Global Environment Modeling

December 2016
Volume 26, Issue 2

The GEMstone

Notes from GEM Chair

Michael Wiltberger

It's been over a year since I took over the reigns as chair of the GEM program and I'm pleased to report that because of the active involvement of you in the GEM community the program remains strong and ready to tackle the upcoming challenges.

This last summer we had a very successful joint meeting with the CEDAR community in Santa Fe. Let me start, by thank the members of the joint planning committee that worked tirelessly to ensure that this meeting was not a separate GEM and CEDAR meetings in the same city, but a true joint meeting. The morning tutorial sessions provided excellent insights into the geospace system we approach from different directions. While there where many parallel breakout sessions we did have numerous joint breakout sessions between the two communities. The strength of our meetings remains the sessions operated in workshop mode that allow a discussion not possible at the larger scientific meetings we commonly attend.

This past year saw the release of two major documents important to the space physics research community. First, was the release of the National Space Weather Action Plan (SWAP) by the National Science and Technology Council. This plan highlights and the related bill in the US Senate the attention space weather is receiving at the highest levels of government. For the NSF and GEM community it calls for prioritization of efforts to support basic research related to space weather and the development and testing of coupled models of geospace. Clearly our efforts in GEM directly address this need and we can play an important role meeting the SWAP's goals. The second document released was the Geospace Portfolio Review. The GEM program was reviewed quite favorably within this assessment with a recommendation that NSF should continue to support our community-defined research challenges. It also calls for the creation of an Integrative Geospace Science program that can foster even stronger collaboration between the traditional aeronomy, magnetosphere, and solar programs within the geo-

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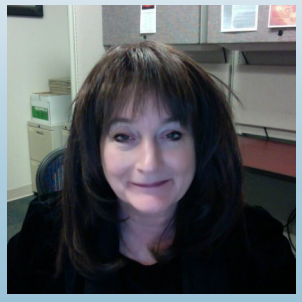
space section. The portfolio review is still undergoing evaluation by a National Academy committee and once that is in place the GEM steering committee will work closely with our NSF officials to ensure a robust future for GEM and our research priorities.

The 2017 GEM Meeting will be held in Portsmouth, VA from June 18-23 and will once again be our traditional standalone meeting. The steering committee will be working closely with FG leaders to ensure that all of our sessions fully embrace the workshop mentality essential to GEM. I look forward to seeing you at the GEM mini meeting before this year's Fall AGU meeting. Once again this year's meeting is being held at Holiday Inn Golden Gateway on Sunday December 11th.

My thanks to all of you that make GEM a great program and I look forward to working with you in my final year as chair. If you ever have questions or concerns about GEM and it's future please feel free to contact me directly. My email address is wiltbemj@ucar.edu and my phone number is 303-497-1532.

We thank Janet Kozyra for her wonderful service during her tenure as the GEM Program Manager.



2017 GEM Summer Workshop
Portsmouth, Virginia
June 18-23, 2017

The GEMstone Newsletter is edited by Peter Chi (gemeditor@igpp.ucla.edu) and Marjorie Sowmendran (margie@igpp.ucla.edu). The distribution of GEMstone is supported by the National Science Foundation under Grant AGS-1405565.

Solar Wind-Magnetosphere Interaction Research Area Report

Coordinators: Katariina Nykyri and Steve Petrinec

Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures Focus Group

Co-Chairs: Hui Zhang, Q.-G. Zong, Michael Ruohoniemi, and David Murr

The "Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures" focus group held three sessions with 25 presentations covering the following research areas: 1. Kinetic and transient processes in the foreshock, bow shock, and magnetosheath 2. Dayside magnetopause processes and transport 3. Magnetospheric signatures of dayside transients.

1. Kinetic and transient processes in the foreshock, bow shock, and magnetosheath joint session with the "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction" Focus Group

Kinetic effects throughout the dayside magnetosphere are driven to a large extent by an array of local and external transient phenomena. The purpose of this joint session was to determine how results from these focus groups can be combined to understand these effects on the dayside system from a global perspective.

Terry Liu showed THEMIS observations of a new ion and electron foreshock upstream of a foreshock bubble's shock. Foreshock bubble's shock could be an additional accelerator and a particle source for the parent shock acceleration. Sanni Hoilijoki and Heli Hietala presented, on behalf of Yann Pfau-Kempf, recent results obtained with the hybrid-Vlasov model Vlasiator. Magnetosheath perturbations are found to deform the bow shock so that transient foreshock-like field-aligned ion beams form, a scenario supported by Geotail observations. Heli Hietala presented ARTEMIS observations of ULF wave growth in the foreshock at lunar distances. The growth rate obtained from the two spacecraft measurements, as well as the other properties of the waves, match well the results of a dispersion solver that uses the observed ion beam distribution as an input. Andrey Samsonov presented a method for incorporating kinetic foreshock effects into a global MHD model. They simulated four events with very distant subsolar magnetopause crossings that occurred during nearly radial IMF intervals lasting from one to several hours. They changed the solar wind boundary conditions for a global model assuming that the density and velocity in the foreshock cavity decrease to ~60% and ~94% of the respective ambient solar wind values during intervals with small IMF cone angles. Christina Chu presented a hot flow anomaly (HFA) analog simulated in BATS-R-US and observations of how it affected the magnetosphere. This work will be used to analyze ground signatures observed with HFAs. Hui Zhang presented a statistical study to determine what kinds of discontinuities are more efficient to generate HFAs. Their results show that magnetic field on at least one side of the interplanetary discontinuities has to be connected to the bow shock in order to form HFAs. Discontinuities with large magnetic shear angles are more efficient to form HFAs. Current sheets with thickness from 1000 km to about 3162 km are more efficient to form HFAs. HFAs are more likely to form when the reflected flow from the bow shock is along the discontinuity.

2. Dayside magnetopause processes and transport

The "Transient phenomena at the Magnetopause and Bow Shock and their Ground Signatures" focus group jointed with the "Magnetic Reconnection in the Magnetosphere" and "Dayside Kinetic Processes in Global Solar Wind-

Magnetosphere Interactions" FGs in the afternoon of Tuesday (06/21/2016). This joint session had talks on observation and modeling with an emphasis on global magnetospheric aspects of reconnection. Sun-Hee Lee showed that (1) the inverse dispersions of energetic ions were observed by MMS/EIS in the magnetosheath just outside the magnetopause and the observed ion structure can be explained as the effect of a transient solar wind dynamic pressure pulse, and (2) using combined ground radar and MMS/EIS observations, they estimated a longitudinal extent of 1.5 R_E for the reconnection line. Naritoshi Kitamura reported that the extension of the Geotail mission until March 2019 was approved for the coordinated observations with the MMS spacecraft. A conjunction event between Geotail and MMS on 18 November 2015 showed that the magnetopause reconnection line shifts toward the winter hemisphere for southward IMF. Richard Denton used magnetic and particle data from MMS to find the motion of the MMS spacecraft through the reconnection structure described in the Burch et al. Science paper.

Chih-Ping Wang showed that during a prolonged (~5 hr) northward IMF interval with very steady SW/IMF conditions, ARTEMIS at X = 60 R_E near the dusk magnetopause boundary layer observed quasi-periodic (7-10 min) perturbations in the plasma and magnetic field propagating tailward with a spatial scale of ~8 R_E in the X direction. Simulation of this event with LFM model shows that K-H waves are formed in the near-Earth flanks and propagate to the mid-tail, which qualitatively explain the observed perturbations. Cong Zhao used magnetometer and fast plasma instrument measurement from four MMS spacecraft to calculate the gradient of magnetic and plasma pressure as well as the curvature force. The force analysis shows that the magnetopause is in force balance and reveals multiple sub-layers exist in the magnetopause. Maimaitirebike Maimaiti showed a case study when RISR-N was located in the noon sector and directly measured reverse convection in the dayside throat region while the IMF was transitioning from strong positive By to strong positive Bz. Time-lagged correlation analysis reveals that the IMF By influence acted on a lag time which was 10 minutes faster than that of the Bz component, and this was attributed to the occurrence of magnetic merging at two different magnetopause sites as determined by favored merging geometries for the two components of the IMF.

On the theoretical side, Sanni Hoilijoki showed that reconnection rates at the dayside magnetopause in a global hybrid-Vlasov simulation correlate well with the analytical model by Cassak and Shay [2007]. In addition, their results indicate that magnetosheath waves affect the reconnection rate. Xuanye Ma showed that magnetic reconnection with a super-critical perpendicular sheared flow forms an expanding outflow region to maintain the total pressure balance, and violates the Walen relation. Plausible observational signatures in the outflow region include decreased density and pressure and increased magnetic field strength. Sasha Ukhorskiy showed that, for the first time, the high-resolution LFM global MHD model was coupled with a symplectic test-particle code and used to investigate the role of the Kelvin-Helmholtz (KH) instability in the magnetopause losses of energetic hydrogen and oxygen ions. They showed that the KH substantially increases the loss rates for both ion species at the dusk as well as the dawn magnetopause flanks and that after the magnetopause crossing and prior to the escape into the interplanetary space, energetic oxygen remains in the magnetosheath much longer than hydrogen, which is consistent with recent MMS observations. Andrey Samsonov calculated magnetopause positions for stationary cases with northward and southward IMF orientations using a set of empirical and global MHD models. The differences in positions of selected reference points between northward and southward cases characterize the strength of MI currents, but their exact meaning is still not understood. Kris Maynard used OpenGGCM to show evidence that reconnection happens at two simultaneous X-lines during FTE formation. They quantified the reconnection rate using the quasi-potential.

3. Magnetospheric signatures of dayside transients

This session was joint with the "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interactions" and "ULF wave Modeling, Effects, and Applications" FGs. There were 8 presentations, and throughout the session discussion topics included (1) preferred driving condi-

tions/magnetopause perturbations for triggering different magnetospheric signatures and (2) modeling the ULF response to localized magnetopause indentations.

Slava Merkin presented results from the effort coupling the high-resolution version of the LFM global magnetosphere with Sasha Ukhorskiy's test particle simulation. The work was done primarily by Kareem Sorathia at JHU/APL and showed that losses of magnetospheric energetic particles (100 keV protons and O+ ions) at the magnetospheric flanks were enhanced by the well-developed Kelvin -Hemholtz instability. De-sheng Han discussed throat aurora, using statistical analysis to show that auroral features relate to scales of ~3 R_E in the equatorial plane and are the ionospheric signatures of the interaction of cold magnetospheric ions with dayside magnetopause reconnection. This implies that throat aurora may provide important information on studying the interaction of cold magnetospheric plasma with magnetopause reconnection. Boyi Wang discussed the driving mechanisms of poleward moving auroral forms (PMAFs) with coordinated all sky imager and satellite observations, showing a strong statistical relationship with southward turnings of the IMF (72%), with a response time of ~8 minutes. Boyi Wang also discussed the dayside auroral response on closed field lines to an IMF discontinuity, using multiple satellites in the dayside magnetosphere, magnetosheath, and solar wind. They associated the IMF discontinuity with a localized, propagating magnetopause compression, brightening/azimuthal propagation of dayside diffuse aurora, and localized magnetospheric ULF waves with large amplitudes. Michael Hartinger discussed how the high-latitude ground magnetic response to an interplanetary shock depends strongly on the local ionospheric conductivity; inter-hemispheric comparisons from recently deployed Antarctic AAL-PIP magnetometers, Greenland magnetometers, and global MHD simulations show the response varies rapidly with location relative to the auroral oval. Hui Zhang presented HFA generated Pc3 ULF waves observed by multiple spacecraft and ground magnetometers. The ULF waves are standing Alfvén waves. The wave power of poloidal mode is stronger than that of toroidal mode. The Pc3 ULF waves were observed at dawn, noon and dusk sectors, indicating the magnetospheric response to the HFA is global. The goal of the work presented by Heli Hietala is to determine impact rates of magnetosheath high speed jets and their properties at the magnetopause, which can then be used as input to global magentospheric models. The high speed jets are related to kinetic foreshock processes, and drive significant local increases in dynamic pressure and ULF fluctuations at the magnetopause. The jets occur preferentially in radial IMF conditions, happening at rates as large as 9/hour with typical perpendicular scales of 1.34 R_E. Alexa Halford spoke about BARREL observations of a solar energetic electron event. There were ULF oscillations observed with precipitation and it is yet unclear if this is due to the movement of the open closed boundary or processes within the magnetosheath as these same oscillations were not observed in the solar wind.

Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction Focus Group

Co-Chairs: Heli Hietala, Xochitl Blanco-Cano, Gabor Toth, and Andrew Dimmock

The Dayside Kinetics FG held four joint sessions during the Summer 2016 GEM-CEDAR Workshop. The Tuesday (06/21) session on "Dayside magnetopause processes and transport" held together with Magnetic Reconnection FG and Transients FGs is summarized in the Magnetic Reconnection FGs report, and the Wednesday (06/22) session on "Magnetospheric signatures of dayside transients" held with UMEA FG and the Transients FG is summarized in the UMEA FGs report.

Thursday 06/23:

Kick-off session of the first dayside modeling challenge

joint with Modeling Methods and Validation FG

Heli Hietala introduced the new Dayside Kinetics focus group, co-chairs, and overview of the

challenge. We wish to start this new focus group on "Dayside Kinetics" with a modeling challenge where, after agreeing on a short interval of steady solar wind input conditions from the first MMS dayside season, we will conduct comparisons of the various dayside phenomena. The aims of the challenge are to (i) Collect coordinated in situ and remote observations to assess the dynamics of the magnetospheric system and for model validation; (ii) Quantify agreement/disagreement between datasets and models; (iii) Determine reasons for data/model, model/model, and data/data differences; (iv) Advance our understanding of multiscale plasma processes and their role in SW-magnetosphere interaction.

