dynamo.

Breakout session 1, entitled "Low-Altitude Energy Deposition: Energy transfer from the collisionless magnetosphere to the collisional ionosphere," was chaired by Josh Semeter. Semeter opened the session by demonstrating that local measurements of the evolving plasma state by incoherent scatter radar (ISR) and ground-based optics elucidate time-dependent MI coupling on time scales relevant to auroral formation. Specifically, the phasing among variations in Te, Ti, Ne, Vi and ionization rates constrain models of how imperfect MI coupling arises. One continued challenge for both the ionospheric and magnetospheric communities is to account for observations at the open-closed field line boundary. For steady southward IMF, this boundary region is characterized by intense Alfven wave activity, large fluxes of low energy (<1keV) counterstreaming electrons, and outflowing ions (R. Ergun); the electron fluxes are responsible for polar boundary intensifications (PBI's) and F-region discrete auroras. Ergun noted that although these electrons carry strong localized currents (both upward and downward) the net current over the Alfvenic region can be quite small.

J. Fedder addressed the issue of why global magnetospheric modelers need to be concerned with the details of low altitude energy dissipation. He noted that the magnetotail itself is a result of ionospheric drag and Joule dissipation, in addition to reconnection. The fact that Joule dissipation is consistently larger on the dayside than the nightside is also a result of ionospheric effects---namely, the high conductance and strong electric fields in the convection throat on the dayside and the anticorrelation of electric fields and auroral Pederson conductance on the nightside.

Several speakers considered how magnetospheric energy flux is partitioned in the IT system. Globally, magnetospheric Poynting flux exceeds precipitation kinetic energy flux by at least a factor of 5 (J. Fedder), although the local intensities can be comparable in regions of active aurora. For Poynting flux, a coupled AMIE-TIGCM model predicts that 90-95% goes to Joule heating, with the remaining 5-10% accelerating the neutral wind (G. Lu). Lu also noted that although the Joule heating per unit volume peaks at ~120km (where the Pedersen conductance peaks), the Joule heating per unit mass peaks at ~300km. Joule heating, therefore, affects the F-region neutral atmosphere more effectively. B. Emery presented a statistical analysis of DE satellite data showing that the partitioning to Joule heating decreases during negative IMF Bz periods, suggesting an inverse correlation between the percentage of Poynting flux going to Joule heat and magnetic activity. It was generally agreed that the partitioning of Poynting flux has not yet been adequately described.

The coupling of magnetospheric MHD models and ionospheric models is being pursued by several investigators (e.g., A. Burns, W. Wang, A. Ridley). Such efforts enable studies of the global energy budget in the entire ITM system, but validating the methodology remains a challenge. Initial results from a coupled LFM-TING model show that estimates of energy deposition rate change greatly when an interactive neutral atmosphere model is coupled with a magnetospheric model (W. Wang). These results also predict a north-south asymmetry in energy flux into the IT system, which would create a hemispheric asymmetry in Joule heating and conductance. This prediction may have observational support in the study of conjugate auroras by S. Mende and N. Ostgaard, who found that auroral break-ups were not symmetric for any observed substorm. They also found that the relative offset in local time between hemispheres was correlated with the IMF BY/|BZ| ratio. The asymmetry was attributed to magnetic tension acting on open field lines before reconnecting in the magnetotail. Further validation of model predictions, as well as a rigorous treatment of the general convergence properties of coupled ionosphere-thermosphere-magnetosphere models, is needed.

Breakout session 2, entitled "Two-Timings and Double-Crossings: Cross-Scale Aspects of MI Coupling," was chaired by Bob Lysak. The session considered spatial and temporal scales in the aurora and their relationship to M-I coupling at the smallest physical scales. Lysak introduced the session by pointing out that there appears to be a bi-modal distribution of auroral arc scales, with a 10-km peak that may be associated with direct absorption of wave energy and a 1-km peak that is not well understood. Lotko talked about the role of anomalous resistivity and ionospheric field line resonances in producing small-scale features. Mende presented observations of low-energy ions being modulated at about 1 Hz--a typical wave frequency in the auroral zone. P. Song addressed the role of the neutral atmosphere in modifying the wave fields. R. Ergun talked about solutions for localized double layers to account for features observed in parallel E-field data from FAST. L.-J. Chen described BGK models of small scale (less than a Debye length) electrostatic solitary waves, arguing that these structures could play an important role in the anomalous resistivity needed for reconnection. Finally, S. Shepherd and M. Ruohoneimi presented statistical observations of E-field variability derived from SuperDARN. They noted that the actual Joule heating rate can be seriously underestimated due to undersampling small-scale E-field variability.

The group seemed to be in agreement that the small-scales contain essential physics for the production of auroral arcs. However, the question of whether these small scales are necessary to include in order to accurately model global dynamics remains to be resolved. The question is obviously critical to both the MIC working group, and the GEM community at large.

Breakout session 3, entitled "Beyond the Knight Relation – nonadiabaticity, nonlinearity, bi-directionality in electron dynamics," was chaired by Bill Lotko. The purpose of the session was to reexamine the Knight-Fridman-Lemaire (KFL) formula relating field-aligned current to the field-aligned potential drop. The KFL formula is used extensively in global MHD models of the magnetosphere to characterize non-ideal effects associated with collisionless electron acceleration and precipitation at low-altitudes. While observations going back to early work by Lyons et al. [1979] provide compelling evidence that this formula is reasonably accurate in large-scale inverted-V precipitation regions, we now know that other important electron acceleration processes occur at low altitude that are not described by the 1D adiabatic Vlasov physics on which the Knight formula is based. These nonadiabatic acceleration processes involve parallel electric fields sustained by current-driven micro-instabilities; large-amplitude, localized parallel electric field structures (double layers) that the FAST satellite has resolved in downward current regions (Ergun, Anderson et al.), and Alfven wave induced acceleration that can be qite intense near the cusp and nightside polar cap boundary (results and models relevant to Alfvenic acceleration were discussed by Y. Song, R. Lysak, Y.-J. Su, J. Lu). FAST observations that validate the KFL formula were described by L. Peticolas, together with examples where the KFL formula appears to break down within an inverted-V precipitation channel when the field-aligned current becomes very intense and substantial microturbulence is present. The use of ground-based radar and optical data to monitor the precipitating electron distributions entering the KFL formula were also discussed (J. Semeter). These results support the breakdown of a linear current-voltage characteristics during certain phases of a substorm surge. Some aspects of the issues discussed in this breakout can be found in the slides residing at http://www-ssc.igpp.ucla.edu/gem/appendix/GEM-MIC-WG2-2003-Beyond-Knight.pdf.

The results presented in this session, and discussions of the various acceleration processes that ensued, indicate a need to develop new and realistic yet simple models of nonadiabatic electron energization for use in global MHD models. Equally important is the development of observational strategies that will not only help to reveal the basic physics involved, but also serve to validate models as they are developed. These processes are important because they influence global dynamics by enhancing the (colllisionless) energy dissipation in ways that are not characterized by the KFL formula, especially in downward field-aligned currents and Alfvenic acceleration regions. When electron precipitation accompanies nonadiabitic acceleration, the ionosphere is modified in spatial regions where the KFL formula would predict little or no precipitation, especially, in Alfvenic acceleration regions.

The issues raised in each of the above breakout summaries will be used to define next year's WG-2 agenda. The co-chairs encourage new and ontinued participation as the MIC campaign continues to mature.

Joshua Semeter
Joshua.semeter@sri.com
Bill Lotko
William.lotko@dartmouth.edu

Inner Magnetosphere/Storms Campaign

Working Group 1: Plasmasphere and Ring Current

The Inner Magnetosphere Storms Working Group 1 (IMS/WG1) held four independent and three joint sessions during the June 2003 GEM Workshop. The sessions focused on new work regarding inner magnetospheric electric fields, the stormtime ring current morphology and dynamics, plasmaspheric density structure, and coupling between the ring current, lasmasphere, and ionosphere.

IMS WG1 and WG2 cosponsored two tutorials at the Workshop: Michelle Thomsen presented "Storm-Time Dynamics of the Inner-Magnetosphere: Observations of Sources and Transport" and Vania Jordanova presented "Modeling Geomagnetic Storm Dynamics." Thomsen spoke about the importance of geosynchronous orbit observations in forming our opinion of the inner magnetosphere. This altitude is a natural boundary between the plasma sheet in the near-Earth tail and the plasmasphere/ring current/radiation belts in the inner magnetosphere. She demonstrated how the local time and energy dependence of the ion and electron measurements across the dayside and nightside are being used to improve our understanding the dynamics of magnetic storms. Jordanova discussed some of the modeling techniques used for simulating the plasma distributions in the inner magnetosphere. A detailed description of her ring current model was given, along with a review of many recent results regarding the stormtime ring current. She also presented a new relativistic electron version of her model and some initial results. Both tutorials are online at the GEM website:
http://www-sc.igpp.ucla.edu/gem/tutorial
In the kickoff session for WG1, the following questions were posed to the audience: What is the bare minimum set of physics a model needs in order to get a reasonable description of the subauroral E-fields? What is the full set of physics for a complete description? Which essential processes are going to be the most difficult to capture quantitatively? And finally, is self-consistency necessary, or is an imposed E-field model sufficient? These questions were continually raised during the sessions, and there were numerous presentations and discussions addressing each of these topics.

