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The GEMstone

Notes from NSF Program Director

Michael Wiltberger

Change continues to be an enduring theme during my brief time at the National Science Foundation. As most of you know, my term as Magnetospheric Physics Program Director was relatively short since I was selected to be the new head of the Geospace Section on August 13th 2017. I want to thank Sarah Ruth for her excellent stewardship of the section in gap between my appointment and Therese Moretto -Jorgenson leaving the position.

We are currently searching for new a Magnetospheric Physics Program Director. We are looking for an experienced magnetosphere scientist with a flair for scientific leadership and an interest in community service, who is excited about the opportunity to work with us to maintain an excellent magnetospheric research program and shape the investment in magnetosphere science at NSF. Appointment to this position may be on a career civil service appointment or rotator position. Rotator positions can be either Intergovernmental Personnel Assignment (IPA) or Visiting Scientist, Engineer, and Educator (VSEE) assignments. Applicants interested in the rotator position can find more information at https://www.usajobs.gov/GetJob/ViewDetails/484516500. Applicants interested in the career civil service position can find more information at https://www.usajobs.gov/GetJob/ViewDetails/484515800.

In 2017 29 projects where submitted to the GEM program of which we able to support 4 projects for a success rate of 14%. A factor contributing the low success rate was the need address potential for significant reduction in FY18 operating budget in our award process. In order to address this issue, we began following the recommendation of the Geospace Portfolio Review and begin the process of transitioning from funding grants in continuing increments to single obligations. Another budget issue of note is that until December 8th 2017 the government is funded under a continuing resolution (CR). Under the CR we had been allocated a fraction of our typical operating budget and this delayed our ability release funds for current grants and start new awards.

As I discussed in my presentation to the GEM community at the annual meeting we are in the process of removing the deadlines from the GEM program solicitation. While this revision is in progress the solicitation is archived and it is not possible to submit proposals to the GEM program. We are expecting the approval process to be completed shortly and announcement will be made to the GEM News-

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letter once the solicitation is available. This change will make the GEM program the same as the magnetospheric physics core program, proposals are accepted at any time. This allows proposers to submit their best effort on a timeline that works for their schedule.

While we search for a new magnetospheric program director, Carrie Black is serving as the acting Magnetospheric Physics Program Director. She can be reach via email to cblack@nsf.gov or phone call to (703)292-8518. As the section head I'm also available to answer any questions you might have about the NSF. My NSF email address is mwiltber@nsf.gov and my phone number is (703)292-4690. If you are ever in the DC area feel free to contact me for an in person visit to NSF. I look forward to seeing everyone in Santé Fe, NM for the next GEM meeting.

Notes from GEM Chair

Jacob Bortnik

As I take a moment to pause and reflect on the state of the GEM community, a specific word comes to mind: dynamism! This spirit of vigorous activity and progress could not be more aptly expressed than in the recent GEM summer workshop, held over the week of 18-23 June 2017, in the seaside city of Portsmouth, VA. In attendance this year were 156 scientists, 73 students, and 6 guests representing 12 countries and approximately 66 different institutions. As always, the GEM students were in top form – our student representatives ensured a smooth and fair judging process and five awards were given out on the last day, one in each of the GEM research areas. A sixth award went to Ms. Shreeya Khurana, who won the CCMC research contest, and was presented her award on the last day of the GEM meeting. Shreeya won over 7 other prestigious awards for this project, and did all this while still a freshman at Montgomery Blair High School.

Having had a front-row seat to the breadth and complexity of organizing this workshop, I want to specifically thank the Virginia Tech team (Bob Clauer, Zhonghua Xu, Ashley Barker, and others) for their tireless efforts in making this workshop such a success. Our workshop organizers will serve their final year in 2018, and we are currently in the process of selecting our new organizers for 2019.

In 2018 the GEM summer workshop returns to Santa Fe, NM, and will be held at the Eldorado hotel over the period 16-22 June 2018. Plans are currently being made to coordinate with the CEDAR meeting, which is scheduled for 24-28 June, 2018, at the same venue. We're planning joint sessions over the weekend of the 23rd and 24th, and will have sessions of mutual interest to be arranged nearer the weekend. The intent is to allow members of both communities to attend either, both, or a portion of each meeting as time allows.

As always, many changes are afoot: the GEM steering committee welcomes Vania Jordanova as the new "at large" member, Josh Rigler as the USGS liaison, and we thank our outgoing student representative Anthony Saikin for his service and welcome Ryan Dewey as the new student representative. We are also excited at the organizational changes happening at the NSF that directly impact GEM: having briefly served as the Magnetospheric Physics Program Director, Dr. Michael Wiltberger has now stepped up to serve as Head of the Geospace Section (GS), in the Division of Atmospheric and Geospace Sciences at NSF under the Intergovernmental Personnel Act, starting in August 9,

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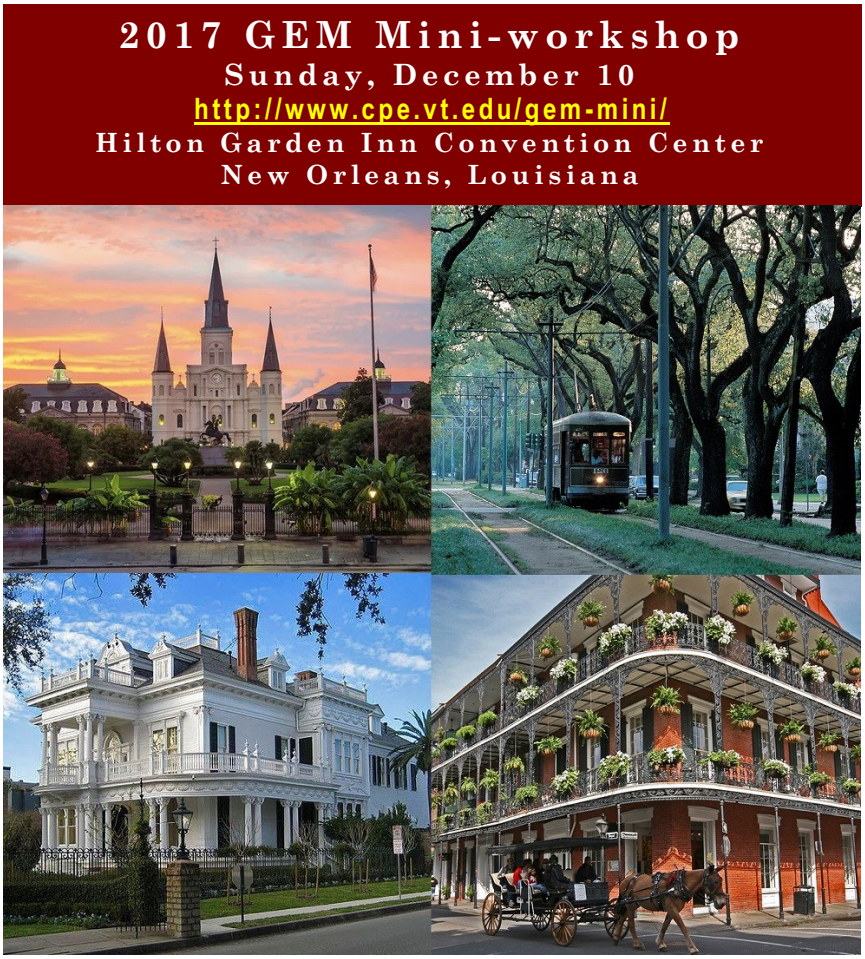
2017. Having personally worked with Mike as vice chair while he served as chair of GEM, I can attest to the fact that he is a first class scientist and outstanding organizer, and look forward to seeing GEM and the GS flourish under his leadership.

Internally, the GEM steering committee has been busy thinking about the many challenges and opportunities that abound. Earlier this year, we composed an "Anti-Harassment Policy" which has been published on the front page of the GEM wiki, to make absolutely clear that GEM is a fair and inclusive community, and harassment of any kind is not acceptable. We hope that harassment will not ever occur at GEM events, but we want to make sure everyone is aware of the procedure to follow if something does. We have put together a "Best Practices" document, which is now available on the front page of the GEM wiki to capture the many details that are involved in virtually every role of the GEM steering committee, timelines for various tasks, and practical advice on proposing and running a successful focus group. Finally, a frequent item of discussion by the steering committee is the changing culture of GEM as our community grows, from being an interactive workshop environment towards a more AGU/SPA like environment. We want to know what you, the community, feel about this and how we might better organize our meetings to capture the best of both worlds. You should soon be getting a poll to gauge the level of interest of various tradeoffs that are available in adjusting our meeting style.

I'd like to end my message by reiterating that GEM is a dynamic, exciting, and organically evolving community. It is my great honor to lead GEM for a short while, and I want to make sure that your voices are heard and represented and that our community thrives. The mini-GEM workshop is scheduled for December 10th 2017, at the Hilton Garden Inn, New Orleans Convention center. Consider attending, proposing a new focus group, or getting involved in some way. The GEM spirit of dynamism is built on your ideas! See you in the Big Easy.



Solar Wind-Magnetosphere Interaction Research Area Report

Coordinators: Katariina Nykyri and Steve Petrinec

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 sessions during the Summer 2017 GEM Workshop. The Tuesday (06/20) session on "Magnetosphere-ionosphere coupling processes associated with localized disturbances caused by dayside kinetic phenomena" held with the ULF FG and the Proposed Links FG is summarized in the ULF FG's report, and the Thursday (06/22) session on "Magnetopause phenomena" held together with Magnetic Reconnection FG is summarized in the Magnetic Reconnection FG's report.

Tuesday 06/20:

Dayside Kinetics Challenge session

joint with *Modeling Methods and Validation* FG

The southward IMF event on 2015-11-18 01:50-03:00 UT, featuring an MMS-Geotail magnetopause conjunction with SuperDARN radar observations has been set as the challenge event. During this challenge we analyze the various dayside phenomena (magnetic reconnection, FTEs, magnetosheath waves, etc.). We aim to conduct comparisons between (i) observations and models with different levels of kinetic physics; (ii) different models; (iii) in situ and remote observations. So far, we have over a dozen observers who have signed up to analyze the measurements, and three different simulation models: particle-assisted MHD (Ilja Honkonen), MHD with embedded PIC (Yuxi Chen), and global hybrid-PIC (Yu Lin).

In this session, attended by over 40 observers and modelers, we had presentations of the observations made throughout the magnetosphere during the event, as well as on the preliminary simulations. The session chairs (Heli Hietala and Lutz Rastaetter) presented the slides and results of those challenge team members who were unable to attend this year's workshop.

Starting from global scale observations, Rishi Mistry and Heli Hietala reviewed the analysis of ACE, Wind, and ARTEMIS solar wind measurements that led to the chosen input values for the models. The details of the analysis are available on the CCMC website. Andrew Dimmock compiled OMNI and THEMIS statistics of solar wind and magnetosheath observations under similar conditions to the challenge event. While purely southward IMF conditions are a staple for simulations, they are rarely observed. Toshi Nishimura presented radar observations during the 2015-11-18 campaign event. He described a 2-d perspective of the bursty magnetopause reconnection during the event, and presented the azimuthal size and propagation speed of the reconnection jets. Christine Gabrielse reviewed the nightside observations: Three THEMIS spacecraft were located in the tail near midnight around -8 to -9 R_E X_{GSM} during the Dayside Challenge event (01:50-03:00UT). They observed plasma sheet thinning during the event, followed by a small dipolarization, particle injection, fast earthward flow ~24 minutes after the event, and a large dipolarization, particle injection, and fast earthward flow ~40 minutes after the Challenge Event.

Moving to smaller scale observations, Xochitl Blanco-Cano studied waves observed by MMS near and inside the magnetosheath jet structure associated with the northward turning of the IMF at the end of the Challenge interval. They find that the fluctuations near the jet have the properties of mirror mode waves and are associated with temperature anisotropy $T_{perp} > T_{par}$. In contrast, off an-

gle propagating waves are observed inside the magnetosheath jet, probably transmitted from the upstream (no temperature anisotropy is associated with these waves). Rick Wilder showed MMS wave and electric field data from the event, with a special focus on the parallel electric fields associated with whistlers on the separatrix. The presence of a beam as well as potential anisotropy was observed, as well as trapped energetic electrons that may be accelerated by a combination of the whistlers and the non-linear parallel electric fields. Steve Petrinec showed the densities of the minor ion species as observed by MMS/HPCA during the dynamic magnetosheath intervals (possibly FTEs) associated with the Challenge interval. Enhancements in the He+ and O+ ions above 1 keV were observed at these times.

With respect to preliminary simulation results, Ilja Honkonen contributed a reference MHD simulation to the challenge. He found that the X-line location was similar to the estimates based on MMS and Geotail observations. The model is available at CCMC and the code at github.com/iljah/pamhd for anyone to download, use, study, modify and redistribute. Yuxi Chen performed a three-dimensional one hour-long global simulation using the MHD with embedded PIC (MHD-EPIC) model to study the dayside magnetopause reconnection. They studied both the global and kinetic scale phenomena that are related to the reconnection, and the simulation results agree with the observations.