First, we had three presentations on different approaches to including kinetic effects in global simulations. Sanni Hoilijoki presented the global hybrid-Vlasov simulation model Vlasiator that describes ions as six dimensional velocity distribution functions and electrons as charge-neutralizing fluid. Global 5 dimensional (2D-3V) show that Vlasiator can generate important features of solar wind-magnetosphere interaction, for example, oblique 30s foreshock waves, magnetosheath mirror mode waves and multiple X-line and FTE formation at the dayside magnetopause. Yuxi Chen presented MHD-EPIC - an MHD simulation with an embedded particle-in-cell (PIC) model - and its 2D and 3D applications for Earth's dayside reconnection. Crescent phase space distribution was found near the reconnection site, and they also demonstrated that the global structure of dayside reconnection does not change much with ion mass. Amitava Bhattacharjee presented integration of kinetic effects in multi-fluid global simulations, discussing different closure schemes and the 5-moment and 10-moment models.

Second, we had three presentations on available observations. Naritoshi Kitamura gave an overview of two good conjunction events between Geotail and MMS on 2 October 2015 (decay of mesoscale FTE during quasi-continuous spatially extended reconnection at the magnetopause [*Hasegawa et al., GRL*, 2016]) and 18 November 2015 (the magnetopause reconnection line shifts toward the winter hemisphere for southward IMF [*Kitamura et al., GRL*, 2016]). Heli Hietala presented a list of THEMIS-Cluster-Geotail dayside conjunctions that offer a possibility to observe foreshock/bow shock, magnetosheath, and magnetopause simultaneously. She also noted that ground-based observatories can offer support in resolving/validating the global picture. Andrew Dimmock gave a summary of a data analysis tool [*Dimmock et al.,* 2013], which compiles large datasets of in-situ measurements used for either statistical mapping or analysis. He discussed how these large databases could be generated for upstream criteria comparable to model input conditions facilitating new model-data comparison studies.

Third, we had a vibrant discussion among the 30-40 session participants (approx. 50/50 observers and modelers) on the science priorities, specs and metrics of the challenge. Another important subject of discussion was determining the most optimal and feasible approach to comparing experimental and simulated datasets. We discussed the possible merits of three, 30-45 minute runs with different geometries: a southward IMF polar plane run, a northward IMF polar plane run, and an equatorial plane run. We discussed the pros and cons of metrics including FTEs, magnetosheath waves and turbulence (power spectra, thin current sheets, heating), foreshock and bow shock generated transient structures, magnetospheric effects (excited magnetospheric waves and energetic particles) and the properties of the magnetopause reconnection diffusion region.

Friday 06/24:

Kinetic and transient processes in the foreshock, bow shock, and magnetosheath

joint session with Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures FG

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source for the parent shock acceleration. Sanni Hoilijoki and Heli Hietala presented, on behalf of Yann Pfau-Kempf, recent results obtained with the hybrid-Vlasov model Vlasiator. Magnetosheath perturbations are found to deform the bow shock so that transient foreshock-like field-aligned ion beams form, a scenario supported by Geotail observations. Heli Hietala presented ARTEMIS observations of ULF wave growth in the foreshock at lunar distances. The growth rate obtained from the two spacecraft measurements, as well as the other properties of the waves, match well the results of a dispersion solver that uses the observed ion beam distribution as an input. Andrey Samsonov presented a method for incorporating kinetic foreshock effects into a global MHD model. They simulated four events with very distant subsolar magnetopause crossings that occurred during nearly radial IMF intervals lasting from one to several hours. They changed the solar wind boundary conditions for a global model assuming that the density and velocity in the foreshock cavity decrease to ~60% and ~94% of the respective ambient solar wind values during intervals with small IMF cone angles. Christina Chu presented a hot flow anomaly (HFA) analog simulated in BATS-R-US and observations of how it affected the magnetosphere. This work will be used to analyze ground signatures observed with HFAs. Hui Zhang presented a statistical study to determine what kinds of discontinuities are more efficient to generate HFAs. Their results show that magnetic field on at least one side of the interplanetary discontinuities has to be connected to the bow shock in order to form HFAs. Discontinuities with large magnetic shear angles are more efficient to form HFAs. Current sheets with thickness from 1000 km to about 3162 km are more efficient to form HFAs. HFAs are more likely to form when the reflected flow from the bow shock is along the discontinuity.

GEM Student Poster Prize Winners in 2016

(From left to right) John Haiducek (U MI) for global systems modeling, Katie Raymer (U Leicester, UK) for solar wind magnetosphere interaction , Nadine Kalmoni (U College London, UK) for magnetosphere ionosphere coupling, Mykhaylo Shumko (U MT) for inner magnetosphere.
Not pictured are winners Mojtaba Akhavantafti (U MI) for magnetotail and plasma sheet, Terry Liu (UCLA) for solar wind magnetosphere interaction tied with Katie Raymer, and Thomas Kim (SwRI/UTSA) for general.

Magnetotail and Plasma Sheet Research Area Report

Coordinators: Andrei Runov and Matina Gkioulidou

Tail-Inner Magnetosphere Interactions Focus Group

Co-Chairs: Frank Toffoletto, Vassilis Angelopoulos, Pontus Brandt, and John Lyon

The GEM Tail Inner magnetosphere interactions (TIMI) had its final session at the 2016 GEM workshop in Santa Fe NM. Katie Garcia-Sage, presented some recent work she has done examining the stability under tearing and interchange of LFM simulations using a criteria based on the work of *Lembege and Pellat* [1982]. They found in some cases the code could be unstable to tearing near the Earth and possible also to interchange. W. D. Cramer presented work using the OpenGGCM-RCM code to investigate to simulate multiple geomagnetic storms with a variety of solar wind driving conditions and correlate the various mechanisms with changes in ring current-generated geomagnetic disturbance. Under this analysis they found that changes in ring current geomagnetic disturbance correlate better with steady convection than occurrence of fast flows. Christine Gabrielse analytically modeled localized dipolarizing flux bundles/bursty (DFB) bulk flows to demonstrate their ability to create both dispersionless and dispersed injection signatures at multiple spacecraft simultaneously. She demonstrated that the localized nature of the DFB results in localized, sharp magnetic field gradients that give energetic electrons a boost earthward on the DFB's dawnside (from gradB drift), but cause electrons to gradB drift tailward on the duskside (which can result in flux decrease at the front's duskside). The B gradients allowed electrons to travel earthward all the way from the reconnection site, but she also noted that much of the injection's electron population may originate in the plasma sheet before encountering the DFB. Finally, Jiang Lu report that dipolarizing flux bundles can send traveling Pi2 waves deep inside the plasmasphere, but these waves did not cause significant change to the energy spectrum there.

Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms Focus Group

Co-chairs: Kyle Murphy, Toshi Nishimura, Emma Spanswick, and Jian Yang

The Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms Focus group (FG) intends to elucidate connections between auroral structures and their magnetospheric counterparts, and to bring closure to the question of substorm triggering. This report covers the three stand-alone sessions we had, and the report from the Magnetic Reconnection FG will cover a joint session we had together. Sessions 1 and 2 were devoted to event discussions and general contributed talks, and Session 3 focused on auroral streamers.

1. Event discussion

Prior to the workshop, the FG co-chairs selected three isolated substorm events based on availability of colored all-sky imager data and satellite conjunctions and invited three substorm experts (Larry Lyons, Larry Kepko and Tony Lui) to analyze those events from their viewpoints. In this session, they presented their interpretations of the events and opened lively discussions with the well-attended audience. We for the first time saw an agreement of substorm precursor sequence among three substorm experts in one of the three events. This is a substantial progress in the long-lasting arguments of substorm pre-onset sequence in the substorm community. However, while they all recognized existence of poleward auroral activity prior

to onset in the other two events, their interpretations were considerably different. The differences arose from limited viewing conditions by imagers and current limited understandings of the role of poleward auroral activity prior to substorm onset. These issues will be addressed at future workshops by selecting different events and by soliciting a broader range of contributions including from modelers.

Event #1: Larry Lyons presented auroral images, suggesting PBI formation and equatorward propagation of a streamer minutes before onset. He also suggested a streamer made close contact to a growth phase arc. However, comments were raised about whether the near-Earth plasma sheet between ~8 to 18 Re could be mapped less than 1 degree in latitude. Larry Kepko's analysis showed that the poleward expansion of onset arc did not seem to disturb an existing arc poleward of the expanding one. He suggested that viewing angle might mislead our perception of aurora motion. Tony Lui mentioned that a streamer was present before onset but there was a considerable separation from the thin onset arc.

Event #2: Larry Lyons pointed out two streamers propagated equatorward and one of them made close contact with the growth phase arc before onset. He showed radar data, which suggested equatorward flows associated with streamers. He also showed THEMIS plasma sheet observations, suggesting weakly enhanced earthward flows. Larry Kepko and Tony Lui agreed with the interpretation of the optical sequence by Larry Lyons. Andrei Runov pointed out that the electric field data were not reliable for this event, due to shadow effects.

Event #3: Larry Kepko pointed out the onset expansion exhibited something like omega band. He suggested that maybe there were streamers beyond the view of an ASI. Larry Lyons showed SuperDARN data, suggesting the existence of a Harang Reversal. Tony Lui thought this was possibly a streamer-triggering-substorm case.

2. Contributed talks

Liz MacDonald showed a beautiful auroral image taken by a professional photographer. The aurora exhibited spatially quasi-periodic beads, each accompanied with vertical rays. It happened during a storm main phase. Eric Donovan and Jun Liang showed results comparing time series of >30 keV electron flux and ground riometer data. One application is to improve the magnetic field mapping accuracy. Shin Ohtani modeled the PBI orientation and width in the ionosphere. Dick Wolf presented criteria of Kelvin-Helmholtz instability and interchange stability in the near-Earth plasma sheet high pressure region that corresponds to a growth-phase arc. Misha Sitnov used system science approach to investigate the substorm triggers and drivers. Larry Kepko presented auroral images, suggesting beading as a consequence of a flow braking.

3. Streamer session

The purpose of this session was to address the broad science questions "How commonly do substorm precurosrs occur?" and "What are the similarities and differences of PBIs/streamers/ plasma sheet flows during isolated substorms, active-time substorms and non-substorm times?" outlined in the Focus Group Proposal. To this end the session discussed the role of streamers in substorms onset and ionospheric dynamics, the relation between substorm onset and fast flows, and the penetration of flows into the inner magnetosphere. Katie Garcia-Sage, Bashi Ferdousi, Bob Lysak and Jian Yang presented simulation of substorms and plasmasheet flows discussing (a) the differences between convective and substorm initiated flows (b) mapping of plasma sheet flows to the ionosphere and the resulting auroral/streamer signatures (c) substorms onset and (d) the relation between growth phase bubbles and streamers. Xianging Chu and Bob McPherron presented a statistical analysis of fast flows and substorm onset using Point Processes to determine whether the two phenomena where statistically linked. Nadine Kalmoni presented statistics of the azimuthal structuring of the onset arc demonstrating that all are structured and that auroral beads observed at onset are a special case when the structuring is very clear. Jiang Lui presented a statistical analysis of field aligned currents from THEMIS. Toshi Nishimura discussed the similarities and differences between streamers during different geomagnetic activity and Drew Turner presented observations

from the Van Allen Probes and MMS discussing how injections can make it deep into the inner magnetosphere.

Tail Environment and Dynamics at Lunar Distances Focus Group

Co-Chairs: Chih-Ping Wang, Andrei Runov, David Sibeck, Viacheslav Merkin, and Yu Lin

The Tail Environment and Dynamics at Lunar Distances FG held two session at the 2016 GEM summer workshop. The first session is a joint session with Modeling Methods and Validation FG on mid-tail modeling challenge. The second session include presentations of recent progress on various topics of the mid-tail.

Session 1:

Modeling challenge for an event observed ARTEMIS in the mid-tail under prolonged N IMF from 13-14 Feb 2014. We focused on a few intervals during which IMF By changed direction, steady solar wind/IMF remained steady, or solar wind/IMF fluctuated slightly. Simulations using 3D hybrid code and MHD code were conducted. The MHD simulations, including GUMICS, BATS-R-US, LFM, and OpenGGCM, were conducted on NASA CCMC with lower grid resolutions and by different modelers with higher grid resolutions.

http://people.atmos.ucla.edu/cat/download/2016GEM/mid-tail%20modeling%20challenge/

Xueyi Wang presented results from Auburn University 3-D hybrid simulations. He showed the magnetotail dynamics for different steady IMF conditions. For this challenge event, the large-scale tail configuration from the hybrid simulation is found to be similar to those of the CCMC global MHD simulations.

Chih-Ping Wang compared the differences between the predictions from different CCMC global MHD simulations conducted. All the models predicted the large-scale mid-tail current sheet motion in respond to IMF By direction change, consistent with ARTEMIS observations. For steady solar wind/IMF, LFM and OpenGGCM predicted mesoscale perturbations while GUMICS and BATS-R-US did not. The perturbations in CCMC LFM are near the flanks and likely caused by Kelvin-Helmholtz vortices, while the perturbations in CCMC OpenGGCM are associated with flapping of the tail current sheet.

Ilja Honkonen compared the performance of different global MHD models in different regions from the near-Earth magnetosphere to the magnetotail. For this event, he presented the results from GUMICS simulations. GUMICS predicted well large-scale response to IMF By direction changes and the agreement is better for higher resolution run.

Joseph Jensen presented results from OpenGGCM with high grid resolution and compared the results with the lower grid run from CCMC OpenGGCM. The high-resolution run produced mesoscale perturbations on the flanks under steady solar wind/IMF that were not seen in the lower-resolution CCMC OpenGGCM run. The mesoscale perturbations are likely caused by waves propagating tailward along the flanks.

Slava Merkin presented results from a LFM run with grid resolution twice higher than that of the CCMC LFM run. The high-resolution run produced both K-H perturbations along the flanks and mesoscale current sheet flapping across the mid-tail. The flapping was not seen in the CCMC LFM run.

The main conclusion for this session is that higher grid resolutions are necessary to simulate mesoscale dynamics in the mid-tail. In order to catch the generation and propagation of the mesoscale perturbation to and within the mid-tail, higher grid resolutions need to be specified throughout the simulation domain, not just the mid-tail region.

Session 2:

http://people.atmos.ucla.edu/cat/download/2016GEM/June%2023%20session/

Gabor Facsko presented statistical analysis of plasma parameters and the magnetic field that were from Grand Unified Magnetosphere Ionosphere Coupling simulation (GUMICS-4) magnetohydrodynamic code near the orbit of Moon made for a time period which covers a full year. The velocity and the magnetic field downstream of the bow shock near the lunar orbit are very much like those in the solar wind. Density and temperature of the plasma are, however, strongly modified by the Earth.