Inner Magnetospheric Stormtime Electric Fields: C:son Brandt began the session by summarizing findings from HENA concerning the local-time distribution of the main phase ring current, showing a regular skew toward post-midnight. Kintner described some of the practical impacts that magnetospherically-driven electric fields can have on the mid and low latitude ionosphere, specifically on the redistribution of electron density and the creation of troughs and steep density gradients. Boonsiriseth described her MACEP calculations for the May 1997 storm, showing good agreement with in situ observations from Polar. Sazykin presented RCM results of the March 31, 2001 storm, with SAPS structures arising through much of the main phase. The ion pressure peaked premidnight, in approximate agreement with HENA data for this event. Jahn then showed two proposed methods for measuring inner magnetospheric electric fields, one from multiple in situ particle measurements and the other from successive ENA images.

Partial/Symmetry ring Current Transitions: DeZeeuw showed results from his MHD-RCM coupled model for IMF turnings, illustrating overshielding and a rapid change from a partial to a symmetric ring current. Weygand presented a superposed epoch analysis of SYM-H and ASY-H, correlating it with Ey,sw, detailing the timings of symmetric and asymmetric delta-B observations as a function of storm phase. Lyons showed Geotail data that indicate that pV^{γ} is not always conserved, with substorms reducing the ring current source populations at all energies. M. Chen presented ring current modeling results for the October 1998 storm, showing that AMIE E-fields can create a very asymmetric ring current that peaks on the duskside. Russell showed a compilation of inner magnetospheric magnetometer data, binned according to Dst*, MLT, R, and MLAT, concluding that the stormtime ring current is asymmetric and that the currents go up linearly with Dst (to -100 nT, at least). C:son Brandt showed that D_ENA, a perturbation extraction from HENA data, can have a different time history than Dst, and the peak of the disturbance can be off by up to 30 minutes. Valek showed MENA images of the plasma sheet, with high density times correlating to high solar wind densities.

<u>Plasmaspheric Density Structure</u>: Gallagher started off the session with an overview of the terminology being encouraged by the IMAGE Mission for observed features of the plasmasphere. With the advent of plasmasphere imaging through the extreme ultraviolet imager (EUV) and the radio plasma imager (RPI), many new terms were being introduced without coordination. The objective for the new lexicon is to reduce confusion as researchers strive to understand the physical processes that shape plasmaspheric density distributions. Song presented an analysis of mass loss and refilling for the storm on March 31, 2001. The depth of the equatorial density, the steepness of the density distribution, and the flatness of the near-equatorial density distribution have been used to quantify the field-aligned density distributions. During this storm and after plasmaspheric erosion, the equatorial densities primarily below 40 degrees magnetic latitude are depleted. At lower altitudes there is little change in density resulting from erosion. No density maximum was observed at the magnetic equator during filling. Field lines were filled significantly in less than 28 hours during recovery. Denton presented the results of analyzing field-aligned density distributions in the plasmasphere and magnetospheric trough using POLAR wave observations. A power-law dependence of density along a field line as a function of L was assumed. Typically a power-law coefficient of 0.5 was found within the plasmasphere and 2.5 outside in the magnetospheric trough. No remaining dependence on magnetic local time or Kp was found. The average L dependence for the equatorial density agrees well with Carpenter and Anderson [1992]. Separate comparison between the Denton and Song approaches also appears to show reasonable agreement even though the functional forms used were different.

Gallagher presented a preliminary statistical analysis approach for IMAGE EUV observations. In one technique images were grouped by the integrated Kp and Dst from the preceding 24-hours and by the linear trend in Kp and Dst during that time period. Without excluding low altitude ionospheric contributions to EUV observed intensities, the total plasmaspheric content was reduced from quiet to active times by 32% when binned by Kp and by 54% using Dst. The period from May to July 2000 was analyzed for dependence on solar rotation longitude following the example of Fred Rich [JGR, 2003]. At 800km, a 50% increase in density is found near noon for a solar longitude of about 70 degrees. At larger distances peaks appear at dawn and dusk. Goldstein presented an analysis of the plasmaspheric drainage plume. He showed a broad, initial plume surge in the sunward direction, a rotation of the eastern plume edge toward the west with a thinning plume, then the plume wraps during recovery. The plume also thins on its westward edge due to loss of the original outer plasmasphere on the dawn side of the plasmasphere. He reports that Spasojevic has just mapped a plume to the auroral zone where she sees a correspondence suggesting ring current collisional loss. He finds TEC plumes are not seen together with EUV plasmaspheric plumes unless SAPS are present. Freeman presented BATSRUS MHD flow simulations for the plasmasphere. Instantaneous snapshots of the flow pattern from BATSRUS were shown. In these simulations you can see replication of potential flow pattern corresponding to May 25, 2000 with a narrow tail. The simulations also show a distinct change in the evening flow pattern between southward and northward IMF. Undulations were seen in the IMS during another time period at ULF periods. He also showed a lobe feature around 10am local time that travels antisunward. This is a wave undulation at around L of 5 or 6.

Ring current-Plasmasphere Interactions: C:son Brandt started the session by describing two types of ring current-plasmasphere interactions. There are "direct" interactions between ring current ions and electrons, cold plasmaspheric electrons and waves (e.g., EMICW, plasmaspheric hiss) that lead to pitch-angle scattering into the ionosphere. There are also "indirect" interactions of ring current and plasmasphere that occur through M-I coupling. He showed ring-current associated field-aligned currents inferred from HENA observations. Ring-current associated field-aligned currents can cause ionospheric conductivity gradients that lead to the formation of a mid-latitude SAP electric field. Complementing this presentation, Goldstein showed EUV observations illustrating how SAP electric fields can affect lasmaspheric erosion and plume formation. By adding a simple model of the SAP potential, a localized potential drop on the dusk side, to the Stern-Volland electric field, he was able to reproduce qualitatively the plasmaspheric features seen in EUV images. S. Liu presented comparisons of storm-time ring-current electron simulations with CRRES observations that illustrated the "direct" interaction between the ring current and plasmasphere. He found good agreement between simulated and observed ring-current electron flux profiles at low energies if he invoked an electron loss model that incorporated the dynamic plasmaspheric boundary. Finally, Liemohn presented a study of the influence of ionospheric conductance on the morphology and intensity of the ring current and plasmasphere. He compared plasmaspheric results with EUV images using 3 different E-field models: the McIlwain, Weimer, and a self-consistent model, for the April 2002 storm. The conclusion is that the self-consistent simulation produced the best match to the data.

MIC/IMS joint session: Electrodynamics of Inner/Midlatitude MI-Coupling as a Plasma Source Region. Kintner led off the discussion with a challenge: can models of the inner magnetosphere explain ionospheric motion? And this: is the ionospheric response significant to the magnetospheric dynamics? He then gave a review of coupling between the inner magnetosphere and subauroral ionosphere and thermosphere. Ridley gave an overview of the strengths and weaknesses of using results from the AMIE model at midlatitudes. Makela then presented correlations of Jicamarca ISR data and solar wind parameters, showing that the interplanetary electric field can penetrate to the equator (undershielding) for hours at a time. Dick Wolf showed some results from the RCM of SAPS and other E-field features. He noted that there is positive feedback in the ionosphere: faster flow lowers the conductivity, which increases E and thus makes even faster flow. C:son Brandt presented comparisons of satellite and groundbased data, showing that Iridium FACs are morphologically consistent with HENA and ISR data. Finally, Goldstein showed that the Volland-Stern model gets most of the plasmapause structure correct, but adding a simple SAPS E-field gets the plasmaspheric plume shape even better.

IM/S Joint Session (WG1, WG2, WG3) Recent

GEM Storms Analysis: Fraser kicked off this joint session with an introduction of the new ULF Waves Working Group. He defined ULF waves to run from 0.002-5 Hz with: Pc1 0.2-5 Hz, Pc2 0.1-0.2 Hz, and Pc3-4 7 mHz up to 100 mHz. Pc5's period can be longer of course. Pi1 oscillations are 1-40 seconds and Pi2 is 40-150 seconds in period. Pi is pulsation impulsive and Pc is pulsation continuous. All waves are present in the magnetosphere. Wavelengths scale to the size of the magnetospheric cavity. Propagating waves exit. ULF waves interact with particles, fields, and plasmas in many ways and locations in the magnetosphere, plasmasphere, and ionosphere. The working group was initiated in response to the increasing importance of the new methods and analysis of ULF waves in investigating the subjects of magnetospheric and ionospheric physics that are the focus of GEM campaigns. Brian considers WG3 to be a working group that contributes to the others.

The Alfven velocity controls ULF waves in the magnetosphere. Mass loading leads to a double peak in the Alfven velocity, as you look inward. The first peak is perhaps just inside L=6 and the second inside L=2. The minimum between is due to mass loading in the plasmasphere.

One of the motivations of having a ULF working group is to discuss the derivation of densities in the magnetospheres. They want to pick up on relevant campaigns and contribute where needed, e.g. plasma density measurements for WG1.