The next steps of the challenge are to (i) continue the simulations (we encourage more models to join), (ii) perform more comprehensive analyses of both the observations and the simulations, and (iii) make quantitative comparisons.

You can find more information of the challenge at:
https://ccmc.gsfc.nasa.gov/support/GEM/Dayside_Kinetic_Processes/Dayside_Kinetic_Challenge/Introduction.php

Thursday 06/22:

Dayside Kinetics Contributed Science session

We solicited short presentations on dayside kinetic phenomena and their role in global magnetospheric dynamics. We had so many requests that unfortunately we could not fulfill all of them due to time constraints. We also briefly reviewed the goals of the FG and plans for future activities. The session had over 30 participants.

Sun Hee Lee presented a "Comprehensive Case Study of Magnetosheath Pressure Pulses and Rapid MP/BS Motion": A series of density/pressure pulses in the magnetosheath and a rapid transition from the magnetosphere to solar wind were observed by MMS during intervals with solar wind discontinuities and/or radial IMF intervals. The magnetospheric responses to these transient pressure pulses are observed in the magnetic field perturbations in the inner magnetosphere from the Cluster data and ground magnetometer data. Boyi Wang presented 2-D optical observations of dayside diffuse aurora brightening associated with magnetosheath high-speed jets. The observations by south-pole station all sky imager in conjunction with THEMIS satellites shows that magnetosheath high-speed jets are associated with both diffuse and discrete aurora brightening. The average size of the diffuse aurora pattern is ~4 Re after being mapped to the equatorial plane. Katariina Nykyri presented the work of her student, Miles Bengtson, on “Global Perspective on Substorm Onset and Trigger”: they investigated ARTEMIS, THEMIS, MMS and Geotail observations and also ground based signatures, and based on timing analysis they concluded that the magnetosheath activity on the dayside (observed by MMS) triggered the substorm. They think that these magnetosheath/partial magnetopause observations and auroral imaging require more collaborative analysis, and therefore the event could be interesting for this FG in the future. Daniel Graham gave an overview of the proposed ESA mission THOR (Turbulence Heating ObserveR) to investigate turbulence in the near-Earth plasma environment, with unprecedented fields and particle measurements. THOR is designed to investigate how turbulence heats plasmas, how energy is partitioned between different particle species, and how dissipation operates in different regimes of turbulence. David Mackler presented a single MMS burst case study of a magnetosheath current sheet crossing where he identified plasma turbulence. He did this by using the Partial Variance of Increments method on fast survey flux gate magnetometer data in addition to identifying the slope and break of the power spectral density. Seth Dorfman presented the first satellite measurement of

the ULF wave growth rate in the ion foreshock (Dorfman, et. al., GRL 2017). The measured growth rate is found to fall within dispersion solver predictions during the initial growth time.

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 four sessions at the 2017 GEM summer workshop. The 1st session include presentations of recent progress on various topics of the mid-tail. The 2nd and 3rd session are a joint session with "Magnetotail Dipolarization and its Effect on the Inner Magnetosphere" and "Magnetic Reconnection in the Magnetosphere" FGs. The 4th session is a joint session with "Modeling Methods and Validation" FG on mid-tail modeling challenge.

Session 1:

Anton Artemyev presented the unique dataset gathered by two ARTEMIS spacecraft in 2010 at radial distances between lunar orbit and ~ 200 Earth radii. He identified an X-line at around ~80 Earth radii and collected statistics on hot plasma flows originating from this distant X-line. Ion spectra within these flows are well fitted by a power-law distribution with the exponential tail starting at energy ~ 2-5 keV. He estimated that the hot ion population transported toward Earth can contribute significantly to high-energy (>50keV) ion fluxes in the near-Earth magnetotail.

Fekireselassie Beyene presented his method of estimating the total amount of magnetotail flux and showed the results from a storm time and substorm time interval. He concluded that during the substorm interval the peak flux was double the minimum flux and that during the storm interval the peak flux was less than twice the minimum flux.

Lei Cheng used the 3-D Global Hybrid simulation model (ANGIE3D) to show:(1) Alfvénic waves are generated in reconnection, propagating earthward and tailward near the plasma sheet boundary layer (PSBL). (2) Alfvénic waves propagate to the north (along the direction of B) in the Northern Hemisphere and to the south (against B) in the Southern Hemisphere in the dipole-like field region.

San Lu presented the investigation of ion temperature gradient in the Earth's magnetotail using multi-spacecraft observations and 3-D global hybrid simulations. He demonstrated that the ion temperature ZGSM-profile is bell-shaped at different geocentric distances. Using 3-D global hybrid simulations, he showed that mapping of the XGSM-gradient of ion temperature along magnetic field lines produces such a bell- shaped profile.

Stefan Kiehas presented investigation of midtail flows from a five year (2011–2015) statistical survey of ARTEMIS data at around 60 RE downtail. He found that a significant portion of fast flows is directed earthward (43 % (Vx > 400 km/s) to 56 % (Vx > 100 km/s)). A dawn–dusk asymmetry in the flow occurrence is seen with about 60% of tailward perpendicular flows occurring in the dusk sector. On the other hand, earthward flows are nearly symmetrically distributed over the dawn and dusk sectors. This indicates that the dawn-dusk asymmetry is more pronounced in the near-Earth region than further downtail.

Chih-Ping Wang presented the first observational event showing the connection between an earthward moving plasma bubble in midtail at X ~ –60 R_E and equatorward moving high-latitude ground magnetic bays at ~70^o latitude. Enhancements of Pi2 waves were observed both within the plasma bubble and magnetic bays.

Session 2 and 3: The report for these two joint sessions will be submitted by Magnetic Reconnection FG.

Session 4:

Modeling challenge for an event observed ARTEMIS in the mid-tail under prolonged

N IMF from 13-14 Feb 2014. We focused on two intervals: (1) solar wind/IMF remained steady for ~4 hr. (2) IMF By changed and IMF became almost purely northward for ~1hr. Global MHD simulations of GUMICS, BATS-R-US, LFM, and OpenGGCM were conducted for this event on NASA CCMC. Additionally, higher-resolution runs were conducted for LFM (by Slava Merkin) and for OpenGGCM (by Joseph Jensen). The simulation results were compared with ARTEMIS observations in midtail and also observations in the ionosphere and ground, including flows and convection maps from SuperDARN, particle precipitations and aurora images from DMSP, field-aligned currents (FACs) from SWARM and AMPERE, and ground magnetometers.

(1) Steady solar-wind/IMF, 3-7 UT, 13 Feb 2014 ARTEMIS was in the northern lobe near the dusk flank and observed mesoscale perturbations in plasma and magnetic field. Both LFM and OpenGGCM predict mesoscale perturbations in midtail. The cross-tail configurations of GUMICS and BATS-R-US are similar to those of LFM and OpenGGCM in large scale but without mesoscale variations. The perturbations in LFM are near the flanks and likely caused by Kelvin-Helmholtz (K-H) vortices, while the perturbations in OpenGGCM are mainly in the tail current sheet associated with flapping motion. The higher-resolution OpenGGCM run does produce some flank perturbations, but it remains to be determined whether they are associated with K-H vortices. The LFM simulations (both the CCMC and high-resolution runs) qualitatively account for the mesoscale variations of Bx, n, Vx observed by ARTEMIS, and the Pc-5 perturbations observed by SuperDARN ionosphere flow velocities and ground magnetic fields. The FACs strengths from the high-resolution run are higher than the CCMC run and are closer to those of SWARM. The polar-cap size predicted by LFM is in better agreement with the aurora image from DMSP than other models.

(2) IMF By change, 18-23 UT, 14 Feb 2014 (IMF By changed from +6 to ~0 and returned to +6. IMF By was ~0 and IMF Bz ~ +4 nT from 19-21 UT)

ARTEMIS was near midnight and observed plasma sheet plasma with no significant flows, indicating that the tail plasma sheet extended beyond 60 R_E. Only OpenGGCM predicts that the tail plasma sheet remained longer than 60 R_E when IMF By became ~0. Both LFM and OpenGGCM predict small reverse convection cells on dayside high latitudes when IMF was predominantly northward, in agreement with the SuperDARN convection maps. The predictions of polar-cap size by OpenGGCM are in much better agreement with DMSP aurora images on the nightside than other models. OpenGGCM also predicts the formation of an elongated north-south structure of closed field-line region within the polar-cap after IMF By returned from ~0 after 21 UT, which is in qualitative agreement with the north-south cross polar-cap arcs observed by DMSP. The model shows that this polar-cap closed field-lines structure is connected to tail. The thermal energies for the precipitating ions and electrons within the polar-cap arcs observed by DMSP were very close to those observed by ARTEMIS, supporting the OpenGGCM predictions.

In conclusion, even for this prolonged N IMF event the midtail structures and variations predicted by the four global MHD models are very different. Using higher grid resolutions can improve some of the predictions. But it remains a big challenge to identify other factors that can help further improvement.

Magnetotail and Plasma Sheet Research Area Report

Coordinators: Andrei Runov and Matina Gkioulidou

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)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 ULF FG will cover a joint session we had together. Session 1 had talks and discussions on tail flows, injections, and MI coupling. Session 2 was devoted to event discussions. Session 3 was for general contributed talks.

1. Tail flows, injections and MI coupling

The first session was dedicated to discussion regarding the coupling of tail-ionosphere system during substorms concentrating on the link between flow bursts, injections and MI coupling during substorms. The session had 4 speakers who discussed various aspects of each phenomena. Yan Song discussed the formation of discrete aurora in ionosphere and the role of Alfven waves and parallel electric fields. Bob McPherron presented a data -model comparison of substorm dynamics tail flow bursts. Christine Gabrielse provided a comprehensive overview of the propagation and evolution of the injection region from multi point in-situ THEMIS observations and ground-based all-sky imager and riometer observations. Eric Donovan presented a detailed overview of “STEVE”, a new auroral arc identified by citizen scientists apart of the Alberta Aurora Chasers Facebook Group group working with www.Aurorasaurus.org.

2. Event discussion

Prior to the workshop, the FG co-chairs selected a substorm event (2017-3-3) based on availability of colored all-sky imager data and THEMIS satellite conjunction and asked three substorm scientists (Toshi Nishimura, Kyle Murphy and Tetsuo Motoba) to analyze the event from their viewpoints. A particular emphasis was placed on the precursor sequence of the large substorm event. In this session, they presented their interpretations of the events and opened lively discussions with the audience. All three presenters agreed that a precursor streamer and weak but distinct tail flows were present. This became the third event (among 8 events) where we had a consensus of the substorm sequence in this FG activity. However, it was noted by Kyle Murphy that the event was embedded in a geomagnetic storm and decoupling auroral activity to test causality is extremely difficult during such active events. Robert McPherron and Anna DeJong commented that this is not an SMC event but they consider this a substorm. Eric Donovan showed that equatorward moving proton aurora in this event suggested the presence of a substorm growth phase. A certain level of preceding activities was unavoidable due to the selection of a large substorm in order to address past comments from attendees that we should discuss a large event for detecting signals more definitively than those during small isolated substorms. This point may be addressed by selecting and comparing both types of events.

Another activity we had in the second session was modeling of BBFs and streamers. Robert McPherron and Mostafa El-Alaoui presented an MHD simulation of 2008-3-14 substorms and streamers. They emphasized a presence of a series of BBFs, sometimes with more than one of them aligned azimuthally. The BBFs showed tilting and

winding, originating in a dynamic X-line. They found an overall qualitative agreement with THEMIS observations of flows.

3. Contributed talks

James Weygand showed spherical elementary current (SEC) distributions and demonstrated how the SECs could be used to characterize the rate of change of the ionospheric magnetic field dB/dt during substorms. Understanding the geographical distribution of dB/dt during substorms is a key component to characterizing geomagnetically induced currents during substorms. Robert McPherron reported statistics of substorm waiting times, and bay size (amplitude and duration) using the SML index. Shin Ohtani showed an ionosphere model of PBIs and proposed ionosphere triggering of PBIs. He discussed with the audience how his model relates to magnetospheric signatures of PBIs. Grant Stephens reported an updated version of Tsyganenko magnetic field model with AL effects considered. The model magnetic field successfully reproduced substorm-time magnetic field variations. Christine Gabrielse presented a statistical study of ionospheric fast flows associated with auroral streamers. Ionospheric measurements were found powerful for characterizing 2-d structure and evolution of flow channels that are difficult to measure in space. Drew Turner showed multi-point measurements of narrow and wide injections. The last two presentations led to a discussion of potentially holding a joint session with the dipolarization FG for combining multipoint space and ground conjunction studies of 2-d injection evolution.

