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The GEMstone Newsletter

Notes from the GEM Chair

Vania Jordanova

I hope this letter finds you all safe and healthy. Due to the continuing uncertainties with the COVID-19 pandemic, the GEM Steering Committee (SC) decided, similarly to last year, to once again hold a fully virtual workshop. The GEM 2021 summer workshop will occur from July 26 to July 30, with Sunday July 25 as the Student Day. We will follow the original format of GEM, with plenary sessions in the morning, Focus Group (FG) breakout sessions in the afternoon, and poster sessions in the evening. We encourage you to take this opportunity to share your research, technical efforts, and ideas with the GEM community. Although we realize that the big celebration will happen once we are able to meet in person again, this year is the 30th anniversary of the first GEM meeting and we envision a program that celebrates this significant milestone!

It was great to see so many of you at our Virtual GEM (VGEM) 2020 workshop last year. Although in a virtual setting, we were able to hear excellent tutorials prepared by our plenary speakers and updates from our agency representatives, as well as great science debates in the FG oral and poster sessions. We learned about newly selected DRIVE Science Centers (SOLSTICE, CGS, CUSIA, and MACH), and are looking forward to seeing the innovations they lead to. We started important discussions about "Decadal future and beyond" as the community prepares for the next Solar and Space Physics Decadal Survey. We continued our Under-Represented Minority (URM) discussions with a talk on "How to make your PhD program more diverse". The Student Day was a massive success with nice tutorials and several invited talks. In addition, we began much needed discussions about diversity and inclusion and mental health wellness. We were impressed by the amazing response and support from the community on these topics! As we continue these important discussions, we have posted more information about available resources on the GEM websites and on the Slack (gemworkshop.slack.com) "support-each-other" channel. I would like to thank the meeting organizers Chia-Lin Huang and Chris Mouikis and the UNH IT team, who have done a fantastic job with the organization of VGEM 2020, as well as the GEM SC and FG leaders, who have worked extremely hard to make this virtual workshop happen! It is clear that VGEM 2020 with about 700 participants (including more than 200 student registrants) was a huge success that exceeded all our expectations! We are strongly considering having a virtual component as part of GEM going forward, based on the success of VGEM 2020.

In This Issue

The changes in the GEM governance adopted during the past year have been reflected in the bylaws, including the establishment of an "Executive Council" to assist during times of crisis or emergency. The GEM SC held regular virtual meetings and the minutes from these telecons have been posted on the GEM Wiki (gem.epss.ucla.edu) to increase transparency. The SC conducted several searches; please join me in welcoming Adam Kellerman as the new GEM Vice-Chair (Chair-Elect) and Ian Cohen as the new At-Large Member of the GEM SC. In addition, we welcomed Jesse Woodroffe who became the new NASA Liaison, replacing Mona Kessel. A decision was made to stagger the terms of the Research Area Coordinators (RACs) so that a major part of the SC does not rotate off at the same time. This allows the addition to the GEM SC of new members with fresh ideas every year, while simultaneously preserving institutional memory. I would like to thank the three RACs that are rotating off this year, Matina Gkioulidou, Seth Claudepierre and Shin Ohtani, for their outstanding service over the past six years. We will open the search for new RAC positions in a few months. Please consider applying and/or nominating candidates!

The GEM community stands with the numerous professional and academic societies around the world that have pledged to support diversity, equity and inclusion (DEI). As stated in the "GEM Inclusion Statement" posted on the GEM Wiki, the GEM SC and leadership commit to being intentionally and actively anti-racist through education and best practices. To take concrete actions, we formed a GEM DEI subcommittee that crafted a mission statement and several definitions of DEI to be used as reference. The DEI subcommittee is developing a strategic plan on DEI at GEM, following NSF requirements to have a plan for recruitment of attendees underrepresented in science. Please send us any suggestions you would like to see included in it. A GEM DEI happy hour was initiated to have a friendly chat about DEI related topics in the GEM community and the world at large. To join these conversations please look for announcements in the GEM Newsletter; everyone is welcome, from students and early-career researchers to senior leaders in the field - we need all perspectives. Also, to ensure that all participants in all GEM activities have an environment that is free from harassment, GEM has adopted an "Anti-Harassment Policy", following the NSF "Sexual Harassment for Conferences" and "Conference Workshop Symposium Participant Notice", please see the GEM Wiki for further details. Finally, the loss of Sam Bingham last year resonated deeply throughout the community and showed why we need to care about mental health, and in a greater sense, for our community. We created the "Sam Bingham Community Care Initiative", to honor Sam's memory and to help the community find supportive activities at GEM. To honor the life of GEM colleagues that we have lost in recent years, we started a new GEMstone section "In Memoriam" where the community can submit a photo and a short paragraph in their memory.

This issue of the GEMstone includes reports from the Focus Groups that are part of the five Research Areas that form the GEM program, as well as reports from the GEM Liaisons who represent our connection to the worldwide space science community. We thank Allison Jaynes for compiling it. As several FGs are coming to an end this year, there will be a call for new FG proposals in the fall. We recommend that anyone interested in submitting a FG proposal reviews the advice from previous FG leaders on how to achieve a workshop style in their FG, which is available on the GEM Wiki.

We look forward to seeing you all virtually in July and please don't hesitate to reach out if you have any questions, comments, or concerns.

Notes from the GEM Program Director

Lisa Winter

Many thanks to the GEM community for all the hard work and perseverance this past year. It has been a tough year with loss and hardship. Like many of you, NSF has been in full telework mode the past year but has risen to the challenge and proposals and supplement requests are being processed as "normal". Thanks to those who served as reviewers and helped to sustain the science community in continuing to fund the science and scientists behind the work.

Congratulations to the awardees from the Magnetospheric Physics and GEM programs this year! Funded projects include studies of magnetosheath transport, M-I coupling, substorm particle injection, magnetotail particle injections, and space weather. There are a number of first-time PIs this year, including early career researchers. I'd like to extend a special congratulations to Allison Jaynes who was this year's GEM CAREER awardee! Allison is studying the connection between pulsating aurora and inner magnetospheric dynamics. She will also be creating two new programs targeting recruitment and retainment of women and under-represented minorities in STEM fields.

At NSF, several internal changes occurred during the past year. Our Geospace section head and formerly GEM program officer, Mike Wiltberger, returned to his position at HAO. Mike did a great job in both roles, and we thank him for his service to the Geospace community and wish him luck as he returns to an exciting research program! In the interim, I am currently the acting section head in addition to my role running the GEM and Magnetospheric Physics programs. We expect to be recruiting a new section head in the coming months so please reach out if you are interested in joining the team! We may also have an opening for an IPA program officer, so again reach out if you are interested and keep a look out! NSF has just been ranked the 5th best place to work in the government so consider joining our great team. Higher up the chain at NSF, there have been additional changes including our Division Director Anjuli Bamzai moving to a new role as a Senior Advisor for the Geoscience Directorate on Climate. Candace Major has joined us in the Division Director position and is doing a great job. And at the highest levels our new NSF Director Sethurman Panchanathan has now been leading the agency for the past year.

We in Geospace are very excited about a new solicitation for a Grand Challenge in Integrated Geospace. Full proposals are due August 23, which should give time to the GEM community to discuss ideas at the upcoming summer meeting. The solicitation is available here: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505884. Please reach out with any questions. We anticipate making 2-3 awards of up to $900,000 and 2-3 awards of up to $2,500,000 each. The teams must include early career researchers and we are looking for collaboration of scientists across all geospace areas. We are hoping that these awards will make substantial contributions to understanding the chain from "Sun to mud" and stimulate new collaborations and ideas.

Both the Magnetospheric Physics and GEM programs continue to accept proposals with no deadline. I anticipate the program having panels twice a year (fall and spring). Please send us your new ideas! Remember that NSF proposals are evaluated on both intellectual merit and broader impacts and if there are any questions about what makes a good broader impacts component, feel free to reach out!

Lastly, new and exciting changes may be coming to NSF. The President's 2022 budget proposes an increase to $10.7 billion for NSF, the largest proposed increase. Additionally, among the new priorities for NSF, our new Director has included climate research which is housed in large part within our Division of Atmospheric and Geospace Sciences. I encourage the GEM community to think towards how we can contribute to understanding and predicting climate given the potential opportunities and the global imperative to seeking solutions to climate change. Another important and relevant pillar for NSF priorities is inclusivity. GEM has taken this seriously by creating a DEI group and I commend the work that they and the rest of the GEM community will do to ensure that all are welcome in the geospace sciences.

Meeting Organizer Report

Chia-Lin Huang and Chris Mouikis

The 2020 GEM Summer workshop was organized in the midst of the COVID-19 pandemic. By March of 2020, the GEM Steering Committee (SC) decided to cancel the already scheduled in-person meeting in Honolulu, Hawaii. Instead, the GEM SC elected to organize the first Virtual-GEM Summer Workshop (VGEM-2020). Organizing VGEM-2020 was an enormous challenge. The objective was to not only run a series of online talks but to create a "GEMy" workshop experience. At the time, it was not clear if this was achievable. There was very little precedent of large-scale virtual meetings and with varied levels of success. Hence, the GEM SC formed an ad-hoc committee that worked tirelessly over the remaining four months with the Meeting Organizers (MO), in order to create a blueprint of a virtual meeting that would serve the GEM community the best way possible. The video conferencing was done using the Zoom platform with the full support from the University of New Hampshire Audiovisual Services department. Choosing the Slack platform for offline communications proved to be an invaluable way to keep the discussions alive after the end of each talk or session (as a reminder, at the time very few people knew about Slack). Furthermore, it created a record of all the communications and side discussions and established an open channel for future communications. In addition, a web developer was hired, who built a web site that became the "glue" of the meeting. The web site interfaced the meeting schedule with the different Zoom and Slack communications, making it intuitive to navigate through the meeting. However, the biggest success of the meeting was the overwhelming level of participation. The GEM community embraced the opportunity to come “virtually” together and to not only have a very productive meeting but also a joyful and supportive for each other experience.

VGEM-2020 Summer Workshop

The VGEM-2020 Summer Workshop took place from July 21st to the 23rd. Due to the new virtual format it was decided to run it over three days with plenary sessions starting at 11:00 am EDT, and two concurrent sessions in the afternoon. Two poster sessions and other activities were planned for the evening hours (EDT). The virtual format of the meeting allowed an unprecedented number of members of our community to participate.

There were 692 registered participants out of which 207 were students. Compared to previous in-person meetings, VGEM-2020 had more participants from smaller schools and institutes in the US, as well as more participants from international schools and institutes from across the world including underdeveloped countries. In addition, more retirees, undergraduate students, members of the CEDAR and SHINE communities and industries participated during the meeting. This time the participants had the choice to state their preferred pronounce; 401 participants identified as he/him/his, 281 as she/her/hers, 7 as they/them/theirs, 1 as ze/zir/zirs, 74 asked to use their name and 10 preferred not to answer. In addition, 92 participants identified themselves as minority in the STEM field, while 85 preferred not to answer.

From these statistics of VGEM-2020, it becomes abundantly clear that the virtual format promotes the creation and development of on an inclusive and equitable environment and that a hybrid format should be considered as a possibility for future workshops.

Graduate students and young scientists get the opportunity to present themselves and their work through the poster sessions and traditionally more than 100 posters are presented every year. Therefore, the SC decided that it was imperative to retain the poster sessions at maximum capacity. However, doing this in a meaningful way in a virtual setup required a lot of brainstorming and improvisation from the ad-hoc committee. Despite the difficulties presented due to the virtual format, two poster sessions were organized where ~100 posters were presented. Presenters were asked to upload their posters early so participants will have the chance to have a quick look and decide which posters to attend. In addition, the presenters were encouraged to also upload a video of their presentations. To achieve this, the meeting website allowed the uploading of files for each poster and the easy viewing of the uploaded material. Both sessions were well attended. Each session was divided in eight Zoom sessions where assigned hosts and moderators made sure that the posters were properly presented and most importantly that it was an engaging experience for everybody.

A number of additional sessions were organized during the meeting. The Student Day took place on July 20th and it was a half-day session with 7 student tutorial talks, two invited talks from scientists and a delightful discussion with Prof. Lou Lanzerotti talking about the history of GEM. A very successful virtual Town Hall session, “The Decadal Future and Beyond”, was organized to discuss the current understanding of Geospace, remaining gaps, and challenges, as well as the needs for future investigations. Finally, the Sam Bingham memorial event was organized to remember the tragic loss of a young scientist that was an active member of our community. This event has initiated a long overdue discussion on the wellness of our community that will be continued and systematically addressed in future meetings.