Anton Artemyev presented simultaneous observations of the magnetotail current sheet from THEMIS D ($r \sim 10\ R_E$), Geotail ($r \sim 30\ R_E$), and ARTEMIS P1 ($r \sim 55\ R_E$). Distributions of plasma (ion) density and temperature along and across the magnetotail is studied for fourteen events (each event include several current sheet crossings at different downtail distances). He demonstrated that plasma temperature varies across and along the magnetotail more significant than plasma density does. This temperature variation across the tail mainly contributes to the cross tail pressure balance.

Shin Ohtani proposed based on his model calculation and reexamination of previous observations that the poleward boundary intensification (PBI) of auroral emission is an effect of ionospheric polarization caused by a polar-cap flow channel approaching the auroral oval, rather than an ionospheric manifestation of distant reconnection. The distant reconnection may start independently of PBIs or may be triggered by the Alfvén wave reflected at the ionosphere changes the plasma and magnetic configuration in the distant plasma sheet. The sequence of substorm growth-phase processes in the magnetosphere and ionosphere is an important target for the Heliophysics System Observatory.

Katariina Nykyri created 2.5-D macro-scale local simulation based on ARTEMIS event which showed quasi-periodic ~10 minute oscillations of the plasma parameters at the mid-tail dusk side flank. The observations of the virtual probe in the simulation created in the magnetospheric interial frame was compared with the ARTEMIS measurements. The simulations were in good agreement suggesting that the vortex with the size of 8 R_E was created by a 12-20 R_E KH wave.

Miles Bengtson (an Embry-Riddle M.S student supervised by Katariina Nykyri) discussed an event in ARTEMIS data showing high tailward ion and electron flow speeds possibly originating from mid-tail reconnection site. Significant electric fields were observed during the event as well as the reversal of the electron to ion temperature ratio.

Peter Chi presented an investigation of the nature of the narrowband ion cyclotron waves at the Moon in the magnetotail using ARTEMIS observations, a type of waves first detected by the Apollo Lunar Surface Magnetometers. The combination of ARTEMIS field and particle measurements and wave modeling suggests that these waves can be generated by asymmetric velocity distributions due to (1) the absorption of plasma sheet particles by the Moon or (2) pickup ions from the lunar exosphere. ARTEMIS also detected right-handed waves at approximately the proton gyrofrequency, a different wave type associated with the ion/ion resonant instability in the PSBL previously observed by ISEE and Geotail.

Joachim Birn presented results from test particle tracing in the dynamic fields of a 3-D MHD simulation of near tail reconnection and plasmoid ejection, associated with tailward propagating “anti-dipolarization fronts” (ADFs). Tailward moving energetic ions near the plasma sheet boundary typically were accelerated close to the near-Earth x-line and ejected along the magnetic field, while energetic particles near the equatorial plane underwent more complicated trajectories with possible acceleration at multiple sites within the tailward moving plasmoid and ADF.

Inner Magnetosphere Research Area Report

Coordinators: Scot Elkington and Seth Claudepierre

Inner Magnetosphere Cross-Energy/Population Interactions (IMCEPI) Focus Group

Co-Chairs: Yiqun Yu, Colby Lemon, Mike Liemohn, Jichun Zhang

IMCEPI organized three sessions, one of which joint with the "Storm-time Inner Magnetosphere-Ionosphere Convection" FG. We had 19 presentations in total, including one initiating our Challenge event on the topic of spacecraft charging (in the second session).

1. Challenge Event

We discussed our challenge topic on "spacecraft charging" that is associated with ring current particles dynamics. We worked with LANL/SHIELD project and NASA/CCMC to fulfill such a challenge. March 17, 2013 event was selected as the candidate event, and we encouraged researchers to simulate the event and provide model results (i.e., electron/ion energy-dependent flux in the equatorial plane/ionospheric grids) to CCMC for the post-processing of charging warning to a particular spacecraft.

The concepts, status, and action plan for the challenge are available at:
http://aten.igpp.ucla.edu/gemwiki/index.php/Image:IMCEPI_Challenge_SC_charging_2016GEM.pdf

2. Joint Session with "Storm-time Inner Magnetosphere-Ionosphere Convection" FG

The two FGs shared the same audience and speakers to jointly address the following topics: (a) the impact of large-scale or transient electric fields on inner magnetosphere populations, and (b) the role of particle precipitation of magnetospheric origin on the ionospheric electrodynamics.

Seven speakers presented recent advances from both observational and modeling perspectives on the role of electric fields. For examples, Richard Selesnick reported that large-scale electric field in the inner magnetosphere is capable of replenishing the inner radiation belts. Sam Califf analyzed Van Allen Probes observations of Subauroral polarization streams and confirmed the convectional description of SAPS, as well as suggested the role of SAPS in the plasmasphere erosion. Scott Thaller investigated the asymmetries of dusk/dawn electric field. Joe Huba simulated the SAPS channel during the March 17, 2015 event and focused on the plasamsphere/ionosphere electrodynamics during disturbed time. Carlos Martinis reported conjugative analysis of ground-based/magnetosphere observantions of auroral arcs and ring current particle dynamics.

In addition to these observational efforts, numerical studies also showed significant advances towards achieving a better global geospace model regarding the electric field and coupling with the ionosphere. For example, Raluca Ilie showed a recent implementation of inductive electric field in global MHD model, and Yiqun Yu implemented a more physics-based precipitation module in a global model. These studies had helped us better understand the inner magnetospheric electric field and its role on the ionospheric electrodynamics as well as its feedback effects on the magnetospheric dynamcis.

3. Session on "Wave-particle Interactions"

This session mainly focused on plasma waves in the inner magnetosphere and their impact on plasmasphere/ring current/radiation belts. We had 5 speakers presenting mainly the properties of EMIC waves, and its effect. For example, S. Tetrick (by A. Saikin) statistically studied the location of EMIC waves relative to the plasmapause. D. Wang investigated the occurrence rate of EMIC waves during different phases of storm time. A. Saikin

tested the linear theory for the EMIC wave generation. J. Zhang showed the relationship between EMIC waves and electron precipitation with conjugative observations of Van Allen Probes and BARREL. K. Liu conducted PIC simulations and investigated the dependence of Ion Bernstein instability on the proton-to-electron mass ratio.

4. Session on "Plasma-field Coupling"

This session mainly focuses on the coupling processes in the tail-inner magnetosphere, including tail injections and the subsequent impact on the inner magnetosphere dynamics. On these topics, both observations and modeling studies contributed to our discussion. For example, Jiang Liu presented results from an investigation of dipolarization flux bundles using THEMIS that attempted to understand how they contribute to injections into the inner magnetosphere. An evaluation of the role of Pi2 waves in accelerating particles during DFBs suggested that they are too weak to contribute. Thiago Brito demonstrated their capability to trace particles through electric and magnetic fields from a BATS-R-US/RAM-SCB simulation of a substorm period in the July 18, 2013 storm. Colby Lemon showed preliminary results of an RCM-E simulation in which ion losses driven by field line curvature scattering were calculated, showing general agreement with DMSP precipitating ions over several passes through the SAPS region, but leaving open the question of whether FLC scattering is the dominant driver of ion precipitation in that region. Christian Ferradas traced ions in a dipole magnetic field and Weimer electric field model in order to demonstrate that "nose structures" that are seen in ion spectrograms result from the competition between ExB drifts and gradient-curvature drifts, and contrasted the types of nose structures seen in different phases of magnetic storms. Jichun Zhang presented a follow-up analysis of similar "nose" structures in electron spectrograms, and suggested that although ExB and gradient/curvature drift paths are aligned for electrons, these nose structures also result from details of the electron drift trajectories and the different drift path topologies of electrons detected at different energies.

Quantitative Assessment of Radiation Belt Modeling (QARBM) Focus Group

Co-Chairs: Weichao Tu, Jay Albert, Wen Li, and Steve Morley

In the 2016 GEM Summer Workshop, "Quantitative Assessment of Radiation Belt Modeling" (QARBM) Focus Group held four sessions on Tuesday June 21st, Wednesday June 22nd, and Friday June 24th. All of the sessions were well-attended with helpful discussions. There were 41 scheduled talks in total and a few walk-in talks over the 4 sessions, covering a wide range of topics, as listed below:

Session 1 - "Radiation Belt (RB) particles and modeling"

In the first session thirteen talks were presented on the observational and modeling results for the acceleration, transport, and loss of radiation belt particles. The session starts with five observational study talks covering topics of: the statistical relation between radiation belt electrons and solar wind parameters/geomagnetic indices based on the Van Allen Probes data, long-term comparison of the radiation belt electron variations between the Van Allen Probes era and previous two solar cycles, the secular drift of the SAA using the SAMPEX proton data, the source of inner zone electrons by sudden injections observed by Van Allen Probes, and the near-instantaneous energization of radiation belt electrons by IP shocks during the 17 March 2015 event. The following eight talks reported recent modeling studies on various topics, including: simulations of ULF wave-driven transport, energization, loss of RB electrons during the 17 March 2013 & 2015 storms using the LFM/MHD results combined with a radial diffusion model; modeling the seed population of the radiation belts with the LANL SHIELDS modeling framework; recent development and forecast performance of the data-assimilative VERB code; CCMC modeling results (using SWMF+RCM+RBE) for the RB "dropout" and "buildup" challenge events organized by our FG (with more covered in Session 4); modeling of dropout and drift loss to the magnetopause using CIMI model for the challenge event on 1 June 2013; response of radiation belt simulations

to different radial diffusion coefficients using the 3D VERB code; a review of the recent modeling work on electron dropouts; and a data/modeling integration of the non-linear acceleration of RB electrons by VLF chorus rising tones.

Session 2 - "Waves and local interactions"

This session consists of thirteen talks which were focused on characterizing various wave properties and plasma conditions that are required as inputs to RB models. We started with quantifying the ULF wave radial diffusion coefficients using global ground based magnetometer measurements, followed by reproducing the observed energy-dependent structure of electron radiation belts during storm recovery with an event-specific diffusion model. Then two talks were presented regarding constructing the plasma density evolution on the global scale using neural network. The following five talks discussed interesting characteristics of whistler mode chorus waves including their frequency spectra, polarization properties, coherent scale size, and saturation characteristics. Subsequently, three talks were presented regarding EMIC waves including the statistical distribution using Van Allen Probes data, modeling EMIC wave properties using linear theory and hybrid simulation, and evaluation of electron scattering caused by observed EMIC waves. At last, an interesting talk was presented regarding nonlinear local parallel acceleration and precipitation of electrons by oblique whistler-mode waves.

Session 3 - "ULF waves and nonlocal transport"

This session was joint with the "ULF Wave Modeling, Effects, and Applications" FG. There were 8 presentations, with discussion emphasizing the need for data-model comparisons – e.g., validating diffusion coefficients with event-specific wave measurements. Radial diffusion in non-dipolar fields was discussed, and found to lead to faster outward radial transport than standard results. Observations and test particle simulations of outer belt electron radial transport were presented for ULF waves with varying properties – m number, monochromatic versus broadband frequency spectrum – producing very different types of radial transport/radial PSD profiles. The importance of pitch angle dependence on radial diffusion and the calculation of diffusion coefficients was discussed, comparing results from 3 simulations (with different assumptions for wave activity) plus observations for the 17 Mar 2015 event. Diffusion simulation results were presented indicating that drift shell splitting effects and a fully 3D diffusion matrix can reduce electron PSD enhancements during storms. A simulation was shown of the radial intrusion and slow decay of energetic electrons in the Earth's slot region by incorporating radial diffusion transport and hiss-induced pitch angle scattering processes. RBSP and Arecibo ISR E-field measurements near L=1.4 were shown; electric fields were consistent with plasma sub-corotation and could be included in future diffusion coefficient calculations. The role of ULF waves in high energy particle acceleration in the auroral acceleration region was presented, with future application of the theory to particle acceleration in the Earth's radiation belts. A statistical study of the azimuthal wave number associated with globally coherent ULF waves was discussed, using ground magnetometer measurements.

Session 4 - "RB "dropout" and "buildup" challenges and future plans"

The final session featured seven presentations, and extensive discussion, focusing on the four challenge events chosen for this focus group. The first presentation highlighted the importance of the choice of parameterization for diffusion processes in radiation belt modeling. The following five talks all targeted the challenge events specifically: a study of the formation of the inner electron belt during the storm-time enhancement challenge event (2013 St. Patrick's Day storm); event-specific wave parameters and diffusion coefficients; calculations of the last closed drift-shell; and distributions of law-altitude electrons during the chosen events. The final presentation of the session gave an overview of the community resources for the challenge events - links to the community resources curated by the focus group, including readme files and overview presentations for the challenge events, can be found from the QARBM focus group page on the GEM wiki. The session concluded with discussions of: 1. the inputs, boundary conditions and verification data that the community felt were required for quantitative and comparative modeling of the challenge events, and 2. the approach to coordinating study of the challenge events over the next year.

Magnetosphere-Ionosphere Coupling Research Area Report

Coordinators: Marc Lessard and Shin Othani

The Storm-Time Inner Magnetosphere-Ionosphere Convection (SIMIC)

Co-Chairs: Joseph Baker, Michael Ruohoniemi, Stanislav Sazykin, Peter Chi, and Mark Engebretson

The overarching goal of the "Storm-Time Inner Magnetosphere-Ionosphere Convection" (SIMIC) Focus Group is to bring together experimentalists, theorists, and modelers to synthesize a new understanding of coupled magnetosphere-ionosphere dynamics during geomagnetic storms. At the 2016 GEM-CEDAR Summer Workshop the SIMIC Focus Group had three breakout sessions: one on Monday afternoon joint with the "Inner Magnetosphere Cross-Energy/Population Interactions" (IMCEPI) Focus Group and two sessions on Thursday afternoon joint with the CEDAR "Storms and Substorms Without Borders Grand Challenge". The format for the three sessions and the nature of the ensuing discussions are summarized as follows:

(1) Joint with the GEM IMCEPI Focus Group:

Speakers in this session were asked to emphasize the following two topics: (a) the impact of large-scale or transient electric fields on inner magnetosphere populations, and (b) the role of particle precipitation of magnetospheric origin on ionospheric electrodynamics. Seven speakers gave presentations on a variety of topics, including: inner radiation belt replenishment, the role of SAPS in plasmaphere erosion, dawn/dusk electric field asymmetries, and the connection between auroral arcs and ring current particle dynamics. Several studies emphasized recent advances in numerical modeling, such as inclusion of inductive electric fields and physics-based precipitation modules.