Magnetotail Dipolarizations and Their Impact on the Inner Magnetosphere Focus Group

Co-Chairs: Christine Gabrielse, Matina Gkioulidou, Slava Merkin, Drew Turner, and David Malaspina

The "Magnetotail Dipolarizations and their Impact on the Inner Magnetosphere" Focus Group kicked off its inaugural year with two joint sessions (combined with the Midtail and Reconnection Focus Groups, with ~ 70 attendees), two panel-led "controversy" sessions (each with ~35 attendees), and one contributed session (~45 attendees). The over-arching theme of this year's discussion was defining dipolarization, including how different scale-sizes relate and impact the magnetosphere.

The panel on the "controversy sessions" consisted of R. McPherron, J. Birn, A. Runov, S. Ohtani, M. Sitnov, X. Li, R. Wolf. Through dialogue with each other and the audience, they addressed the following questions:

1. How do you define dipolarization?
2. Is there a difference between small- and large-scale dipolarization?

a. If there is a difference, how do the two types compare/contrast?

b. If there is a difference, do the two types impact the inner magnetosphere differently? (Or similarly?) Specifically, on injections/particles?

3. How are current models doing at modeling dipolarizations (small and/or large scale)? Should they be modeled differently?
4. What key observations are required to constrain/test current models?

Definitions and Paradigms

Bob McPherron began by reminding us that the original definitions (in a 1972 Planetary and Space Science paper, and his 1979 paper) was "a return to dipolar orientation". Using GEO spacecraft, they saw each onset causes an increase in magnetic field, or "dipolarization"—data that looks very similar to what THEMIS now presents around 10 RE. Baumjohann et al. [1999] later discussed the tailward moving dipolarization front that reaches the near-Earth neutral line distance downtail about 45 minutes after onset. This definition of the "dipolarization front" differs from the "front" discussed in Nakamura et al. [2002], Sitnov et al. [2011], and Runov et al. [2009; 2011], which is the earthward-propagating boundary between the ambient plasma sheet and the hot, tenuous plasma following reconnection.

Andrei Runov expressed some regret at the word-choice, given that the terminology is now a bit confusing (not to mention the fact that a

Google search will alter the search term to "depolarization"). To reduce this confusion, he suggested to change our way of thinking regarding the phenomenon. Instead of discussing magnetic field, total magnetic field elevation angle, etc., we should discuss the phenomenon in terms of currents. He pointed out that there are clearly two, distinct current systems. One, the substorm current wedge, is responsible for the global dipolarization. The other, a local current system generated in a high beta regime, supports the "dipolarization front". This locally generated diamagnetic current flows on the boundary between rarefied, hot plasma coming from reconnection and compressed, colder plasma ahead of the front.

Runov also explained the difference between the "dipolarization front" and the "dipolarizing flux bundle". The former is the sharp boundary (about one thermal ion gyroradius thin) separating two plasma populations, whereas the latter follows the front, lasting ~40-50 seconds, and is the region where the electric field enhances. Joachim Birn also included the caveat that these events have to be sufficiently fast, agreeing that they last on the order of minutes. Tying in the Baumjohann et al. tailward-propagating front with the transient earthward-propagating front, he expressed that the earthward-propagating dipolarization event piles up in the near-Earth, transition region. He agreed that the region of enhanced Bz behind the front is the dipolarizing flux bundle (DFB), but views the flow channel behind the DFB (where the magnetic field is not enhanced) as separate. Birn explained that there is a "snowplow effect" before the front, observed as in increase in pressure, but behind the front is reduced entropy. He pointed out that most people now see the transient, small-scale dipolarization and the global dipolarization as two different stages of the same thing.

Misha Sitnov shared his observation that we usually pay attention to the final result of the process that occurs within ~9 RE, what he referred to as "substorm scale dipolarizations" lasting ~20-60 minutes. However, he noted, similar structures are seen by MMS at 25 RE. THEMIS has even observed the tailward-retreating front expanding all the way to lunar distances. Sitnov expressed his opinion that the conversation surrounding "dipolarization" is semantics; meaning, it is simply some way that the field becomes more dipolar. The method could be a front, a DFB, a substorm, or something completely different. Because the inner magnetosphere has such a large background magnetic field, he pointed out that the phenomenon is more pronounced in the particles.

Xinlin Li shared a similar view, pointing out that one can model the dispersionless injection associated with dipolarization in order to infer information about the dipolarization. Models allow for making the dipolarized region narrow or wide in order to fit the dispersion observed in injections. Shin Ohtani expressed that in the past, dipolarization was a very simple concept that simply explained that the magnetic field went from a more stretched state to a more dipolar state. He explained that using the auroral definition [e.g., Akasofu 1972; Friedrick 2001], tail stretching and ensuing dipolarization was observed as the poleward boundary moving equatorward, then expanding poleward. The magnetic field at the equator increases sharply close to Earth, then gradually farther out.

Ohtani also pointed out the conundrum of the term "dipolarization" in the near-Earth region where the intense ring current contributes to a field that is "more dipolar" than a dipole. In essence, it is strange to call something "dipolarization" when the field becomes stronger than a dipole. Continuing the topic of conundrums, and perhaps similar to points made about semantics, Ohtani expressed that it is difficult to demarcate between scale sizes: there is no clear line between "large" and "small". On the extreme "large scale", we have sawtooth events, which are larger than the substorm dipolarization for example. His preference, therefore, is to use "substorm" as part of the definition when discussing dipolarization. The original definition was a substorm-related reconfiguration of the near-Earth magnetic field, and thus a change in tail current which appears in the ionosphere and which forms the substorm current wedge.

Dick Wolf, on the other hand, agreed with Birn's analysis and distinguished between two stages in the dipolarization process. He pointed out that if the ionosphere is perfectly conducting (such that the field-line feet are fixed), a localized,

depleted flux tube will come to rest in a shortened form. It will have a different shape from the background, a downward parallel current on the eastside and upward on the westside. The equatorial motion involves just an induction electric field which doesn't map to the ionosphere. However, if the collapse is narrow across Y and conductance is finite, then parallel current leads to westward potential electric field in the ionosphere and in the equatorial plane. The ionospheric foot points move equatorward, and the equatorial crossing point moves earthward. The depleted flux bubbles take the same shape as the background. The time-integrated potential electric field is typically at least as big as the time-integrated inductive electric field. The currents map to the sides of the narrow channel in the ionosphere, and an intense potential electric field exists in the channel. This process would not work for a wide injection, as the currents would map to widely separated spots in the ionosphere. This would not result in an intense potential electric field, and therefore no strong flows.

Entropy and Bubbles

Matina Gkioulidou brought up the question of entropy and how it plays a role in bubble formation and propagation. Wolf explained that although you cannot measure entropy directly, it can still be the agent behind the physics. Ohtani shared that he was against any definition based on physics (e.g., referring to the small-scale dipolarizations as entropy "bubbles"). In such cases that the physics behind the phenomenon is later discovered to be different, the field would be stuck with an incorrectly named process. Instead, he advocated to defining phenomena based on morphology (what it looks like in the data), after which the physics can be discussed.

Runov explained that he did try to address it with observations. Using Wolf's formula for the entropy function, he found it significantly dropped behind the front. The physics is there; however, because he could not obtain concrete numbers, the study did not progress past reviewers. The conversation opened up to the idea, though, that there may be away to estimate it using multi-spacecraft data combined with models. The idea is to translate to the language of local forces (i.e., Li et al., 2011). From their work, the DFB was clearly propelled earthward by curvature force, stopping when the gradient of total pressure became comparable to the magnetic tension force. Vassilis Angelopoulos pointed out that the entropy description allows us to estimate a final state given the initial state, but it doesn't describe the forces (as the force balance does).

Misha Sitnov slightly disagreed, saying that most processes are driven by interchange such that reconnection ends up as the final point, after interchange instability. Mike Wiltberger disagreed, stating that his model shows reconnection occurring first.

The Relationship between Scale Sizes

We then shifted the topic of conversation to the relationship between scale sizes: how do they fit together? Do multiple DFBs make the large-scale, global dipolarization?

Shin Ohtani started us off by pointing to Tanskanen et al. [2002] and Akasofu [2013]. From these works, he believes that 10,000 BBFs are required to compile the energy of the substorm—meaning, the large-scale morphology cannot be simply the compilation of multiple BBFs. Angelopoulos questioned whether or not Akasofu included the thermal energy in his calculation, a question that was followed by Joachim Birn who explained that the major energy source is in the thermal speed, not flow speed. In that case, the accumulation of multiple BBFs/DFBs should suffice. McPherron agreed that his favorite idea is a cumulative effect. Sitnov, on the other hand, stated that dipolarization fronts have no relation to substorms, and that substorms have no relation to storms.

Runov emphasized his earlier point that we are dealing with two sub-systems, or two distinct plasma regimes. What happens in the magnetotail regarding dipolarization fronts may or may not be created by reconnection, it doesn't matter so much as the fact that it is a high beta regime. Time scales are different than in the low beta regime. In the high beta regime, transient structures are supported. These are connected to a local current system, which propagate earthwards, create field-aligned currents, and connect to a low beta region. The major deposit of energy

goes to heating of the local, ambient plasma. The VxB channel accelerates particles around it, which builds localized pressure inside, providing field-aligned current and connecting the low beta regime to the high beta regime.

Runov further explained that when these processes power enough to create a sustained system—and the ionosphere is responsive—then global dipolarization happens. If it isn't powerful enough, or the ionosphere is not responsive, then global dipolarization does not happen. Pointing to Mercury as an example of a planet with transient dipolarizations but no substorms nor sustained dipolarization, he suggested that the low beta regime is not involved because there is no ionosphere to maintain the current system. Meanwhile, at Earth, each DFB twists flux tubes and creates field-aligned current that the ionosphere then maintains even after the DFB is gone. This allows the time response to be much longer than the actual DFB's lifetime.

Ryan Dewey explained that currents close through Mercury's conducting core, not an ionosphere. Runov asked him if he knew why dipolarizations occur in Mercury's post-midnight sector, because at Earth they start in the pre-midnight sector. Dewey explained that the running hypothesis is that the higher concentration of sodium on Mercury's duskside could affect local reconnection rates, modifying the asymmetry.

McPherron explained that he used to think the substorm current wedge originated at the X-line. However, no current wedges form on the dayside—even though there is dayside reconnection—which is evidence that flow bursts are an essential feature. He pointed out that in his MHD simulation, he only saw two flow bursts coming in. This opened discussion on the fact that during a substorm, there are 2-3, sometimes up to 6, flow bursts, and that only 2-3 are enough for flux to build up. Runov, in response, underscored that the effect could be cumulative, BUT it has to be more than that. The process must include the currents, which will sustain the build-up.

Because most flows do not make it in to geosynchronous orbit, Ohtani was still uncomfortable with the idea. Citing Pulkkinen [1992] and Kaufmann [1987], he pointed out that most current enhancement occurs within 10 RE. Therefore, the current must somehow intensify just outside GEO…how? McPherron suggested that as the magnetic field strength goes up, the flow velocity decreases to below instrument measurement levels.

Unconvinced, Ohtani pointed to his 2006 paper that demonstrated the magnetic field at geosynchronous orbit can continue to be stretched even though Geotail observed the flow at large distances. He concluded that the magnetic field measured at GEO by GOES is determined by a more global current system. For example, in a psuedobreakup, Geotail observed the dipolarization front and fast earthward flow. Meanwhile, at GOES, the magnetic field became more stretched. Then, after substorm onset, there was dipolarization. He therefore sees localized and large-scale dipolarizations as completely different events that may have no physical connection.

This concluded Session 1.

Session 2

We began session 2 by recapping session 1, and answering an audience question about bursty bulk flows (BBFs). Angelopoulos explained that they are fast flows lasting over ten minutes with a series of distinct dipolarizations and dawn-dusk Ey. He also explained that the most efficient flux transport occurs via the DFB (75% of flux transport occurs within the BBFs). Runov further detailed the BBFs by saying that many observations have shown the cross-scale structure of the DFBs are only one to a few RE wide. In terms of plasma physics, that's a few tens ion inertial lengths.

Christine Gabrielse answered an audience question that yes, electrons can be transported all the way from the reconnection region (her 2016 and 2017 papers show the localized gradients in B from the strong, narrow front assist earthward transport by trapping electrons so they can't grad B drift out of the flow channel), although ions have different drift motions. Drew Turner expressed that all of these terms are related to the small-scale.

Using ground magnetograms, McPherron obtained substorm parameters, such as that it can expand East and West. The difficulty is that

you must know the onset time in order to do the inversion. Plus, you're looking at changes on the ground, which is an indirect observation. If the onset is isolated, it is easier to accomplish.

Entropy Part II

The discussion about entropy and how models deal with it resurfaced at this point. Sitnov shared his opinion that in a global simulation with a boundary, entropy is stable—it is decreasing with R—which makes it different than reality. Birn explained that when you compress the tail and assume some closed field boundary, you get flux tubes.