ULF Working Group Aims:

- Cooperate with IAGA on developing a ULF wave index for use in statistical studies and other applications.
- Deliver products routinely to the community, e.g. plasma density profiles and heavy ion concentrations.
- Consult with the GPS-TEC community on plasmaspheric density measurements.

In the future they plan to meet at the Fall 2003 AGU MiniGEM workshop to plan specific "campaigns."

The rest of the session was devoted to recent results on the selected GEM Storms. Barker et al discussed efforts to study and predict radiation belt (RB) electrons. They are using the radial diffusion equation, where they assume a radial diffusion coefficient that varies with L^6 at L=4 and L^{10} at geosynchronous. Radial diffusion can describe the trends, but does not well describe the RB magnitude. For one storm in September they were able to reproduce both. Feidel presented their work with data assimilation using the Salammbo code. It takes considerable effort to insure that quality or correct data is fed into the modeling code, otherwise garbage-in leads to garbage-out. They took many conjunctions and looked for the best fit between observation sites. A LANL GEO and CRRES MEA conjunction on Sep 3, 1990 17:03 worked well. They did the same thing with GPS, LANL and CRRES on Sept. 15, 1991, which worked well. Each channel must be examined to determine sensitivity to contamination. With conjunction a $\sin(\alpha eq)^N$ pitch angle distribution can be determined. Without conjunction they must set the distribution function to a default profile. They intend to be able to input up to 20 satellite data measurements into the model. This form of data assimilation is called model nudging. Liemohn presented the influence of ionospheric conductance on their ring current modeling. They computed azimuthal currents in the magnetosphere to get field aligned currents (FAC) through a potential solver to compute electric fields. They include charge exchange, collisions, and vary the electric field model. They perform a Poisson solution for potential throughout the ionosphere. The self-consistent calculation does better than other (non-self-consistent) e-field approaches. A parametric study of how the ionospheric conductance changes the ring current was shown. Gallagher presented a brief overview of the quality and quantity of IMAGE Mission extreme ultraviolet imager (EUV) observations of helium ions during the IMS/WG1 storms. Observations are limited to between midnight and dawn for the October 2, 2000 storm. There are extensive observations of various structures, e.g. the convection plume and plasmapause erosion to slightly less than L=2 during the March 31, 2001 storm. For the October 21, 2001 storm, mostly nightside observations of plasmapause erosion and the plume are available. Observations during the April 17, 2002 storm are spotty.

IMS joint session: Inner Magnetosphere Interconnectedness and IMS Wrapup:
The main decision about the future of IMS was that an IMS Challenge will be issued within the next year. All IMS researchers are requested and encouraged to contemplate possible candidate events and challenge format details. The challenge will be defined at the GEM Mini-Workshop before the Fall AGU meeting, on Sunday December 7, 2002. Everyone is invited to come and participate in this discussion. More information on this IMS Challenge will be given in a future GEM Messenger announcement.

Mike Liemohn, Co-Chair
liemohn@umich.edu
Dennis Gallagher, Co-Chair
Dennis.gallagher@nsfc.nasa.gov
With contributions from Dick Wolf, Margaret Chen, and J.-M. Jalen

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Working Group 2: Radiation Belts

Observations of Electron Variability and Loss

1. Relativistic electron response to storms appears to be dependent on a delicate balance of losses and acceleration processes. Statistics show that roughly 20% lead to decrease, 30% no change, and 50% show increases.(Reeves, Friedel)

2. The possibility of using HENA global pressure measurements to estimate inner magnetospheric magnetic fields was discussed, This provides another handle on the Dst effect - the adiabatic response to storms, and improved calculation of the second invariant. (Brandt)

3. Solar cycle variation of storm response was discussed including the distinctly different responses to solar wind drivers such as solar max CME's / magnetic clouds, short duration solar wind speed enhancements (which occur often, not allowing long-term build up of relativistic particles), and declining-phase fast speed streams (recurring, long duration, very geoeffective, leading to long term build up). The current solar cycle already shows recurrent streams returning. (Li)

4. There is mounting evidence from PSD measurements of inner magnetosphere PSD peaks near L=5 indicating internal acceleration. Flat to slightly increasing PSD occurs beyond geosynchronous. Questions remain on whether the plasma sheet can provide the source for the radiation belts. There is enough PSD at some times (relation to central plasma sheet is problematic), but transport is very "lossy." There is a consensus opinion of the group to stick with single set of units for PSD studies (suggested using same units as Green and Selesnick and Blake; 1st adiabatic invariant in MeV/Gauss and PSD in $c^3/(\mathrm{cmMeV})^3$ (Taylor, Green).

5. Study of geosynchronous losses during moderate to weak activity indicates that a combination of magnetic field topology changes (stretching) and loss processes (waves, EMIC?) may explain persistent losses for the high energy component. Very important is plasma sheet pre-conditioning of the inner zone with high densities - "superdense plasma sheets" - leading to enhanced stretching, and plasmasheric plumes which are required to bring EMIC resonance conditions into the 1 MeV range. (Green, Onsager)

6. Low altitude NOAA spacecraft data can be used to study the MLT distribution of electron precipitation and it's dependence on magnetic activity. The lower energy precipitation has an MLT variation similar to chorus emissions. (Friedel)

WG2: VLF Waves and Electron Variability (Chair: Richard Thorne)

In contrast to ULF waves, which violate the third invariant and cause radial diffusion, VLF/ELF waves can violate the first two adiabatic invariants and induce both scattering loss to the atmosphere and a local source of energy diffusion.

1. Ground based VLF transmitter signals have been observed on the Image spacecraft. The waves are relatively weak (10 W) indicating a low efficiency (10^{-5}) for transmission through the ionosphere but such waves are still important for understanding the overall loss of inner zone electrons. (Song)

2. A superposed-epoch analysis of electron acceleration events with ground based ULF waves activity and VLF chorus activity (using microbursts observed on Sampex as a proxy), suggests that VLF waves provide a better correlation with electron increases observed at lower L (4-5), while both processes are important at geo-synchronous orbit. The implication is that local acceleration by the VLF waves provides more effective acceleration in the heart of the radiation belts at lower L. (O'Brien)

3. Microbursts of energetic electron precipitation have been observed by the long duration balloon flight (MAXIS). Soft electron precipitation events are observed at all MLT while hard events (related to relativistic electron events) are only seen in the dusk MLT region. This suggests that at least two separate processes are responsible for the electron loss. (Millan)

4. A study of 26 disturbed events on CRRES indicates a strong correlation between enhanced and sustained chorus emissions and subsequent enhancement of MeV energy electrons in the outer zone. This is suggestive of local acceleration by such waves. CRRES data have also been used to show that plasmaspheric hiss is substantially enhanced during active conditions. This implies that loss by such waves will be more important during the recovery phase of a storm. CRRES data have been used to demonstrate that EMIC waves can contribute to the scattering loss of electrons below 2 MeV in regions just inside the plasmapause or with plumes of higher density. (Thorne, Meredith, Horne, Summers)

5. Bounce averaged pitch-angle diffusion rates for relativistic electrons interacting with stormtime EMIC waves (1nT) and plasmaspheric hiss (100pT) indicate that losses can be substantially enhanced when EMIC waves are present. Lifetimes at 1 MeV can drop from 3.5 days due to hiss alone to less than a day when EMIC scattering is added. (Albert)

WG2 and WG3: ULF Waves and Electron Acceleration (Chairs: Anthony Chan and Scot Elkington)

This joint session is summarized in the WG3 (ULF Waves) Report.

WG2: Theory and Modeling of Acceleration and Loss (Chairs: Anthony Chan and Richard Thorne)

An analysis has been made of the metastable drift paths of particles that encounter the region of minimum B off the equator near the dayside magnetopause. Such metastable drift paths separate the long term stably-trapped closed drift trajectories from the open drift paths that intercept the magnetopause. Analysis of the metastable orbits is important for understanding magnetopause shadowing loss. (Ozturk)

A parametric study was presented of the rapid acceleration of outer radiation belt relativistic electrons by interplanetary shock-induced electric fields. The effects of various parameters of the induced pulse fields on the pre-existing electrons was discussed. (Gannon)

An analysis was given of electron phase space density during an interplanetary shock impact. The significance of the radial profile of the phase space density of pre-existing electrons was discussed. It was also pointed out that an extremely large interplanetary shock, though rare, can have long lasting (years) effects on the radiation belt environment, while moderate shocks, which occur more frequently, can also accelerate the radiation belt electron rapidly but their effects won't last long (days to weeks). An analysis was described of electron phase space density based on test particle simulation. (Li)

The cyclotron resonant interaction of electrons with a non-linear monochromatic wave can either lead to diffusion, phase bunching or particle trapping. All three interactions result in pitch-angle scattering and energy change. Numerical evaluation of potential acceleration processes indicate that diffusion may be too slow while particle trapping could provide rapid acceleration of the few electrons able to be trapped by the wave. (Albert)

Quasi-linear diffusion rates for electron interaction with chorus emissions indicate that energy diffusion is extremely sensitive to the ratio between the electron plasma and gyro frequency. Stochastic acceleration is most efficient in the region just outside the plasmapause, where this ration falls to a minimum value near 2 or 3. Acceleration to MeV energies can then occur on time scales comparable to a day. (Thorne, Horne)

6. The distribution of electrons resulting from inward radial diffusion is extremely sensitive to the adopted electron lifetimes. Generally radial diffusion dominates and provides an effective source at higher L while losses provide a sharp inner boundary to the outer zone population. Model simulations indicate that loss rate comparable to a few days under moderately quiet conditions, and under a day during a storm provide the best fit to data in the absence of an internal source. (Shprits and Thorne)

Geoff Reeves, Co-Chair
reeves@lanl.gov
Richard Thorne, Co-Chair
rmt@atmos.ucla.edu

Working Group 3: ULF Waves

This year's GEM Workshop marked the start of the Working Group on ULF waves within the Inner Magnetosphere/Storms Campaign (IM/S). Coordinated by Brian Fraser and Mark Moldwin, this new WG was initiated in response to the increasing importance of new methods and analysis of ULF waves in investigating the subjects of magnetospheric physics that are related to the GEM Program. Four sessions of this WG were held over June 25 - 27 (Wednesday - Friday).