Take away points from organizing VGEM-2020:

- 2-3 times more participants than usual in-person meetings.
- The VGEM website proved to be a great way to organize the GEM workshops around.
- The Zoom sessions allowed all attendees to see the slides clearly.
- Slack provided a wonderful place for discussion and reflection, and a resource going forward.
- Slack allowed for people to join discussions from parallel sessions, at a later time.
- Uploading presentations and in particular posters early, allows for much better discussions.
- The presence of hosts/moderators for the FG sessions improved the quality of the sessions.

The plenary session tutorial talks were recorded, and the videos are available on the “NSF GEM Workshops” YouTube channel: https://www.youtube.com/channel/UChd0dRgzvr8JVIL48zHxPGA.

GEM 2020 Mini-Workshop

Due to the COVID-19 pandemic, the mini-GEM 2020 workshop was decided to be virtual as well. Traditionally, the mini-GEM workshop is collocated with the annual Fall AGU meeting and is organized the Sunday before the start of the meeting. Since the Fall AGU meeting was also virtual, the GEM SC decided to move the workshop to January

19 – 22, 2021 instead, in order to relieve the participants from the on-line meeting overload that we all experienced during this past year. There were 12 sessions organized that were spread over the four-day period. This time, each Focus Group (FG) had the responsibility to provide the video conferencing communications while the Slack channel was again used extensively for the offline communications. All sessions were well-attended and the FGs had the opportunity to communicate and coordinate their research with the GEM community.

Student Representative Report

Matthew Cooper, Agnit Mukhopadhyay, and Mei-Yun Lin

This year's virtual GEM saw a spike in student attendees. Over 180 students registered for the conference, with 123 maximum participating in Student Day. Dr. Lou Lanzerotti gave a historical perspective on the founding of the GEM consortium by the NSF. The first five tutorials following covered basic plasma physics theory, as well as the major regions of the magnetospheric system. Unlike previous years, this year's GEM tutorials also included invited speakers, as well as student solicited topics from the Town Hall at the previous mini-GEM.

Due to this year's virtual setup, we elected to forgo hosting the normal Student Dinner on Monday night. The Student Poster competition was also not held this year. The Thursday lunch that was piloted last year where the student nominees are allowed to give their 'campaign' speech also wasn't held due to disparities in time zones and the shortness of the VGEM conference itself.

The student-invited plenary speaker this year was Dr. Lauren Blum, who spoke about the launching of a geosynchronous CubeSat mission. Student volunteers aided the organizers in managing the breakout rooms for the poster sessions.

This year, Mei-Yun Lin (University of Illinois-Urbana Champagne) was elected as the next GEM student representative and will replace Matthew Cooper (New Jersey Institute of Technology). This year's student election process was run differently due to the online nature. Student nominees sent in a two paragraph bio, as well as a three minute video describing why they were running for the position. SurveyMonkey was originally used as the voting medium but had to be switched to SurveyPlanet due to registration issues. Mei-Yun's term will run through the 2022 GEM workshop. Outgoing student representative Matthew Cooper would like to thank everyone at GEM, including the VGEM organizers and support staff, the Steering Committee for its support of initiatives vital to the strengthening of GEM, and the students for their continued involvement in the GEM community. Matt would also like to thank his senior representative (Ryan Dewey) and fellow representative, Agnit Mukhopadhyay (University of Michigan), for their continued support and help during his tenure.

Solar Wind - Magnetosphere Interaction (SWMI) RA Reports

Coordinators: Steve Petrinec and Brian Walsh

Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction

Heli Hietala, Xochitl Blanco-Cano, Gabor Toth, Andrew P. Dimmock, Ying Zou

The Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction focus group held two concurrent sessions on Thursday between 1:00 pm-2:30 pm and 3:00 pm-4:30 pm ET. The sessions were well attended with a peak audience of 82 participants. Discussions took place both during the Zoom sessions and over the Slack channel.

Session 1: Thursday Concurrent Session 1 1:00pm-2:30pm ET

Andrew Dimmock (IRF, Uppsala) began the meeting with a welcome and a few updates on the focus group activities. The first was to inform everyone that the focus group period has been extended by 1 year, and the final focus group meetings are planned for the in-person summer GEM workshop in Hawaii, 2021. Secondly, details from our GEM challenge special issue in ESS-JGR were provided which contains publications of our challenge activities over the duration of the focus group.

Daniel Graham (IRF Uppsala, Sweden) provided an overview of the MMS science being conducted by the IRF Uppsala team. A wide variety of topics were discussed such as magnetic reconnection, whistler generation at quasi-perpendicular shocks, bow shock ion reflection, and electrostatic waves at the magnetopause.

Chih-ping Wang (UCLA, USA) presented a THEMIS-DMSP conjunction event to show magnetospheric processes responsible for the variations of soft electron precipitation. As shown by the three THEMIS probes, the large precipitation variations observed by DMSP were contributed by strong spatial and temporal variations in the plasma sheet cold electron fluxes, waves of three different modes (kinetic Alfven waves, ECH, and chorus waves), and upward field-aligned currents.

Brian Walsh (Boston University, USA) discussed the upcoming LEXI mission designed to place an X-ray telescope on the lunar surface to generate images of the dayside magnetopause. The project is part of the NASA Lunar Surface and Technology Payloads (LSITP) program and is scheduled for lunar deployment in 2022

Hyunju Connor (University of Alaska Fairbanks, USA) estimated neutral densities near the subsolar magnetopause using XMM-Newton X-ray observations and OpenGGCM global MHD model. The estimated neutral densities are higher during solar minimum than solar maximum, suggesting that photoionization plays an important role in this outer exosphere region.

Martin Archer (Queen Mary University of London, UK) discussed parameterizing the steepening of foreshock ULF waves into shocklets and SLAMS. He introduced an independent and dimensionless quantitative measure of wave steepening based on the tail weight of dB/dt, showing this well orders the phenomena and correlates highly to $|d\mathbf{B}|/B$ allowing future quantitative comparisons of steepening under different upstream conditions and at different environments across the solar system.

Yuxi Chen (University of Michigan, USA) presented the MHD-EPIC simulation results of the southward IMF challenge event, compared the simulation magnetic field and plasma properties with the MMS observations, and studied the evolution of the X-lines at the magnetopause.

Session 2: Thursday Concurrent Session 1 3:00pm-4:30pm ET

Hyomin Kim (New Jersey Institute of Technology, USA) presented ionospheric signatures at interhemispheric conjugate locations in response to hot flow anomalies (HFAs) observed by the MMS spacecraft near the bow shock. A series of HFA events occurred for less than an hour, of which the ground responses were shown as traveling convection vortices (TCV), EMIC waves, and ionospheric convection flow changes/enhancements with approximately 8 min delays. Solar wind and geomagnetic activities did not appear to provide favorable conditions for such dynamic signatures on the ground.

Terry Liu (UCLA, USA) presented case studies that show that magnetosheath jet-driven bow waves can accelerate ions and electrons. From a statistical study, they showed that large solar wind dynamic pressure, large plasma beta (low magnetic pressure), and large Alfven Mach number favour the formation of jet-driven bow waves. They also showed that it is common for them to accelerate particles indicating their potential contribution to the particle acceleration at the parent shock.

David Sibeck (NASA/GSFC, USA) presented observations from a time interval when the THEMIS spacecraft straddled the post-noon bow shock. The observations confirm the direct transmission of correlated foreshock cavity density and magnetic field strength variations into the magnetosheath.

Sun-Hee Lee (NASA/GSFC, USA) used Magnetospheric Multiscale (MMS) spacecraft observations to identify 23 FBs from September 2015 to January 2020. Ion intensities at energies for 5.2 to 37.4 keV are generally greater during than before or after the events, suggesting that FBs can accelerate particles to these energies.

Ahmad Lalti (IRF Uppsala, Sweden) presented MMS observations of whistler waves upstream of quasi-perpendicular bow shocks. They analysed 11 quasi-perpendicular shock crossings, all of which having a precursor wave train upstream. They characterize the precursor waves, identifying them as the whistlers mode. Then they analyze the velocity distribution function, exploring the resonance condition, and use a kinetic dispersion solver to better understand the mechanism of the generation of such waves.

Adam Michael (Applied Physics Laboratory, USA) discussed MMS observations of periodic low-frequency waves at the dawn-flank, high-latitude boundary layer on February 25, 2016, likely generated by the Kelvin-Helmholtz instability. With the global MHD magnetosphere model, GAMERA, a reinvention of the high-heritage LFM code, they show that despite the pristine slow wind impacting the magnetosphere, the high-latitude boundary layer is unstable to KHI. The waves within the global MHD model are consistent with MMS observations and occur where the IMF direction causes the draped field to be perpendicular to the flow velocity.

Particle Heating and Thermalization in Collisionless Shocks in the MMS Era

Lynn Wilson, Li-Jen Chen, Katherine Goodrich, Ivan Vasko

Session 1

Attendance: ~30+ people

Lynn Wilson: Gave a talk on the partition of energy at interplanetary shocks. The main conclusion is that electrons contribute significantly to the energy budget of low Mach number (Mf < 6) collisionless shock waves.

Terry Liu: Gave a talk on magnetic reconnection in foreshock transients showing that reconnection aided/affected the particle energization in these environments.

Vadim Roytershteyn: Gave a talk on high resolution PIC simulations showing that PIC simulations consistently underestimate the amplitude of high frequency electrostatic waves while over estimating the amplitude of quasi-static electric fields. These results are critically important to understanding particle dynamics in collisionless shocks.

Hadi Madanian: Gave a talk on the modulation of high Mach number shocks by reflected ions. The basic idea is that ion reflection induces nonstationarity rather than maintaining a stationary discontinuity in high Mach number shocks.

Ivan Vasko: Gave a talk on electrostatic solitary waves and their origin in collisionless shock waves. The work illustrates that not only are these waves not consistent with previous assumptions (i.e., they are not electron phase space holes), they likely arise indirectly from an ion/ion two stream instability.

Mike Liemohn: Gave a quick dog-and-pony show advertisement for his GEM modeling and resource group.

Session 2

Attendance: ~30+ people

Drew Turner: Gave a talk on MMS in situ observations of the formation of a collisionless shock. If correct, this would be the first time such a phenomena has been observed.

Naoki Bessho: Gave a talk on PIC simulations of magnetic reconnection occurring within a quasi-parallel collisionless shock. The idea is to test whether this phenomena is present in the Earth's quasi-parallel bow shock. So far as they can tell, it does seem like reconnection plays an important role in the energy dissipation in quasi-parallel collisionless shocks.

Andrew Dimmock: Gave a quick presentation on the Solar Orbiter working group focusing on shock waves and particle energization.

Alexandra Brosius: Gave a talk on the importance of how one implements MVA on the quality of the output results. Her work shows that one needs to take great care to determine the proper time intervals and frequency filters otherwise the results will not only be inaccurate, they can be completely misleading.

Colby Haggerty: Gave a talk on hybrid simulation work that shows really high Mach number shocks that generate cosmic rays actually start to modify the traditional Rankine-Hugoniot relations. That is, the density compression ratio can exceed 4 and the power law spectra of cosmic rays undergoing diffusive shock acceleration becomes steeper, not flatter.

Katy Goodrich: Gave an impromptu talk on some new Parker Solar Probe observations of the Cytherian bow shock. She is finding that there are more magnetic holes and double-layers within the shock than one finds at Earth, which is currently unexplained.

Session Style

An informal virtual session. People were free to ask questions as they pleased and all talks generated some good discussion.

2021 mini-VGEM

Attendance: ~30+ people

Aaron Tran: Gave a presentation on electron heating in quasi-perpendicular shocks using 1D and 2D PIC simulations specifically looking at the cross-shock electric fields. The work investigated the competition between whistler precursors and quasi-static fields in energizing the electrons across collisionless shocks and future work necessary to resolve this issue.

Lynn Wilson: Gave a short presentation on the discrepancy between observations and simulations of electric fields, based upon his recent work found at: https://doi.org/10.3389/fspas.2020.592634. The work illustrates the large divide between current PIC simulations and observations in regards to electric fields.

Savvas Raptis: Gave a presentation on magnetosheath jets close to the bow shock observed by the MMS spacecraft. The work suggests that shock ripples and SLAMS may play a role in the generation of magnetosheath jets.

Ivan Vasko: Discussed observations of electrostatic solitary waves (ESWs), measured by MMS, showing that most are actually ion phase space holes not electron holes. This is significant because prior to this, all ESWs observed outside the auroral acceleration region were assumed to be electron holes. They also showed that the holes do not propagate strictly along the magnetic field, again in contrast to previous work. These finds are important for energy dissipation in collisionless shocks.