Don Mitchell shared that the phenomenology is similar at Saturn, which doesn't depend on reconnection. The field is stretched by a different mechanism. In that case, whatever preconditions the system is less important than how the system reacts to the configuration.

Sitnov's thought is that for small-scale fronts and related processes, we need to understand the source region or mechanism (such as reconnection), which can only be simulated with kinetic codes. He stresses that with MMS, it is prime time to understand what causes this ideal process that releases the stresses in the magnetotail. Although he is uncertain that we have a model that can accomplish this, he feels we have enough data to empirically put the substorm sequence together. We are now asking ourselves: What happens to dipolarization fronts when they penetrate the inner magnetosphere? No equilibrium model exists in the inner magnetosphere, so we rely on Wolf's ring current model and the quasi-static approximation. This works very well in the inner magnetosphere, and MHD works well in the tail; however, we are lacking a robust description for the transition region. One suggested solution is to utilize hybrid models, which can take energy-dependent drifts into account.

It was then pointed out that San Lu is using a hybrid code that is coupled to the transition region using PIC code, which is used to model ~7-10 RE. (However, it doesn't go farther in than that.) The resolution is as high as the computers can take.

Looking Forward

Sitnov then suggested we compare one global, one hybrid, and one PIC model for the same event to see if the resolution is enough. Anton Artemyev shared that hybrid models produce the current sheet better than kinetic models, because kinetic models are stationary. The problem is the boundary conditions: if the initial state is not correct, the model cannot produce the system's evolution. He also reminded the audience that there is no such thing as a good or bad model…but good or bad questions to ask the model.

Ohtani shared that the question we should ask is whether we can have a substorm without the ionosphere? He reminded us that before the THEMIS era, substorms were called "the two-minute problem" because the resolution of observations allowed for a two minute window of uncertainty. This window of uncertainty is what gave rise to the in-out vs. out-in interpretation of the onset phenomenology. Because of the ionosphere's importance in this, he asked whether we include the ionospheric effect well enough? What aspect(s) are we missing? How do we associate what we see in the auroral images with phenomena in the tail?

Wolf answered the first question by explaining that we cannot neglect the ionosphere: it's an active participant in the process. He also agreed with earlier points that no one model can get everything correct. McPherron agreed, pointing out from his model that conductance is essential for substorms: if conductivity is increased, bubbles can make it farther earthward.

Eric Donovan shared that as far as modeling goes, one thing that is troubling is that the simulation movies are so different than what he observes in the ionosphere. His perspective is that the movies (with all the fast flows, bubbles, and DFBs) are what happen AFTER the expansion phase occurs in the ionosphere. Learning how to reconcile what the simulations show with the 2D picture from the ionosphere is something that we should take very seriously. For instance, the simulations look very chaotic. However, in the late growth phase, things are very ordered…auroral arcs are very clear. He therefore does not see how BBFs, flux bundles, DFBs, etc. can be causal for the onset in the inner magnetosphere.

Donovan suggested that we make maps

of the magnetospheric models in the ionosphere. What would the diffuse aurora look like in the ionosphere? What would the proton aurora be doing? Then compare with the data. He also suggested that a mission with 50 spacecraft in the nightside transition region between 6-12 RE, similarly distributed, would provide the better fidelity required to explore what is really happening.

Runov shared that what he would like to see is an increased fleet of low-orbiting spacecraft equipped with high energy particle detectors and better magnetometers. These would remove the need to remote sense the magnetic configuration. This could be very powerful, but we would require auroral observations to assist with the models in order to complete a comprehensive picture.

To address the question of, "Is the auroral observation an ionospheric source or a magnetospheric source," Drew Turner suggested conjugate imagers in the Northern and Southern hemispheres. Donovan followed up by stressing that our field has really undervalued imaging. We are willing to spend millions on satellite missions, but balk at spending money on imagers.

In the spirit of forward-looking ideas, Ohtani shared that it would be great to have an EM imager: low energy, stereo imaging. The ENA image could look at the change of topology with the flux enhancement.

Contributed Talks

We had ten contributed talks that discussed dipolarization and its effect on the inner magnetosphere.

1.Sheng Tian presented on "Poynting flux at the PSBL in conjunction with the ground aurora: dipolarization at L~6". He created a new mapping perspective using a vertical and a horizontal box, where the vertical box maps to the PSBL while the horizontal box maps to the equator. He showed that the dipolarization front correlates to poynting flux in the PSBL which mapped to the ionosphere where aurora was observed. Enhancement of ion outflow occurred right after the increase in poynting flux.

2. Grant Stephens presented on "Magnetotail thinning and dipolarization during substorms: Empirical picture", using an empirical model (TS07D). He replaced uniform equatorial current sheet thickness with multiple current sheets of differing thicknesses to reproduce current sheet thinning in the growth phase. He also utilized a new field aligned current description to reproduce the Harang reversal, which proved to be critical to reproducing the substorm dipolarization. The model is not a statistical average, but a statistical average for specific events.

3. Katie Garcia-Sage presented on "Global MHD Simulations in the context of Magnetotail Stability Theory". She showed that a ridge or "hump" in Bz could form downtail, which could be interchange unstable. The ridge corresponds to fast flows at the flanks, and remains stable for a long time before going unstable. She showed that distant reconnection causes flows which break around -20 RE. On average, she sees a nice, smooth entropy profile downtail, but gets a high Cd ridge sitting at the velocity convergence. This builds up in what she calls the "flow braking region", which is at -25 RE (not at -12 RE where we typically think of flow braking).

4. Don Mitchell presented on "Ion injections inside geosynchronous orbit: charge- (not mass) dependent (quasi-) adiabatic acceleration". He found that all ion species were being energized by the same process (adiabatically). A 180 keV O ion behaves like a 180 keV H ion. The energy gain of the O6+ particles is six times that of a singly charged ion.

5. Kareem Sorathia presented "Ion Transport and Acceleration at Dipolarization Fronts: High-Resolution MHD – Test-Particle Simulations". Using Mike Wiltberger's LFM simulation, he followed particles in a convection surge (an increase in earthward flow/azimuthal EY). The inverse magnetic field gradients associated with a localized dipolarization front form magnetic islands that can trap ions in their guiding center trajectories. This trapping enables ions to propagate earthward. When he traced many particles, a core group remained at 90 degrees, even though many were pitch angle scattered. These would be able

to continue traveling earthward with the front. Looking at the phase space density evolution, he saw a transition to a kappa distribution.

6. Tetsuo Motoba presented on "Response of energetic particles to dipolarization with GEO". He discussed whether large/impulsive dipolarization electric fields are necessary for particle injections. In observations, these fields are azimuthally localized, and range from a few mV/m to tens of mV/m.

7. Andrei Runov discussed "Ion distributions within dipolarizing flux bundles (DFBs) in the near -Earth plasma sheet and the tail-dipole transition region". Using THEMIS event studies, PIC simulations, Test Particle Modeling and, he discussed how ion injections associated with DFBs may provide a free energy source for the EMIC and MS wave excitation in the inner magnetosphere because DFBs may bring 90 degree anisotropic distributions into the inner magnetosphere.

8. Yiqun Yu discussed "Effects of bursty bulk flows on large-scale current systems". She coupled MHD with ionosphere and ring current using BATSRUS, RCM, and RIM to plot field aligned current patterns. As BBFs break around -10 RE, vortices emerge in pairs on the edge of the breaking region (type 1) and in the inner magnetosphere (type 2), connecting to the substorm current wedge. BBFs continually impinge on the dipolar region and brake, disturbing the pressure distribution and field aligned currents. A new ring current is created as a result of multiple localized BBFs.

9. Xiangning Chu discussed "Magnetotail flux accumulation leading to auroral expansion and substorm current wedge: A case study". Because pressure gradient and flux tube volume are hard to obtain from in-situ observations, the SCW cannot be obtained from spacecraft. He explained that the substorm current wedge is generated by accumulated flux from the dipolarized magnetic field lines, which causes poleward expansion. Flow braking and diversion can bend field lines and generate field aligned currents.

10. Eric Donovan presented his view, in response to the earlier discussion, that it is an instability—not flux pile-up—which causes auroral brightening.

Joint Sessions with "Magnetic Reconnection in the Magnetosphere" and "Tail Environment and Dynamics at Lunar Distances" FGs

The "Magnetic Reconnection in the Magnetosphere" focus group joined with the "Tail Environment and Dynamics at Lunar Distances" and "Magnetotail Dipolarization and Its Effects on the Inner Magnetosphere" FGs on Monday afternoon at GEM this year (06/19/2017). These two joint sessions encouraged cross-focus group interaction, and open ended discussion on the topics including the onset of tail reconnection, the role of cross-tail instabilities, the difference between the tailward and earthward reconnection jets/flux bundles, the interaction of dipolarization fronts with ambient plasmas. There were approximately 70 attendees in these two joint sessions.

Vassilis Angelopoulos kicked off the first session with a tutorial talk. Vassilis provided a broad view of the observation and modeling of the nightside phenomena and substorms. Topics include the ionospheric signature, substorm current wedge (SCW), near-Earth-neutral line, current disruption versus reconnection models, external-driven versus spontaneous onset, dipolarization fronts, bursty-bulk flows (BBFs). In particular, Vassilis challenged global modelers for a quantitative assessment of the rate and intensity of BBFs, which brought up discussion on the timescale difference of BBFs and SCW. At the end of his talk, Vassilis suggested the idea of employing neural networks, to conjoint statistics of occurrence rates and characteristics from multi-mission datasets.

Misha Sitnov described the internally driven (aka spontaneous) onset of magnetotail reconnection, which is only possible - in the case of electrons magnetized initially by the normal magnetic field - when that field has a region with a tailward gradient. 3D PIC simulations of the corresponding ion tearing instability show that its distinctive features are: 1) spontaneously generated earthward plasma flows that precede the

topology change, 2) new Hall pattern, opposite to the classical quadrupole pattern near the X-line; 3) new dissipation region (j*E'>0) at the dipolarization front that may form before the X-line electron dissipation region."

Heli Hietala presented ARTEMIS two-spacecraft observations of reconnection in the presence of density asymmetry in the lunar distance magnetotail. The observations also indicate the reconnection flow channel had a finite width, of the order of 5 Earth radii.

Andrei Runov discussed kinetic properties of earthward-contracting dipolarizing flux bundles (DFBs) observed by THEMIS in the near-Earth tail and tailward progressing rapid flux transport (RFTs) enhancements observed by THEMIS in the near-tail and by ARTEMIS at lunar orbit, respectively. The DFBs and RFTs are considered as earthward and tailward ejecta from near-Earth reconnection. It was shown that whereas DFBs interacts with near-tail plasma populations and particles within DFBs gain energy from the increasing magnetic field, the RFT particles do not interact with ambient field and plasma and keep the energy gained during reconnection. The plasma state within RFTs is close to isothermal.

Joachim Birn presented a comparison of ion distributions earthward and tailward of the reconnection site, obtained by a combined MHD/test particle approach. While ions on the earthward side might experience multiple, Fermi or betatron-like, acceleration, leading to multiple beams and ring-like distributions, ions on the tailward side experience only single direct acceleration, adding a beam to an unperturbed population.

The GEM-style forum successfully stimulated active discussions between the presenters and audience, including Bob McPherron, Mostafa El Alaoui, Eric Donovan, Matina Gkioulidou, San Lu, Xiangning Chu, Chih-Ping Wang, Drew Turner, Christine Gabrielse et al.

Inner Magnetosphere Research Area Report

Coordinators: Scot Elkington and Seth Claudepierre

Storm-Time Inner Magnetosphere-Ionosphere Convection Focus Group

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

This is the fifth and final year of the Storm-time Inner Magnetosphere-Ionosphere Convection (SIMIC) Focus Group, which aims to bring together ground- and space-based observations in conjunction with numerical simulation results to to synthesize a new understanding of how plasma distributions, convection electric fields, and current systems emerge and evolve in the inner magnetosphere and conjugate ionosphere during geomagnetic storms.