(2) Joint with the CEDAR Substorms and Storms Without Borders Grand Challenge:

This session was focused on elucidating the magnetosphere-ionosphere coupling processes involved in the generation and evolution of the Sub-Auroral Polarization Stream (SAPS). A particular emphasis was placed on evaluating the accuracy with which numerical models can reproduce widely distributed observations of SAPS. To this end, contributions were solicited from data providers and modelers specific to 2 targeted SAPS event periods: March 16-17, 2013, and June 16-17, 2015. Five speakers gave a series of overview presentations highlighting the important observational features during these events, such as the location, strength, and longitudinal extent of the SAPS flows in relation to storm phase, interplanetary conditions, ionospheric and magnetospheric preconditions, and the locations of the ionospheric trough, auroral oval, precipitation boundaries, and the R1/R2 field-aligned currents. Overall, the simulations were found to do a reasonably good job of predicting the occurrence of SAPS but often missed its location and magnitude. Some specific issues identified to explain the deficiencies in model-data comparisons include misplacement of the Hardy precipitation model and unphysical tying of conductance to field-aligned current magnitude.

(3) Joint with the CEDAR Substorms and Storms Without Borders Grand Challenge:

This session was organized around developing a detailed understanding of the driving influences for and evolution of the magnetosphere-ionosphere system during the following four geomagnetic storm events: (1) March 17-18, 2013, April 27 –

May 4, 2011, (3) May 7-14, 2012, and (4) September 1-5, 2012. Particular emphasis was placed on the first event because it has generated the most interest among researchers from both the GEM and CEDAR communities. Three contributed presentations were focused on the first event while session conveners provided overview summaries of audience contributions for the other three. Some of the issues discussed include: evidence for saturation of DMSP flows when compared to conjugate Van Allen Probes data; the possibility of SAPS and SAIDs being driven by different mechanisms; auroral streamers as a source of ion temperature spikes observed by PFISR; how the magnetosphere-ionosphere responds to different interplanetary features (e.g. shock vs sheath vs magnetic cloud); erosion of plasmaspheric material inside the plasmapause; the ionospheric trough as a preconditioning influence for modulating the development of the Tongue of Ionization (TOI); and, the development of wave structures inside the duskside SAPS.

Merged Modeling & Measurement of Injection Ionospheric Plasma into the Magnetosphere and Its Effects (M3-I2) Focus Group

Co-Chairs: Vince Eccles, Barbara Giles, and Shasha Zou

M3-I2 held four sessions during the GEM/CEDAR Joint Workshop. The first focused on the magnetospheric effects of ionospheric injection. The second focused on the ion upflow and outflow physics from the ionospheric boundary through the topside ionosphere to the polar wind. The third and fourth sessions focused on collaboratively integrating these two areas in physics discussions and planning.

Session 1: Monday PM1 - Status, Questions, & Opportunities: Magnetospheric Effects of Ionospheric Injection

It has become apparent to the magnetospheric and inner magnetospheric modeling community that model results are dramatically altered by the presence and placement of ionospheric ions throughout the magnetosphere. Both quiet time and storm time ionospheric upflow and outflow must be correctly established to advance a better understanding of the magnetosphere-ionosphere-thermosphere (M-I-T) coupled system. This must be a GEM-CEDAR joint effort to address:

- the ionosphere boundary layer,
- the ion energization region of the polar wind
- the magnetospheric response to solar wind drivers and the ionospheric outflow
- the feedback into the lower ionosphere-thermosphere

Invited speakers reviewed the status of current understanding and modeling of the effects of ionospheric ion injections on the magnetosphere. The GEM Focus Group Chairs presented goals-overview of plans and moderate a discussion on new in situ observational opportunities for metric studies on plasma sheet, ring current, and substorm dynamics to direct improvements in the current Geospace General Circulation Models (GGCMs).

Charles R. Chappell (invited speaker) of Vanderbilt University reminds the GEM community of the necessary but slow paradigm shift towards viewing the ionosphere as the dominant source of magnetospheric plasma. In the 1960s the solar wind plasma was viewed as the dominant source. The earth's polar wind of ionospheric outflow was identified in the 1970s and there was a substantial increase in observations of O+, H+, and He+ outflow in the 1980s. The main magnetosphere models and theoretical studies did not account for these observations until the late 1990s. In the 2000s the new paradigm begins to take hold with the move towards multiple species MHD models and coupling with polar wind outflow models. A recent Chapman Conference has produced a book on the effects of ionospheric outflow on the whole magnetosphere system (due out soon). Continued studies on the effects on the different magnetosphere regions are needed to complete the community's full shift to

the new perspective of the ionosphere-magnetosphere system. Because the magnetosphere community primarily uses MHD models it is necessary to include Delcourt ion trajectory studies [*Delcourt et al.,* 1993] to follow the history of injected ions. This helps explore the process of populating the different regions and the energization of these ion populations.

Dan Welling (invited speaker) of the University of Michigan stated the primary result from the coupling of ionospheric outflow models and MHD magnetosphere models: Outflow Really Matters! A number of effects observed: (1) dayside reconnection rate influenced by cold plasma presence, (2) polar cap potential is reduced (or limited) with increased presence of O+, (3) the magnetosphere tail is stretched, (4) fast outflows escape through the tail but slow populations 'hang around' to increase their relative importance and influence, (5) source location and composition of the outflow matters to different magnetosphere regions, (6) O+ cusp outflow can influence the initiation of a substorm, which causes nightside auroral ion outflow, which can drive subsequent sawtooth substorms, (7) ring current calculations are improved with better H+/O+ composition in the ring current region. The final conclusion is that the coupled ionosphere-magnetosphere behavior needs to be studied in greater detail because the magnetosphere affects the ionosphere, affects the magnetosphere, affects the ionosphere, affects ... A final suggestion was put forward that magnetosphere models need a minimum of three ion fluids: H+ from the solar wind, H+ from the ionosphere, and O+ from the ionosphere.

Subsequent speakers provided a short synopsis of their current work.

Barbara Giles of Goddard Space Flight Center/NASA presented a survey of the Magnetospheric Multiscale (MMS) Mission, which are available at https://lasp.colorado.edu/mms/sdc/public/ website. One quick observation from the FPI shows that H+, He+, O+ species are seen in the Warm Plasma Cloak.

Naritoshi Kitamura of ISAS/JAXA presented MMS FPI data showing O+ 1000 eV beam and H+ 100 eV beams in the tail lobe in nightside region. Dayside shows no O+ beams but H+ beams are structured between 100 to 1000 eV.

Matina Gkioulidou of APL Johns Hopkins University presented Van Allen Probe ring current observations. O+ outflow at 300 eV is seen during storm periods with multiple bands of energy in the O+ outflow. Additional O+ outflow observed in the post midnight sector begs the question on the source region: is it Joule heating or auroral processes?

Jonathan Krall of NRL presented SAMI3 model results of the plasmapause. The dawn side plasmapause is most evident in the model results. Rick Chappell commented that the drift of plasma from noon to nightside generally produces this steepening on the dawn side. The SAMI3 results may be capturing this effect.

Chris Mouikis of University of New Hampshire presented a Dst epoch study of outflow for isolated moderate storms. The storm epochs were divided into pre-storm, main phase, early recovery and late recovery. Magnetic local time & latitude dial plots of H+ outflow and O+ outflow demonstrated clear trends through the storm epochs. This is an excellent study to be used as a benchmark for ionospheric outflow model results.

Lynn Kistler of University of New Hampshire has gathered multi-satellite, multi-instrument measurements of a particular storm with sawtooth oscillations. LANL was used for sawtooth identification, ACE for solar wind drivers, CLUSTER for plasma sheet O+ presence, FAST for auroral outflow, IMAGE for auroral morphology. She is producing a morphology of the magnetosphere-ionosphere (M-I) interactions during sawtooth substorm events of October 1, 2001. Dr. Kistler presented an early conclusion that the 1st observed sawtooth substorm may be connected to auroral outflow from the previous substorm (10 eV O+ outflow observed in nightside). The next sawtooth substorm seemed to be connected to cusp outflow.

Session 2: Monday PM2 - Status, Questions, & Opportunities: Polar Wind and the Ionospheric Boundary

This session was to review the status of current understanding and modeling of ion outflow to the magnetosphere initiated in the ionospheric boundary. There are many open questions on ion energization for the ionospheric polar wind that the community still must address. However, to address

this question properly, the spatial and temporal variations of the ionospheric boundary (below 600km) must be defined accurately in the polar and sub-auroral regions for appropriate comparison of PW model results to satellite data. This effort should strive to marshal new in situ and ground-based observational abilities with current modeling capabilities to addressing these open issues.

Convener Shasha Zou identifies the flow chart of *Strangeway et al.* [2005] (Figure 1) as a useful starting place for a discussion on the outflow processes from the ionosphere. There are multiple processes for different regions of the polar ionosphere that drive ion outflow such as Joule dissipation (ion scale height), electron heating (scale height), kinetic flow processes (non-Maxwellian flow), and wave-particle heating. Defining the ionospheric boundary will be very important for outflow modeling. GPS TEC can provide important structure definition to the ionosphere plasma content. Incoherent scatter radars can help define F region and topside conditions in sub auroral and polar regions. The main questions for the upflow and outflow of ionospheric plasma are:

- What are the energization processes?
- How influential is the spatial and temporal structuring of the ionosphere?
- What are the differences over the ranging seasonal and solar conditions?

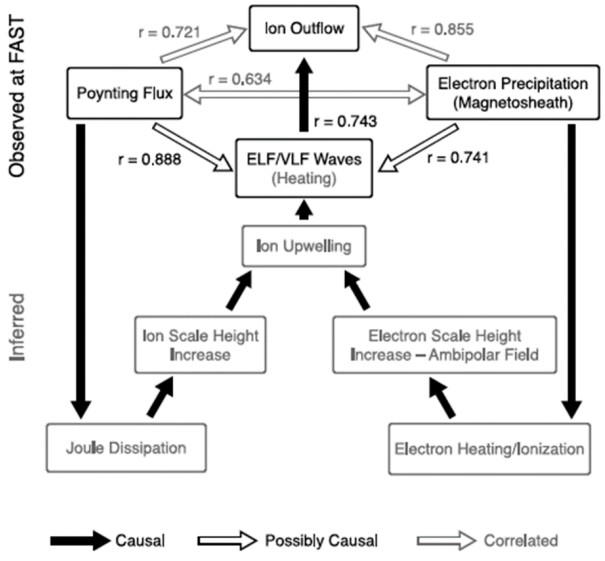

Figure 1. Pathways of ion outflows from Figure 1 of *Strangeway et al.* [2005].

Roger Varney (invited speaker) of SRI identified areas for improvement in ion outflow modeling. First, the vertical neutral winds within an active cusp region can lift the ionosphere dramatically to initiate ion upflow. Soft precipitation and Joule heating in the cusp can help cause a vertical lift of up to 150 m/s. These represent non-hydrostatic flows in the thermosphere. One of the issues in thermospheric modeling is that the models stop at 600 km. There is a need to extend into the kinetic exosphere altitudes. Second, ion energization through wave-particle interactions is poorly defined, but it is very important. The ion temperature anisotropy ($T_{||}$ / $T_{\perp}$ ~ 5) is a source of free energy for instabilities. Candidates for wave-particle interactions are numerous: Landau resonance with broadband extremely low frequency (BBELF) waves, Landau resonance with electromagnetic ion cyclotron (EMIC) waves, and others. The altitude range of the energization by wave-particle processes is the big question [*Bouhram et al.* 2004; *Barghouthi et al.* 1997, 1998; *Retterer et al.* 1987]. Structure of the Cleft Ion Fountain sounding rocket (SCIFER) sees energization at 1200 km and higher. The Svalbard EISCAT rocket study of ion outflows (SERSIO) sees it at 520-780 km in cusp. The AMICIST sounding rocket sees ELF heating at 880km. Storms, solar cycle, season and polar region may influence energization altitudes. Third, in the cusp and auroral region it might be important to handle the parallel E fields in a self-consistent treatment of high latitude electric fields. The parallel fields may be important within collisionless plasmas. Subsequent discussion on Roger Varney's presentation identified the need for kinetic plasma models to address wave-particle interactions fundamentally. Current modeling that assigns an altitude range is insufficient since the size of heating region may be limited in altitude, horizontal region, and in time. Transport models need dynamic parameterization or fundamental model to provide best results.

George Khazanov (invited speaker) from Goddard Space Flight Center/NASA divides the M-I system into the altitude ranges of: collisional (100 to 1000km), semi-collisional (1000 to 2500km), and collisionless (2500 up). Fokker-Planck physics is important for ion outflow (*Khazanov and Liemohn*, 1997-2000) with kinetic modeling for H+ and O+ with at least Maxwellian electron fluid with super

thermal electrons added.

Subsequent speakers provided a short synopsis of their current work.

Shunrong Zhang from Millstone Hill Radar provided an overview of ISR capability for observing plasma upflow at ~400km during disturbed conditions. Madrigal CEDAR website is available to explore these data.

Bruce Fritz of the University of New Hampshire reviews the potential science of the RENU2 rocket flight. It measures neutral upwelling in cusp region, N2+ emissions for plasma flow, indicates that Alfven waves can drive electron precipitation.

Doug Roland reviewed the potential science of VISION rockets.

W.K. (Bill) Peterson of Laboratory for Atmosphere and Space Physic reviewed the ePOP experiment. It carries a radio receiver, GPS instruments, ion mass spectrometer, scintillation monitor, and a magnetometer. The mass spectrometer measures thermal ion energy range from 1 to 10 V and it sees N+ and O+ fluxes and low flux values of NO+ and O2+. Currently only quantitative estimates of outflow distributions can be generated. The data is limited to 5-minute passes a day over US (composition, velocity, energy). Input is requested to define measurement period to optimize science.