Michael Gedalin: Discussed the issue of whether small-scale electrostatic waves could affect the cold, fast incident ion populations. The talk was based upon his recent publication found at: https://doi.org/10.3847/1538-4357/ab8af0

Open discussion: The talks were followed by a ~20 minute open discussion on outstanding problems in collisionless shock research. This involved topics of measurement limitations from spacecraft and the gap we need to bridge for closure between electric field measurements and PIC simulation results.

Session Style

An informal virtual session. People were free to ask questions as they pleased and all talks generated some good discussion.

Magnetotail and Plasma Sheet (MPS) RA Reports

Coordinators: Matina Gkioulidou and Chih-Ping Wang

Magnetotail Dipolarization and its Effects on the Inner Magnetosphere

Christine Gabrielse, Matina Gkioulidou, David Malaspina, Drew L. Turner, Slava Merkin

Goals & Objectives

The overarching goal of this focus group is to utilize both in situ and ground-based observations alongside state-of-the-art models and theory to better incorporate magnetotail dipolarizations in global stand-alone and coupled magnetospheric models, refining our conceptual models of this phenomenon and examining its impacts on the inner magnetosphere.

In our pursuit of that goal, we plan to work with the community in formulating and investigating science questions that pertain to this focus group topic and its overarching goal, some examples of which include:

1. What are the mechanisms responsible for both elementary and global magnetotail dipolarizations and are they captured by current state-of-the-art models?
2. What is the role of reconnection and/or other plasma instabilities in producing elementary magnetotail dipolarizations?
3. What is the relationship, if any exists, between elementary magnetotail dipolarizations and more global dipolarization during substorms?
4. What is the role of elementary magnetotail dipolarizations in:

- enhancements of the ring current?
- creating the seed electron population for the radiation belts?
- the generation of different wave modes (e.g., ULF, chorus, hiss, EMIC, equatorial noise, etc.) in the inner magnetosphere?

Key Activities During Summer Workshop

The summer 2020 GEM workshop was our first time running a virtual workshop with fewer sessions. We used the opportunity to regroup, refresh, and refocus. We reviewed previous workshop activity since the focus group's inception. We also solicited talks that would help direct which science questions to focus on next. Those talks were presented in the first session. We compiled the questions and forward-looking perspectives from Session 1 to use as input for discussion in Session 2. In Session 2, we also surveyed the community on what session format they would prefer to use going forward. The overarching opinion was to continue the format we had introduced early on, which was to present a "challenge question" in advance that is addressed by the community during the workshop. This was a successful format in the past that has resulted in papers that would not have been written without the focus group's structure and guidance. Using the GEM session as a place to connect data analysts and modelers to solve questions was also discussed.

Challenge questions the community discussed as important were as follows:

- PV to the gamma: Not easy to confirm with magnetic models. Heat flux across the field would violate it. Can we observe this? Models can address. Confirmed by 2D but leave out cross-tail drifts. 3D PIC could address. Ionospheric outflow/inflow could violate it too.
- Divergence of heat flux
- Field aligned currents
- Building up of dipolarization/SCW isn't over!
  - Would be important modeling challenge. RCM? PIC?
  - Observations of multiple simultaneous flows? (4-5 streamers) SCW shows build-up from mid-latitude positive bay (Pi2s)
  - Lack 2D cross-plasma sheet mission to answer this question. Idea: use NASA program to rideshare/ put additional payload on launches to more readily access space.
- How much current can be contributed to total SCW? Not all currents go to ionosphere, must close locally.
- Must be different instability to account for energy budget?

Significant Accomplishments

One significant accomplishment is our Focus Group's ability to listen to the community and provide a Focus Group that fits their needs. We heard there was confusion on terminology, so we began our Focus Group with a panel that discussed terminology. We heard there was lack of understanding on the different types of models, so the following year we had a panel of modelers explain what their models are capable of studying in terms of the physics. Next we heard that trying to debate in real-time was difficult. Although audience members have interesting and valid counter-points to a speaker, without any time to reflect and respond it is difficult to have meaningful discourse. So, we responded by creating the "Challenge Question" format, where a Challenge Question, highlighted by the community, is posed months ahead of time. Community members can address the question by submitting their talk title/ opinion about the answer. Focus Group leaders facilitate the debate by coordinating the speakers ahead of time. At the GEM meeting, speakers debate amongst each other, having had adequate time to prepare. Audience participation is very welcome. A very successful example of this is detailed below, and resulted in publications and collaborations that would not have organically formed without the Focus Group's leadership.

2021 has had some challenges, not just with Covid but with extra meetings (e.g., Helio2050) that has left the community a bit tired. We are working on determining the best use of the virtual summer 2021 GEM meeting. It may include time to discuss Decadal Survey white papers and collaboration on that. It may include addressing a Challenge Question. We are waiting for Helio2050 to conclude to feel out the community's posture for the GEM workshop in July.

We do fully intend to continue our Challenge Question format, as this format had resounding support when we asked for feedback from the community.

Community Engagement and Participation

Notes on community engagement and participation at the GEM 2020 Summer Workshop are listed below:

(i) Solicited speakers:

Session 1:

- Christine Gabrielse: Intro and review of FG activities and resulting publications
- Kareem Sorathia: The role of mesoscale injections in ring current evolution: Global MHD and test particle simulations
- Slava Merkin: Ballooning-interchange Instability at the Inner Edge of the Plasma Sheet as a Driver of Auroral Beads: High-resolution Global MHD Simulations
- Amy Keesee: Tying the reconnection region to the dipolarization front and injections
- Xiangning Chu: How much of the currents surrounding the DF are connected to the ionosphere, and contributing to a SCW?
- Louis Richard: MMS Observations of Short-Period Current Sheet Flapping
- Bob McPherron: Solar Wind Coupling and Magnetic Indices

Session 2 had no formal presentations, other than the Focus Group leaders facilitating conversation by displaying slides with the compiled questions and ideas from the solicited talks in Session 1. This resulted in a very "workshop style" conversation that gave the community the floor.

(ii) There were ~70 participants in each session

(iii) We used Slack Channel and video chat software. Session 1 set the scene and session 2 was a very interactive session that was focused on listening to the community.

(iv) We try to give early career folks a platform and facilitate the discussion so that people with different backgrounds and personality types can be heard. This was a different year, but when we invite speakers we do try to bring in underrepresented groups.

Assessment of Progress Toward Goals

We have made significant progress towards our goals. An example are the list of papers that have been presented at or have come from the GEM Focus Group, found here: https://gem.epss.ucla.edu/mediawiki/index.php/FG:_Magnetotail_Dipolarization_and_Its_Effects_on_the_Inner_Magnetosphere

A lot of interest, and therefore effort, has gone into addressing the third science topic from our proposal, "What is the relationship, if any exists, between elementary magnetotail dipolarizations and more global dipolarization during substorms?" as evidenced by the papers listed under the next question.

Significant Publications

Papers that explicitly call out the Focus Group in the acknowledgments section:

Birn, J., Liu, J., Runov, A., Kepko, L.,& Angelopoulos, V. (2019). On the contribution of dipolarizing flux bundles to the substorm current wedge and to flux and energy transport. Journal of Geophysical Research: Space Physics,124,5408-5420. https://doi.org/10.1029/2019JA026658

Ohtani, S. (2019), Substorm Energy Transport From the Magnetotail to the Nightside Ionosphere. Journal of Geophysical Research: Space Physics, 124. https://doi.org/10.1029/2019JA026964.

Nishimura, Y., L. R. Lyons, C. Gabrielse, J. M. Weygand, E. F. Donovan & V. Angelopoulos (July 2020), Relative contributions of large-scale and wedgelet currents in the substorm current wedge. Earth Planets Space 72, 106. https://doi.org/10.1186/s40623-020-01234-x

Gabrielse, C., Spanswick, E., Artemyev, A., Nishimura, Y., Runov, A., Lyons, L., et al. (July 2019). Utilizing the Heliophysics/Geospace System Observatory to understand particle injections: Their scale sizes and propagation directions. Journal of Geophysical Research: Space Physics, 124, 5584-5609. https://doi.org/10.1029/2018JA025588

Other papers that resulted from Focus Group discussions (but without explicit acknowledgment):

Merkin, V. G., Panov, E. V., Sorathia, K., & Ukhorskiy, A. Y. (Oct 2019). Contribution of bursty bulk flows to the global dipolarization of the magnetotail during an isolated substorm. Journal of Geophysical Research: Space Physics, 124, 8647-8668. https://doi.org/10.1029/2019JA026872

Ohtani, S., J. Gjerloev (August 2020), Is the Substorm Current Wedge an Ensemble of Wedgelets?: Revisit to Midlatitude Positive Bays, Journal of Geophysical Research: Space Physics, https://doi.org/10.1029/2020JA027902

A much longer list of papers that includes those that were discussed during GEM Focus Group sessions can be found here: https://gem.epss.ucla.edu/mediawiki/index.php/FG:_Magnetotail_Dipolarization_and_Its_Effects_on_the_Inner_Magnetosphere

Other Activities

Each year we also organize an AGU session on the FG topic.

In 2020, we had two oral sessions and one poster session. There was a total of 49 abstract submissions. There were 16 talks, 4 of which were invited. We utilized AGU's "poster walk" option to give poster presenters the option to orally present their poster to the broader audience, which worked well and was appreciated.

Mini-GEM 2021 continued the discussion on Challenge Questions. The following are notes taken from the meeting:
Challenge questions?
1. MHD vs kinetic instability - until recently (MMS, kinetic models) couldn't answer - Now is more feasible. Ballooning vs. firehouse etc.
2. Role of bursty transport/mesoscale DFBs in formation of substorm current wedge/global dipolarization: Do we really have consensus? Is flux pileup true? Can models explain observations? So far no - (Ground-based, near-tail, mid-tail, ...)

- So how do we answer this? More s/c coverage? More MI coupling?
- Invite ground-based/AMPERE scientists to participate: They do (e.g. Shin Ohtani & SuperMAG)
- Are we really missing observations or are we just stubborn?
- We lack directly testable physics-based questions - What physical relationship do observationalists need to check? Can theorists/modelers suggest what we can check for in the data?
- Machine learning approaches to simulate/tease out the kind of coverage we need for individual events? (e.g.

Grant Stephens and Misha Sitnov)

- FACs - volume of space is missing!
- THEMIS great but would love more s/c for FAC, dissipation determination
- TWINS could help (often projected to equatorial plane, but there are intervals of overlap between TWINS that provides 3D picture)
- What about AMPERE and existing assets?
- Note: MMS can determine current with well-designed instrument with one s/c
- IRIDIUM~800km
- Current closure happening somewhere between CS and ionosphere. (Where???)
- What happens inside the transition region? Pressure build up?
- We have global recurrent structures. Global vs. mesoscale. Can mesoscale build global?
- Do we have SCW consisting of wedgelets?
- Do we have dipolarization consisting of DFBs/flow channels? Sustained current system may not be the SCW. Different and should be distinguished, addressed observationally and with models.
- How can we pull in more community members, if this is the question everyone is interested in, how to broaden?
    - Different models, how well can we reproduce statistics? E.g. statistics of BBFs, ground-data
    - Can your model capture the known statistical behavior of the observations? This can be applied to DFBs, wedgelets-->SCW
    - Local models, global models, analytic, different types!
- SCW is a superposition of different current systems of different sense (R1--DFB, R2--pressure pileup ahead of DFB). How well do current models like GAMERA that include energy-dependent drifts and test particles reproduce this R1/R2 system? What happens with R2 system? For R1, when DFB stops it stays there. But R2 may propagate further inward, expand azimuthally quickly (from SCW expansion).

From chat box:
- Does magnetotail reconnection trigger DFs or vice versa? And How is plasma heating is related to DFs? If at all.
- DFs are magnetic signatures of a diamagnetic current that flows in the plasma gradient layer were plasma density drops significantly. Reconnection, most likely, is responsible for the formation of this plasma density gradient. Thus RX is first DF is second.