We held one session with seven contributed presentations on Wednesday afternoon. Bharat Kunduri presented a statistical study of sub auroral polarization streams (SAPS) based on data from US mid-latitude SuperDARN radars collected between January 2011 and December 2014. The study shows that SAPS are observed during a wide variety of geomagnetic conditions, but the probability of their observation increased with geomagnetic activity, as parameterized by the Dst index. SAPS moved equatorward and duskward with increasing geomagnetic activity. SAPS velocities increased with geomagnetic activity, speeds increased toward dusk, and were directed increasingly poleward. Simultaneous SuperDARN and GPS TEC data showed that the location of SAPS and the midlatitude ionospheric trough coincided. Yiqun Yu presented her self-consistent electric field modeling in the RAM-SCB-E model. The calculations of the loss-cone term and the diffusion coefficient produce results that are in better agreement with observations. Binzheng Zhang demonstrated his modeling capability for the electrojet turbulence in SAPS. The electrojet turbulence model is useful for conditions with strong electric fields. Cirstian Ferradas presented the Van Allen Probes observations and modeling results for the temporal evolution of ion spectral structures near the inner edge of the plasma sheet during a geomagnetic storm. Soléne Lojosne presented a statistical study of the duration of ~200 SAPS-like events based on more than two years of $E \times B/B^2$ measurements from the two Van Allen Probes. SAPS events were identified using two signatures: a local minimum of E´B in the azimuthal direction, and location near a plasmapause boundary layer crossing (marked by a sharp decrease in spacecraft potential). The occurrence characteristics based on this data set were consistent with those derived from ground observations: most intense SAPS occurred near 21 MLT, and L decreased with increasing magnetic activity, as measured by Kp, Dst, and AE. The median duration of the observed SAPS events was ~9 h. Sebastian De Pascuale constructed a plasmasphere model by using Van Allen Probes data in the dusk sector, and a piecewise approach combining profiles of saturation, depletion, and plasmapause location, but assuming no perpendicular transport (convection) and no diurnal variation. The model can be used to produce saturated density profiles, depleted density profiles, plasmapause activity dependence, and estimated refilling rates. Jonathan Krall compared the results of the SAMI-3 plasma transport model (SAMI3/RCM) with observations from geosynchronous orbit for a 12-day interval in May 1994 characterized by a persistent magnetic storm during which a plasmasphesric plume was seen once per day during a period of elevated Kp. The modeling suggests that convection -dominated flows were responsible for near-Earth plasmasphere erosion, and that high speed field-aligned plasma flows contributed to the density peaks.

These presentations were followed by a short discussion about potential future research. An identified topic of interest is the examination of features occurring in both the ionosphere and the magnetosphere, including but not limited to the

tongue of ionization.

Because CEDAR held its 2017 Workshop during the same week, we were not able to involve colleagues from the CEDAR community as much as we did in previous years. We plan to summarize the findings within the scope of SIMIC, including relevant presentations at the upcoming AGU Fall Meeting December, in the final report of the Focus Group.

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

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

This year, our IMCEPI FG organized 3 breakout sessions with 16 presentations in total, including one session planning our Challenge topic of spacecraft charging. All sessions were well attended with more than 50 audiences in the room. The goal of our FG is to bring together researchers to address the broad questions of interest to the inner magnetosphere FG: the coupling processes across different inner magnetosphere populations and M/I systems. The three breakout sessions focused on (1) the particle dynamics in the inner magnetosphere and their coupling to the ionosphere, (2) the wave dynamics in the inner magnetosphere and effects on the particle dynamics, and (3) the challenge topic related to the ring current energy populations.

(1) Session on the particle dynamics in the inner magnetosphere and coupling to the ionosphere

We had 6 speakers presenting recent advances on the ring current energy particle dynamics from both observational and modeling perspectives. In specific, Cristian Ferradas reported the temporal evolution of ion spectral structures during a storm time through both observational and modeling methods. Chao Yue statistically studied, based on Van Allen Probes data, the pitch angle distributions for different energy protons in the inner magnetosphere and found pancake PAD, field-aligned PAD, and butterfly PAD for low-, warm-, and high-energy protons respectively. Asymmetry was also found in the equatorial plane. Philip Fernandes on the other hand showed global distribution of O+/H+ ratios as function of geomagnetic activity, again based on years of Van Allen Probes observations. Consistency as well as new distribution features was discovered as compared to earlier studies. Thiago Brito modeled ring current ions fluxes at GEO and their trajectories from plasmasheet during substorms using backward particle tracing methods and found reasonable agreement with observations. The coupling of the magnetospheric dynamics to the ionosphere, e.g., particle precipitation, is also discussed. For example, George Khazanov presented the formation of superthermal electron precipitation in the MI coupling system, and Yiqun Yu reported their recent advancement in the modeling of auroral conductance in global models with the help of magnetospheric electron precipitation.

(2) Session 2: wave dynamics in the inner magnetosphere

This session mainly focused on plasma waves in the inner magnetosphere and their impact on the plasmasphere/ring current/radiation belts. We had 6 speakers presenting various plasma waves in the magnetosphere and their effects in the magnetospheric particle dynamics. Mykhaylo Shumko reported the microburst scale sizes derived from FIREBIRD-II observations. Kyungguk Min talked about the ion Bernstein instability generated from ion ring distribution from both theoretical and modeling perspectives. Anthony Saikin statistically examined the global distribution of EMIC waves and analyzed the plasma conditions that favor the EMIC wave excitation. Zhaoguo He also analyzed the EMIC wave generation during a substorm event using multiple satellite observations. Sam Bingham talked about the seed populations of whistler mode waves during two types of storms: ICME or CIR-driven. Finally, Run Shi related the plasma injection convection with the low-frequency hiss observed in the inner magnetosphere. All the above presentations have revealed the variety and dynamics of different plasma waves and their close association with ambient plasma conditions and dynamics as well as the subsequent impact on different populations.

Discussion of the challenge topic of space-

craft charging:

We discussed our challenge topic on "spacecraft charging" that is associated with ring current particles dynamics. Since last GEM workshop, we initiated such a challenge topic and March 17, 2013 event was selected as the first event to work on. This year, several speakers shared their thoughts and stepped further, with discussion emphasizing the metric to be compared among different models.

Lutz Rastaetter firstly gave an overview of the CCMC facility on calculating the spacecraft charging using the precipitation flux at designed altitude. Then, ring current modelers from three different groups presented their own modeling capability and results. For example, Vania Jordanova presented the capability of RAM-SCB and suggested the effect metric/science predictions from moldering results. Colby Lemon reported the modeling results using the RCM-E model and compared to ring current particle observations with good agreement. Alex Glocer finally talked about CIMI model and proposed the skill scores as the measure of the performance of different ring current models.

Inputs from the audience also provided valuable discussion. For example, (a) Electric potential charging on the spacecraft is a dangerous situation, which is worthy examination; (b) A unified list of parameters to be compared between the data and the models is needed. Plans of future meetings were also discussions. A post-GEM discussion has carried out through emails and the models are currently aligned up to determine the differential flux at the same energy grids.

Quantitative Assessment of Radiation Belt Modeling (QARBM) Focus Group

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

In the 2017 GEM Summer Workshop, "Quantitative Assessment of Radiation Belt Modeling" (QARBM) Focus Group held four sessions on Wednesday June 21st and Thursday June 22nd. All of the sessions were well-attended with helpful discussions. There were 39 scheduled short talks over the 4 sessions, covering a wide range of topics, as listed below:

Session 1 - "Observations of radiation belt processes"

In the first session ten talks were presented on the observational studies of the dynamical processes in the radiation belts based on the long-term Van Allen Probes data and the new data from MMS, Lomonosov, etc. The session starts with three presentations on the long-term or statistical studies of radiation belt electrons, with topics including: the long-term perspective on outer belt electrons by comparing Van Allen Probes era with the previous two solar cycles, untangling the solar wind drivers of radiation belt using an information theoretical approach, and statistical studies on the peaks in electron phase space densities. Then the following three talks focused on the observed loss of radiation belt electrons, including detailed event studies on the radiation belt dropouts observed by Van Allen Probes to understand the underlying loss mechanisms, studies showing new signatures of ultrarelativistic electron loss in the heart of the Earth's radiation belts, and new observations of electron precipitation by the ELFIN-L instrument on Lomonosov Spacecraft. The remaining four talks in the session discussed the observed properties of various magnetospheric waves, including the statistics of low frequency hiss, estimation of the plasmasphere electron densities from hiss wave observations, the phase coherency scales of individual chorus elements and the greater chorus active region observed by Van Allen Probes and MMS, and EMIC waves observed by the Van Allen Probes.

Session 2 - "Modeling of local processes and transport"

This session focused on various plasma excitations and their detailed effects on energetic electrons. Oscillations in electron flux seen by Van Allen Probes were shown and analyzed in terms of radial diffusion processes, presumably driven by ULF waves. One talk focused on the loss of relativistic and ultra-relativistic radiation belt electrons

using quasi-linear diffusion by EMIC waves, while in another talk transport coefficients for EMIC waves were obtained directly from test particle simulations and used in a modified Fokker-Planck equation. A three-wave coupling mechanism for the generation of highly oblique chorus waves was presented, and other talks treated diffusion coefficients for such waves computationally and analytically. Particle-in-cell (PIC) simulations of the generation of magnetosonic waves were shown, as were LAPD and PIC findings of electrostatic waves generated along with whistler-mode waves. Finally, broadband electrostatic turbulence was discussed and interpreted as phase space electron holes, and diffusion coefficients analogous to those for upper band chorus waves were presented.

Session 3 - "Global modeling, metrics and validation"

This session was joint with the "Modeling Methods and Validation" FG. There were eleven presentations, with discussion emphasizing the need for metrics and validation methods that can be used to quantitatively assess the global modeling of radiation belt dynamics. The session started with an overview talk on the global radiation belt modeling, metrics and validation, an introduction on the existing and new measures of model performance, and a brief comparison between the different metrics. Following those metrics talks, modelers presented their new modeling results and expressed their interests in testing those proposed metrics with their results. One talk presented the global validation of the reduced Fokker Planck computations of radiation belts dynamics. Two talks discussed the newly developed magnetic field models, including the latest TS07D model and the event -specific magnetic field models by fitting to in-situ data. On the simulation of the radiation belt dynamics, one talk focused on simulating the electron precipitation loss observed by multiple NOAA POES satellites using a drift-diffusion model; one talk used the MHD-test particle simulation to simulate the prompt electron acceleration by the 17 March 2015 interplanetary shock; and the remaining three talks simulated the global dynamics of radiation belt electrons based on various Fokker-Planck models, such as the CIMI model with new applications of whistler wave distribution models, the UCLA 3D diffusion model in modeling diffusive transport of 100s keV electrons in the slot region, and the long-term VERB code simulation with parametrized EMIC waves.

Session 4 - "New challenge results and plans"

The final session consists of nine presentations and extensive discussion focusing on new results from multi-satellite observations and "QARBM" challenge events. One talk showed the statistical study of spatial extent of relativistic electron precipitation, and another talk discussed a statistical examination of favorable plasma conditions concerning EMIC wave excitation. Interesting wave characteristics were also presented including Langmuir waves modulated by rising-tone chorus, response of whistler mode waves to interplanetary shocks, and whistler wave growth during ICME and CIR-driven storms. Two other talks discussed the construction of electron density in the inner magnetosphere using neural network. Recent updates on the quantitative assessment of "QARBM" challenge events were presented for the "dropout" and "enhancement" events respectively. The final presentation of the session also provided an overview of the existing community resources for the challenge events, followed by an open discussion on the missing resources for the challenge events, approaches to assess modeling results with various metrics, and plans for FG activities over the next year.

Magnetosphere-Ionosphere Coupling Research Area Report

Coordinators: Marc Lessard and Shin Othani

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

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

Focus Group Background and Goal

Over the past four decades, it has become progressively more obvious that the Earth's ionosphere is a significant source of the plasma in the magnetosphere and a strong influence on the dynamics of the near earth space environment. The ionospheric source is contributing to the formation of the plasmasphere, the plasma sheet and the ring current and through wave particle interactions is playing a major role in the formation and dynamics of the radiation belts. Hence, the understanding of the strength and dynamics of the outflow of ionospheric particles up into the magnetosphere and their subsequent energization and movement is of critical importance to understanding how the magnetosphere is populated and influenced by these initially very low energy, few eV particles. These particles are transformed in energy as they move through the magnetosphere, contributing to the different major particle regions. ***Our goal is to understand the origin, energization and dynamics of these particles through both measurement and merged modeling. We want to compare these two approaches in order to build and test an accurate and successful GEM Geospace General Circulation Model that can be used in the future to predict ionosphere-magnetosphere coupled dynamics. This is the principal motivation for this proposal in support of the new GEM focus group of the same title.***

Group Activities

The focus group held two sessions at the GEM Workshop in Portsmouth Virginia on June 21st and 22nd. The Wednesday AM Session chaired by Barbara Giles focused on the ion outflow effects in the magnetosphere, plasma sheet and ring current. Merged modeling & measurement (MMS, Van Allen Probes) studies were presented. It is clear that the new measurements from both of these spacecraft will bring detailed new insight into the study of the contributions of the ionospheric source. There were an average of 47 people who attended this session. The papers presented are listed below.

<u>Wednesday Morning Session:</u>

—Barbara Giles: Overview of the Working Group Goals

—Barbara Giles:MMS Measurements/ Opportunities for Ionospheric Outflow into the Plasma Sheet

—Rick Chappell: MMS Measurements of Lobal and Polar Wind outflow into the Plasma Sheet

—Dan Welling: Magnetospheric Modeling including Ionospheric Outflow

—Lynn Kistler: When do we need to consider the solar wind as a source for oxygen in the magnetosphere?