At the combined WG1/2/3 session on the Inner Magnetosphere/Storms Brian Fraser outlined the anticipated scope of WG3 and what it hopes to contribute overall to GEM and outlined the sessions reported below.

The initial aim of WG3 is to contribute to the IM/S and other GEM campaigns in areas where ULF waves play a role in understanding the physics of regions and phenomena under study. In this manner the expertise of the group can interact on a broad base. Current exciting topics of research involving ULF waves include, for example, the acceleration of electrons to MeV energies in the radiation belts and the upstream solar wind as a source of long period ULF waves seen in the magnetosphere. It is also appreciated that ULF waves manifest themselves in a wide variety of geophysical observations of our magnetosphere and ionosphere and the understanding of their effects on a variety of instruments, including radars, optical imagers, riometers, cold plasma detectors, energetic particle detectors etc., are important.

<u>ULF Wave Diagnostics:</u> (Chair: Peter Chi)
The session on ULF diagnostics was convened on Thursday morning, and it included seven talks on the techniques and results based on both satellite and ground observations of ULF waves. Kazue Takahashi started the session with the study on the field-aligned distribution of plasma density inferred from the eigen frequencies of magnetospheric field lines, observed in the CRRES electric field and magnetic field data. If the density fall-off rate is modeled as $r^{-\alpha}$ (where r is the radial distance to the Earth) the ratio between the second or the third harmonic to the fundamental mode frequency suggests that statistically α is roughly 2. Richard Denton then showed the analysis of the field-aligned density distribution, also derived from CRRES observations of field line resonant frequencies, as a polynomial function. Using a nonlinear solver to match the modeled eigenmodes with the observed values, he found that the observations of multiple harmonics sometimes show a condition that the plasma density has a local maximum at the equator. Ian Mann reported results of magnetospheric density based on ground magnetometer data. Applying the cross-phase analysis on neighbouring stations, he and colleagues found that the phase difference may reverse its sign across the plasmapause latitude. This reverse cross-phase is expected to occur when the density varies faster than r^{-8}, a condition that can exist at the plasmapause. The plasmapause location and the magnetospheric density are both in good agreement with those found by IMAGE EUV and RPI measurements. Hideaki Kawano presented two studies done by the Kyushu group: One found that the density at L = 1.3 temporarily increased after the onset of the storm main phase; the other is a collaborative work with the Alaskan GIMA group on identifying the plasmapause location at multiple local times. Brian Fraser described several other ULF diagnostics techniques based on ground observations, including the HARRD method that determines the density distribution in low L-shells without assuming any density model, as well as the calculation of interstation phase lag near the cusp/cleft region to determine the boundary of open and close field lines. He also emphasized that the ionospheric mass loading effect should be taken into account in inferring plasma density when L < 1.3. Dave Berube presented a computer routine that automatically detects the eigen frequencies of field lines in the cross-phase spectrograms of ground magnetometer data. He also shows the statistical analysis of the plasmaspheric density inferred from the eigenfrequencies frequencies observed by the MEASURE magnetometers. The comparison between the mass density inferred by MEASURE data and the charge density obtained by IMAGE RPI data suggests that the average ion mass is higher at disturbed times. In the final presentation, Peter Chi showed the magnetospheric density distribution obtained by the travel time of preliminary reverse impulses, a magnetoseismic method that is complement to the field line resonance technique. The density inferred by the travel-time method is in good agreement with that obtained by the field line resonance method. The density levels and the plasmapause location are also consistent with those predicted by the Carpenter-Anderson density model.

<u>Impact of Externally Driven ULF Sources</u> (Chair: Brian Fraser)
This session addressed processes by which long period 0.1 - 10 mHz oscillations in the solar wind may act as direct drivers for ULF waves of

similar frequencies observed within the magnetosphere and on the ground. Howard Singer presented details of the original analysis by Kepko et al. (2002) which showed that oscillations with frequencies ≤ 3 mHz in the Bz component at GOES-8 correlated with similar frequencies in the solar wind density seen upstream by WIND. A new study on one month's data showed the existence of the so-called "magic frequencies" of 0.2, 0.7 and 1.3 mHz in the correlated data. However discontinuities and shocks were removed from the solar wind density data and the arbitrariness of this process was questioned. These frequencies may relate to solar oscillations and it was agreed further work is needed to associate these waves with solar structures. Marc Lessard noted that oscillations with frequencies < 1 mHz, have been seen with bunched electron particles at 100 - 200 keV, drifting with periods of 0.1 - 0.7 mHz, by the LANL satellites. Particular modulations were seen at 0.18 and 0.32 mHz with a statistical study showing a peak at 0.1 mHz. These were labeled S-ULF waves. In comparison, GOES-7 magnetic field data showed 0.14 and 0.55 mHz oscillations. It was difficult to see how these S-ULF modulations could be excited by helio-seismic sources but in some cases they could result from ExB drifts. Jimmy Raeder reported on the response of the topside ionosphere to solar wind forces using MHD code which showed a density fluctuation driver was more effective than an Alfven B field fluctuation upstream source. More power was coupled into the magnetosphere under +Bz (IMF) than -Bz(IMF) with the fundamental frequency dominating and most power concentrated in the auroral zone. Using the BATS-R-US code with a realistic solar wind input GEOTAIL data, including 1 - 2 mHz ULF waves, John Freeman identified three modes of induced waves in the magnetopause. These were a body wave (FLR or cavity mode), a surface wave at the magnetosphere (Kelvin Helmholtz instability) and waves in the convection pattern outside the plasmapause. These simulation studies will provide impetus for experimentalists to look for these predicted wave modes. Finally, Wendell Horton described the properties of magnetospheric high beta drift compressional waves in the mHz frequency range and which are unstable under drift reversal or an inverted temperature-density gradient. The existence of these waves requires a detailed comparison with experimental data.

In summary, the hypothesis of upstream solar wind density structures or waves coupling energy into the magnetosphere requires further study both from the viewpoint of defining a unique source in the solar wind data and uniquely relating these to waves or perturbations in the magnetosphere. Data analysis techniques are also an important consideration.

<u>ULF Waves and Electron Acceleration</u> (Chairs: Anthony Chan and Scot Elkington)

Prompted by results from recent observational and theoretical studies, this session focused on the role of ULF waves in transporting and accelerating magnetospheric electrons to MeV energies. The first speaker, Don Brautigam, presented new results where CRRES electric field measurements are being used to estimate a storm-time radial diffusion coefficient. Because CRRES is a single spacecraft assumptions must be made about the azimuthal spatial structure of the electric fields, following Holzworth and Mozer [JGR, 1979] and Riley and Wolf [JGR, 1992], for example. Next, Scot Elkington discussed methods for obtaining the power spectrum of ULF waves, for input into radial diffusion coefficients, using global MHD simulations. Like Brautigam, Elkington also used the basic methods of Holzworth and Mozer [JGR, 1979] to make Fourier series in the azimuthal coordinate and to then perform an FFT in the time variable. Results were shown for a global MHD simulation of the September 1998 storm using the Lyon-Fedder-Mobarry code, in which at least 80% of the power was shown to be contained in the m=1 and m=2 modes (here m is the usual azimuthal wave number). In collaboration with Elkington, Yue Fei and Anthony Chan have used these power spectra to evaluate new radial diffusion coefficients for ULF-wave-driven transport. The resulting phase-space density radial profiles are in good agreement with those obtained from corresponding MHD-particle simulations. Mary Hudson presented work done in collaboration with Kara Perry of the three-dimensional transport of MeV electrons in MHD wave models, using test-particle simulations. These are the first results for the challenging problem of full three-dimensional motion (including bounce motion - previous work has mostly assumed equatorially-mirroring particles). Finally, Xinlin Li's talk on necessary conditions for radial diffusion to occur and on the expected signatures of radial transport in spacecraft data closed the session with some very lively and stimulating discussion.