Inner MAGnetosphere (IMAG) RA Reports

Coordinators: Seth Claudepierre and Raluca Ilie

Dynamics through Multi-spacecraft and Ground-based Observations and Modeling

Hong Zhao, Lauren Blum, Sasha Ukhorskiy, Sean Fu

At the 2020 VGEM workshop, the focus group (FG), System Understanding of Radiation Belt Particle Dynamics through Multi-Spacecraft and Ground-Based Observations and Modeling, had two sessions, one featuring a panel discussion on the role of mesoscale processes in radiation belt dynamics and one focusing on the general contribution presentations. Both sessions were well attended and filled with discussions. Most presentation slides from the 2020 VGEM workshop can be found at the google drive:

https://drive.google.com/drive/folders/1Oc_bqnDBrM-B4YtJC9o9yh29WKlo1gcCz?usp=sharing

Session 1: Panel Discussion: The Role of Mesoscale Processes in the Radiation Belt Dynamics

Panelists: Kareem Sorathia, Oleksiy Agapitov, David Malaspina, Chris Crabtree, Drew Turner, and Xin An

In this session, a panel discussion on the role of mesoscale processes in the radiation belt dynamics was conducted. With over 110 participants, six panelists briefly presented their slides on their understanding and open questions on the mesoscale processes, and fruitful discussions have been conducted after their presentations. Kareem Sorathia gave a scene-setting presentation on introducing the mesoscale processes in the inner magnetosphere and discussing the mesoscale processes vs. kinetic processes. The important role of modeling in fully understanding the mesoscale processes is also discussed. Then, David Malaspina depicted the basic pictures and new understandings of mesoscale processes associated with particle flows, wave generation, and wave-particle interactions. Questions such as the relation of waves collocated with the injection structures and how to estimate the energy flowing to the particle acceleration through mesoscale processes have been raised for discussion. Chris Crabtree briefly introduced the studies on the mesoscale processes in the radiation belts at NRL. Specifically, he discussed the role of dipolarization fronts and nonlinear processes on particle acceleration. The experiment, SMART, which is expected to test the electrostatic to electromagnetic nonlinear processes in the near-Earth space environment, was also introduced. Oleksiy Agapitov focused on the comparison of quasilinear and nonlinear processes, as well as the supporting evidence from observations and the implications of the two. He suggested that, though the quasilinear theory overall fits well with the observations, nonlinear processes still play a vital role in radiation belt dynamics and could significantly affect the particle dynamics – the question is mostly on when and how. Drew Turner, focusing on the particle injections, discussed the sources of radiation belt electrons and the role of mesoscale injections in populating the radiation belts. Event studies using data from the Van Allen Probes and MMS suggested more than sufficient source for >500 keV radiation belt electrons in the plasmasheet; however, the question then comes to why very few >300 keV electron injections have been observed by the Van Allen Probes in the radiation belt region. Lastly, Xin An talked about the waves and structures around the injection fronts and focused on the observations and roles of TDSs and KAWs. Questions have been raised about how KAWs generated around the injection fronts and what are the relative contributions from these different mechanisms to the electron precipitation. The panel discussion concluded the critical role of mesoscale processes in many aspects of radiation belt studies and pointed out the future directions on exploring and quantifying the role of mesoscale processes in radiation belt dynamics.

The second part of this session consisted of three general contribution talks. Due to the high demand, all general contribution talks have been restricted to 5 minutes each. Jaya Joseph presented a case study on when the impenetrable barrier is breached using data from POES. She showed that the impenetrable barrier indeed had been breached over the past decades, and the puncture of the outer belt boundary is complicated and cannot be predicted by a single parameter alone. Rachael Filwett focused on the solar protons in the inner magnetosphere and their connection to radiation belt dynamics using data from the Van Allen Probes. Several event studies have been shown during solar proton events, and the enhanced solar proton access to the inner magnetosphere during storm times is discussed though the underlying physical mechanisms are still under investigation. Sungjun Noh talked about the upper limit of proton anisotropy in the inner magnetosphere and its relation to the EMIC waves. Combining the theoretical approach and observations from the Van Allen Probes, he concluded that the proton anisotropy usually has a clear upper bound regardless of the location, geomagnetic condition, and even the existence of the EMIC wave.

Session 2: General Contribution Presentations

In the second session for this FG, we had a large number of contributed talks. These were focused on a number of different topics, spanning new techniques in modeling efforts to data analysis combining wave and particle observations from a number of different instruments.

Luisa Capannolo, Zach Beever, Mike Shumko, Murong Qin, Arlo Johnson, and Riley Troyer all presented on the precipitation of energetic particles into Earth's atmosphere utilizing a variety of different measurement platforms including the FIREBIRD-II and AC6 CubeSats, as well as ground-based platforms including ISR and all-sky imagers. These studies included investigations of the energy spectrum, spatial extent, and scattering mechanisms driving the electron precipitation. There were also presentations examining the properties and effects of various wave modes in the inner magnetosphere. Wen Li presented on lightning-generated whistlers, Qianli Ma on the effects of the whistler-mode chorus and hiss on electron pitch angle distributions, Sasha Drozdov on the role of hiss, chorus, and EMIC waves on multi-MeV electron dynamics, and Homayan Aryan on chorus and hiss wave models. These talks explored both the detailed properties as well as the large scale impacts and combined effects of various wave modes. Finally, some modeling updates and long-term radiation belt observations were presented. Alex Boyd presented a new data product for the whole Van Allen Probes mission, combining electron fluxes from 3 instruments, and Anthony Saikin made an effort to reconstruct the radiation belts across solar cycles 17-24 (1933-2017). Modeling talks included an application of machine learning for modeling of medium energy (120-600 keV) electrons in Earth's outer radiation belt, by Artem Smirnov, and application of information theory for radiation belt electron PSD, by Simon Wing. Scot Elkington provided an update on MHD modeling efforts utilizing event-specific diffusion coefficients, and Sasha Drozdov (representing Yuri Shprits) presented a community-wide effort for the radiation belt model/forecast validation organized by International Space Weather Action Teams. Together these talks highlighted the range of radiation belt related studies ongoing in the community and the benefits of multipoint measurements for both modeling and data analysis studies to address open questions in the field.

Self-Consistent Inner Magnetospheric Modeling

Cristian Ferradas, Chao Yue, Jacob Bortnik, Qianli Ma

Session 1: Ring Current Dynamics

Our focus group activities opened up at VGEM 2020 with a session focusing on the ring current dynamics from both observational and modeling perspectives. The session consisted of two scene-setting talks followed by a discussion about the open questions in the physics of the ring current and inner magnetosphere, and three contributed talks. For our first scene-setting talk, Vania Jordanova discussed key aspects of self-consistent ring current modeling. Remaining challenges, like a better knowledge of the ion composition at the boundary of inner magnetospheric models and the implementation of self-consistent wave-particle interactions, were highlighted. Matina Gkioulidou, in charge of our second scene-setting talk, discussed key observations to guide self-consistent modeling. One needed observation that was mentioned was measurements of particle precipitation which are key to determine the ionospheric feedback to the inner magnetosphere. Following the scene-setting talks, the discussion with our speakers was centered around key questions that our focus group should aim to answer and ideas for activities in the coming years. One important conclusion from this discussion was that statistical studies of observed parameters are needed in order to get a broader picture of the statistical behavior of the inner magnetosphere and its coupling with the global magnetosphere and also to compare these results with models as a means to evaluate our current models. For our first contributed talk, Shanshan Bao discussed ring current modeling as part of a coupled magnetosphere-ionosphere-thermosphere (MIT) system. The newly developed fully two-way coupled MIT system mini-Multiscale Atmosphere-Geospace Environment (MAGE) model was presented. The next talk was given by Yiqun Yu and she discussed simulation results of the role of field line curvature (FLC) scattering in ring current ion losses. It was shown that the FLC scattering process mainly takes place on the nightside, it occurs over a wider region for oxygen ions, and precipitating ions in the tens of keV energy range can be a dominant energy source in the evening sector, thus showing that it cannot be neglected by models. Humberto Godinez gave our last contributed talk and presented on ring current estimation using Ring current Atmosphere interactions Model with Self Consistent magnetic field (B) (RAM-SCB) and Van Allen Probes data with ensemble Kalman filter data assimilation. This talk posed the question of what other data sets might be of use for assimilation for ring current models.

Session 2: Wave-Particle Interactions

Session 2 focused on the modeling and observational studies of wave-particle interactions in the space environment of ring current. This session was started with two invited scene-setting talks. Richard Denton presented an overview of self-consistent modeling of wave-particle interactions in the ring current, and Lunjin Chen presented a review of the recent modeling efforts on the electron microbursts driven by chorus. This was followed by a panel discussion about our focus group activities, and seven contributed talks covering the source of plasma waves and their effects on particles. Longzhi Gan presented the formation of electron butterfly distributions due to nonlinear interaction with chorus. The next two talks addressed the roles of cold plasma. Chao Yue presented how the electron density modulates the plasma waves and ring current ions, and Xiangning Chu presented the acceleration of cold ions and electrons near the plasmapause. Related to the topic of particle heating, Jinxin Li talked about the parallel electron acceleration by hiss in the outer plasmasphere. Sapna Shekhar gave a talk about the ring current ion nose spectra observed by TWINS, and a talk about the observation of atmospheric relativistic electron loss from the radiation belt. Finally, following the topic of wave-induced particle loss, Shreedevi Porunakatu Radhakrishna presented the ion precipitation from the inner magnetosphere by EMIC waves.

The Impact of the Cold Plasma in Magnetospheric Physics

Gian Luca Delzanno, Natalia Buzulukova, Barbara Giles, Roger Varney, Joe Borovsky

The activities have proceeded as planned in the FG proposal, where the first year was devoted to gather input from the community and raise awareness on the many impacts that cold electrons and cold ions have in magnetospheric physics. An additional goal of the FG is to facilitate better connections between the GEM and CEDAR communities.

Specifically, we have taken the following initiatives:

1) We have organized a session entitled 'Cold Plasma Populations Throughout the Geospace System' at the virtual CEDAR workshop on Friday 26th June (attendance ~100 people). The session was structured with six panelists who gave short introductory tutorials on various impacts of the cold plasma in the magnetosphere/ionosphere system. Two contributed talks were also presented and the session was closed with a group discussion soliciting input on future planning activities. The details of the session can be found here: http://cedarweb.vsp.ucar.edu/wiki/index.php/2020_Workshop:Cold_Plasma

2) We have organized a group discussion at the Virtual GEM workshop (July 21st-23rd) to plan the activities of the focus group (attendance ~100 people). The session had two scene setting talks (by Elena Kronberg and Thom Moore) and the remaining one hour of discussion with community participation was structured around the following questions:

a) What are the open questions associated with the cold-plasma in magnetospheric physics?

b) What kind of measurements are necessary to fully understand the role of the cold plasma in magnetospheric physics?

c) How do we include the impact of the cold-plasma in magnetospheric modeling, including global codes?

d) What kind of activities would you like to see carried out in this cold-plasma FG?

3) At the Virtual GEM workshop, we have organized a technical session on the 'Impact of the cold plasma in the inner magnetosphere' jointly with two more FGs ('Self-Consistent Inner Magnetospheric Modeling' and 'System Understanding of Radiation Belt Particle Dynamics through Multi-spacecraft and Ground-based Observations and Modeling'). The session consisted of two scene-setting talks (by Dan Welling and Lynn Kistler) and a series of contributed talks ranging from magnetosphere-ionosphere coupling to wave-particle interactions.

4) The IMAG tutorial at the virtual GEM workshop was given by Prof. Rick Chappell from Vanderbilt University, who was nominated by our FG. The title was 'The Impact of Ionospheric Plasma on the Magnetosphere'.

5) We have organized a virtual workshop entitled 'The Impact of the Cold Plasma Populations in the Earth's Magnetosphere' during the last week of September 2020. About 100 colleagues registered for the workshop with a total of 47 talks that covered the whole spectrum of impacts of the cold plasma in magnetospheric physics. Five one-hour-long group discussions were centered around the following topics:

a) The importance of cold electrons in magnetospheric physics

b) What do we need to know about outflow physics?

c) What would be a good set of cold plasma science targets/challenges for the community?

d) Measurement concepts: how do we measure cold ion and cold electron distribution functions?

e) Do we need a dedicated cold-plasma space mission?

The website of the workshop can be found here: https://cnls.lanl.gov/CPP20/

6) A white paper that involved most FG leaders and wide community support was submitted to the Heliophysics 2050 workshop, which is envisioned as a preliminary step to lay out a long-term science strategy in the next Decadal Survey. The title of the white paper is 'The Need to Understand the Cold-ion and Cold-electron Populations of the Earth's Magnetosphere: Their Origin, Their Controlling Factors and Their Impact on the System'.

An important component of the community input was towards identifying a set of open problems that could be posed as 'challenges' to the community, in the classic spirit of GEM. This input is still being collected and it is expected that some challenges will be formalized in the second year of the FG.