—Jichun Zhang: Ionospheric outflow variations observed by MMS during the 23 June 2015 intense storm

—Matina Gkioulidou: Low-energy (<keV) O+ ion outflow into the inner magnetosphere: Van Allen Probes observations

—Andrew Menz: O+ enhancement observed by the Van Allen Probes

The Thursday AM Session chaired by Shasha Zou focused on ion outflow magnitude and structures generated by the ionospheric boundary conditions and the resulting regional magnetosphere effects. Merged modeling & measurement studies were also presented in this session. There were an average of 35 people in this session. The papers presented are listed below.

Thursday Morning Session:

—Shasha Zou: Overview of Ionospheric Outflow & Ionospheric Boundary Goals
—Shasha Zou: Observations of Ion Upflows
—Poorya Hosseini: Ground-based Magnetospheric Wave Measurements in Ionosphere
—Jacob Bortnik: Modeling Plasmasphere Dynamics—A Neural Network Approach
—Jonathan Krall: Plasmasphere Modeling
—Ralluca Ilie: Observations of Nitrogen Ions in the Ionospheric Outflow
—Spencer Hatch: Stormtime Alfvenic Ion Outflow & Electron Precipitation
—Robert Allen: Polar O^{6+} Observations
—Naritoshi Kitamura: Measurements from the March 4-8, 2016 Storm (Given by Sarah Vines)
—Lynn Kistler: The ESCAPE mission

Upcoming Event

The focus group will have a session at the December AGU meeting entitled "**Generation Mechanisms of Ion Upflow/Outflow and Suprathermal Particles in the Coupled Magnetosphere-Ionosphere System"**. Session ID: SA010. We look forward to seeing you at this session!

3D Ionospheric Electrodynamics Focus Group

Co-Chairs: Hyunju Connor, Haje Korth, Gang Lu, and Bin Zhang

The "3D Ionospheric Electrodynamics and Its Impact on the Magnetosphere-Ionosphere-Thermosphere Coupled System" focus group (3DMIT, 2016-2020) seeks to bring researchers together to address scientific questions of interest to the broad GEM/CEDAR community: 1) where, when, and how magnetospheric energy contributes to the IT system and 2) how the IT system feeds back to the magnetosphere.

This is the first the GEM meeting for the new 3DMIT focus group and two breakout sessions were held this year. Since it is the first year of this new focus group, we intended to set up a general view of the focus group and encouraged to initiate broad discussions on science questions with regard to various coupling pathways with in the magnetosphere-ionosphere-thermosphere system. Both sessions were relatively well attended (~30 participants in both breakout sessions) with active discussions on a range of magnetosphere-ionosphere coupling topics.

Session 1:

The first breakout session started with an introductory talk by Dr. Katie Gacia who's currently leading the Metric and Validation focus group on the challenge of ionospheric conductance for 3-D electrodynamic coupling, which is closely related to one of the focused topics of the 3DMIT focus group. Discussions suggested that future joint sessions between 3DMIT and Metric and Validation based on ionospheric conductance would advance the understandings on the electrodynamic coupling within the geospace system significantly, and we are looking forward to hold joint sessions at the next GEM workshop. Based on a coupled geospace model, Dr. Yiqun Yu showed recent advance of modeling ionospheric conductance using physics-based calculations for the diffuse auroral precipitation and compared with other types of calculations including empirical specifications and MHD parameterizations. Dr. Anna Dejong showed observational results comparing the ionospheric conditions during an SMC initiating substorm and an isolated substorm and suggesting possible feedback roles of ionospheric conductance on the substorm dynamics. After the ionospheric conductance discussions, Dr. Chigomezyo ngwira showed statistical analysis for the possible dependence of magnetosphere-ionosphere system and geomagnetic field perturbations on the dipole moment of the Earth's magnetic field. The last speaker of this session, Dr. Bharat Kunduri showed statistical analysis based on the SuperDARN observations and GPS TEC measure-

ments to characterize the relationship between the Sub-Auroral Polarization Stream (SAPS) and the mid-latitude ionospheric trough, suggesting the importance of ionospheric electrodynamics on the SAPS phenomenon.

Session 2:

In this session, we had another five speakers presenting recent advances on the understandings of dynamics magnetosphere-ionosphere-thermosphere coupling from both observational and modeling perspectives. Dr. Jun Liang showed interesting PFISR observations of electron density/ temperature variations in E- and F-region ionosphere associated with pulsating auroras in the high-latitude ionosphere. The altitudinal displacement between the peaks of electron density and temperature enhancements initiated extensive discussions on the possible mechanisms, including magnetospheric wave dynamics and electron heat flux. Dr. Marc Lessard showed most recent observational results from the Rocket Experiment for Neutral Upwelling 2 (RENU 2) to investigate the possible impacts of small-scale wave/particle dynamics on the upwelling of F-region neutral thermosphere. Discussions suggested that a combination of further data analysis and theoretical modeling would facilitate our understandings on small-scale physical processes within the coupled ionosphere-thermosphere system. Dr. Denny Oliveira used satellite observations to perform a statistical study on the several-hour global response time of the neutral thermosphere to major magnetic storms caused by CMEs, which was also consistent with previous modeling results. Dong Lin presented initial results from a global magnetosphere-ionosphere simulation to explore the possible roles of solar wind number density on the un-saturated cross polar cap potential under extreme northward IMF conditions, which is also an excellent test case for the magnetosheath force balance hypothesis describing the coupling between the solar wind and magnetosphere-ionosphere system. Our last speaker of the session, Spencer Hatch, presented statistical analysis on IMF control of Alfvénic energy transport and deposition at high-latitude ionosphere-thermosphere system using the FAST electric and magnetic field measurements, and found the statistical results are in reasonable agreement with global magnetospheric simulations which requires further investigations on the driving mechanisms.

Global System Modeling Research Area Report

Coordinators: Frank Toffoletto and Alex Glocer

Modeling Methods & Validation Focus Group

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

The Modeling Methods and Validation Focus Group held two individual sessions at the 2017 summer workshop, as well as 4 joint sessions with the ULF Wave Modeling, Dayside Kinetics, Tail Environment at Lunar Distances, and QARBM focus groups.

Monday - ULF Modeling Challenge - joint session

Report issued by ULF Wave Modeling FG

Tuesday - Dayside Kinetics Challenge - joint session

There were ~40 in attendance, with a ~ 50/50 split between attendees with a focus on modeling vs. data. Heli Hietala gave an overview of the challenge event 2015-11-18 1:50-3:00 UT. She showed data availability from Artemis (solar wind), MMS and Geotail (magnetopause), and SuperDARN (dawnward flows on dayside). The challenge will focus on accurate modeling of the magnetopause location, FTEs, and reconnection.

Heli then presented a talk from Rishi Mistry, who showed a two-hour difference in arrival times of a rotational discontinuity for two spacecraft in the solar wind separated in y. This data will be used to determine standard simulation inputs for the purpose of the challenge.

Heli next presented a talk from Andrew Dimmock about how the solar wind conditions here compare to average conditions. This event is rare in that it is driven by a large Bz without By and a density larger than average.

Tosh Nishimura spoke on ground-based observations for the challenge event. He showed that reconnection jets in the magnetosphere and magnetosheath observed with MMS lead to ionospheric flows to the north and dawn. TS01 was used for mapping.

Christine Gabrielse presented observations from THEMIS, which was in the magnetotail during this event.

Xochitl Blanco-Cano showed magnetosheath wave observations from MMS near and inside of the jet. She found higher plasma beta inside the jet and mirror mode waves from a temperature anisotropy.

Rick Wilder presented MMS observations of parallel E-fields and oblique whistler waves on the dayside separatrix.

Steve Petrinec presented MMS/HPCA observations of minor ions in FTEs and O+ ions in the sheath.

Lutz Rastaetter presented a talk from Ilja Honkonen about PAMHD, a particle-assisted MHD code. This model is implemented at its first (MHD-only) stage and will soon be run at higher resolution. Test particle and particle-in-cell modeling are being added and will be available in the near future.

Yuxi Chen presented MHD-EPIC simulations of an FTE during an idealized event.

Tuesday - Conductance Challenge

Vania Jordanova presented recent advances in the conductance specification of RAM-SCB. The code includes a self-consistent E-field, with effects from wave-particle interactions. Using an event-specific wave distribution results in stronger waves than a statistical approach. The Robinson formula is used to determine the conductance from the resulting particle precipitation. There was discussion on the advantages and disadvantages of using a conductance based on precipitation patterns vs. current.

Rob Redmon presented a talk by Ryan McGranaghan discussing a conductance calculation from DMSP observations, the GLOW model, and MSIS.

George Khazanov showed that looking only at the magnetospheric loss cone misses the ~10 eV peak in secondary electron fluxes.

Burcu Kosar showed that results from Aurorasaurus indicate visible aurora about 60% of the time at lower latitudes than what OVATION predicts.

Katherine Garcia-Sage presented a talk by Bob Robinson that indicated conductance can be determined from AMPERE results and showed the results for the challenge event Oct 13-15, 2016.

We encourage continuing participation in the first conductance challenge: Oct 13-15, 2016. Please come to present data and model results at the upcoming mini-GEM in December, and consider contributing results for upcoming model/data comparisons.

Tuesday - Mid-Tail Challenge - joint session

Report issued by Tail at Lunar Distances FG

Wednesday - QARBM - joint session

Report issued by QARBM FG

Thursday - General Validation Session

Howard Singer discussed NOAA's Metrics and Validation activities, including space weather forecasts available online. He discussed working on a plan to improve funding for operations to research and validation.

Seth Claudepierre discussed obstacles in global MHD model validation, focusing on differences between the solar wind specification at the upstream boundary and the solar wind that eventually reaches the bow shock. Higher frequency fluctuations may be filtered out, spurious density perturbations may form. He also identified the gap region inside of the Earthward boundary as a potential source of error for field line resonance modeling. He compared meteorological vs. climatological validation methods, and temporal vs. spatial ambiguity in data/model comparisons.

Dan Weimer presented the ionospheric equivalent current as a metric for comparison to data or model results. It is derived from magnetometer data and can be used to derive conductivity.

Jason Shuster showed a novel model/data comparison technique to help resolve some of the temporal/spatial ambiguity in modeling of the reconnection site.

Alexa Halford reported on the efforts of the CCMC/LWS Tracking Progress in Space Weather working team. She discussed Application Usability Levels (AULs) for tracking progress along the research to operations pipeline. The working group is soliciting information here (http://spacewx.weebly.com/tracking-progress.html) on tools and methods to be entered into a database for metrics and space weather resources. She advertised the upcoming AGU Fall Meeting panel session on this topic.

Gabor Facsko presented results of a year-long simulation of the GUMICS global MHD model. He showed simulation output at a 5 minute cadence from Jan 29, 2002 - Feb 2, 2003 compared with Cluster results, focusing on the dayside boundary locations for the solar wind vs. sheath vs magnetosphere.

Yari Collado-Vega showed results of a CCMC magnetopause location challenge for global MHD models at geosynchronous orbit. She identified uncertainties in making the comparisons based on ionospheric conductance, ring current effects, and OMNI vs. other solar wind propagation techniques.

The Magnetic Reconnection in the Magnetosphere Focus Group

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

In the final year of the Magnetic Reconnection in the Magnetosphere focus group, five sessions were convened at the summer workshop. Two sessions were individual (with approximately 50 attendees each), one was joint with the "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction" focus groups (approximately 33 attendees), and two were joint with the "Magnetic Reconnection in the Magnetosphere" focus group jointed with the "Tail Environment and Dynamics at Lunar Distances" and "Magnetotail Dipolarization and Its Effects on the Inner Magnetosphere" focus groups (approximately 83 attendees). Summaries of each session follow. The co-chairs thank the members of the GEM community that helped make the focus group sessions an intellectually stimulating environ-

ment over the course of the last five years.

Session 1 – Joint with the "Tail Environment and Dynamics at Lunar Distances" and "Magnetotail Dipolarization and Its Effects on the Inner Magnetosphere" focus groups - Monday, June 19

These two joint sessions encouraged cross-focus group interaction and open ended discussion on the topics including the onset of tail reconnection, the role of cross-tail instabilities, the difference between the tailward and earthward reconnection jets/flux bundles, the interaction of dipolarization fronts with ambient plasmas.

Vassilis Angelopoulos kicked off the first session with a tutorial talk. Vassilis provided a broad view of the observation and modeling of the nightside phenomena and substorms. Topics include the ionospheric signature, substorm current wedge (SCW), near-Earth-neutral line, current disruption versus reconnection models, external-driven versus spontaneous onset, dipolarization fronts, and bursty-bulk flows (BBFs). In particular, Vassilis challenged global modelers for a quantitative assessment of the rate and intensity of BBFs, which brought up discussion on the time-scale difference of BBFs and the SCW. At the end of his talk, Vassilis suggested employing neural networks to conjoint statistics of occurrence rates and characteristics from multi-mission datasets.