ULF Wave Observation Techniques (Chair: Brian Fraser)

The aim of this session was to highlight the various techniques which may be used to observe ULF waves and illustrate the wide range of magnetospheric phenomena which exhibit wave signatures. Discussion centered on magnetometer, radar and IMAGE satellite wave observations. The SAMBA array introduced by Eftyhia Zesta observes ULF waves using a chain of fluxgate magnetometers ranging from the northern cusp to the southern cusp spanning the Americas. This is conveniently located 180 deg in longitude from the Japanese 210 deg Magnetic Meridian Chain. The advantages of the cross-phase analysis techniques and conjugate studies in determining FLR frequencies and plasma densities were outlined in initial SAMBA data, including storm-time results. A comparison of analysis techniques suggested FFT methods may be more useful in conjugate studies while wavelet analysis is often better for intra-hemisphere studies. The importance of the LANL satellite's MPA instruments in observing eV electron and ion species densities at times of high flows, when heavy ions separate, was illustrated in a study of the 12 August 2000 storm by Michelle Thomsen and presented by Peter Chi. This is one of the few available techniques to measure ion species concentrations as distinct from simple total heavy ion mass loading. Recent IMAGE satellite observations reported by Mark Adrian showed the existence of radial fingers of enhanced plasma density in the plasmasphere at quiet times. These bifurcated structures rotate slower than corotation. Simultaneous IMAGE and Antarctic magnetometer array data show concurrent ULF waves with periods of ~ 33 min (f ~ 0.5 mHz). Near the same time periodic waves were observed in the solar wind dynamic pressure. The radial finger structure has been modeled with an ExB standing wave model which supports the idea of ULF waves producing the radial finger density pattern. The need for more Pc5 wave data on the dayside for this event illustrates the need for coordination of ULF wave data on a global basis. The potential of SuperDARN and other radars to detect Pc5 ULF waves when operating in high resolution special modes has been known for some time. Recently new techniques have been developed to enhance these observations and extend them to higher frequencies. For example, Darren Wright described Pc4-5 ULF wave signatures seen by the Cutlass radars in Scandinavia are enhanced when the ionosphere in the field of view is heated by the EISCAT facility. Here waves with very high wave numbers (m = 81) have been observed. In the plasmatrough ionosphere Pasha Ponomarenko noted that the TIGER southern hemisphere SuperDARN radar has observed Pc3-4 frequencies with both high and low m numbers as well as narrowband night-time Pc4 waves. These waves are more easily observed using the ground or sea scatter echoes and indicate a new technique to expand the ULF wave observation capabilities of the SuperDARN radar networks in both hemispheres.

ULF Wave Index (Chair: Brian Fraser)

The papers in this session were not presented but will be the basis of a WG3 session at the mini-GEM Workshop to be held on December 7, 2003, preceding the Fall AGU Meeting.

Summary

Following these initial sessions of the IM/S WG3 ULF Waves working group two goals to be completed in two years were decided.

1. Produce global maps in near-real time of plasma density distribution in the plasmasphere - magnetosphere using worldwide ULF FLR observations.

2. Establish a ULF wave activity index for use in radiation belt and other statistical studies.

Brian Fraser, Co-Chair
Brian.fraser@newcastle.edu.au
Mark Moldwin, Co-Chair
mmoldwin@igpp.ucla.edu

Global Geospace Circulation Model Campaign

Data Assimilation

The GGCM campaign focused on Data Assimilation (DA) during this year's summer workshop.

There is no doubt that data assimilation has improved atmospheric modeling significantly. For example, if your local weather forecast was correct today it is mainly because it was derived from an advanced numerical model that uses data assimilation. Because of that success DA techniques have found their way into other fields, for example oceanic modeling, earth system modeling, and recently in ionospheric modeling. The Tuesday morning tutorial (Dr. Ludger Scherliess -Utah State University, "Data Assimilation for the Space Environment") laid the ground for this session. Dr. Scherliess introduced the GAIM effort which aims at developing a data assimilative model for the ionosphere, primarily for the nowcast and later for the forecast of ionospheric electron density. The tutorial made it amply clear why DA is much more advanced for ionosphere modes compared to magnetosphere models: there are much more ionospheric data available compared to the magnetosphere. Numerous GPS stations and other ground and space based instruments now provide of the order of 10^5 to 10^6 measurements per day. So many measurements not only make DA feasible but actually require DA models to make good use of the data, and Dr. Scherliess' talk demonstrated that assimilative models can produce dramatically better results compared to first principle models without DA. The following magnetosphere DA session then focused on the beginnings of the use of DA in magnetospheric models. Several speakers either showed some simple attempts (compared to GAIM, for example) of magnetospheric data assimilation or discussed potential approaches and pitfalls. From these discussions several issues became clear:

(i) The magnetosphere is a much more driven system than the ionosphere-thermosphere system, which is in turn more directly driven than the magnetosphere. Thus, the original goal for data assimilation, i.e., overcoming the ill effects of poor model initialization, applies to a much lesser extent to magnetospheric models. On the other hand, the largest data deficiency in magnetospheric models may be the solar wind and IMF input because of the poor location of the monitors (too far off the sun-Earth line, or too far upstream). Magnetospheric DA models probably need to take this into account.

(ii) DA in atmospheric models also serves to filter out the fast timescale (inertia-gravity waves, Rossby waves, considered noise) which is of little significance for the mostly geostrophical dynamical evolution. It is not clear if such a separation of scales in the magnetosphere exists, and how different scales in the magnetospheric dynamics would interact with data assimilation procedures.

(iii) The magnetosphere exhibits significant internal dynamics (substorms) which may have a significant stochastic component, or self organized criticality, and which may not be well described by the evolution equations. It is not clear yet and needs to be explored how that would affect data assimilation approaches.

(iv) Several regions of the magnetosphere, for example the radiation belts or the ring current, may exhibit characteristics that more closely resemble atmospheric motion, in particular longer time scales and strong initial value dependence. DA models for such regions may thus be easier to develop and they may borrow from the methods developed for atmospheric models (3DVAR, 4DVAR, Kalman Filter). In fact, all of the initial DA efforts presented in this session addressed only isolated regions or processes of the magnetosphere.

(v) Introducing data assimilation into global numerical magnetosphere models poses the greatest challenge. Although there are not enough data presently available for meaningful magnetospheric data assimilation, some missions on the horizon (THEMIS, MMS, Magnetospheric Constellation) will change that. Also, the experience with atmospheric and ionospheric DA models indicates that the model development is a slow process that may not take years, but decades to come to fruition, thus making a strong development program a necessity.

Jimmy Raeder, Co-Chair
J.Raeder@unh.edu
Mary Hudson, Co-Chair
Mary.Hudson@Dartmouth.edu

Tail/Substorm Campaign

Working Group 2: Substorm Triggering

The final meeting of the Substorm Observations and Substorm Triggering Working Groups of the Tail/Substorm Campaign contained discussions summarizing the current status of topics of interest with the goal of specifying "where we are today." A synopsis of the proceedings follows.

A recap of the "substorm challenge" (Raeder) was presented in a discussion of the state of MHD-based global modeling of the magnetosphere during substorms. The MHD-based global models qualitatively reproduce a remarkable number of substorm features, however most comparisons were quantitatively off, and several important issues were unresolved: triggering, the location and cause of the start of expansion, timing within 2 minutes, effects of resistivity/diffusion, and the role of the ionosphere. Two speakers (McPherron, Blanchard) addressed triggering of substorm onset by northward turnings of the IMF. The consensus is that at least the majority of substorms are triggered. Other speakers (Henderson, Lessard, Erickson) focused on specific auroral features and their significance to the substorm onset mechanism: torches and omega bands, the location of breakup relative to the Harang discontinuity, the assertion that the breakup arc is stationary before onset contrasted with the assertion that the breakup arc forms just before onset. These speakers asserted that M-I coupling plays a significant role in the substorm onset mechanism. There were several presentations (Lyons, Mende, Donovan, Erickson) that discussed various proposed substorm onset mechanisms. These presentations generally focused on the dynamics of the inner edge of the plasma sheet or of M-I coupling.

The significance of these discussions for the GGCM is that while an MHD backbone reproduces the gross features of a substorm well, the correct modeling of substorms will require modules that include the proper physics of the inner plasma sheet and of M-I coupling.

Finally, new observations were presented (Brandt, Jahn, Li) that may play a role in future substorm research, such as CLUSTER II measurements of plasma sheet thickness (as small as 0.2 RE) and ENA observations of the plasma sheet, including such features as plasma sheet dropouts and tracking of substorm injections.

Gerard Blanchard, Co-Chair
gblanchard@selu.edu
Larry Lyons, Co-Chair
larry@atmos.ucla.edu

Working Group 3: Steady Magnetospheric Convection

The Steady Magnetospheric Convection Working Groups held three sessions during the 2003 GEM Snowmass Workshop.

The first session focused on magnetotail equilibrium and convection. Gary Erickson opened the session with an enumeration of critical questions whose answers will elucidate the nature of transport in and equilibrium of the magnetotail, constrain substorm theories, and identify the solar wind states that lead to SMCs. Among the questions are: How is the pressure crisis avoided? Should there be a minimum in B in the mid-tail (~12 Re) region? Bubbles are one way to avoid the crisis. If that is the case then it suggests interchange unstable flux tubes. Drift of plasma sheet plasma toward the flanks represents another possibility, as shown by Chih-Ping Wang, who calculated the (energy dependent) mag drift of particles using the MSM model with a modified T96 B-field model and applying a monotonically increasing E-field and polar cap area. The simulation shows that as the E-field becomes large, the radial gradient of B moves earthward and the stretching of field lines changes flux tubes' volume, thus changing particle energization as drift proceeds earthward and the diamagnetic drift becomes as important as the E-drift at midnight for high E-field. The proton pressure distribution agrees with pressure maps derived from DMSP.