Session 3 & 4: Friday PM - Recap, Organize, And Planning

These sessions were provided to reviewed the earlier sessions and plan for future focus area studies.

Robert Strangeway (invited speaker) of UCLA presented the importance of understanding the ion outflow physics in the terrestrial environment as well as other planets. He briefly reviewed the terrestrial observations, which highlight that precipitating electron density is the single best controlling factor for ion outflow but also the hardest to parameterize in models. He then talked about several areas for progress necessary to further advance our understanding of ion outflow physics. For example both dayside and nightside data show there is a lower flux limit and upper flux limit to ion outflow. Multi-species coupled ionosphere-thermosphere-magnetosphere models are a necessary step. However, the anisotropy of the ion distributions in the magnetosphere must be addressed in the MHD transport models.

Naritoshi Kitamura (invited speaker) of Institute of Space and Astronautical Science (ISAS/JAXA) presented a comparison between the USU Generalized Polar Wind model results and the Akabono satellite data. He found that the model prediction of ion density was 30-500 smaller than observations in these middle altitudes (~2000 km) within the polar cap. There is much work to be done in the model-measurement comparisons for the different regions of the aurora, cusp, and polar cap. Dr. Kitamura gave the important caution that the H neutral profile of MSIS is wrong. The important resonant reactive collision between H and O+ and O and H+ will be strongly affected by the incorrect H profile within MSIS.

Open flow discussions on the science and plans of the M3-I2 focus group hit on previously identified points from the earlier sessions.

First, ion outflow particle energy and location of the outflow from the ionosphere are important because they determine where the ion populations go in the magnetosphere. Delcourt Ion tracing studies are important for this effort to examine ion energization history within the magnetosphere and to determine ion distributions in the different regions. These are necessary insights into the examination of MHD model magnetic fields configurations when comparing ion measurements with the models. The kinetic populations derived from the ray tracing can also identify where MHD models can benefit from kinetic physics parameterizations.

Second, magnetospheric models need to incorporate kinetic physics due to the anisotropic particle distributions. Parameterizations of heat flux along magnetic field lines in MHD models can be the next advance in MHD modeling of the magnetosphere. It is also important to understand why MHD so successful in modeling the magnetosphere. Is this a tuning of fudge factors or an accidental strength of MHD in the plasma regimes of the magnetosphere? Third, because ion outflow affects ring currents, substorms, plasma sheet, and reconnection, it will be important to collaborate with the different GEM focus groups in these areas.

Third, the energization processes within the ion upflow/outflow models is currently poorly understood and modeled. The ionospheric bounda-

ry must be defined properly within these models to make proper one-to-one comparisons of models and measurements. Potentially, data assimilation can be used to define the polar, auroral, subauroral regions of the ionospheric boundary. This can be used to benchmark coupled M-I models and to drive the lower boundaries of ion upflow models. There needs to be a fundamental plasma physics modeling study to better understand the wave-particle energization processes thought to be important in the ion outflow.

Finally, the workshop turned towards defining specific storm periods useful for model-measurement comparisons. There should be continuing studies using older data sets from Cluster, Polar, LANL, Akebono, Themis, and Geotail. These observations should be compared with new satellite data sets for similar conditions to insure interpretive continuity. It was also noted that experimentalists use different units than modelers when discussing energy flow, sources, and sinks. The best units for experimentalists are $eV/cm^2/s$ for flow and $eV/cm^3/s$ for deposition or sources.

Several dates were put forward for the different altitude regions for addressing M3-I2 issues:

- **TOPSIDE ALTITUDES (500-2000km):** Ion upflow/outflow models should first compare against solar angle climatologies for benchmark topside ionosphere modeling. Some data periods for topside altitudes are supported by several satellites (DMSP, FAST) and ISRs.
- 2000 Oct 24, 1998 Jan 27, and 2002 Jan 20 (ISR-FAST conjunction).
- **MIDDLE ALTITUDES (2000-5000km):** Polar Satellite is a good source of data for these altitudes. 1997 Jan 10-11 has good comparisons with Geotail, Wind, FAST, Freia. 2000 Apr 6-7 has Akebono, FAST, POLAR support.
- **MAGNETOSPHERE (beyond 2 Re):** 2015 Dec 31, 2016 Jan 20, 2016 Mar 6-8, 2015 Jun 22-23. All have multi-satellite support.

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Global System Modeling Research Area Report

Coordinators: Frank Toffoletto and Alex Glocer

The Magnetic Reconnection in the Magnetosphere Focus Group

Co-Chairs: Paul Cassak, Andrei Runov, Brian Walsh, and Yi-Hsin Liu

In year four for the focus group on Magnetic Reconnection in the Magnetosphere, four sessions were convened at the summer workshop. Two sessions were individual (with approximately 70 and 34 attendees, respectively), one was joint with "Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms" (81 attendees) and one was joint with the "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction" and "Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures" focus groups (73 attendees). The sessions were driven by talks but led to lively discussion. Summaries of each session follow, followed by a brief discussion of future plans.

Session 1 – Individual session - Monday, June 20

This session began with scene-setting talks on dayside reconnection, highlighting recent observations from the Magnetospheric Multiscale (MMS) mission. Allison Jaynes showed that FEEPS high-energy electron measurements on MMS reveal the importance of these energies in reconnection, and are beginning to shed light on the relationship between reconnection processes and acceleration of 30-100's keV electrons. New features observed include: energetic electron acceleration up to 100 keV at the magnetosheath boundary layer, microinjections of energetic electrons in the dusk/midnight sector, and inverse energy dispersion of energetic ions in the magnetosheath. John Dorelli summarized early results from the first dayside MMS season and discussed implications for global magnetosphere modelers. Two general topics were discussed: (1) MMS has seen electron demagnetization consistent with signatures (e.g., "crescent distributions") seen in full PIC simulations of asymmetric magnetic reconnection, and (2) MMS has seen large intermittent parallel electric fields (much larger than those predicted by steady collisionless reconnection theory).

In other talks on dayside reconnection, Meng Zhou discussed high frequency electrostatic waves in the vicinity of ion diffusion region on the Earth's magnetopause detected by MMS. They found that energy dissipation contributed by these high-frequency waves is negligible compared to that contributed by the lower-frequency process. Joo Hwang discussed ongoing magnetic reconnection along the boundaries of large-scale nonlinear Kelvin-Helmholtz waves detected by MMS. The observed field and particle features, in particular electron distribution functions, indicate that MMS traversed the outer region of the electron diffusion region where the bulk kinetic energy is transferred to field and internal energy. Jan Egedal argued that MMS measurements at the dayside magnetopause show that electrons from the high density inflow penetrate some distance into the low density inflow, and are characterized by crescent-shaped distributions. A theoretical model was presented which relates the salient details of these observations to electron dynamics in the inner reconnection region.

Slava Merkin gave a scene setting talk on magnetotail reconnection, presenting analytical results on kinetic and MHD stability of the magnetotail, including tearing and ballooning/

interchange, for new classes of magnetotail equilibria allowing spontaneous onset of magnetic reconnection. He then showed Katie Garcia's results on how the stability parameters can be calculated in global MHD simulations revealing the formation of reconnection-prone tail configurations as a result of solar wind driving. Tony Lui emphasized that magnetic reconnection and current disruption are not mutually exclusive. 3D particle-in-cell (PIC) simulation results published by *Sitnov et al.* [2014] demonstrate that magnetic reconnection can be a consequence of current disruption and vice versa. Misha Sitnov, using 3D PIC simulations of spontaneous formation of dipolarization fronts from 2D tail like current sheet equilibria, showed that ion and electron temperature variations across the front (in the X-direction) are consistent with THEMIS observations (*Runov et al.,* 2011, 2015; *Sergeev et al.,* 2015), while their variations along the front (in the Y-direction) are out of phase, weakly correlated with flapping and strongly correlate with buoyancy-driven structuring of the front. Moderate ion and electron temperature anisotropy and agyrotropy at and right behind the front are strongly enhanced further downstream near the newly formed X-line. Finally, Liang Wang discussed comparative multi-fluid moment/ PIC simulations of asymmetric magnetic reconnection. The 10-moment model evolves pressure tensors for both electrons and ions, and the results agree well with PIC with either local or non-local approximations to the heat flux.

Session 2 – Joint with "Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms" - Monday, June 20

John Foster presented a scene setting talk on ground-based observations with radars and global positioning system (GPS) total electron current (TEC) that reveal the circulation of ionospheric F-region plasma related to dayside reconnection. The temporal and spatial variations of enhanced-TEC SED plumes and polar patches at ionospheric altitudes map to similar features and dynamics at the dayside magnetopause. Bill Lotko presented a scene setting talk about how global simulations show that the ionosphere influences dayside and nightside reconnection in several ways: 1) via outflows of ionospheric O+ which can reduce the Alfven speed in the reconnection inflow region and thus the reconnection rate; 2) via meridional gradients in the ionospheric Hall conductance, which cause a dawn-dusk asymmetry in ionospheric convection and the reconnection rate that supports it; and 3) via the effective resistance of the ionosphere to field-aligned currents flowing from reconnection dynamos (principally nightside), which regulates the location of the magnetotail x-line.

Observational presentations included Vasillis Angelopolous, who discussed the Heliophysics/ Geospace System Observatory, which goes beyond the International Solar-Terrestrial Physics program (which employed isolated single probes to establish global connections on longer time-scales) to build upon an emerging paradigm of global coupling through transient, regional flows and to seek a fuller understanding of how kinetic plasma processes lead to regional activations, and how these are affected by / drive global connections. Several nice system conjunctions explore the cross-scale coupling of dayside-nightside reconnection in 2015-2016; the THEMIS orbit maneuver execution is on track for numerous conjunctions in the next few years. Ying Zou argued that as polar cap arcs reach the nightside auroral poleward boundary, they lead to poleward boundary intensifications (PBIs) and thin-oval intensifications ~85% of the time. These oval intensifications happen <~10 min and at almost the same longitude of the contact, consistent with MHD simulations where reconnection is triggered by lobe inflows. Stefan Kiehas showed a five-year statistical ARTEMIS study around −60 Earth radii downtail, finding that ~30% (V_{perp}) to ~50% (Vx) of all flows are directed earthward (V > 300 km/s). A dawn-dusk asymmetry with preference to the dusk sector is also found, which is more pronounced for tailward flows and increases with flow speed.

On the theoretical side, Misha Sitnov discussed the results of 3D PIC simulations of 2D mag-

netotail equilibria, including spontaneous formation of dipolarization fronts and reconnection onset. He showed that field-aligned currents caused by fronts may be due to Hall effects and with mixed hemispheric parity due to the tail current sheet flapping motions. Haoming Liang showed that the Hall electric field accelerates lobe oxygen but not protons because the Hall electric field is smaller than the oxygen gyroradius. He plotted distribution functions of oxygen near the dipolarization front and showed that the dipolarization front thickness is related to the oxygen concentration in the plasma sheet.

Session 3 – Joint with "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction" and "Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures" - Tuesday, June 21

This joint session had talks on observation and modeling with an emphasis on global magnetospheric aspects of reconnection. Sun-Hee Lee showed that (1) the inverse dispersions of energetic ions were observed by MMS/EIS in the magnetosheath just outside the magnetopause and the observed ion structure can be explained as the effect of a transient solar wind dynamic pressure pulse, and (2) using combined ground radar and MMS/EIS observations, they estimated a longitudinal extent of 1.5 R_E for the reconnection line. Naritoshi Kitamura reported that the extension of the Geotail mission until March 2019 was approved for the coordinated observations with the MMS spacecraft. A conjunction event between Geotail and MMS on 18 November 2015 showed that the magnetopause reconnection line shifts toward the winter hemisphere for southward IMF. Richard Denton used magnetic and particle data from MMS to find the motion of the MMS spacecraft through the reconnection structure described in the *Burch et al.* Science paper.

Chih-Ping Wang showed that during a prolonged (~5 hr) northward IMF interval with very steady SW/IMF conditions, ARTEMIS at X = 60 R_E near the dusk magnetopause boundary layer observed quasi-periodic (7-10 min) perturbations in the plasma and magnetic field propagating tailward with a spatial scale of ~8 R_E in the X direction. Simulation of this event with LFM model shows that K-H waves are formed in the near-Earth flanks and propagate to the mid-tail, which qualitatively explain the observed perturbations. Cong Zhao used magnetometer and fast plasma instrument measurement from four MMS spacecraft to calculate the gradient of magnetic and plasma pressure as well as the curvature force. The force analysis shows that the magnetopause is in force balance and reveals multiple sub-layers exist in the magnetopause. Maimaitirebike Maimaiti showed a case study when RISR-N was located in the noon sector and directly measured reverse convection in the dayside throat region while the IMF was transitioning from strong positive By to strong positive Bz. Time-lagged correlation analysis reveals that the IMF By influence acted on a lag time which was 10 minutes faster than that of the Bz component, and this was attributed to the occurrence of magnetic merging at two different magnetopause sites as determined by favored merging geometries for the two components of the IMF.

On the theoretical side, Sanni Hoilijoki showed that reconnection rates at the dayside magnetopause in a global hybrid-Vlasov simulation correlate well with the analytical model by *Cassak and Shay* [2007]. In addition, their results indicate that magnetosheath waves affect the reconnection rate. Xuanye Ma showed that magnetic reconnection with a super-critical perpendicular sheared flow forms an expanding outflow region to maintain the total pressure balance, and violates the Walen relation. Plausible observational signatures in the outflow region include decreased density and pressure and increased magnetic field strength. Sasha Ukhorskiy showed that, for the first time, the high-resolution LFM global MHD model was coupled with a symplectic test-particle code and used to investigate the role of the Kelvin-Helmholtz (KH) instability in the magnetopause losses of energetic hydrogen and oxygen ions. They showed that the KH substantially increases the loss rates for both

ion species at the dusk as well as the dawn magnetopause flanks and that after the magnetopause crossing and prior to the escape into the interplanetary space, energetic oxygen remains in the magnetosheath much longer than hydrogen, which is consistent with recent MMS observations. Andrey Samsonov calculated magnetopause positions for stationary cases with northward and southward IMF orientations using a set of empirical and global MHD models. The differences in positions of selected reference points between northward and southward cases characterize the strength of MI currents, but their exact meaning is still not understood. Kris Maynard used OpenGGCM to show evidence that reconnection happens at two simultaneous X-lines during FTE formation. They quantified the reconnection rate using the quasi-potential.