Misha Sitnov described the internally driven (spontaneous) onset of magnetotail reconnection, which is only possible - in the case of electrons magnetized initially by the normal magnetic field - when that field has a region with a tailward gradient. 3D PIC simulations of the corresponding ion tearing instability show that its distinctive features are: 1) spontaneously generated earthward plasma flows that precede the topology change, 2) new Hall pattern, opposite to the classical quadrupole pattern near the X-line; and 3) new dissipation region (j*E'>0) at the dipolarization front that may form before the X-line electron dissipation region.

Heli Hietala presented ARTEMIS two-spacecraft observations of reconnection in the presence of density asymmetry in the lunar distance magnetotail. The observations indicate the reconnection flow channel had a finite width, of the order of 5 Earth radii. Andrei Runov discussed kinetic properties of earthward-contracting dipolarizing flux bundles (DFBs) observed by THEMIS in the near-Earth tail and tailward progressing rapid flux transport (RFTs) enhancements observed by THEMIS in the near-tail and by ARTEMIS at lunar orbit, respectively. The DFBs and RFTs are considered as earthward and tailward ejecta from near-Earth reconnection. It was shown that whereas DFBs interacts with near-tail plasma populations and particles within DFBs gain energy from the increasing magnetic field, the RFT particles do not interact with ambient field and plasma and keep the energy gained during reconnection. The plasma state within RFTs is close to isothermal.

Session 2–Individual Session-Tuesday, June 20

The theme of this session was to discuss aspects of dayside magnetic reconnection, motivated both by Magnetospheric Multiscale (MMS) data and by comparisons between THEMIS observations and ionospheric signatures of dayside reconnection using SuperDARN. Richard Denton started the session by spurring discussion of how to determine the boundary normal (LMN) coordinate system when using MMS data. Observers should examine eigenvalue ratios, consistency with results using different time intervals and methods, and consistency with the geophysical context. An interesting discussion followed of how the procedure is affected when there is a guide field or drift waves and other three-dimensional effects present

Rick Wilder then showed the first direct measurement of an electron jet from symmetric reconnection in the magnetosheath. Coincident with the jet was a parallel electric field channel which acted to heat electrons, and was associated with a streaming instability and electron phase space holes. An interesting discussion of the meaning of negative J dot E followed.

Mike Shay discussed two- and three-dimensional particle-in-cell simulations of asymmetric guide field reconnection motivated by the 2015 Dec 08 MMS event (Burch Frontier event). He showed that the strongest electron heating is upstream of the magnetospheric side of the x-line, was not due to particle mixing, and is not due to 3D effects. This is an interesting contrast to the 2015 Oct 16 (Science paper) event, which was shown by

Le et al. to have significantly more heating in 3D than 2D. The guide field also breaks the symmetry between the two exhausts, which affects where drift waves are expected to arise.

Ying Zou presented two recent results of her study of the ionospheric signatures of dayside reconnection. First, she talked about efforts to infer the azimuthal spreading of magnetopause reconnection. Previous simulation studies addressed reconnection starting from a localized region and spreading in the out-of-plane direction, but whether this happens at Earth's dayside magnetopause has not been observed. Using THEMIS satellite data at the dayside magnetopause and SuperDARN radars at the conjugate ionosphere, she observed that reconnection does spread azimuthally in time and that the spreading speed is closer to the magnitude of magnetopause current carrier speed than the Alfven speed. Second, she discussed the azimuthal width of magnetopause reconnection. She combined in-situ and remote-sensing observations to reliably determine the azimuthal width of magnetopause reconnection. She used two THEMIS satellites simultaneously at the Earth's magnetopause and SuperDARN radars at the conjugate ionosphere to find that reconnection is often a few-hundred km wide in the ionosphere and a few Earth radii wide at the magnetopause.

Session 3 – Individual Session - Wednesday, June 21

Approximately half of this session was devoted to new science, and half was devoted to wrapping up the current focus group and discussing potential directions for a future focus group. Mike Shay presented kinetic PIC simulations of turbulence to determine x-line statistics. Spatial filters at the Debye length are much more effective than time averaging at removing spurious x-lines due to numerical noise. The average reconnection rate is 0.1. This could be relevant to magnetosheath reconnection.

Then, Joachim Birn presented a comparison of ion distributions earthward and tailward of the reconnection site, obtained by a combined MHD/test particle approach. While ions on the earthward side might experience multiple, Fermi or betatron-like, acceleration, leading to multiple beams and ring-like distributions, ions on the tailward side experience only single direct acceleration, adding a beam to an unperturbed population.

The potential directions for reconnection research within GEM was broad-based and truly a community effort. Rick Wilder led a discussion of topics that would be interesting in the next five years, including local waves and turbulence, kinetic differences as a function of the guide field strength, global physics including conjunctions with THEMIS, the impact of heavy ions, and energy partition during reconnection. In addition to the new opportunities afforded by MMS and its expected conjunctions with THEMIS and other spacecraft, advances in capturing kinetic effects in global magnetospheric simulations will allow new studies and comparisons with the observational data.

Misha Sitnov led a discussion about another possible topic of interest: dissipation. This is relevant to reconnection, but also more broadly to the GEM community since the magnetosphere is the main natural laboratory of collisionless plasmas. He said that understanding the collisionless dissipation remains one of the most compelling and mysterious problems in plasma physics. There are many questions that could be addressed, including: Is collisionless dissipation always linked to topology changes, and if not what are other prospective regions/mechanisms (e.g., dipolarization fronts)? What is the role of turbulence in collisionless dissipation (e.g., at the magnetopause)? How does dissipation depend on scales (ion/electron), composition, kinetic structure (velocity distributions)? What is the role of dissipation in the energy conversion and transport in the geospace?

Session 4 – Joint with the "Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction" focus groups - Thursday, June 22

This session focused on topics of mutual interest between the two focus groups. Andrey Samsonov presented an event in which a directional discontinuity characterized by a significant IMF Bz change from positive to negative (a southward turning) impacted the magnetosphere. He showed that the previously formed magnetic barrier near the magnetopause must be dissipated due to magnetosheath reconnection and this process increases the propagation time of the discontinuity through

the subsolar magnetosheath up to 14 minutes.

Sanni Hoilijoki showed that the global hybrid-Vlasov simulation model Vlasiator can be used to investigate the proton velocity distribution functions close to the dayside magnetopause reconnection region. In addition to D-shaped distributions, evolution of more complicated structures can be studied.

Joo Hwang presented MMS observations of a series of ion-scale flux transfer events. Field and particle data indicate that the current layer between an old and a new X-line is unstable to the tearing instability, generating multiple FTEs. Heli Hietala presented THEMIS observations of a magnetosheath high-speed jet triggering (local) magnetopause reconnection, as the high dynamic pressure jet compressed a thick but high-shear non-reconnecting magnetopause. These would be the first in situ observations of a process for which there has only been indirect evidence so far.

Future Directions

This was the final year for the Magnetic Reconnection in the Magnetosphere focus group. The focus group activities and accomplishments will be summarized in a separate report. Thanks in a large part to the ongoing MMS mission and the expected conjunctions with other missions including THEMIS that will take place in the near future, we suspect that a new focus group on some aspect of magnetic reconnection would have no shortage avenues for future discussion.

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" focus group (UMEA, 2016-2020) seeks to bring researchers 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 this year: two standalone and two joint with other focus groups. Sessions were well attended (e.g., ~80 participants in the first breakout session) with lively discussions on a range of ULF wave topics. Several presentations are posted on the GEM wiki.

1. UMEA update and plans, general discussion of ULF wave modeling and observations

This session began with updates on UMEA activities, including Heliophysics/Geospace System Observatory (HGSO) coordination for ULF wave studies. An overview of the 2 May 2017 Poker Flat Incoherent Scatter Radar (PFISR) conjunction event included in situ EMIC wave and precipitation measurements, ULF modulation of ionosphere electron density and conductivity, and ULF waves in ionospheric flows. Propagating structures seen in PFISR and SuperDARN could map to ULF waves seen at numerous THEMIS, Cluster, GOES, and RBSP satellites. The 2 May event is promising for understanding many aspects of global ULF wave energy transfer and will be discussed further at mini-GEM, with updated information posted to the GEM wiki.

Expanded ULF wave observation datasets were also discussed. High-time resolution (6s) SuperDARN radar measurements are providing new information about statistical distributions of ULF waves observed in the ionosphere. New releases of NOAA GOES magnetometer data will provide 20+ years of 0.512 ms measurements while an automated wave detection scheme will create an extended database of ULF wave events. High-latitude South Pole all-sky camera measurements enable investigations into ULF modulation of dayside aurora, including the relationship with Pc3 compressional waves from the ion foreshock. Finally, the theory of magnetospheric buoyancy waves was discussed, with new MHD simulations showing evidence of these waves between the plasmapause and middle plasmasheet.

2. ULF wave interactions with the radiation belts and ring current

This session focused on observations and modeling of ULF wave interactions with the radiation belt and ring current populations, with emphasis on advances that are most needed to characterize ULF wave interactions in these regions.

Picking up from the last presentation in the first session, the theory and observations of inner magnetosphere ULF waves were discussed in the context of drift mirror waves and compressional poloidal waves. Observations, theory, and simulations with realistic geometries are providing more constraints on the properties of these waves in the inner magnetosphere, with significant differences between waves in low and high Beta regimes and with/without pressure anisotropy. More observations are needed for statistical data-model comparisons.

Other presentations focused on higher frequencies, with observations indicating (1) that the relationship between plasmapause location and helium band EMIC wave activity is not as strong as previously thought and (2) that EMIC waves are commonly associated with H+ injections with no clear change in anisotropy before/after injection. 3-D simulations of radiation belt dynamics indicate that without EMIC waves, electron phase space densities are overestimated and localized loss processes cannot be reproduced. Presentations and discussion indicate the importance of constraining EMIC wave properties and generation mechanisms from observations so they can be accurately specified in models.

Finally, a presentation of global simulations of ULF waves driven by Alfven fluctuations indicate the magnetosphere can act as a bandpass filter for solar wind drivers with broadband frequency spectrum, leading to the generation of a variety of magnetospheric ULF waves that could interact with radiation belt electrons. Observations of ULF Pc5 waves and radiation belt electron fluxes near geostationary orbit indicate post-noon ULF waves are more strongly correlated with flux changes. More modeling and observation work is needed to better understand how ULF waves interact with radiation belt electrons.

3. ULF wave modeling, including CCMC modeling challenge: Joint with MMV

New results were presented from the CCMC ULF wave modeling challenge, comparing ULF wave output in different global MHD simulation codes with the same driving conditions. Several challenge events were discussed as candidates for the next stage of the ULF wave modeling challenge, including QARBM FG events with RBSP observations that could be used to validate simulated diffusion coefficients and magnetopause surface wave observations that could be used to validate simulated surface wave properties and coupling to other wave modes. Additional events were also proposed, including more recent events with global coverage from ARASE, RBSP, MMS, THEMIS, GOES, and other satellites, along with metrics to validate simulations such as azimuthal wave number measurements from GOES. UMEA plans a telecom and follow up discussion at mini-GEM.

The rest of the session included further presentations and discussion of ULF wave modeling: MHD simulations of ground magnetic perturbations and currents during pressure pulses with different IMF By conditions, comparisons between observations and models during a cavity mode event excited by an interplanetary shock, and theory of 3D Alfven resonances. These presentations and discussion highlighted the need for 3D models that can capture the system response to a range of driving conditions, along with the need for globally distributed observations to validate the models.

4. Magnetosphere-Ionosphere coupling processes associated with localized disturbances caused by dayside kinetic phenomena: Joint with “Dayside Kinetic Processes…” and “Testing proposed links…”

Dayside kinetic phenomena such as magnetosheath high speed jets and hot flow anomalies (HFA) generate localized disturbances on the magnetopause that in turn drive a range of processes in the magnetosphere and ionosphere. The session

began with an overview of global current systems and ground perturbation patterns generated by localized disturbances, including discussion of how travel time magnetoseismology can be used to infer properties of disturbances; currently, there is an ISSI team developing new magnetoseismology techniques. The next presentation provided an overview of magnetospheric ULF wave observations during different types of HFAs, with estimated scales of 5 RE on the magnetopause. Attempts to model this type of localized disturbance using ad hoc specification in global MHD simulations have been challenging.

The rest of the session included presentations showing observations of magnetosheath high speed jet induced auroral features and magnetospheric ULF waves, modeling discussion of how velocity fluctuations affect surface wave growth and scale sizes in the magnetosheath, and statistical comparisons between geostationary ULF wave period and IMF magnitude that suggest ion foreshock sources. Discussions in this session highlight the need for globally distributed observations to compare with models; these are needed to characterize the global ULF response to disturbances with different scales on the magnetopause.

Geospace Systems Science (GSS)Focus Group

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

The Geospace Systems Science Focus Group held its fourth-year sessions at the GEM Summer Workshop in Norfolk. Two sessions were held, entitled “System Science Progress” and “Periodic Events in the Magnetosphere”.