There are some morphological similarities between SMCs and substorm recovery, such as a double oval configuration and a thick plasma sheet. These similarities suggest that perhaps SMCs are not very different from substorm recoveries. However, there is a very important difference which is an extended thin current sheet embedded in the thick plasma sheet. The thin current sheet could play a key role for transport and equilibrium in the magnetotail because it may mean "unfrozen" particle transport over longer distances and an X-line in a different position along the tail axis.

Two critical questions relating the efficiency of transport in SMCs are: How steady the delivery of plasma is to the inner magnetosphere and whether convection gets close to Earth. Regarding the first question, it is now established that "steady magnetospheric convection" in SMCs is almost never steady. It must be recalled that the original nomenclature was established based mainly on ionospheric observations of convection bays, which are steady, long lived depressions in the westward electrojet. Correlations between magnetospheric measurements of bulk velocity and AL index done by J. Borovsky suggest that turbulence is highest for SMCs and that burtsy bulk flows (BBFs) are more common during SMCs than in other conditions, thus suggesting the possibility that increased BBF activity stirs the plasma sheet to increase the level of turbulence. Relating the second question, M. Thomsen suggested a method to measure the strength and variability of the (ExB + gradB + Curvature) drift of particles at geosynchronous altitude by using LANL plasma measurements of the Alfven layers and the MLT location of the crossing of the plasma sheet. A method that complements energetic neutral atom images of the plasmasphere with LANL measurements of energetic particles was proposed by J. Goldstein as a tool to extend the coverage of the plasmasphere beyond the ENA threshold. This method can also be used to test new models of inner magnetosphere electric field. M. Liemohn and X. Cai have initiated simulations of the ring current during SMCs, using the University of Michigan RAM simulation code. The two events modeled thus far show very low nightside geosynchronous density independent of the choice of electric field model, in contrast with storms. However, the simulation underestimates the strength of ground-based magnetic perturbations. This could be due to the choice of electric field model. The next steps are to introduce a new self-consistent E-field model, to run the RAM simulation for several more SMCs, and to compare the simulation results with observations.

The response of the middle plasma sheet (X < -10 Re) to extended southward IMF periods (>8 hrs) was addressed by E. Tanskanen. Three different modes of response were identified: A loading mode, when the increase of total plasma sheet pressure was greater than 100%, an unloading mode, when the decrease in total pressure was less than 50%, and a steady magnetospheric convection otherwise. An analysis of 15 cases of Geotail measurements shows that the typical duration of the loading mode is 1h 36 min, while the unloading mode's duration is 45 min, and SMCs have a characteristic duration of 1h 39 min. Furthermore, convection in SMCs is such that Vx is not steady at all but rather suggests an increase in the rate of occurrence of short duration BBFs (labeled "micro BBFs"). It was suggested that this study should be followed by a correlation of mode occurrence with solar wind velocity and pressure.

J. Birn presented theoretical calculations of bubble propagation in the magnetotail. Bubbles are localized regions of reduced pressure and entropy embedded in the plasma sheet. The transverse dimensions of the bubbles were varied between 1000 km and 60 Re. The calculations show that as bubbles propagate earthward, they develop strong magnetic-field-aligned flows, increase in pressure and in the By component. Initial density and speed determine how far the bubble will penetrate: faster, less dense bubbles will penetrate further. It was shown that anisotropy inside the bubble is not an important factor and that significant magnetic-field-aligned currents are generated by vortical motion just outside the bubbles.

The SMC workshop continued with a session addressing constraints on substorm theories. The motivation of this session was the question of what can we learn about substorms by the fact that SMCs are devoid of them. G. Erickson posed some intermediate questions whose answer should help answer the principal question. For instance, Is there a Harang discontinuity during SMCs? If not, How is this related to the absence of substorms? J. Hughes and B. Bristow presented SuperDARN observations which show that a Harang discontinuity does develop during SMCs, although with different properties, namely a smaller local time width and a more patchy structure. Also in contrast with substorms, SMC discontinuities do not show a monotonic progression toward lower latitudes.

During this session's discussion, it was pointed out that SMCs are characterized by significant auroral activity, with a significant fraction of intensifications occurring in the high latitude portion of the oval (in the poleward component of the so-called double oval). This behavior appears to differ from a typical substorm progression of auroral intensification at low altitude that propagates in the poleward direction. It is not clear whether this means that there is a X-line located closer to 50 Re than to 20 Re. It was also pointed out that even though SMCs are assumed to produce no Pi2 pulsations, the poleward boundary intensifications (PBIs) and north-south auroral structures that commonly accompany SMCs do have Pi2 pulsations. Therefore, Pi2s are not an exclusive property of substorms.

The third session addressed the solar wind states that lead to SMCs. The motivation for this session is the mounting evidence that there are rather narrow regions in phase space where the solar wind needs to be for SMCs to occur. G. Erickson started the session by pointing out that Kamide early on had found that storms could develop substorms depending on the level of solar wind turbulence. J. Borovsky showed that SMCs tend to occur for solar wind velocities lower than nominal and for modestly southward IMF Bz ($Bz \geq -10$ nT). P. O'Biren analyzed the distribution of duration of SMCs as a function of solar wind parameters and their first derivative. Using the definition of SMC as a period where $AE(t) > 200$ nT (to guarantee enhanced convection) and $AL(t) - AL(t-1) > -25$ nT (to guarantee no onsets), O'Brien showed that the distribution of duration is not an exponential. Rather, SMCs have a subexponential distribution. Therefore, the longer a "steady convection" condition has been going, the longer it is likely to continue. Superposition analysis showed that high solar wind velocity inhibits SMCs and that lower velocities produce longer SMCs. Furthermore, SMCs prefer a narrow Bz range around a low value (IMF Bz ~ -3 nT), although very steady Bz does not appear to be necessary for SMCs to occur. These results suggest that there may be an elegant solution where solar wind conditions determine the SMC response of the magnetosphere.

E. Zesta combined solar wind measurements with DMSP measurements of cross-polar cap potential drop to show that the polar cap area is reduced immediately after the passage of a solar wind pressure pulse thus raising the question of how nightside reconnection responds to pressure pulses. Zesta defined the efficiency of reconnection by the ratio of the cross-polar cap potential and the potential available to the magnetosphere. For the January 10, 1997 event that ration was 13% before the passage of a pressure pulse and 26% after it. L. Lyons analyzed several pressure pulse events to identify the response of geosynchronous magnetic field and particles to pressure pulses. He showed that when the pulse arrives the nightside magnetic field has a reconfiguration more in agreement with dayside magnetopause compression and dipolarization than with a simple compression. The question was raised of whether this is due to a ring current enhancement or to an enhancement of the field-aligned current system. The strong global response to even small pressure pulses was claimed to have been observed in mid-latitude horizontal component magnetic field increases.

M. Henderson presented observations of LANL SOPA measurements and polar orbiting satellite images to speculate that SMCs are a state between isolated substorms and sawtooth oscillations. The latter are defined as quasi-periodic, recurrent substorms that are not necessarily triggered.

For next year the GEM-SMC Working Group is planning a session focused on magnetotail and near-Earth convection.

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

New Campaign Proposals

Solar Wind Interaction with the Magnetosphere (SWIM)

The GEM Steering Committee asked two groups to study possible new GEM Campaigns. One of these two groups (SWIM) held three working group sessions that examined the status of two outstanding problems and solicited ideas for the possible foci of the new campaign and how it would be organized.

The first working group session, chaired by Pat Reiff, examined properties of the cross polar cap potential drop. Jerry Goldstein opened the session by reporting a delay of about 30 minutes in the erosion of the plasmasphere after a southward turning of the IMF. This same time delay has been found in the initiation of the main phase of geomagnetic storms and possibly indicates the time needed to establish a new convection pattern. Tom Hill reviewed the development of the Hill potential that predicts a saturation in the polar cap potential. George Siscoe presented his understanding of the Hill potential in terms of current limitation imposed by the dynamic pressure dependent Chapman-Ferraro current on the magnetopause. Mark Hairston, Dan Ober and Simon Shepherd reviewed a variety of datasets on the CPCP saturation. Many data now exists for study and a campaign addressing this problem seems quite feasible at this time. One interesting feature of the data is that the response of the polar cap to the interplanetary electric field seems more linear the longer is the averaging interval over which the IEF and polar cap response are intercompared. This dependence suggests that at least part of the apparent saturation may be due to induction effects. Other speakers stressed the importance of the apparent differences in the potential drop in the northern and southern polar caps, and the evolving magnetospheric geometry as reconnection proceeds.