Session 4 – Individual session - Friday, June 24

The final session included observational and modeling discussions of both dayside and magnetotail reconnection. Brian Walsh discussed different models for the macroscopic properties of reconnection and presented initial observational work to separate between them. Rishi Mistry presented exhausts formed from symmetric guide field reconnection, as observed by MMS in the magnetosheath. These extremely high resolution measurements are compared to 2D PIC simulations, showing good agreement. Yongliang Zhang presented an improved method to self consistently estimate the deep tail reconnection location using energy-latitude dispersion of polar rain electrons observed by LEO satellites. Heli Hietala showed ARTEMIS two-spacecraft observations of reconnection in the lunar distance magnetotail near the dusk flank during a period when the north lobe had high density mantle/boundary layer plasma and the south lobe had a much lower density. The Hall magnetic field and jet profiles were shifted in accordance to this density asymmetry, which was also clearly visible in the ion distribution functions measured within the jet.

Jean Berchem presented the results of a large-scale iPic3D simulation of the dayside magnetopause, which uses the initial and boundary conditions from a high-resolution global MHD simulation and resolves the electron diffusion region (EDR). The results indicate that crescent-shaped electron distributions can be present relatively far away from the EDR; hence, the observation of crescent-like distributions is a necessary but not sufficient condition to identify the encounter of an EDR. Yi-Hsin Liu discussed comparisons of reconnection with a guide field with a pressure gradient caused by density or temperature. The asymmetric nature of the X-line is essential in understanding the diamagnetic suppression of magnetic reconnection.

For the observational part of a three-pronged observation/simulation/theory study, Andrei Runov presented results of event studies of ion velocity distribution function observations within and around dipolarizing flux bundles (DFBs) in the near-Earth plasma sheet. The results indicate that the ion distributions within DFBs often exhibit a perpendicular anisotropy, which may provide free energy for EMIC wave excitation. Joachim Birn demonstrated characteristic ion velocity distributions at dipolarization fronts (DFs) obtained by test particle orbit integration in the MHD fields of near-tail reconnection and flow bursts. After a brief field-aligned anisotropy right at the DF, the distributions consisted of two, parallel and antiparallel, field-aligned beams combined with a ring-like perpendicular population. Phil Pritchett presented results from 3D PIC simulations of the formation of reconnection exhaust jets with finite cross-tail extent that evolve to form the characteristic dipolarization front structures. In the near-Earth region, the ion velocity distributions at 5-10 d_i in back of the front show evidence for a depletion in the parallel phase space density in the velocity range of 1-2 V_{Ti}.

In discussions of numerical efforts, Kai Germaschewski presented the status of the next generation OpenGGCM, a global magnetosphere model that incorporates extended-MHD and now multi-fluid effects, using 5- and 10-moment models that for each species include a scalar and pressure tensor, respectively. These models have shown promise in reconnection test cases like the Harris sheet

and island coalescence problem, and have now been applied to global simulations of Jupiter's moon Ganymede, where they show consistent results on the global structure of Ganymede's magnetosphere, as well as expected significant departures from a simple resistive- MHD model due to Ganymede's large ion inertial scales. Yi-Hsin Liu discussed efforts to design PIC simulation services at NASA's CCMC, and ideas for joint projects in support of MMS mission. In particular, CCMC plans to launch services that help MMS scientists analyze particle distributions and determine the reconnection plane using local kinetic simulations. Masha Kuznetsova introduced the CCMC implementation of post-processing and visualization tools (based on the RECONX algorithm by Alex Grocer, John Dorelli and Colin Komar) that calculates and displays separator surfaces, separatrices, and magnetic null locations. They suggested to initiate a Separatrix Location Challenge based on the proximity of MMS during reconnection crossing events with the separatrix calculated from global magnetosphere models using the RECONX tool.

Future Directions

Next year will be the final session for the Magnetic Reconnection in the Magnetosphere focus group. We expect MMS observations and analysis with related theoretical and numerical efforts will be a strong component of the session, which will follow the second dayside phase. We plan to be an outlet for magnetospheric studies of reconnection both at the kinetic and global scales, and expect conjunctions with other satellite and ground -based measurements will continue to be a crucial aspect of group discussions.

Geospace Systems Science (GSS)Focus Group

Co-Chairs: Joe Borovsky, Bill Lotko, Vadim Uritsky, and Juan Valdivia

The Geospace Systems Science Focus Group held its third-year sessions at the GEM Summer Workshop in Santa Fe. Two sessions were held, entitled "Driver Geoeffectiveness and Geospace System Response" and "System Behavior and System Tools".

The discussion session on "Driver Geoeffectiveness and Geospace System Response" had six presentations. Shin Ohtani spoke on "Penetration/ Reconfiguration electric fields at low latitudes", examining the global (nightside and dayside) response of the equatorial electrojet to changes wherein the solar-wind magnetic field turns southward. Shin prefers the term "reconfiguration" to "electric-field penetration" because the eastward electric field is produced by a system reconfiguration, which is observed to take about 30 min. Katarina Nykyri spoke on "The Magnetospheric Heating Problem", which focused on the fact that there is more heating on the dawn flank of the low-latitude boundary layer than on the dusk flank. Reconnection and the Kelvin-Helmholtz instability may be the cause of this heating, with the Kelvin-Helmholtz instability being more prevalent on the dawn side owing to the Parker-spiral orientation. Through this heating, the ion-to-electron temperature ratio stays approximately constant. THEMIS finds a similar anisotropy in the amplitudes of Pc 4 and 5 oscillations. The system impact of this asymmetric heating is that the heating may regulate the source of plasma for the inner magnetosphere and control the properties of that plasma. Lynn Kislter spoke on "The Role of Heavy ion Outflow in Driving Sawtooth Oscillations" describing a study relating heavy-ion outflows to periodic sawtooth events during magnetic storms. The motivation is to confirm global MHD simulations indicating that a feedback in ionospheric ion outflow can regulate the recurrence period of periodic sawtooths. The ACE, LANL geosynchroous, Cluster, and FAST spacecraft are being used in the study. Preliminary findings for CME-driven storms are that the 2nd tooth shows strong auroral outflow and that the 3rd and 4th teeth

show stronger polar-cap outflows. Preliminary findings for SIR-driven storms are that lower-energy cusp outflows mixed with nightside auroral outflows are seen. Matina Gkioulidou spoke on "The Properties of the high-energy and low-energy ring current". The study finds that low-energy protons (7-80 keV) vary with Sym H whereas higher-energy protons (100-600 keV) have a longer time-scale variation. The variations in the low-energy proton population is interpreted as temporal variations due to injections from plasma sheet. Low-energy protons may be transported more by convection, showing good correlation with Sym-H, whereas higher-energy protons may be transported more by diffusion, showing no correlation with Sym -H. Chris Mouikis spoke on "Ring Current Pressure Development for CMEs and CIRs using Van Allen Probe Observations". Examining 0.1-60 keV protons with Van Allen Probes it was found for both CME-driven storms and CIR-driven storms that there is strong convective control of the protons during early and main phases with partial ring current becoming more symmetric in recovery. Examining 0.1 -60 keV oxygen ions with Van Allen Probes it was found that there is a much-higher contribution from nightside plasma sheet on open drift paths for CME-driven storms. Bob McPherron spoke on "Dynamic Magnetospheric Forcing". Here, physical interpretation of the reaction of several geomagnetic indices to the solar wind was mad. The AL index responds to the DP-2 (driven) and DP-1 (substorm-current-wedge) currents, with reaction time lags that peak at ~25 and ~50 min that we attribute to driven (DP-2) and unloading (DP-1) component. The MPB index reacts to the DP-1 current. The fact that solar wind predicts a substantial part of MPB suggests that unloading is also driven by the solar wind. Like the AL index, the AU index also has two components: the first is always present and has a very long response of nearly five hours (its cause is unidentified) and the second has a reaction that peaks at a ~25 minute lag and appears to be driven and modulated in strength by conductivity during the summer season. Reductions in the reactions of geomagnetic indices to the solar wind with increasing driver strength result from polar-cap potential saturation.

The discussion session on "System Behavior and System Tools" had nine presentations. Joe Borovsky spoke on "Solar-Cycle Dependence of Coupling". Here the statistical properties of errors in the prediction of geomagnetic indices from the solar wind were examined, with a non-random systematic error that is related to the strength of driving. Since the strength of driving is related to the phase of the solar cycle, systematic errors in the prediction of geomagnetic indices are found that vary with the solar cycle. As more-accurate driver functions are used, the systematic errors shrink, and the variation of geoeffectiveness of the solar wind with phases of the solar cycle vanish. Mark Engebretson spoke on "The Ground-Based Magnetometer Array Planning Workshop". Here the system-science community was informed about a May 5-6, 2016 workshop charged to discuss how investigators in the ground-based magnetometer array community might support the recommendations of the decadal survey and geospace portfolio review and suggest steps leading toward their optimal operation and scientific use. One issue addressed was that the current organizational and funding situation of magnetometer arrays in the US by NSF has not been cohesive and is not adequate. A second issue addressed was that many older magnetic sensors are deployed that do not cover the full frequency range of interest. One outcome would be to form a collaborative magnetometer network organization (DASI) of system O&M and data products (SuperMag). Delores Knipp spoke on "Anomalous Neutral Density Storms". US Space Command is trying to forecast neutral density via a Dst index model: 12 problem storms have been identified wherein the Dst-based forecast model didn't work. These storms tend to be stronger storms that produce a significant excess of NOx in the upper thermosphere, which has a cooling effect on thermosphere. An outstanding question is why do only some storms have this behavior? Some correlation with charged-particle precipitation is manifest in the data, and the question arises is electron or ion precipitation more important? Superposed epoch analysis finds that storms with preceding shocks produce greater enhancements in neutral density: another question arises as to whether or not this behavior is a feature of so-called shock aurora? Bob McPherron spoke on "The Association of Substorm Onsets with Fast Flows". Three different lists of nightside onsets were compared: onsets in the Su-

perMag data set, onsets in the MPB data set, and onsets in the Nishimura list. Nishimura onsets immediately precede the arrival of a fast flow; fast flow occasionally precedes an MPB onset, but the fast flows suddenly increase at the time of MPB onset and persist for about 40 minutes after MPB onset. Additionally, MPB onsets are associated with large increases in the solar-wind Bz compared to Nishimura onsets. It was concluded that Nishimura onsets are ionospheric precursors of the arrival of a fast flow near midnight and that it takes multiple flow bursts to create the conditions responsible for an MPB onset. Mikhail Sitnov spoke on "Dynamic System approach to the empirical analysis of CME- and CIR-Driven Storms". It was noted that CME-driven storms have stronger ring currents and larger Dst perturbations whereas CIR-driven storms have longer durations by shorter Dst main phases. The derivative d (Sym-H)/dt unfolds the phase space and provides new information about the system dynamics for these storms. Thom Edwards spoke on "Recent Developments in Field-Aligned Current Modeling and FAC Identification". He described how he and Dan Weimer are using data and data techniques to produce a model for field-aligned currents. Dan Weimer spoke on "Field-aligned Currents Do Not Saturate". It is well known that the cross-polar-cap electrical potential saturates when the interplanetary electric field exceeds about 3-4 mV/m; the question was asked whether or not field-aligned currents into the polar cap saturate. No obvious field-aligned-current saturation was found, rather a linear increase in the current with increasing solar-wind electric field was found. In fact, it was found that both the Region-1 and Region-2 currents increase essentially linearly with the strength of the interplanetary electric field up to highest electric fields in the data set. Jonathan Krall spoke on "The Effect of Exospheric O and H on Geospace". Enhanced hydrogen in the inner magnetosphere will lead to an increase in the charge-exchange loss of ring-current oxygen ions. A study was described of the impacts of variation in the amount of hydrogen in the inner magnetosphere when the hydrogen is varied artificially in the MSIS atmospheric model. Bill Lotko spoke on "The Effect of Auroral Potential Drops on the Location of the Nightside X-line". When field-aligned potential drops in the auroral field-aligned currents are added to the LFM simulation code, the currents into the ionosphere are reduced for the same amount of solar wind driving. The nightside reconnection dynamo adapts to the addition of these field-aligned potential drops by moving closer to Earth.

The sessions at the 2016 GEM Summer Workshop did not leave time to discuss future plans for the GSS Focus Group. That discussion was deferred to the Mini-GEM in San Francisco.

ULF wave Modeling, Effects, and Applications Focus Group

Co-Chairs: Michael Hartinger, Kazue Takahashi, and Brian Kress

The "Ultra Low Frequency Wave Modeling, Effects, and Applications" (UMEA) focus group started this year. Our goal is to bring researchers in different areas together to address broad questions of interest to many GEM FG: What excites ULF waves? How do they couple to the plasmasphere/ring current/radiation belt? What is their role in magnetosphere-ionosphere coupling?

UMEA held four breakout sessions – one standalone and three joint with other focus groups – with more than 30 presentations plus a few walk-ins. All sessions were well attended with 62 signups to our mailing list. Two tutorials on ULF wave modeling and observations were also presented in the Friday morning GEM plenary session, providing background and motivation for future UMEA activities.

1. Introducing the UMEA focus group

This session focused on introducing the UMEA focus group, discussing outstanding questions in ULF wave research, and planning future activities. The co-chairs introduced themselves and the FG, with Michael Hartinger discussing this year's joint sessions, the ULF wave modeling challenge effort, and other activities. The rest of the session was devoted to presentations on recent progress and outstanding questions in ULF wave research.