The summary of the activities described above can be found on the FG website: https://gem.epss.ucla.edu/mediawiki/index.php/FG:_The_Impact_of_the_Cold_Plasma_in_Magnetospheric_Physics#2.29_Focus_Group_discussion_on_planning_activities_for_the_next_years

Magnetosphere – Ionosphere Coupling (MIC) RA Reports

Coordinators: Shin Ohtani and Hyunju Connor

Merged Modeling &

Measurement of Injection Ionospheric Plasma into the Magnetosphere (M^3I^2) and Its Effects -- Plasma Sheet, Ring Current, Substorm Dynamics

Shasha Zou, Barbara Giles, Rick Chappell

During the 2020 virtual GEM workshop, two M3I2 oral sessions were hosted from 1 pm to 4:30 pm on July 22, 2020. There were twelve speakers from eleven different institutions, including three graduate students and two international speakers from Japan and China. About 60 participants called in the live sessions.

In the first session, following the session introduction by Rick Chappell, Alex Glocer from NASA GSFC gave the first invited presentation on merged modeling of magnetospheric plasma sources. Using the Space Weather Modeling Framework (SWMF), Alex studied the contribution of the ionospheric proton to the magnetosphere during different storm phases and how the ionospheric proton and O+ were energized. He also discussed the hemispheric asymmetry of ion outflows and plasmaspheric plumes, as well as their impact on magnetospheric dynamics, such as reconnection. The second invited talk was given by Roger Varney from SRI. Roger reviewed and summarized the progress and outstanding challenges associated with modeling ion energization and outflow, such as the influences from the thermospheric composition and neutral wind, particle precipitations, in particular soft precipitation. He also discussed the importance of Joule heating at meso scales as well as various wave-particle interactions, such as heating by BBELF waves and stochastic Alfven wave acceleration.

There were four contributed talks given during the first session: Mei-Yun Lin from UIUC discussed how the polar wind solution changed in response to the presence of N+ ions, and the data-model comparison she presented demonstrated that including the presence on N+ improved the polar wind solution significantly. She also concluded that extra energy sources, such as wave-particle interactions, could profoundly influence the upward transport of N+. Yue Chao from Peking University presented the episodic occurrence of field-aligned energetic ions on the dayside observed by the Van Allen probe, and these ions were likely from the afternoon sectors and associated with enhanced ionospheric densities, such as storm-enhanced density. Robert Albarran from Embry-Riddle Aeronautical University presented results of kinetic modeling of ionospheric outflows observed by the VISIONS sounding rockets. Using a guiding-center approximation, the model can trace large numbers of particles and evaluate particle energization in the presence of mirror and parallel electric field forces as well as wave heating. The last talk during the first session was given by Bill Lotko on behalf of Binzheng Zhang from the University of Hong Kong. They found that cusp O+ outflow along could generate magnetospheric sawtooth oscillations, and the nightside O+ outflow may not be required to induce sawtooth oscillations. In addition, they concluded that the O+ outflow-Alfvenic Poynting flux feedback loop was not necessary to induce but might facilitate sawtooth oscillations.

There were five contributed talks and one invited talk given during the second session. John Lyon from Dartmouth College presented particle tracing studies using the Gamera MHD simulation. He found that low energy cusp O+ outflow could enter the plasma sheet with energies in the keV range, and efficient energization might occur in the Bursty Bulk Flow regions. He also discussed the pitch angle distribution of the O+ tail and the grid convergence between particle tracing and global simulation. Jonathan Krall from Naval Research Laboratory gave the invited presentation focusing on data gaps of cold plasma outflows. He discussed the dependence of plasmasphere refilling on thermosphere atomic oxygen density, neutral winds, as well as exospheric hydrogen density. He then discussed the O+ shell of the plasmasphere and its relationship with ring current and H+ outflow as well as its contribution to the plasmaspheric plume in the equatorial plane. Shasha Zou from the University of Michigan presented an event analysis of the storm-enhanced density (SED) contribution to the ion upflow fluxes measured by DMSP. She concluded that the ionospheric storm phase was important for controlling the ion upflow fluxes. Chih-Ping Wang from UCLA presented the impact of soft electron precipitation on O+ upflow using the combined THEMIS and DMSP observations. He discussed the possible wave-particle interactions generating the source electrons and then potential additional energization along the precipitation trajectory. Jiaen Ren from the University of Michigan presented his recent statistical study of ion upflow and downflow observed by PFISR. He found that ion upflow over PFISR occurred twice more often on the nightside than that on the dayside. The nightside upflows were often associated with ion and electron temperature enhancements and during geomagnetic disturbances and the enhanced solar wind driving. Naritoshi Kitamura from the University of

Tokyo presented observation of cold ion outflow and the subsequent transport to the inner magnetosphere, and discussed the needed observations for future mission.

3D Ionospheric Electrodynamics and Its Impact on the Magnetosphere-Ionosphere-Thermosphere Coupled System (IEMIT)

Hyunju Connor, Doğa Öztürk, Gang Lu, Bin Zhang

The focus group titled "3D Ionospheric Electrodynamics and its impact on the Magnetosphere – Ionosphere – Thermosphere coupled system (IEMIT)" had three sessions during the 2020 vGEM Workshop. The first two sessions were stand-alone sessions, and the last session was a joint effort with the MMV FG.

IEMIT Session 1

The first session started with Dr. Bharat Kunduri's discussion of the first deep learning based approach to model dynamic variations in the Birkeland currents. Dr. Kunduri and co-authors used the AMPERE data set to investigate the response of FACs to different IMF conditions. Their predictions showed seasonal dependencies and exponential responses to abrupt changes in IMF conditions. Through this work, the team demonstrated that deep learning algorithms can improve our understanding of the coupled dynamics of the solar wind - magnetosphere - ionosphere system.

The session continued with an early-career contribution from Agnit Mukhopadhyay, in which the new Magnetosphere - Ionosphere - Thermosphere Conductance (MAGNIT) Model was introduced. In this new model developed by Agnit Mukhopadhyay and co-authors, the auroral precipitation is calculated using the global quantities obtained by field line tracing from the SWMF MHD code and the ring current model. The comparisons of the MAGNIT-SWMF simulations versus AMPERE FACs and NOAA HPI showed the importance of grid resolution, updating the loss cone variation factor, and ring current models in global modeling efforts.

Dr. Hyunju Connor followed with a presentation on chorus wave driven auroral precipitation and its importance on the ionospheric conductance. Using quasi-linear theory and a parameterized electron impact ionization model, Dr. Connor and the team showed that the lower band chorus waves produce strong dawnside Pedersen conductance patterns, which are southward and stronger than the ones produced by the electron cyclotron harmonic (ECH) waves.

The fourth talk of the session was presented by Dr. Xiao-Chen Shen, who discussed the properties of the rising and falling tone ECH waves and the conditions they occur under. Using statistical analysis of RBSP data, Dr. Shen and the team found that ECH waves have 1-2 minute periods and can span 0.26 L, with a preference of the nightside and quiet times.

Dr. Maxime Grandin presented an invited contribution on auroral proton precipitation fluxes. Dr. Grandin and the co-authors used the velocity distribution functions obtained from hybrid-Vlasov simulations and investigated the precipitation fluxes on the dayside under northward IMF and on the nightside under southward IMF conditions. Their results showed nightside proton precipitation enhancements associated with Earthward traveling dipolarizing flux bundles and dayside field-aligned proton beams as a result of lobe reconnection.

The session continued with another early-career contribution from Minghui Zhu, whose talk investigated the roles of field line curvature and EMIC wave scattering on ion precipitation and how it impacts the ionospheric electrodynamics. Minghui Zhu and the co-authors showed that ion precipitation due to FLC scattering occurred in the nightside, outer (L>4-6 Re) region in a narrow MLAT range of 60°. In comparison, they demonstrated that the ion precipitation due to EMIC wave scattering occurred in the dusk and midnight sectors on a wider MLAT range. Their results showed that proton precipitation was not negligible and significantly affected the ionospheric convection electric potential.

The seventh talk of the session was also an early-career contribution by Dong Wei on intense dB/dt variations driven by near-Earth BBFs. Dong Wei and the co-authors reported a case study using Cluster and Swarm spacecraft to identify the BBF signatures in the magnetosphere and the ionosphere. Selecting seven ground magnetometers in the close vicinity of the Cluster and Swarm ground tracks, the team showed an intense dB/dt signature associated with the BBF driven FAC system.

The last talk of the session was presented by Dr. Amy Keesee and it was on the deep learning approach to forecast ground magnetic perturbations. Dr. Keesee and the team trained neural networks with 1-minute OMNI (input) and SuperMAG (output) data to predict horizontal magnetic field perturbations, as well as dB/dt. The preliminary results showed good agreements between predictions and data. The presentation also showcased many interesting results led by various early-career researchers.

IEMIT Session 2

The second session started with Dr. Kevin Pham's contribution discussing the thermospheric impact on the magnetosphere through ion outflow. Using two different F10.7 as drivers, Dr. Pham and the co-authors showed that through increased neutral density and the corresponding increase in ion outflow, conductance gradient can show dawn-dusk asymmetries, which can significantly affect the magnetosphere. Dr. Pham also showed dawn-dusk asymmetry in ionospheric potential led to a duskward ExB drift in the magnetosheath, further contributing to the asymmetries in the magnetosphere.

The second talk of the session was an invited contribution on the coupling of magnetosphere to the thermosphere presented by Dr. Daniel Billett. Using SCANDI for neutral winds, SuperDARN for ion convection, and ESR and all-sky images to infer ionization, Dr. Billett and the team showed the timescales for thermospheric response can vary from minutes to hours depending on ionization and Joule heating.

Dr. Larry Lyons followed with a contribution on the physics of substorm longitudinal expansion. Using THEMIS ASI data, Dr. Lyons discussed how substorm onset brightening starts as beading, spreads in the E-W direction, forms a bulge and becomes the westward traveling surge. Statistically showing over 100 cases of streamers leading to the substorm onset, Dr. Lyons and the team suggest inner plasmaspheric sources, namely low entropy plasma intrusions (bubbles) as the magnetospheric-counterparts of these flow channels.

The session continued with a contribution from Dr. Jiang Liu on the dawnside auroral polarization streams. Dr. Liu discussed the conditions that give rise to DAPS, and demonstrated examples of this phenomenon using DMSP, Swarm, and all-sky imager data. In addition, Dr. Liu and the team suggested that the close proximity of DAPS to Omega bands can be explained by both phenomena being related to fast flows in the magnetotail, which can lead to interchange or KH instabilities.

Dr. Leslie Lamarche contributed with the RISR observations of ion heating in the polar cap and a discussion on whether these observations can be explained by models. Dr. Lamarche and team used SuperDARN and AMPERE measurements to drive the IPWM, and compared the results with RISR observations of ion temperature. Their results showed that factors important for ion heating are not fully captured with global and large-scale driving.

The following contribution was on the F-region ionospheric variability across both polar caps, and was presented by Dr. Alex Chartier. Using MIDAS TEC data, Dr. Chartier and the team identified a larger range of TEC variability in January than July for both polar caps. The statistical analysis of the TEC data also demonstrated that the southern polar cap was more variable overall. Using the SAMI3 model, Dr. Chartier and the team identified globally higher ionospheric density in January (than July) and the longer plasma lifetimes in the northern winter hemisphere as the reasons for the larger TEC variability range.

Dr. Beket Tulegenov presented the last contribution of the session. Using DMSP observations and the coupled OpenGGCM-CTIM-RCM simulations, Dr. Tulegenov and the co-authors investigated the behaviour of the open closed field boundary during a storm. Their results showed that OCB location had an MLT dependence and unevenly expanded as the magnetic storm intensified. They also highlighted that a full MLT coverage was needed for better validation of the simulation results.

IEMIT-MMV Joint Session

The joint session opened with the GEM ionospheric conductance challenge activity report presented by Dr. Hyunju Connor. The ionospheric conductance challenge aims to advance global and local physics based models of the ionospheric conductance, in addition to aid with validation and uncertainty quantification of different models. Dr. Connor also presented the EOS article and the LWS FST input prepared by the team, as well as the challenge and review papers under preparation.

Dr. Mike Liemohn presented a case for improving the Robinson formulas especially for extreme events by using larger data sets. Dr. Liemohn provided a recap of the work that has been done on conductance modeling since 1987 and pointed out that a larger data set needs to be used especially to better predict extreme events.