7 presentations were relevant to the topic “System Science Progress”.

Katie Raymer talked about work on the shape of the magnetosphere as governed by the solar wind. Several effects were considered, including the change in the magnetopause location caused by the opening of magnetospheric flux by dayside reconnection, particularly under conditions of low solar-wind dynamic pressure. GEOTAIL magnetopause crossings were used to parameterize the location of the magnetopause and the Heppner-Maynard boundary was discussed as a proxy for the amount of open flux in the magnetosphere.

Stephen Browett looked at the penetration of the solar-wind By magnetic field into the magnetotail and the timescales for that penetration. A penetration efficiency of about 56% was found, with typical timescales for penetration being 1 -6 hours. The penetration times are faster when the IMF is southward, and the penetration times were observed to be faster when the solar wind speed was greater.

Mikhail Sitnov talked about his work on replacing Tsyganenko-type models of the magnetospheric magnetic field with custom models that utilize magnetospheric measurements but select the data used to make a fit by similar solar-wind parameters and similar phase of the geomagnetic storm. He used 3-D binning with the parmameters vBz, SYM-H, and dSYM-H/dt for making models during geomagnetic storms. For models during substorms he used the 5-D space AL, dAL/dt, vBz, SYM-H, and dSYM-H/dt. The substorm models show the presence of a thin current sheet during the growth phase, and the models capture the occurrence of the substorm and the appearance of field-aligned currents. The substorm models have the potential to enable a global visualization of the evolution of the magnetosphere during the substorm process.

Kateriina Nykiri described work with her student Thomas Moore on the kinetic properties of Kelvin-Helmholtz physics on the magnetopause. They looked at asymmetric magnetopause processes giving rise to a hotter dawnside plasma sheet as the specific entropy increases going from the magnetosheath plasma into the plasma sheet. MHD global simulations and Cluster Kelvin-Helmholtz events were utilized. The heating of ions by kinetic Alfven waves were found to be important in the Kelvin-Helmholz processes, along with twisting of flux tubes and plasma compression by the kinetic energy of the solar wind. Times when both Kelvin-Helmholtz activity and kinetic Alfven waves were present can provide very high entropy increases.

Joe Borovsky talked about creating and analyzing a stock market of Earth measurements. Ra-

ther than describe the reaction of one geomagnetic index to changes in the solar wind, he is describing the reaction of a collection of geomagnetic indices to the solar wind, with the argument that the collection of indices better describes geomagnetic activity than does any one index. Correlations between solar-wind variances and magnetospheric variances are substantially higher in this methodology than are single index correlations, and the reaction of the magnetosphere appears to be much more linear in this stock-market methodology.

Brian Walsh and Dan Welling talked about their work on quantifying the magnitude of the effect of the plasmaspheric drainage plume on the dayside reconnection rate. They are looking to answer three questions about the plume at the magnetopause: (1) How dense is the plume plasma? (2) What is its spatial extent? and (3) Does the system reconfigure when reconnection is locally reduced? Among the tools being used is multifluid-BATSRUS, with one fluid for the hot magnetospheric plasma and a second fluid for the cold dense plasmasphere.

Shin Ohtani reported on progress funded by his GEM grant, building a circuit model for the equatorial electrojet and other parts of the magnetosphere-ionosphere system. The circuit picture yields several timescales of the reaction and damping of aspects of magnetospheric dynamics. A particularly interesting aspect of the circuit analysis is that Pi2 oscillations may occur at a time of transition from overdamping to underdamping of the magnetotail-ionosphere current systems.

2 presentations were relevant to the topic "Periodic Events in the Magnetosphere".

Lynn Kistler reported on progress funded by her GEM grant focused on the role of ionospheric outflows on the periodic sawtooth oscillations of the magnetosphere. She looked at Cluster and FAST data for periodic substorms during CME-driven geomagnetic activity and during SIR-driven geomagnetic activity. Simulation codes predict that there should be more O+ in the magnetotail during CME-driven geomagnetic activity. Using FAST, the team was looking at the ion outflows during CME substorms and CIR substorms. The dominant CME source of O+ is the nightside auroral zone: a question to be answered is whether O+ from auroral-zone outflows can come into the magnetotail where it can affect tail reconnection.

Bob McPherron reported on the durations of bays in the SML and MPB indices and on waiting-time distributions between events in the indices. Bay durations were found to occur in two populations, one population with durations less than 14 minutes and the second population with durations of greater than 14 minutes. The waiting-time distributions were shown to have a double-peaked shape, with one peak at about 52 minutes that is dominated by the occurrence of small-amplitude events and a second peak at about 156 minutes that is dominated by the occurrence of large-amplitude events.

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: please go to the web page at http://lists.igpp.ucla.edu/mailman/listinfo/gem
- 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

General Participants

The GEM 2017 Summer Workshop was held at Portsmouth, Virgina from Sunday, June 17th to Friday June, 23rd. There were 235 participants attended the workshop, including 156 Scientists, 73 Students/young scientist, and 6 guests, from over 66 institutions. Among them, there are 19 international participants (12 scientists and 7 students/young scientist) from 11 countries: Austria, Australia, Canada, China, Finland, France, Germany, Japan, South Korea, Sweden, and United Kingdom. The registration information for scientist, scientist and student participants from US shows that top five groups of most participants are from NASA, University of California Los Angeles, University of New Hampshire, University of Colorado Boulder, and University of Michigan.

Student Participants

In this year, the GEM funding supported 67 student/young scientist supports from 27 institutions in 6 countries (comparing to 68 in 2016). It is the most diversity of the student participants in recent GEM Summer Workshops. We managed to provide them full support, including air-tickets and lodging, and partial support as 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 7 students/young scientists from 5 international universities/institutes, including Canada, China, Finland, Germany, and United Kingdom.. They were supported as the US students for their travel and lodging inside the US, except for their international flights. The top three domestic universities are UNH (10), University of Michigan (9), and Univeristy Califonia Los Angeles (8). There were 6 students using their own funding to participate the workshop. They all received the partial registration fee support from GEM.

Following the suggestions of the GEM Steering Committee, all 73 graduate students supported by GEM funding were involved and present 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. 75% of the graduate students are in their 3th or higher year graduate school, but the 25% students who are in 1st and 2nd year of graduate school are also showing their involvement in research and presentable results. We are glad to see more and more students involved actively in their early graduate study.

Although we see more female students in recent years than in decades ago, there is still a large imbalance. This year we supported 47 male students and 20 female students. The imbalance between male and female students will make the existed imbalance in Space Science even worse as those students represent our future workforce. So our community should keep improving the aware-

ness of this issue and provide encouragements and support to female students.

Tutorials and Training Sessions

During the workshop week, we coordinates a variety of activities, including Student Sunday Tutorials, GEM Plenary Tutorials, Agency Reports, GEM Workshop Posters, GEM Workshop Poster Student Competition, GEM Student Invited Talk, GEM Banquet, Student Dinner, GEM Steering Committee Meeting, Ground Magnetometer Chain Workshop, SPEDAS Tutorials, and others.

As previously requested and suggested by the participants, the GEM student tutorial and training sessions are recorded with video-camera for the first time. The presentation slides and video are shared via GEM Wiki UCLA (http://aten.igpp.ucla.edu/gemwiki/index.php/Main_Page), Google Drive (https://drive.google.com/drive/folders/0BznO9ejP9Sd9fmlZWTlXTmdTUDhMR1ZqU3RreG5xRE1zM0FWRmExLUdWZThkLTFWQzFheDA), and YOUTUBE (GEM Summer Workshop Tutorials 2017, https://www.youtube.com/watch?v=XYZgItMZego&list=PL4W060x_s-Pcm3Yduil5wzLIuLFoqFFcK) to all the GEM participants with the permission of present owners.

Student Representative Report

Anthony Saikin, Suzanne Smith, and Ryan Dewey

This year 68 students attended the GEM Summer Workshop in Portsmouth, Virginia. Student Day was held on Sunday, June 17th, and featured 14 student speakers. Eleven students gave tutorials encompassing different magnetospheric regions, processes, models, and current missions. Three students introduced the incoming focus groups: "Magnetotail dipolarization and its effects on the inner magnetosphere" and "Magnetosphere-Ionosphere-Thermosphere Coupling Dynamics". Also, introduced "Dayside Kinetic Processes", which was new last year, but did not get introduced due to the CEDAR/GEM combined meeting.

This year, continuing the trend of the last 2 years, the Student Representatives hosted a panel conversation with three career scientists during the Monday night student dinner. The topic of conversation this year, "Ethics in Research", was selected after conversations with students during the 2016 Mini GEM Student Town Hall. The GEM Student Representatives would like to extend a special thank you to our panelists: Paul Cassak, Alexa Halford, and Lynn Kistler.

For the second year in a row, the Student Representatives organized and hosted the GEM Student Poster Competition. As with last year's poster competition, winners are awarded for each research area.

This year's winners were:

- **Irina Zhelavskaya** (GFZ Postdam) – Global System Modeling
- **Terry Liu** (University of California, Los Angeles) – Solar Wind - Magnetosphere Interaction
- **Boyi Wang** (University of California, Los Angeles/Boston University) - Magnetosphere - Ionosphere Coupling
- **Dong Lin** (Virginia Tech) and Michelle Salzano (University of New Hampshire) – tied for Magnetotail and Plasma Sheet
- **Mohammed Barani** (West Virginia University) – Inner Magnetosphere

This year, Ryan Dewey (University of Michigan) was elected as the next GEM Student Representative and will replace Anthony Saikin (University of New Hampshire). Ryan's term will run through the 2019 GEM workshop. Outgoing Student Representative Anthony Saikin would like to thank everyone at GEM and the GEM Steering Committee for their continued support of students, in creating a cordial environment, and for allowing the opportunity to serve the GEM community. Anthony would also like to thank his predecessors (Robert C. Allen and Lois Sarno-Smith) and the other Student Representative, Suzanne Smith (Catholic University of America), for their continued support and help during his tenure.

GEM Steering Committee

NSF Program Manager

- Michael Wiltberger

Steering Committee Regular Members (Voting Members)

- Jacob Bortnik (Chair, 2017-2019)
- Paul Cassak (Chair-elect, 2019-2021)
- Weichao Tu (2015-2018)
- Christine Gabrielse (2016-2019)
- Dan Welling (2016-2019)
- Vania Jordanova (2017-2020)
- Research Area Coordinators (see below)
- Meeting Organizer (see below)

Steering Committee Liaison Members

- Yue Deng (Liaison to CEDAR)
- Joe Borovsky (Liaison to SHINE)
- Masha Kuznetsova (Liaison to CCMC)
- Mona Kessel (Liaison to NASA)
- Howard Singer (Liaison to NOAA)
- James McCollough (Liaison to AFRL)
- Josh Rigler (Liaison to USGS)
- 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)
- Ryan Dewey (2017-2019)

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
Magnetic Reconnection in the Magnetosphere	2013-2017	Paul Cassak, Andrei Runov, Yi-Hsin Liu, Brian Walsh					●
Storm-time Inner Magnetosphere-Ionosphere Convection (SIMIC)	2013-2017	Josoph Baker, Mike Ruohoniemi, Stan Sazykin, Peter Chi, Mark Engebreston			●	●	
Geospace Systems Science	2014-2018	Joe Borovsky, Bill Lotko, Vadim Uritsky, Juan Valdivia					●
Inner Magnetosphere Cross-Energy/ Population Interactions (IMCEPI)	2014-2018	Yiqun Yu, Colby Lemon, Michael Liemohn, Jichun Zhang			●		
Quantitative Assessment of Radiation Belt Modeling (QARBM)	2014-2018	Jay Albert, Wen Li, Steve Morley, Weichao Tu			●		
Testing Proposed Links between Mesoscale Auroral and Polar Cap Dynamics and Substorms	2015-2019	Toshi Nishimura, Kyle Murphy, Emma Spanswick, Jian Yang		●			
Tail Environment and Dynamics at Lunar Distances	2015-2019	Chih-Ping Wang, Andrei Runov, David Sibeck, Slava Merkin, Yu Lin	●	●			●
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				●	
ULF wave Modeling, Effects, and Applications (UMEA)	2016-2020	Michael Hartinger, Kazue Takahashi, Brian Kress					●
Modeling Methods and Validation	2016-2020	Katherine Garcia-Sage, Mike Liemohn, Lutz Rastaetter, Rob Redmon					●
Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction	2016-2020	Heli Hietala, Xochitl Blanco-Cano, Gabor Toth, Andrew Dimmock	●				●
Magnetotail Dipolarization and Its Effects on the Inner Magnetosphere	2017-2021	Christine Gabrielse, Matina Gkioulidou, Slava Merkin, Drew Turner, David Malaspina		●	●		
3D Ionospheric Electrodynamics and Its Impact on the Magnetosphere-Ionosphere-Thermosphere Coupling System	2017-2021	Hyunju Connor, Haje Korth, Gang Lu, Bin Zhang				●	●