Kazue Takahashi showed how recent multi-spacecraft observations provide us with a great opportunity to advance our understanding of the generation mechanisms of ULF waves in the ring current and the effects of the waves on particles. Mark Engebretson reported on new developments and unanswered questions regarding EMIC waves. Recent statistical studies based on observations from the Van Allen Probes are providing a somewhat different view of their occurrence in MLT and in location relative to the plasmapause than what has been observed at synchronous orbit. Limited satellite and ground-based coverage of these highly localized waves constitutes a major barrier to studies of the effect of these waves on ring current ions and radiation belt electrons. Allison Jaynes showed coordinated observations demonstrating the link between ULF waves, whistler mode chorus, and particle precipitation/pulsating aurora; more satellite-ground conjunction observations are needed to better understand the link between ULF waves and the aurora and the many ways ULF waves can modulate precipitation.

A common theme in these presentations was the value of coordinated investigations with multiple instruments placed on the ground and in situ. Toshi Nishimura presented results from past observational campaigns coordinating ground stations (radars, all sky imagers, ground magnetometers) and satellites to characterize ULF waves and their impact on the magnetosphere-ionosphere system; he further proposed a future campaign/ISR world day proposal for 2018 to examine dawn-asymmetries in ULF wave properties. Discussion after this talk revealed the most favorable satellite/ground configurations for addressing different science questions.

Most of the rest of the session focused on ULF wave modeling and data-model comparisons. Seth Claudepierre presented Pc3-5 ULF wave modeling (LFM) and observations (Van Allen Probes), highlighting the important role that the plasmasphere plays in ULF wave dynamics. He argued that statistical ULF wave power maps from observations provide a benchmark for validating global MHD modeling of ULF waves. Scot Elkington discussed recent progress modeling ULF wave interactions with the radiation belt. Radial diffusion and test particle simulations have revealed much about these interactions, but many open questions remain. Measurements of several wave properties are needed to better understand/model the interactions: frequency spectrum, radial profile, azimuthal extent, propagation direction, azimuthal wave number, driving mechanism.

Finally, several walk-in talks occurred at the end of the session. Alexander Drozdov showed new modeling results comparing radiation belt responses using different radial diffusion coefficients. Xueling Shi showed a case study with coordinated observations of Pi2 pulsations from THEMIS spacecraft, ground magnetometers, and mid-latitude SuperDARN radars at a substorm onset, suggesting a global plasmaspheric virtual resonance. Peter Chi showed MMS satellite observations of ULF waves with very large azimuthal wave numbers, as well as observations of the global distribution of poloidal waves using a very large satellite constellation. Chih-Ping Wang presented a Pi2 event associated with a substorm onset, using THEMIS, GOES, RBSP, and ground magnetometers to investigate whether inner magnetospheric Pi2 is directly driven or excited by resonance, finding multiple lines of evidence consistent with cavity mode resonance.

2. Magnetospheric signatures of dayside transients

This session was joint with the “Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interactions” and “Transient Phenomena at the Magnetopause and Bow Shock and their Ground Signatures” FGs. There were 8 presentations, and throughout the session discussion topics included (1) preferred driving conditions/magnetopause perturbations for triggering different magnetospheric signatures and (2) modeling the ULF response to localized magnetopause indentations.

Slava Merkin presented results from the effort coupling the high-resolution version of the LFM global magnetosphere with Sasha Ukhorskiy’s test particle simulation. The work was done primarily by Kareem Sorathia at JHU/APL and showed that losses of magnetospheric energetic particles (100 keV protons and O+ ions) at the magnetospheric flanks were enhanced by the well-developed Kelvin-Hemholtz instability. De-sheng Han discussed throat aurora, using statistical analysis to show that

auroral features relate to scales of ~3 R_E in the equatorial plane and are the ionospheric signatures of the interaction of cold magnetospheric ions with dayside magnetopause reconnection. This implies that throat aurora may provide important information on studying the interaction of cold magnetospheric plasma with magnetopause reconnection. Boyi Wang discussed the driving mechanisms of poleward moving auroral forms (PMAFs) with coordinated all sky imager and satellite observations, showing a strong statistical relationship with southward turnings of the IMF (72%), with a response time of ~8 minutes. Boyi Wang also discussed the dayside auroral response on closed field lines to an IMF discontinuity, using multiple satellites in the dayside magnetosphere, magnetosheath, and solar wind. They associated the IMF discontinuity with a localized, propagating magnetopause compression, brightening/azimuthal propagation of dayside diffuse aurora, and localized magnetospheric ULF waves with large amplitudes. Michael Hartinger discussed how the high-latitude ground magnetic response to an interplanetary shock depends strongly on the local ionospheric conductivity; inter-hemispheric comparisons from recently deployed Antarctic AAL-PIP magnetometers, Greenland magnetometers, and global MHD simulations show the response varies rapidly with location relative to the auroral oval. Hui Zhang presented HFA generated Pc3 ULF waves observed by multiple spacecraft and ground magnetometers. The ULF waves are standing Alfvén waves. The wave power of poloidal mode is stronger than that of toroidal mode. The Pc3 ULF waves were observed at dawn, noon and dusk sectors, indicating the magnetospheric response to the HFA is global. The goal of the work presented by Heli Hietala is to determine impact rates of magnetosheath high speed jets and their properties at the magnetopause, which can then be used as input to global magentospheric models. The high speed jets are related to kinetic foreshock processes, and drive significant local increases in dynamic pressure and ULF fluctuations at the magnetopause. The jets occur preferentially in radial IMF conditions, happening at rates as large as 9/hour with typical perpendicular scales of 1.34 R_E. Alexa Halford spoke about BARREL observations of a solar energetic electron event. There were ULF oscillations observed with precipitation and it is yet unclear if this is due to the movement of the open closed boundary or processes within the magnetosheath as these same oscillations were not observed in the solar wind.

3. ULF wave modeling

This session was joint with the Modeling Methods and Validation FG. There were 7 presentations, and general discussion included the best ways to perform data-model comparisons (e.g., statistical results rather than event by event), the need for both idealized simulations and event simulations, and the need for models that can capture drift-bounce resonance in 3D and localized magnetopause indentations.

Lutz Rastaetter gave an overview of the ongoing ULF wave modeling challenge at CCMC, where ULF wave output is compared between several global MHD simulations with similar driving conditions: a monochromatic wave in the solar wind and continuum noise in the solar wind. Even with similar driving conditions, different simulations can produce very different output, and this is at least partially attributable to the different magnetospheric densities/Alfven speeds and ionospheric conductivities. Bob Lysak showed results from a 3D ULF wave model with height-resolved ionosphere and new ionospheric conductivities based on solar illumination. The results showed how hemispheric asymmetries in conductivity lead to quarter-wavelength standing Alfven modes. Michael Hartinger used global MHD simulations with different values for ionospheric conductivity (uniform, solar illumination, solar illumination plus auroral oval) to show the ground magnetic response to an interplanetary shock strongly depends on the local ionospheric conductivity. Kevin Urban discussed how ULF wave power observed at ground magnetometers in the Antarctic polar cap depends on IMF Bz, and that CGM coordinates do not organize ULF wave observations well. Colin Komar discussed recent modeling advances to self-consistently simulate the drift resonant interaction of radiation belt electrons in a bounce-averaged kinetic model coupled with a global magnetospheric MHD model. Rualdo Soto discussed ring current ion Pc5 wave modulations detected by RBSPICE on Van Allen Probes, comparing with theory to attribute the modulations to the drift-mirror instability

rather than bounce-resonance. Hyomin Kim statistically surveyed EMFISIS and RBSPICE data from the Van Allen Probes, finding that ULF wave power (in the Pc3 range) and Helium ion flux (85-142 keV) variations are highly anti-correlated mostly during quiet times. As the wave frequencies and the bounce periods of Helium ions in the energy levels are comparable, the results suggest that the bounce resonance interaction might play an important role in Helium ion scattering during quiet times.

4. ULF waves and nonlocal transport

This session was joint with the Quantitative Assessment of Radiation belt Modeling FG. There were 8 presentations, with discussion emphasizing the need for data-model comparisons – e.g., validating diffusion coefficients with event-specific wave measurements.

Greg Cunningham discussed radial diffusion in non-dipolar fields using the DREAM3D code with diffusion coefficients that assume dipole and non-dipole fields. Diffusion coefficients calculated for realistic (non-dipole) background fields better capture dropouts. Theodore Sarris presented observations and test particle simulations of outer belt electron radial transport, with different ULF wave properties – m number, monochromatic versus broadband frequency spectrum – producing very different types of radial transport/radial PSD profiles. Wen Li discussed the importance of pitch angle dependence on radial diffusion and the calculation of diffusion coefficients, comparing results from 3 simulations (with different assumptions for wave activity) plus observations for the 17 Mar 2015 event. Anthony Chan showed REM 3D simulation results indicating that drift shell splitting effects can reduce electron PSD enhancements during storms. Qianli Ma simulated the radial intrusion and slow decay of energetic electrons in the Earth's slot region by incorporating radial diffusion transport and hiss-induced pitch angle scattering processes. Solene Lejosne discussed RBSP and Arecibo ISR electric field measurements near L=1.4, showing electric fields consistent with plasma subcorotation and discussing how measurements could be included in future diffusion coefficient calculations. Yan Song discussed the role of ULF waves in high energy particle acceleration in the auroral acceleration region, with future application of the theory to particle acceleration in the Earth's radiation belts. Michael Hartinger discussed a statistical study of the azimuthal wave number associated with globally coherent ULF waves using ground magnetometer measurements.

Modeling Methods and Validation Focus Group

Co-Chairs: Katherine Garcia-Sage, Mike Liemohn, Lutz Rastaetter, and Rob Redmon

GEM-CEDAR Modeling Challenge and Ionospheric Conductance Modeling Challenge

The Modeling Methods and Validation Focus Group held three joint sessions with CEDAR to present results from the GEM-CEDAR Modeling Challenge and to launch the next joint challenge on ionospheric conductance. All of these sessions were held early in the workshop week, on Monday and Tuesday.

Monday, 6/20: CEDAR-GEM Model Validation Challenge Project Results

The first session began with a review of the CEDAR-GEM Modeling Challenge from Ja Soon Shim, followed by a quick introduction to the Ionospheric Conductance Challenge by Mike Liemohn, to get people thinking about it. Several speakers discussed their work on the selected events for the CEDAR-GEM Challenge, including Yongliang Zhang, Bob Robinson, Larisa Goncharenko, and Katie Garcia-Sage. Masha Kuznetsova took it to a broader level by discussing the issue of how to conduct appropriate data-model comparisons and model validations, including a long conversation about how to quantify uncertainties within models. In the spirit of the GEM and CEDAR Workshops, this session was about half presentation and half open discussion.

The second session, also on Monday, continued the presentations of project results from the CEDAR-GEM Model Validation Challenge. Because Ja Soon Shim has led these challenges within the

CEDAR community since 2009, it was useful to devote a session to a series of reports to highlight the accomplishments of both the GEM and CEDAR communities towards this effort. These included talks by Lutz Rastätter, Delores Knipp, Liam Kilcommons, Yongliang Zhang, Slava Merkin, Burcu Kosar, Joe Huba, and Shunrong Zhang. The session brought together many who are interested in improving not only the accuracy of our numerical models but also the methodologies we use to achieve this. It very nicely showcased the attention by the research community on model validation.

Note that nearly all of these presentations are available at the GEM-CEDAR Challenge website hosted by CCMC: http://ccmc.gsfc.nasa.gov/challenges/GEM-CEDAR/.

Tuesday, 6/21: Ionospheric Conductance Challenge Discussion

The final session in this series opened the conversation on the latest joint ionosphere-magnetosphere modeling challenge: ionospheric conductance. Katie Garcia-Sage set the stage for this session with a brief recap of the previous day and introduction to the new challenge. This was followed by several talks that poignantly revealed the necessity for this challenge. Dan Welling demonstrated that most MHD models use an ionospheric conductance specification based on a small subset of the possible range of geomagnetic activity, therefore requiring extrapolation of the conductance values for the largest events. Ryan McGranaghan then gave a review of ionospheric conductivity calculation methodologies, showing that we could be better. Slava Merkin discussed two microphysical processes that could significantly influence the large-scale ionospheric conductance patterns. Finally, Anna DeJong showed modeling runs with different auroral input models, showing substantial differences between the results for the same event. These brief talks were followed by a lengthy open discussion on how to proceed with a challenge that will bring attention and concentrated effort towards improving our calculations of ionospheric conductance. Consensus was not reached, but a plan for making progress on the definition of this challenge was devised. A session will be held at the GEM Mini-Workshop in San Francisco in December 2016 to continue this conversation and finalize the organization of the Ionospheric Conductance Challenge.

The Modeling Methods and Validation Focus Group also held joint sessions with Dayside Kinetics, Tail Environment and Dynamics at Lunar Distances, and ULF-wave Modeling, Effects, and Applications. Please see these focus groups for the joint session reports.

Joint Sessions

The Modeling Methods and Validation FG also held joint modeling challenge sessions with (1) ULF-wave Modeling, Effects, and Applications FG, (2) Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction FG, and (3) Tail Environment and Dynamics at Lunar Distances FG. Please see the reports by these three FGs for the results of the joint sessions.

GEM on the Internet

GemWiki: http://aten.igpp.ucla.edu/gemwiki/
GEM Workshop Website: http://www.cpe.vt.edu/gem/
GEM Messenger (Electronic Newsletter):

- To subscribe or update subscription: E-mail gemeditor@igpp.ucla.edu
- To post announcements: Fill out the online request form at http://aten.igpp.ucla.edu/gem/messenger_form

Workshop Coordinator Report

Zhonghua Xu and Robert Clauer

Participants

The GEM 2016 Summer Workshop was a joint workshop with CEDAR, so the meeting was larger than usual. On the GEM side, we have 268 participants including 197 scientist participants and 71 student participants, from over 84 institutions. Among them, are 32 international participants (18 scientists and 14 students/young scientist) from 14 countries: Austria, Australia, Brazil, Canada, China, Finland, France, Greece, Hungary, Japan, New Zealand, South Korea, Turkey, and United Kingdom. The registration information for participants from the US shows that top five groups in terms of number of participants include NASA, University of California Los Angeles, University of New Hampshire, University of Colorado Boulder, and University of Michigan.