The session followed with an invited presentation by Dr. Bob Robinson, in which Dr. Robinson summarized the efforts on advancing the specification of auroral precipitation and high-latitude electrodynamics. The talk spanned the activities of CCMC, COSPAR, and CEDAR-GEM working teams. Dr. Robinson reiterated the importance and timeliness of utilizing the global observations to construct a ground-truth database to routinely specify and validate the parameters for auroral electrodynamics.

The next talk was an invited presentation from Dr. Ryan McGranaghan, who provided an overview of the ISSI team (https://www.issibern.ch/teams/multigeopartransfer/) "Novel approaches to multiscale geospace particle transfer: Improved understanding and prediction through uncertainty quantification and machine learning." The activity report included progress made on particle precipitation, ion outflow, and the impact on conductance. Dr. McGranaghan and the team focus on understanding the characteristics of particle precipitation using machine learning algorithms in order to capture and quantify meso-scale effects. Dr. McGranaghan concluded by emphasizing two important points about using machine learning for the geospace environment, which are (i) that the standard metrics are often insufficient, (ii) the ML and physics are not mutually exclusive.

The session continued with an early career contribution by Agnit Mukhopadhyay on the ionospheric control of space weather forecasts. Agnit Mukhopadhyay and co-authors presented a new conductance model called CMEE that is derived using a larger data set and corrections for auroral oval location. The Heidke skill score for the CMEE-SWMF results showed a general improvement in resolving dB/dt values.

Dr. Dong Lin followed with a presentation on diffuse electron precipitation effects on SAPS for the challenge event of 17 March 2013. By using the integrated precipitation model, which utilizes mono-energetic electron precipitation from GAMERA and diffuse electron precipitation from RCM, the mini-MAGE simulations achieved a good agreement with DMSP measurements. Dr. Lin and co-authors emphasized the importance of accurate characterization of ring current, plasmasphere, and diffuse precipitation for better resolving meso-scale structures essential for MIT coupling.

Dr. Christine Gabrielse presented a study on inferring energy flux and conductance from all-sky imagers for the challenge event of 17 March 2013. Motivated by the inability of models to reproduce enhanced conductance observations during the storm main phase, Dr. Gabrielse and the team used high cadence THEMIS all-sky imagers to resolve meso-scale structures that contribute to Hall and Pedersen conductances. Dr. Gabrielse and the team will continue working on determining characteristic scale sizes important for energy deposition and separating the diffuse and discrete aurora using ASIs.

The last talk of the session was another early-career contribution by Xingbin Tian. The presentation focused on the effects of ion precipitation on the height-dependent ionization and conductivity during the challenge event of 17 March 2013. Using RAM-SCB and GLOW models, Xingbin Tian and co-authors simulated proton precipitation from two loss mechanisms, FLC and EMIC wave scattering and showed the importance of proton precipitation for ionospheric electrodynamics especially in the dusk sector.

All talks were followed by discussions on Zoom and Slack channels. As conveners, we want to acknowledge our student volunteers Jaewoong Jung, Agnit Mukhopadhyay, and Dillon Gillespie, who helped tremendously with the moderation of the three sessions. We also want to thank our presenters and participants for such engaging contributions.

Interhemispheric Approaches to Understand M-I Coupling (IHMIC)

Hyomin Kim, Robert Lysak, and Tomoko Matsuo

The Interhemispheric approach to understand M-I Coupling (IHMIC) focus group organized two sessions on July 23 at the 2020 Virtual GEM Workshop. Session schedules as well as the focus group information can be found on the wiki page: https://gem.epss.ucla.edu/mediawiki/index.php/FG:_Interhemispheric_Approaches_to_Understand_M-I_Coupling_(IHMIC)

Session 1

This session began with Dan Welling's presentation on his newly funded NASA DRIVE Center called "The Center for the Unified Study of Interhemispheric Asymmetries (CUSIA)" which looks to address the challenges in understanding the nature of interhemispheric asymmetries by ushering in the next generation of theory and models that account for the ever-present asymmetries imposed onto the geospace system. This talk described the strategy, progress, and upcoming tasks for the Phase 1 DRIVE center. Opportunities for others to become involved were also discussed. Ramon Lopez and Robert Strangeway introduced initial event studies conducted as part of the CUSIA activity, focusing mainly on the effects of large IMF By on ring current models, since those models currently only couple to the northern hemisphere whereas IMF By produces significant interhemispheric asymmetries. Mark Engebretson presented observations of large nighttime magnetic perturbation events (MPEs) relevant to geomagnetically induced currents (GICs) at conjugate high latitudes. The spatial and temporal extent of perturbation amplitudes and derivatives (dB/dt) have been compared between conjugate stations, suggesting that the MPEs tend to favor a current generator model over a voltage generator model. Quarter wave modes, which exist when the ionosphere on one footprint of the field line is in sunlight and the other is in darkness, have been reported by Robert Lysak, who suggested that the ratio between the Pedersen conductances on the two footpoints is greater than 5 and the quarter waves are preferentially excited when they can couple to a cavity mode covering the dayside magnetosphere. Zhonghua Xu presented a statistical survey of interhemispheric comparison of ULF waves associated with interplanetary shocks, concluding that the first ULF wave response is generally observed in hemisphere the shock strikes first – consistent with a shorter transit time for Alfven waves. However, the statistical results for intensity response implicate that there are other controlling factors in the M-I system, such as seasonal variations in ionospheric conductivity and local time dependencies.

Session 2

James Weygand presented examples of hemispherically conjugate auroral omega bands from DMSP SSUSI auroral images. His study suggested that the source of auroral omegas is within the magnetotail and are closely associated with high speed earthward flows. A model, in which neutral winds at magnetically conjugate points in both hemispheres do not map, has been introduced by Stephan Buchert to explain the well-known Sq magnetic variations and to estimate the global Joule heating (JH) by Sq. From Poynting flux analysis, his study showed that a neutral dynamo in one of the hemispheres is the source of JH in the other hemisphere. Qing-He Zhang reported a new and general mechanism for the formation of multiple transpolar auroral arcs (TPA), by using the comprehensive observations from DMSP satellite in the ionosphere, ARTEMIS satellite in the distant magnetotail, all sky imager at Chinese Zhongshan station, and comparing with a high-resolution 3D global MHD simulation. The identified general mechanism is that the auroral arcs are generated by field-aligned acceleration of electrons through the Knight's current-voltage process caused by the Filed-Aligned Current (FAC) sheets that are generated by the strong flow shears in the magnetosphere. The above processes operate on either open or closed field lines. He claimed that the study resolves the decades-long controversy: TPAs on open versus closed field lines. Delores Knipp and Liam Kilcommons showed calculations of Poynting flux in the auroral zone and polar cap from both hemispheres using 5 spacecraft-years of DMSP data. The resolution of their statistical patterns is two-three times that of previous studies. The patterns of median Poynting flux clearly show the most persistent, intense DC Poynting flux in the dayside flow channels. Secondary intensity maxima near dusk and in the post-midnight region may be associated with sub-auroral flow channels. Xueling Shi reported ground observations of large amplitude (>100 nT) isolated magnetic impulses with notable interhemispheric asymmetry, probably associated with field-aligned currents around the magnetopause. Her study concluded that these magnetic perturbations were not directly driven by the solar wind pressure pulses, instead they were driven by upstream transients probably triggered by an IMF rotational continuity. Yu Hong presented GITM simulations showing the inter-hemispheric asymmetries of E-region electron density, F-region neutral density and total Joule heating of I-T system, which are caused by: season, geomagnetic field configuration, particle precipitation and IMF By. The results show that seasons have significant influence on all the parameters; different geomagnetic field configurations lead to daily variation of all parameters; the particle precipitation asymmetry causes obvious effect on electron density and Joule heating, but little effect on neutral density; IMF By results in asymmetric neutral density and Joule heating, but has limited effect on E-region electron density.

Global System Modeling (GSM) RA Reports

Coordinators: Alex Glocer and John Lyon

ULF wave Modeling, Effects, and Applications

Michael Hartinger, Kazue Takahashi, Alexander Drozdov, Maria Usanova, Brian Kress, Xueling Shi

The “Ultra Low Frequency Wave Modeling, Effects, and Applications” focus group (UMEA, 2016-2021) 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 had two sessions at the 2020 Virtual GEM workshop: (1) discussion of the 27 May 2017 CME storm challenge event and short research highlights, (2) ULF wave research highlights from early career scientists. Most presentations are linked on the wiki page: https://bit.ly/33SJ1GI

Session 1, Challenge event and research highlights

UMEA welcomes its newest co-chair, Xueling Shi from Virginia Tech, who chaired the session. Mike Hartinger provided FG updates and an overview of the 27-28 May 2017 storm. This was followed by a more detailed overview by Simone di Matteo who presented the results from Pezzopane et al 2019, including the global evolution of mass density during the storm. Bob McPherron focused on global observations of compressional/radially polarized ULF waves in the Pc4-5 range that were likely internally driven yet had a surprisingly large MLT extent. Boyi Wang examined a large Pc5 modulation of ionospheric electron densities using PFISR observations and compared with satellite observations. Lutz Rastaetter updated on the idealized ULF wave modeling challenge, including efforts to use similar grid resolutions across different codes. Research highlights: Mark Engebretson showed that extreme high-latitude magnetic perturbation event aren’t necessarily tied directly to substorms, Jinxing Li examined the properties and potential sources of micro-injections using MMS observations, and Xiaojia Zhang used THEMIS observations to show that ULF wave power decreases with distance from the magnetopause and this affects the modulation of VLF waves.

Session 2, research highlights from early career scientists

Rachel Rice used MMS observations of KH vortices to understand the spatial scale(s) at which heating occurs. Dong Lin compared simulated ULF wave properties in GAMERA and LFM when using the same driving conditions and discussed next steps in using GAMERA for ULF wave simulations. Boyi Wang showed that HFAs compress the magnetopause, in turn driving ULF waves and leading to drift-bounce resonances. Jayashree Bulusu examined ground-based magnetometer observations of Pi2 waves, finding that non-storm time Pi2 waves have frequencies that depend on plasmasphere conditions. Changzhi Zhai showed coordinated GOES satellite, SuperDARN, and TEC observations of high m-number Pc4-5 waves, with no ground magnetic signature. Simone Di Matteo showed how the adaptive multitaper method can be used for ULF wave analysis, including the identification of power peaks. Yixin Hao used the time-of-flight method to identify a localized drift resonant interaction. Mohammad Barani discussed observations and theory related to ULF wave m-numbers, including detectability thresholds and impacts on radial diffusion.

Magnetic Reconnection in the Age of the Heliophysics System Observatory

Rick Wilder, Shan Wang, Michael Shay, Anton Artemyev

Over 2020, the focus group “Magnetic Reconnection in the Age of the Heliophysics System Observatory” made progress in our understanding of magnetic reconnection, though not as much as would have been made in the absence of the COVID-19 pandemic. During the summer virtual workshop, we had two sessions, with the second session being focused largely on the future of the focus group and potential GEM “challenges”. Kris Pritchard showed several techniques for measuring the reconnection rate during MMS magnetic reconnection events. Prayash Sharma Pyakurel showed an enhance reconnection rate for three-dimensional electron-only reconnection, such as what happens in the turbulent regions of the earth’s magnetosheath. Subash Adhikari showed simulations that suggested magnetic reconnection is in many ways similar to a cascade process, such as turbulence. Joaquin Diaz Pena showed the interplay between polar cap patches and aurora, and their relation to magnetic reconnection at the dayside magnetopause. Akhtar Ardakani showed that heavy ions can change how reconnection carries out in the earth’s magnetotail. Misha Sitnov gave two presentations, the first looking at steady versus unsteady regimes of magnetic reconnection in the earth’s magnetotail and what drives them, and the second looking specifically at the energy dissipation characteristics of unsteady reconnection in the magnetotail. Ian Cohen showed energetic electron observations near active magnetotail reconnection events, and finally, Colin Small showed how a machine learning algorithm can help scientists select magnetopause crossings observed by the NASA Magnetospheric Multiscale Mission. During the second session, there was a discussion on a new "reconnection challenge" and potential topics led by the focus group leader, Rick Wilder. During this discussion several ideas were floated, such as comparing runs with different levels of detailed physics at the reconnection site (PIC vs. MHD vs. Hybrid). Additionally, it was mentioned that investigation into machine learning techniques to study reconnection, especially in the magnetotail, would be valuable.

During the winter Mini-GEM, we discussed what questions relevant to the focus group goals still need to be addressed. For Goal 1, the concern was characterizing and understanding dissipation in magnetic reconnection. Some topics included using Pi-D instead of Joule heating to characterize dissipation, and the challenges in measuring it, including the lack of ion-scale spacecraft separation from MMS. We also noted that the role of wave-plasma energy exchange in dissipation of reconnection is poorly understood. Finally, we noted that dissipation is a difficult concept to define at its core, particularly when one considers reversibility.