At the second session, chaired by Bob Strangeway, Phil Pritchett reviewed our understanding of reconnection based on fully kinetic simulations. It takes only a weak, ~0.1 Bo perpendicular field to magnetize electrons. This guidefield then will suppress reconnection. Thus what is referred to in the magnetospheric community as antiparallel reconnection has some theoretical basis. Finite plasma beta also helps restrict reconnection to near antiparallel directions. Michael Hesse examined a Harris sheet configuration and also found that reconnection favors antiparallel merging. Bill Mattheus reported on Hall effects on reconnection and turbulence. Nelson Maynard reported on observations of reconnection at high latitudes and reminded us that the timing of solar wind discontinuities was vital. Finally, he reported on the use of the green 557.7 nm line to track the reconnection point. Several global observations point to the need for antiparallel field in reconnection. Paul O'Brien showed how dipole tilt affected reconnection. Jimmy Raeder showed how dipole tilt affected the production of FTEs in his global MHD simulation. Chris Russell showed how the neutral line on the magnetosphere would change with IMF clock angle and dipole tilt. This study suggests that increasing dipole tilt reduces the merging line length (and rate) for all clock angles and that the maximum neutral line length occurs for clock angles away from due south for tilted dipole directions. John Wygant closed the session with a discussion of his model of bouncing ions near the reconnection X point.

The third SWIM session began with a discussion of the state of the global hybrid simulation codes by N. Omidi. A tutorial talk early in the meeting by X. Blanco-Cano had established that the magnetosphere underwent phase transitions as the scale size of the interaction normalized by the ion inertial length increased in two-dimensional hybrid simulations. Omidi who has been leading the effort to develop these codes gave more details on the nature of these transitions and presented three dimensional simulations that verified the results of the two dimensional simulations at small ratios (of order 1) of the global scale normalized by the ion inertial length. Omidi's talk was followed by presentations by Fedder and Wang on the need for magnetosheath studies and the importance of studies of the solar wind control of the magnetosphere by M. Lessard and by X-L. Li.

Then followed a discussion of the structure of the campaign and it was decided that there would be two working groups, one concentrating on the solar wind control of the magnetosphere and one concentrating on the nature of the physical processes that underlie this control. This program was presented for public comment on Thursday evening and for a decision by the GEM Steering committee. Since this program was a departure from the latest direction of GEM and would bring in a new community, it met some opposition from those who would like to keep working on old problems until they were solved.

C. T. Russell
ctrussel@igpp.ucla.edu

Geospace Transport (GT)

The GEM Steering Committee had asked two groups to study possible new GEM Campaigns. Two working group sessions were held concerning the proposed new campaign on Geospace Transport. The first working group session, cosponsored by the GGCM campaign, was chaired by J. Birn. This session examined limitations and modifications of MHD modeling of magnetospheric dynamics. Different terms that modify the ideal MHD approach and are hence of potential significance in improving upon the existing global MHD models were identified and discussed. Of particular relevance are pressure anisotropies, non-MHD electric fields, and modifications of the energy transport, especially by heat flux.

Dick Wolf presented joint work with Mike Heinemann on the role of heat flux associated with adiabatic particle drifts in the inner magnetosphere. Michael Hesse discussed the role of non-MHD electric fields in collisionless magnetic reconnection. Antonius Otto discussed quasi-viscous effects at the magnetopause resulting from finite gyroradius modifications of the ion pressure tensor. Dietmar Krauss-Varban discussed challenges and shortcomings of MHD in modelling the solar wind - magnetosphere interaction. Joachim Birn represented results obtained by Lin Yin on the effects of pressure anisotropy in simulations of current sheet formation and reconnection. Chi-Ping Wang further illustrated the importance of magnetic drift in the plasma transport and the Hall term in the generalized Ohm's law in the region of the inner plasma sheet. Li-Jen Chen presented her approach to the understanding of how small-scale kinetic structures can result in melting of the frozen-in magnetic fluxes.

The second session was chaired by Joe Borovsky. This session was devoted to an assessment of the outstanding problems and organization of the new campaign. With audience participation, the goals of the proposed GT Campaign were formulated, attempting to identify the most relevant physical processes to be addressed by the new campaign, and suggestions for a new challenge were discussed. Two potential new Working Groups were identified, focusing on plasma sheet transport and on mechanisms that modify ideal MHD transport.

J. Birn
jbirn@lanl.gov
J. Borovsky
jborovsky@lanl.gov

Student Tutorials

2003 GEM Student Report

I. Overview

GEM sponsored 56 students (40 last year) from 13 different institutes (16 last year) to attend the 2003 GEM workshop. Student interest break down was:

43% Inner Magnetosphere/Storms (50% last year),
21% Magnetosphere-Ionosphere Coupling (20% last year),
13% Tail/Substorms (10% last year),
17% GGCM (20% last year),
20% Not determined or not directly related to the four GEM campaigns.

Among these students, 38% were undergraduate students or first year graduate students, 28% were graduate students of four years or higher.

II. Student Tutorial Schedule

Student tutorials were held on Sunday, June 22. There are four subsessions corresponding to the four ongoing GEM campaigns, and four separate talks on other interesting topics. One student subsession chair was selected to be in charge of the selection and organization of the tutorials for each of the four subsessions. The detailed student tutorial schedule is listed below:

Open remarks and introduction to GEM (Yongli Wang) 5 min

Introduction to the magnetosphere (Karen Remick) 15 min

Session 1: Magnetosphere-Ionosphere
Session Chair: Karen Remick

1. Intro and MI Coupling: Particles (Karen Remick) 15 min
2. MI Coupling: Electrodynamics (William Peter) 15 min
3. MI Coupling: Modeling (John Styers) 15 min

Session 2: Inner Magnetosphere Storms
Session Chair: Robyn Millan

1. Introduction to the plasmasphere (Dave Berube) 15 min
2. Ring current and IM E-fields (Jerry Goldstein) 15 min
3. Radiation belts (Robyn Millan) 15 min

Overview of what data/models/tools are available on the web (Maria Spasojevic) 15 min

XSpace: Visualization of space plasma processes (M. Cowee, G. Fowler, and Y.L. Wang) 15 min

Session 3: Magnetotail/Substorm
Session Chair: Scott Thompson

1. General magnetotail structure (James Weygand) 15 min
2. Substorm phenomenology and models (Manish Mithaiwala) 15 min
3. Steady Magnetospheric Convection (SMC) (Scott Thompson) 15 min

Session 4: Geospace General Circulation Model
Session Chair: Colby Lemon

1. Introduction to the GGCM (Colby Lemon) 5 min
2. Introduction to global MHD simulation (Michelle Reno) 15 min
3. Rice Convection Model (Colby Lemon) 10 min
4. Radiation belt modeling (Kara Perry) 15 min

Introduction to the candidates for the next GEM student representative 5 min

Based on last year's student tutorial feedback which requested more general introduction to the field, also because of so many young students to GEM this year, we set this year's student tutorials at an introductory level. On a scale of 1 to 5, the tutorials were on average rated a 4.0 for usefulness among students before their fourth year graduate study. Also because of this special arrangement, a usefulness rate of only 2.8 was obtained from fourth year and higher graduate students, which is anticipated. 57% students voted to keep the student tutorial the same level of difficulty, and 28% students wanted to increase the level of difficulty.

III. Student-Sponsored Tutorial

A student-sponsored tutorial was presented by Dr. Robert Lysak from University of Minnesota on Thursday, June 26. The topic of his talk is: "Electrodynamic Coupling of the Magnetosphere and Ionosphere."

IV. New Student Representative

This year we had two strong candidates running for the next student representative. Finally Michelle Reno from University of Michigan was selected and she will be the new student representative for 2003-2004.

V. Volunteers for Meeting Settings

A new contribution from students this year was the student volunteers helping with session settings. One or two student volunteers were assigned to each session for equipment settings and light control. The student volunteers were: Austin Barker, Xia Cai, Yue Fei, Katherine Garcia, Tim Guild, Alexa Halford, Elly Huang, Colby Lemon, Yining Li, Shuxiang Liu, Daniel Main, Aramis Martinez, Paul Ontiveros, Karen Remick, John Sample, Yong Shi, Scott Thompson, Jiannan Tu, Yongli Wang, Deirdre Wendel, Jesse Woodroffe, Jichun Zhang. They did a very satisfactory job in helping GEM.

VI. GEM Student Website

This year we set up a student website for GEM student activities. Many items have been added to help GEM students, especially new students, including: Introduction to GEM student tutorial, Tips at GEM, Student participant list, Student tutorial schedule, GEM student newsletters, Student tutorial guideline, etc. I have received many inputs to improve the website and most of these inputs were reflected on the website within one day. This website has proven to be very helpful to many students.

Yongli Wang, Student Representative
ylwang@igpp.ucla.edu

GEM Steering Committee Minutes

June 27, 2003, Snowmass, Colorado

Present: Anthony Chan, Bob Strangeway, Brian Fraser (Australia), Christopher Russell, Dennis Gallagher, Ennio Sanchez, Eric Donovan (Canada), Frank Toffoletto (Workshop Coordinator), Gang Lu, Hideaki Kawano (Japan), Howard Singer (NOAA), Jimmy Raeder, Joachim Birn, Kile Baker (NSF), Larry Lyons, Mary K. Hudson, Mike Liehmohn (for Aaron Ridley), Peter Chi (for Mark Moldwin), Volodya Papitashvili (NSF), Jeff Hughes, Xochitl Blanco-Cano (Mexico), Yongli Wang (Student Rep.)