This year, GEM funding supported 68 students /young scientists from 33 institutions in 12 countries (compared to 57 in 2015). This was the most diverse group of student participants in recent GEM Summer Workshops. We managed to provide most students from U.S. institutions full support, including air-tickets and lodging. Some students received partial support for lodging. Students pay reduced student registration fee regardless whether receiving funding or not, and the GEM support pays the difference between student registration and the full registration fee. We have supported 17 students/young scientists from 14 international universities/institutes, including Brazil, Canada, China, Finland, Greece, Hungary, New Zealand, Russia, Turkey, and United Kingdom. International students were supported for their travel and lodging within the US. No international travel was supported. The top three domestic universities in terms of student participants are UNH (11), UTSA (6), and University of Michigan (5). There were 3 students participants who did not receive GEM support for travel or lodging.

Following the suggestions of the GEM Steering Committee, all 68 graduate students, supported by GEM funding, presented their research in the poster or oral sessions. The rationale is that those students will benefit most from discussing the frontier research topics with our prominent scientists and professors. 80% of the graduate students are in their 3th or higher year graduate school, but the 20% students who are in 1st and 2nd year of graduate school are also showing their involvement in research and presentable results. This is probably due to the fact we started to request evaluations of students' readiness from their advisors.

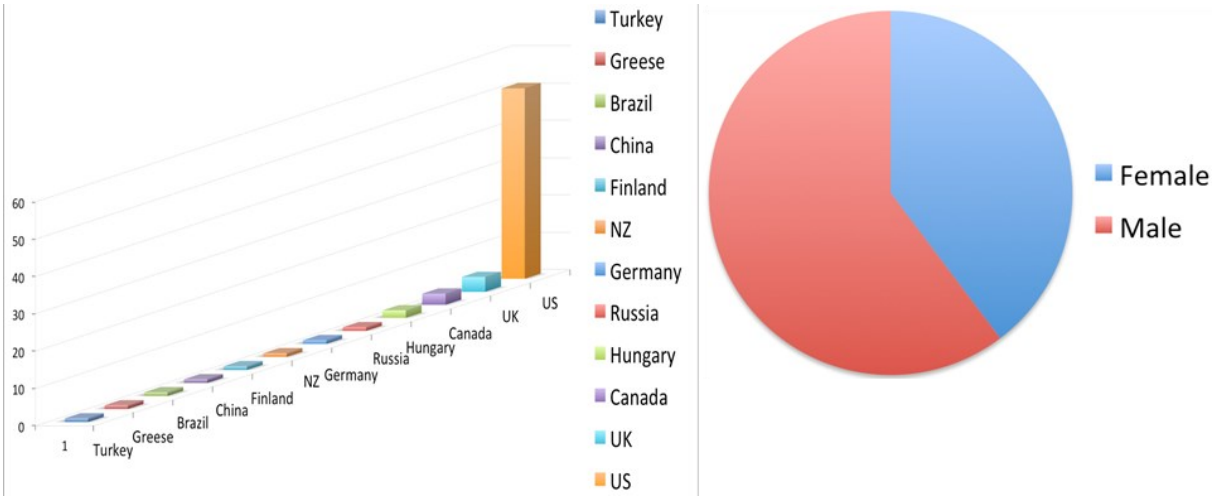

Figure 1. The demographic information of supported students for the 2016 Summer Workshop

Although we see more female students in recent years than in decades ago, there is still an imbalance. This year we supported 41 male students and 27 female students. The trend has changed from 2:1 (male vs female ratio) in 2015 to 3:2 this year. So our community should keep improving the awareness of this issue and provide encouragement and support to female students. Another issue regarding student support is that we encountered the challenge of VISAs for some international students. There were 5 students who were not able to come to the workshop due to this issue, from countries of Canada, China, Russia, and Greece.

Multi-media Resource of Student Tutorials and Training Sessions were recorded with a video-camera. The presentation slides and video are shared via Google Drive and YOUTUBE to all the GEM participants with the permission of presenters. If possible, the GEM workshop will keep providing this service to the community. The joint tutorial sessions with CEDAR are available through CEDAR website. In addition, the students had a proposal training session with some senior scientists together with the CEDAR students. The session was so welcomed by the students and was extended to more than two hours.

GEM Steering Committee Minutes

- Location: Santa Fe, New Mexico.
- Date: June 19, 2016
- Members present: Robert Allen, Jacob Bortnik, Joe Borovsky, Paul Cassak, Peter Chi, Seth Claudepierre, Robert Clauer, Scot Elkington, Brian Fraser, Matina Gkioulidou, Alex Glocer, Larry Kepko, Janet Kozyra, Maria Kuznetsova, Jaejin Lee, Marc Lessard, Robyn Milan, Katariina Nykyri, Shin Ohtani, Lutz Rastaetter, Andrei Ronov, Anthony Saikin, Weichao Tu, Mike Wiltberger.

<u>Business:</u>

Next join GEM/CEDAR?

- Once every 5 years is not enough.
- Try for more frequent "overlap" sessions, but less frequent joint meetings. About 20% of GEM community interested in M-I, so maybe every 2-3 years for joint sessions?

Anti-harassment policy

- CEDAR is developing anti-harassment policies as well as SHINE can get involved. Reached out to NCAR officer on diversity and inclusiveness, got definition of harassment "micro-aggression", little comments that imply racism or are degrading.
- Volunteers to draft a policy: Anthony Saikin, Robert Allen, Matina G., Mike W., Paul Cassak

Location of 2017 meeting

- It will be at Renaissance Portsmouth-Norfolk Waterfront Hotel, Portsmouth, VA, during June 18 - 23, 2017.
- $89/night for room rate, VS $200+/night at Snowmass.

Location of 2018 meeting

- Possible locations: Chicago, Snowmass, Keystone, Santa Fe, Los Angeles, Seattle, and Daytona Beach.
- After discussion and negotiation with the hotels, it would be at Santa Fe, NM, during June 17-22, 2016.

NSF Budget discussion

- Budget increased in GEO Space, MAG from $6.8 to $7.1 Million, had 45 prop 38 index projects, had 3 virtual panels, split proposals so there were less proposals per panel. About 26% success rate in both programs.

Student poster evaluation

- Students took over administration of student posters.
- 31 judges and 38 students participants for the competition.
- GEM Chairman signed certificates as the grand prize.

Quo Vadis — where are we going?

- Initial planning stages of where we as a broad space physics community want to do to go forward.
- Space weather got a lot of attention from congress.
- MREFC proposal ~$100M: need new instrumentation ideas!

Election of new members (candidates)

- Christine Gabrielse
- Wen Li
- Kyle Murphy
- Dan Welling
- Brian Walsh

Liaison updates

- SHINE: July 11, 2016 workshop at Eldorado, Santa Fe, NM. Advanced predictions of IMF on

Earth, physics of SW, solar surface, outer heliosphere.
- JAXA: GEOTAIL extension approved by JAXA, planning on collaborations with MMS, until March 2019. Data available in ISIs JAXA
- ERG: for radiation belts, launched this fiscal year. Data open to public on ERG Science Center.
- CCMC: A meeting every 2 year, open with registration. Focus on validation. Also getting engaged in education. Have a lot of interns, many self funded from overseas.
- Australia: DSTO government research defence is becoming more open with collaboration with University, looking at ionosphere using various techniques, Space cooperative research, CubeSats, and GIC studies. Meeting will host 2017 astronomical congress, as well as COSPAR and AOGS 2020.
- South Korea: NASA official visited and signed collaboration on future missions. Funding approved by Korean government

Student Representative Report

Robert C. Allen, Anthony Saikin, and Suzanne Smith

This year 200 students attended the joint GEM-CEDAR Workshop in Santa Fe, NM, of which 71 students registered through GEM. In the spirit of the joint workshop, both GEM and CEDAR Student Representatives jointly hosted Student Day, in which we included traditions from both of our communities. This led to us changing from the traditional GEM Student Day format of having all talks given by students to having the morning be student-only, and the afternoon being open to both student and scientists alike. Additionally, in the afternoon, career scientists invited by both GEM and CEDAR gave most of the tutorials. The new format went over well, and the Student Representatives look forward to discussing this format with the GEM student community at the 2016 mini-GEM Student Town Hall.

For the second year, the GEM Student Representatives hosted a Career Panel during the Monday night student dinner. This year, the topic was "career pathways". This panel was jointly held between GEM and CEDAR, with each community inviting two panelists each. The GEM Student Representatives would like to thank Elizabeth MacDonald and Katie Garcia-Sage for serving on the panel, as well as the CEDAR invited panelists Jonathan Snively and Chavvi Goenka.

For the first time, the GEM Student Representatives took on the responsibility of revamping, organizing, and implementing the GEM Student Poster Competition. The aim of the restructuring was to provide additional transparency and feedback to students. This was a key topic of conversation during the 2015 mini-GEM Student Town Hall meeting. The changes led to the creation of feedback forms for judges to use in scoring the students, which also had a comment section. These forms were then returned to the students after the workshop was over. This year, the top student was selected from each research area to be the winner. The winners were Thomas Kim (General Science Poster), Katie Raymer and Terry Liu (tied for Solar Wind – Magnetosphere Interactions Poster), Mojtaba Akhavan-Tafti (Magnetotail and Plasma Sheet Poster), Nadine Kalmoni (Magnetosphere – Ionosphere Coupling Poster), Mykhaylo Shumko (Inner Magnetosphere Poster), and John Haiducek (Global System Modeling Poster).

This year, Suzanne Smith was elected as the next Student Representative and will replace Robert C. Allen. Her term will run through the 2018 GEM workshop. Additionally, Anthony Saikin was elected to finish Lois Sarno-Smith's term as Student Representative, with his term running through the 2017 GEM workshop. Outgoing Student Representative Robert C. Allen would like to thank the GEM community for giving him the opportunity to serve as Student Representative, as well as thank the GEM steering committee for always being student-focused and willing to receive student feedback.

GEM Steering Committee

NSF Program Manager

- Janet Kozyra

Steering Committee Regular Members (Voting Members)

- Mike Wiltberger (Chair, 2015-2017)
- Jacob Bortnik (Chair-elect, 2017-2019)
- Paul Cassak (2015-2018)
- Weichao Tu (2015-2018)
- Christine Gabrielse (2016 - 2019)
- Dan Welling (2016 - 2019)
- Research Area Coordinators (see below)
- Meeting Organizer (see below)

Steering Committee Liaison Members

- Joe Borovsky (Liaison to SHINE)
- Josh Semeter (Liaison to CEDAR)
- Mona Kessel (Liaison to NASA)
- Howard Singer (Liaison to NOAA)
- James McCollough (Liaison to AFRL)
- Masha Kuznetsova (Liaison to CCMC)
- Benoit Lavraud (Liaison to ESA)
- Laura Morales (Liaison to Argentina)
- Brian Fraser (Liaison to Australia)
- Robert Rankin (Liaison to Canada)
- Chi Wang (Liaison to China)
- Yoshizumi Miyoshi (Liaison to JAXA, Japan)
- Jaejin Lee (Liaison to Korea)
- Xochitl Blanco-Cano (Liaison to Mexico)
- Lou Lee (Liaison to Taiwan)

Meeting Organizer

- Robert Clauer (2005-2018)

Student Represenatives

- Anthony Saikin (2016 - 2017)
- Suzanne Smith (2016 - 2018)

Research Area Coordinators

Solar Wind-Magnetosphere Interaction (SWMI)

- Katariina Nykyri (2012-2018)
- Steve Petrinec (2015-2021)

Magnetotail and Plasma Sheet (MPS)

- Andrei Runov (2014-2018)
- Matina Gkioulidou (2015-2021)

Inner MAGnetosphere (IMAG)

- Scot Elkington (2013-2018)
- Seth Claudepierre (2015-2021)

Magnetosphere-Ionosphere Coupling (MIC)

- Marc Lessard (2012-2018)
- Shin Ohtani (2015-2021)

Global System Modeling (GSM)

- Frank Toffoletto (2012-2018)
- Alex Glocer (2015-2021)

Communications Coordinator

- Peter Chi (2014 - 2019)

List of GEM Focus Groups

Focus Group	Duration	Co-Chairs	Associated Research Areas				
			SWMI	MPS	IMAG	MIC	GSM
Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures	2012-2016	Hui Zhang, Q.-G. Zong, Mike Ruohoniemi, David Murr	●				
Tail Environment and Dynamics at Lunar Distances	2015-2019	Chih-Ping Wang, Andrei Runov, David Sibeck, Slava Merkin, Yu Lin	●	●			●
Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction	2016-2020	Heli Hietala, Xochitl Blanco-Cano, Gabor Toth, Andrew Dimmock	●				●
Tail-Inner Magnetosphere Interactions	2012-2016	Vassilis Angelopoulos, Pontus Brandt, John Lyon, Frank Toffoletto		●			
Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms	2015-2019	Toshi Nishimura, Kyle Murphy, Emma Spanswick, Jian Yang		●			
Storm-time Inner Magnetosphere-Ionosphere Convection (SIMIC)	2013-2017	Josoph Baker, Mike Ruohoniemi, Stan Sazykin, Peter Chi, Mark Engebreston			●	●	
Inner Magnetosphere Cross-Energy/ Population Interactions	2014-2018	Yiqun Yu, Colby Lemon, Michael Liemohn, Jichun Zhang			●		
Quantitative Assessment of Radiation Belt Modeling	2014-2018	Jay Albert, Wen Li, Steve Morley, Weichao Tu			●		
Merged Modeling & Measurement of Injection Ionospheric Plasma into the Magnetosphere (M3I2) and Its Effects -- Plasma Sheet, Ring Current, Substorm Dynamics	2016-2020	Vince Eccles, Shasha Zou, Barbara Giles				●	
Magnetic Reconnection in the Magnetosphere	2013-2017	Paul Cassak, Andrei Runov, Yi-Hsin Liu, Brian Walsh					●
Geospace Systems Science	2014-2018	Joe Borovsky, Bill Lotko, Vadim Uritsky, Juan Valdivia					●
ULF wave Modeling, Effects, and Applications	2016-2020	Michael Hartinger, Kazue Takahashi, Brian Kress					●
Modeling Methods and Validation	2016-2020	Katherine Garcia-Sage, Mike Liemohn, Lutz Rastaetter, Rob Redmon					●