For Goal 2, the topic of discussion was the relationship between magnetic reconnection and turbulence. Simulations and observations by MMS now show magnetic reconnection occurring during turbulence. Some open questions include how often reconnection occurs in turbulence, and whether the reconnection leads to significant dissipation of the turbulent energy. Also – we still need to study the role of turbulence in magnetic reconnection in different regions of the magnetosphere. For example, in the magnetotail, turbulence associated with magnetic reconnection can accelerate electrons. Additionally, identifying which instabilities are associated with the turbulence and the role of tail flapping were identified as important future studies. On the dayside, the question of which instabilities lead to turbulence (Lower hybrid drift instability, electron vortices, current corrugation) are associated with turbulence at the x-line, and whether this turbulence segments the dayside x-line and impacts the global system need to be investigated.

Goal 3 involved how we move beyond 2D when developing theories and models of reconnection. Open issues include how to handle ion-to-electron mass ratios in particle simulations, which have been shown to be critical in reproducing data in a variety of geospace environments, including the bow shock. Energy release probably is not affected by mass ratio much, but 3D effects such as waves, anomalous resistivity, and parallel electric fields. Additionally, boundary conditions provide a challenge for simulating turbulence, and can even impact the "strength" of the turbulence. Another challenge we identified was how we understand the properties that govern finite length x-lines. What governs how they are limited in length? What causes X-lines to drift?

Finally, for Goal 3 we discussed the local versus global effects of reconnection. Current challenges include how to properly couple kinetic and MHD simulations. For example, how do you properly handle boundary conditions for the coupling? How do we use coupled models to handle reconnection onset mechanisms, where we might not easily be able to decide where the embedded box should go? Additionally, what about global-scale kinetic processes such as pre-onset configurations for reconnection? These things aren't as simple as global being the MHD domain and local being the kinetic. We also discussed how global kinetic simulations such as Vlasiator or the Auburn model can help understand the coupling between local and global physics. We noted that both global hybrid models still use fluid electrons, and thus might miss electron-scale physics that are important for things such as the development of turbulence. Finally, it was suggested that machine learning and data mining techniques may be a promising approach for understanding global physics that may not be captured by MHD simulations.

Our goal in for the future of the focus group and any potential challenge studies will be to address the questions brought up during this open discussion session.

Liaison Reports

CEDAR Liaison Report

Shasha Zou

The current CEDAR science steering committee (CSSC) chair is Delores Knipp, and the chair-elect is Larisa Goncharenko. The main CEDAR workshop organizer is Astrid Maute, and the NSF Aeronomy Program manager is Alan Liu.

The 2020 CEDAR workshop was held virtually from June 22 to June 26. As usual, the student workshop kicked off the CEDAR workshop with a theme "Mapping out the future directions for space physics and aeronomy." More than 200 students participated in the student day, and 65% of them were first-time CEDAR participants. There were eight live or pre-recorded tutorials given, and all talks were recorded and live-streamed on YouTube. Participants used Slido to ask or upvote questions. Several student volunteers summarized the student day tutorials and participant statistics and produced a very nice summary, "CEDAR Student Newsletter."

A total of 731 participants registered for this CEDAR workshop, more than twice of the in-person workshops. The participants came from 36 different countries, with the US (503) leading and followed by India (42). The virtual workshop also enabled participants from Africa, including South Africa, Ethiopia, Ivory Coast, Egypt, and Nigeria. The CEDAR meeting spanned five days and included 23 sessions, ~20% less than the previous year but still covering a broad range of themes proposed by the community. Details about these sessions can be found on the 2020 virtual CEDAR work-shop webpage. One new grand challenge topic was selected, "Understanding the Electromagnetic Energy Input to Earth's Atmosphere," led by Alex Chartier from JHU APL. Bob Schunk from Utah State University was selected as the 2020 CEDAR Distinguished lecturer, and the lecture will be given in the 2021 CEDAR workshop. Martin Mlynczak from NASA Langley Research Center was selected as the 2020 CEDAR prize lecturer and gave a pre-recorded presentation titled "Are we there yet? Assessing Solar Cycles from Earth's Perspective".

The 2021 CEDAR workshop will be held virtually as well from June 20 to June 25, 2021. The student workshop will be on Sunday, June 20, with the themes of “#1: Instrumentation and Techniques” and “#2: Back to the Basics” and will end with a social event, “Wine and Whine.” There will be 33 individual sessions proposed by the community spanning for five days.

NASA Liaison Report

Jesse Woodroffe

Although the past year has faced us with unprecedented challenges, we have risen to the challenge and have succeeded in doing great things together, while still – by necessity – remaining apart. As we look back at our rich history and look forward to our promising future, let’s always remember that as a community of scientists, GEM is first and foremost a community.

However unorthodox a year this may have been, it remained a busy one at NASA, and I’m happy to say that NASA has the largest and most vibrant Heliophysics System Observatory in its history. But that’s only part of the picture – there’s been a lot of exciting things happing as of late, and there’s even more great stuff yet to come!

In December 2020, NASA approved four heliophysics missions to explore the Sun and the system that drives space weather near Earth and demonstrate new technology. Two of these missions, the Extreme Ultraviolet High-Throughput Spectroscopic Telescope Epsilon Mission, or EUVST, and the Electrojet Zeeman Imaging Explorer, or EZIE, will help us understand the Sun and Earth as an interconnected system. NASA also selected the Global Lyman-alpha Imagers of the Dynamic Exosphere, or GLIDE and Solar Cruiser as Solar Terrestrial Probes, or STP, Missions of Opportunity to share a ride to space with the agency’s Interstellar Mapping and Acceleration Probe, or IMAP.

The Extreme Ultraviolet High-Throughput Spectroscopic Telescope, Epsilon Mission, or the Solar-C EUVST Mission, is a solar telescope that will study how the solar atmosphere releases solar wind and drives eruptions of solar material. These phenomena propagate out from the Sun and influence the space radiation environment throughout the solar system. The principal investigator for the NASA contribution to EUVST is Harry Warren at the U.S. Naval Research Laboratory in Washington.

The Electrojet Zeeman Imaging Explorer, or EZIE, will study electric currents in Earth’s atmosphere linking aurora to the Earth’s magnetosphere – one piece of Earth’s complicated space weather system, which responds to solar activity and other factors. The principal investigator for the mission is Jeng-Hwa (Sam) Yee at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

GLIDE will help researchers understand the upper reaches of Earth’s atmosphere – the exosphere – where it touches space. GLIDE will study variability in Earth’s exosphere by tracking far ultraviolet light emitted from hydrogen. The principal investigator for GLIDE is Lara Waldrop at the University of Illinois at Urbana-Champaign.

Solar Cruiser was selected as the technology demonstration mission. Consisting of a nearly 18,000-square-foot (nearly 1,700-square-meter) solar sail, it will demonstrate the ability to use solar radiation as a propulsion system.

The principal investigator for Solar Cruiser is Les Johnson at NASA's Marshall Space Flight Center in Huntsville, Alabama.

We have also had a number of sounding rocket launches over the past few months including VIPER, EUNIS, and KiNET-X. KiNET-X, a geospace experiment studying how energy and momentum are transported between different regions of space that are magnetically connected, sparked significant public engagement.

Parker Solar Probe completed its eighth close perihelion, on April 29, 2021, coming within a record of 6.5 million miles of the Sun's surface at a record speed of over 330,000 miles per hour. Scientists using data from Parker Solar Probe released a new collection of research papers in a special issue of the journal Astronomy & Astrophysics on June 2, 2021.

In other mission news, HERMES Interdisciplinary Science teams were recently selected. The successful teams proposed investigations that address HERMES science objectives using data products from HERMES and from other sources. Additionally, we have issued a Program Element Appendix soliciting proposals for Geospace Dynamics Constellation (GDC) Investigations. The solicitation calls for proposals for complete Principal Investigator (PI)-led science investigations requiring spaceflight instrument development. More information can be found in NSPIRES, Solicitation Number: NNH17ZDA004O-GDC.

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To follow along with updates from NASA Heliophysics, join the newsletter here. You can also let Heliophysics Communications know what you've been working on or volunteer for a panel.

NOAA Liaison Report

Howard Singer

This brief report describes recent highlights and future plans related to NOAA's space weather activities with relevance to the Geospace Environment Modeling (GEM) community.

The National Oceanic and Atmospheric Administration (NOAA) supports robust space science and space weather programs including modeling, observations, forecasting and understanding that are related to Geospace Environment Modeling (GEM) goals to "understand the solar-terrestrial system well enough to be able to formulate a mathematical framework that can predict the deterministic properties of geospace and the statistical characteristics of its stochastic properties." Within NOAA, these activities are carried out mostly in the National Weather Service (NWS) Space Weather Prediction Center and in the National Environmental Satellite, Data, and Information Service (NESDIS) which includes the Office of Projects, Planning, and Analysis (OPPA), the GOES-R Series Program Office, and the National Centers for Environmental Information (NCEI).

Modeling the space environment is a significant challenge that will lead to major predictive capabilities and benefits for those impacted by space weather. A few newsworthy items from SWPC, related to geospace environment modeling, are upgrades to several models and the introduction, or preparation, of new models into operations. Of particular relevance to the GEM community is the University of Michigan's Geospace model in operations at SWPC. This model provides short-term predictions of regional geomagnetic variations at Earth's surface as well as other geospace conditions. It has been in operations at SWPC since October 2016 and in February 2021, it was upgraded to version 2.0 after successful validation and transition to operations. Among model improvements, version 2.0 nearly doubles the grid resolution to better resolve magnetospheric processes and current systems.

Other model changes at SWPC that may be of particular interest to the GEM community are OVATION, Regional Geoelectric 3D and WAM-IPE. A new version of the Oval Variation, Assessment, Tracking, Intensity, and Online Nowcasting (OVATION) model of the auroral oval, originally developed at Johns Hopkins University Applied Physics Laboratory), now includes an expanded range of geomagnetic activity, with coverage to Kp =9 levels. The Regional Geoelectric 3D model (in collaboration with partners at the USGS and data contributed from Natural Resources Canada) was deployed to operations on September 24, 2020, using an improved description of Earth conductivity based on empirical magnetotelluric transfer functions (EMTFs). The WAM-IPE model (WAM; Whole Atmosphere Model, IPE; Ionosphere Plasmasphere Electrodynamics) is in the process of transition to operations on NOAA's supercomputers. The WAM-IPE model, as described on the SWPC website is a comprehensive, 3D, time-dependent, coupled model of the Earth's Ionosphere, Thermosphere and Lower Atmosphere. The model predicts global ionospheric parameters such as the Total Electron Content (TEC), the peak ionospheric electron density (NmF2), and dynamic parameters which are important factors affecting GPS positioning and HF radio communications.

SWPC has also been working to advance Research to Operations and Operations to Research (R2O2R). In part, these activities are in response to the National Space Weather Strategy and Action Plan (NSW-SAP) released in 2019 (see link at: https://www.swpc.noaa.gov/news/national-space-weather-strategy-and-action-plan-released-0). One of the actions in the NSW-SAP is to: "Identify mechanisms for sustaining and transitioning models and observational capabilities from research to operations that will include academic, private sector, and international partnerships." Working together with agency partners, SWPC has been developing plans for a "NOAA Testbed and Proving Ground" that will enable developmental testing, include researchers and operational scientists/experts, and involve government agencies, academia, private sector and international partner participation. One of the goals is to have a facility where we can conduct collaborative exercises and experiments under quasi-operational conditions. Also, this year, SWPC has continued its partnership with NASA and NSF to collaborate on funding opportunities for Operations to Research/Research to Operations (O2R/R2O) applied research that is likely to result in improved capabilities for operations.