Plans for future GEM workshops

Frank Toffoletto outlined the plans for the future GEM work-shops. The Fall 2003 AGU mini-workshop will meet in San Francisco on the Sunday before the fall AGU (Dec 7) followed by an evening steering committee meeting.

The Summer 2004 meeting will be in Snowmass the week of June 20-25. SHINE is considering meeting in Snowmass at around the same time and have a tentative reservation with the Silvertree. Future workshops will have a substantial reduction in the time allocated to traditional agency reports. The NSF agency report will be presented and other agencies will be given the opportunity to provide a viewgraph to that presentation that contains information relevant to the GEM community. Since CEDAR 2004 is to be held on the week of the 27th, the MI-coupling campaign sessions at GEM will be scheduled for the end of the week. Chris Russell, as the GEM representative for SHINE, reported on tentative plans for joint GEM-SHINE meetings in 2004. At least 2 of the new inner magnetosphere campaign events, May 1997 and April 2002, are also of interest to SHINE. Possible topics of joint interest are geoeffective solar magnetic structures of various size scales and killer electrons.

The summer 2005 meeting will be a joint meeting with CEDAR to be held in Santa Fe, NM during the week of June 27– July 1. There was a suggestion that the CEDAR and GEM steering committee should perhaps meet in December to discuss logistics.

No decision for the location and dates for the 2006 meeting has yet been made. The possibility of going back to Snowmass was considered.

NSF Report

Kile Baker pointed out that continued cooperation with CEDAR and SHINE is encouraged by NSF. Volodya Papitashvili requested that future GEM workshops have sessions or a tutorial related to the polar programs. He also mentioned that the office of polar programs will have 1-2 3-year postdoctoral positions available in magnetospheric physics. An announcement should come out during the next cycle of competition for 2004. Kile Baker mentioned that the CEDAR steering committee would like postdoc proposals to be due in January or February.

The ITR program will be replaced by 'cyber-infrastructure' with a reduced emphasis on cutting-edge computer science. The precise definition of this new program is still being developed.

NOAA Report

Howard Singer reported that there is an NRC opportunity in January at NOAA/SEC. Space Weather Week will be April 13-16, 2004.

Campaign Reports

Coordinators Anthony Chan reported for the IM/S campaign. This year the campaign added a new working group (ULF waves). The 2003 IM/S workshop consisted of 3 tutorials and 14 sessions. Planning for the end of the campaign has begun as well as continuing the science goals. There are a couple of areas that they would like to continue work on, namely further defining the relation of the IM/S campaign to the GGCM and firming up plans to formulate a challenge. Those topics will be discussed at the fall workshop. They would also like to work closely on the plasma sheet with the new campaign. IM/S plans to run for 2 more full years.

Jeff Hughes reported for the MIC campaign. They would also like to formulate a challenge. The goal of the campaign is to validate the current state of models and develop an MIC module for the GGCM. Discussion during this meeting led to the identification of some candidate events with a final selection of events to be made during the fall workshop.

Larry Lyons reported for the Tail/Substorm campaign. It was found that the there are several different types of important plasma sheet/auroral zone disturbance, not only substorms. Each type was found to be a distinct type of disturbance and each reflect fundamentally different dynamical processes within the magnetosphere-ionosphere system. This represented a major breakthrough in our understanding. Much was learned about each type of disturbance, though much remains to be understood. The SMC campaign is relatively new and may continue existence as part of another campaign. It may have 2 sessions in 2004 as part of IM/S.

Jimmy Reader reported for the GGCM campaign. There were 2 tutorials this year, one from Ray Roble on his thermosphere modeling work and the other tutorial by Ludger Scherliess on data assimilation. New session topics included: data assimilation and the deficiencies of MHD. There was some discussion as to the role the of GGCM in light of recent developments in the field such as the CCMC, CISM and the Michigan effort (CSEM). It was pointed out that GGCM should redefine itself and establish its relationship to other campaigns and to the modeling centers. A strategy meeting, to better formulate the CCGM campaign, will be held at Dartmouth sometime in the fall by a GGCM task force.

Chris Russell reported for the proposed new campaign, Solar Wind Interactions with the Magnetosphere (SWIM). The focus of this campaign would be move from the inner magnetosphere out to the solar wind interactions magnetosphere interaction region. He pointed out that this new campaign would attract new people to GEM and its utility would be that it would help in the understanding of the physics of the interactions at the outer boundary. The campaign would be divided into 2 workshops, one concentrating on a more global view and the other looking at the details of the interactions.

A proposed alternative campaign was presented by Joachim Birn on Geospace Transport (GT). This campaign would focus on physical processes that effect the plasma sheet such as transport, sources, and sinks. He pointed out that this campaign seeks to put more physics into our understanding so that we can go beyond the traditional MHD approach, identify and verify what is missing, and use the insight gained to develop new modules for the GGCM.

There was lengthy discussion of the various strengths and weaknesses of the 2 proposed campaigns focusing on their timeliness and relevance and on the relation of the proposed campaigns to previous ones. In the end, the general consensus was that neither campaign is well enough defined at this point. It was felt that since GGCM is both unfinished and not well defined some effort should be given to get it under control before the new campaign is identified. It is likely that once a new campaign is eventually accepted it will take another couple of years to fully define it. It was decided that key people recruited from both proposed campaigns be asked to form a joint task force to define a new hybrid campaign. Several names were identified for this task force.

International Liaison Reports

Brian Fraser reported on activities in Australia. He reported on the successful launch of the FedSat satellite on Dec 14 in an 800 km polar obit. The satellite magnetometer has a sample rate of 10 samples/sec with a burst mode of 40 samples/sec. Other experiments include a GPS for TEC measurements. It is expected FedSat will have a 2 year lifetime. He also reported that the AFOSR has provided funding for a TIGER radar in New Zealand to complement the currently operating radar in Tasmania. It is hoped that this new radar will be operational in the next few years. A proposal has been submitted to host the IUGG general assembly in Melbourne in 2007 [Postscript: In June, the Council selected Perugia, Italy, as the site of the 2007 IUGG general assembly].

Xochitl Blanco-Cano reported on activities in Mexico. She indicated that there are not many people in Mexico who could fit under the GEM umbrella and that there is a stronger connection to SHINE.

Hideaki Kawano from Japan reported that Akebono has been in operation for 14 years and that Geotail is still healthy and that the data is available from CDAWweb. ISAS will be merged with NASDA but the role and personnel of ISAS will not change.

Eric Donovan, representing Canada, described the Canadian geospace monitoring program (http://www.phys.ucalgary.ca/NORSTAR/cgsm.html) that consists of several elements including: CANOPUS, CANMOS, the Canadian portion of SUPERDARN, CADI, and the F10.7 monitoring system. He also described the Canadian ground station contribution to the proposed THEMIS program as well as the proposed Ravens satellites.

Student Report

Yongli Wang reported on the activities of the GEM students. This year 55 students attended the meeting. As in previous year, the students held tutorials on the Sunday before the meeting consisting of 4 sessions. This year the students filled out evaluations of the tutorials which will provide valuable feedback to the speakers. They also helped out in running the regular GEM sessions. The new student representative for 2004 is Michelle Reno of the University of Michigan.

GEM Communications

Chris Russell reported on the status of GEM communication. He urged that people be added to the mailing list for the GEM Messenger or for the timely reports from the campaign coordinators after the GEM meeting. As in the past, tutorials for this year will be placed on web.

The meeting adjourned ~8:30 PM.

Minutes as recorded by Frank Toffoletto, GEM meeting coordinator, 9/10/03.

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	Terry Onsager	Terry.Onsager@noaa.gov
Joe Borovsky	jborovsky@lanl.gov	Bill Peterson	pete@willow.colorado.edu
Anthony Chan	anthony-chan@rice.edu	Jimmy Raeder	J.Raeder@unh.edu
Peter Chi	pchi@igpp.ucla.edu	Geoff Reeves	reeves@lanl.gov
Brian Fraser	Brian.fraser@newcastle.edu.au	Aaron Ridley	ridley@umich.edu
Dennis Gallagher	Dennis.Gallagher@msfc.nasa.gov	Chris Russell	ctrussel@igpp.ucla.edu
Ray Greenwald	ray.greenwald@jhuapl.edu	Ennio Sanchez	ennio.sanchez@sri.com
Jeffrey Hughes	Hughes@bu.edu	George Siscoe	siscoe@bu.edu
Mike Liemohn	liemohn@umich.edu	Bob Strangeway	strange@igpp.ucla.edu
Bill Lotko	william.lotko@dartmouth.edu	Frank Toffoletto	toffo@rice.edu
Gang Lu	Ganglu@hao.ucar.edu	Richard Thorne	rmt@atmos.ucla.edu
John Lyon	John.G.Lyon@dartmouth.edu	Yongli Wang	ylwang@igpp.ucla.edu

Current GEM Structure	
GEM Steering Committee Chair: Bob Strangeway	
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
	ULF Waves – Brian Fraser and Mark Moldwin
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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