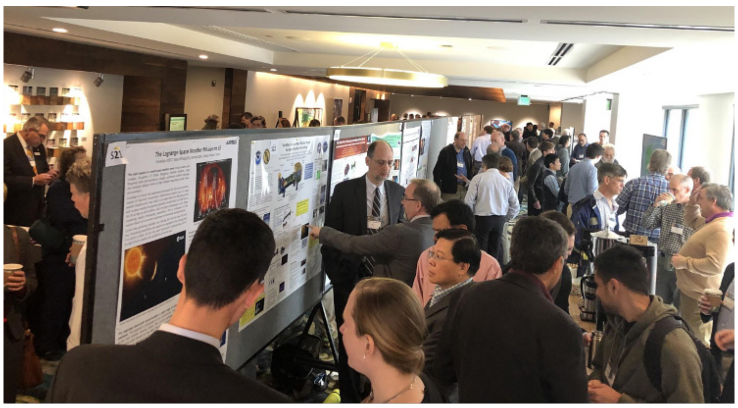
Solar wind observations from the upstream L1 location are critical for both science and space weather operations. NOAA's Deep Space Climate Observatory (DSCOVR) continues to provide real-time data for both of these purposes and NASA's Advanced Composition Explorer (ACE) satellite continues to perform as a backup for DSCOVR. Development of future L1 observations is progressing with plans for launching NOAA's Space Weather Follow On-L1 (SWFO-L1) satellite in early 2025 as a rideshare to L1 with NASA's IMAP mission. Contracts have been awarded for the spacecraft (Ball Aerospace) and the space weather instruments (magnetometer-Southwest Research Institute; SupraThermal Ion Sensor (STIS)-UC Berkeley; and work is continuing on a Compact Coronagraph (Naval Research Laboratory). (Development is also underway for a compact coronagraph that is planned for launch on GOES-U about 2024).

GOES observations have been used for decades by GEM researchers and other scientists, as well as at SWPC and by other nations to support space weather operations. Currently SWPC is using observations from the first of a new generation of GOES satellites, GOES-16, and is preparing to use GOES-17 data later this year. While real-time data are available from SWPC, we work closely with our NOAA colleagues at the National Centers for Environmental Information (NCEI) where the GOES archived data are made available. See https://www.ngdc.noaa.gov/stp/satellite/goes-r.html as well as reprocessed 2 Hz GOES-8-15 MAG data with multiple geophysical frames at https://satdat.ngdc.noaa.gov/sem/goes/data/science/mag/. In addition, some GOES data continue to be available through NASA's CDAWeb and the THEMIS satellite database.

Another set of critical observations for input to models and for use in space weather operations comes from the near-real-time NSF Global Oscillation Network Group (GONG) run by the National Solar Observatory (NSO). SWPC provides substantial funding for GONG operations and operational data processing was successfully transitioned from NSO to SWPC on April 27th.

The 2021 virtual Space Weather Workshop, co-sponsored by NOAA, NASA and NSF, and organized by the University Corporation for Atmospheric Research (UCAR) and an expert, enthusiastic and diverse steering committee was a major success. The meeting brought together industry, academia, and government agencies in a lively dialog about space weather. The outcomes of the meeting will advance the global space weather enterprise and better protect a society that is vulnerable to space weather conditions. The workshop grew beyond our every expectation with over 1095 registrants from 47 nations, including 248 students. We had 80 posters, 62 oral talks, and 18 lightning talks (including student presentations). Particular attention was given to the benefits of Diversity, Equity and Inclusion (DEI) in both the steering committee makeup and the oral presentations. The workshop provided an opportunity to hear presentation from many of those who have been recipients of the NASA-NOAA-NSF O2R grants and from others about advances in space weather modeling, including recipients of space weather related phase 1 Heliophysics Science Center grants. We look forward to next year's Space Weather Workshop that will be held April 25-29, 2022 in Boulder, CO. A potential hybrid format that will include both in-person and virtual participation is under consideration.

Finally, in the realm of space weather policy, on 21 Oct 2020, the President signed into law the bipartisan "Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act" (PROSWIFT). As stated by SWPC's Bill Murtagh, "The new law codifies many National Space Weather Strategy and Action Plan elements including direction to develop formal mechanisms for R2OR2, establishing and sustaining a baseline capability for space weather observations, including magnetometers and neutron monitors, and updating space weather benchmarks. PROSWIFT also establishes roles and responsibilities for Federal agencies on space weather, clearly defining the operational roles of NOAA and the DOD, and the research roles of NASA and NSF." There are sure to be mutual benefits between GEM goals and the opportunities that will come from the PROSWIFT Act.



Poster session during the pre-Covid 2019 NOAA NASA NSF sponsored Space Weather Workshop with over 360 attendees from over 20 nations and including more than 20 students. Next year's meeting will be April 25-29, 2022 in Boulder, CO.

More detailed information about NOAA SWPC, NESDIS and NCEI (previously NGDC) can be found at:

https://www.swpc.noaa.gov/

https://www.nesdis.noaa.gov/OPPA/index.php

https://www.ngdc.noaa.gov/stp/stp.html

USGS Liaison Report

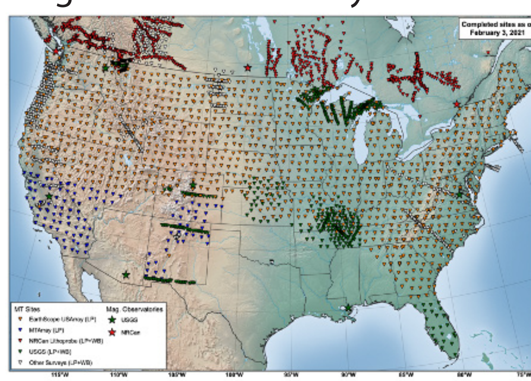
E. Joshua Rigler

The following is a brief summary of operations and research undertaken or supported by the U.S. Geological Survey (USGS) with relevance to the NSF's Geospace Environment Modeling (GEM) program. It is not exhaustive, nor is it indicative of long-term continued efforts.

Magnetic Observatory Operations and Data

The USGS Geomagnetism Program monitors the Earth's magnetic field with high accuracy, (time) resolution, and reliability. It operates 14 magnetic observatories distributed across the United States and its territories. Provisional baseline-adjusted magnetometer data are made available in near real time through USGS web services (geomag.usgs.gov), or via the INTERMAGNET consortium (www.intermagnet.org). "Quasi-definitive" and "Definitive" data are cleaned and calibrated, and typically released within ~1 month and ~1 year of acquisition, respectively. Upgrades to all observatories, including magnetic sensors and acquisition systems, were initiated in 2020, and will continue until complete. In 2019, a pilot program was initiated in partnership with the USGS' Albuquerque Seismic Laboratory to co-install lower-cost, off-the-shelf fluxgate magnetometers at select Global Seismic Network stations. Data from these magnetic variometers are not as rigorously calibrated or quality-controlled as traditional observatory data but are relatively low-noise and available in real-time.

Magnetotelluric Surveys

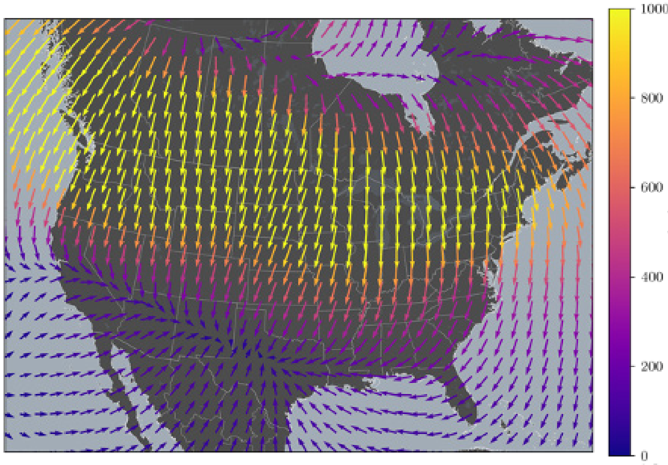


The USGS has been closely associated with NSF's EarthScope USArray program, which completed a gridded magnetotelluric (MT) survey of most of the northern two-thirds of the conterminous United States (CONUS). These data are archived in a publicly accessible online database (ds.iris.edu/spud/emtf). Smaller regional MT surveys were used to augment USArray coverage and support specific industry needs. In FY2020, the USGS received omnibus appropriations to extend an MT survey into the southern third of CONUS, which will provide information critical for generating complete geoelectric hazard maps of CONUS. This work is being completed through a cooperative agreement with Oregon State University.

Targeted Research

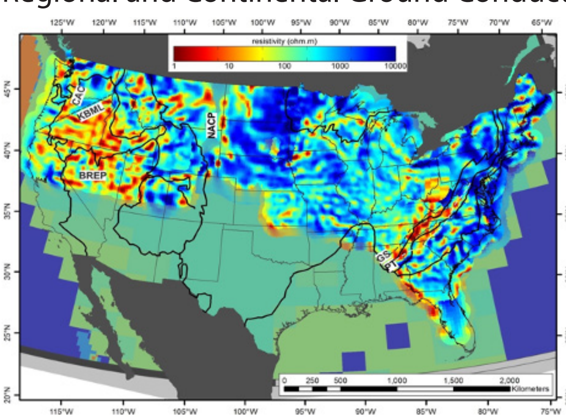
The USGS Geomagnetism Program has a small but active research component that is largely focused on geomagnetically induced currents (GICs).

Geomagnetic Disturbance Maps



As part of a multi-agency collaboration including NASA, NOAA, and NSF (via NCAR's High Altitude Observatory), the USGS developed and continues to update an operations-oriented open-source Python software package for interpolating geomagnetic disturbance given sparse geomagnetic vector input observations (code.usgs.gov/ghsc/geomag/geomag-imp). NOAA's Space Weather Prediction Center (SWPC) incorporated this software into their gridded geoelectric field maps for CONUS.

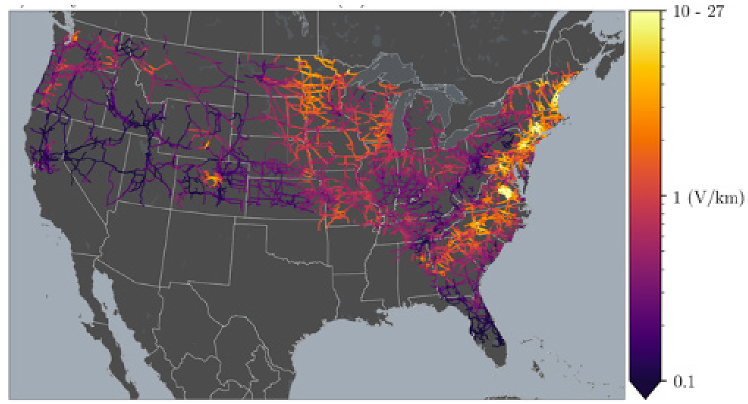
Regional and Continental Ground Conductivity



MT surface impedances can be inverted for geophysically self-consistent conductivity models of the sub-surface. In addition to their solid-Earth scientific value, these conductivity models can be used to generate synthetic impedances at arbitrary locations and density. The USGS uses all available MT data to generate such conductivity models, and is investigating the effects of scaling and distortion on synthetic impedance grids and how these might impact geoelectric hazard assessments.

Geoelectric Hazard Maps

The USGS, in collaboration with NOAA, NASA, and Los Alamos National Laboratory, is working to map time-varying geoelectric fields and evaluate geoelectric hazards that are of concern for the power-grid industry. While geoelectric fields can be measured directly, they are more practically estimated using MT surface impedances and modeled or measured geomagnetic disturbance. Following this approach, it is possible to calculate induced geoelectric fields over extended periods for which USGS and other geomagnetic data are available, using measured impedances. Relatively spatially complete extreme event statistics can be calculated for much of CONUS and projected onto the power grid to generate an industry-relevant induction hazard map. Recent and ongoing studies suggest that, for some parts of the CONUS, the USArray MT survey spacing may be insufficient, resulting in both over and under-estimates of the true induction hazard, depending on the location. In addition, theoretical geomagnetic disturbances have been combined with CONUS MT maps to more realistically assess risk associated with electromagnetic pulses (EMP) arising from high-altitude nuclear detonations. Finally, the USGS is working to uncover and refine under-utilized historical datasets with a particular focus on intervals of extreme geomagnetic activity (for example, May 1921, and March 1989), and present these in context relevant to modern geoelectric hazard analysis.




Des Moines Sunday Register
MAGNETIC STORM CRIPPLES WIRES
STIPP ATTACKS REWARD SYSTEM IN POLICE WORK
ADAMS THEATRE COMPANY GOES TO A RECEIVER
NORTHERN LIGHTS, THE CINEMA OF THE SKIES, IN BRILLIANT SHOWING
CITY IS ORGANIZED FOR HEALTH WEEK
CAR ARBITRATORS TO MEET WEDNESDAY
OLD CITY BASTILE COMMUNITY CENTER

European Liaison Report

Andrew Dimmock

SMILE

The Solar wind Magnetosphere Ionosphere Link Explorer (SMILE), is a joint mission between the European Space Agency (ESA) and the Chinese Academy of Sciences (CAS). Using images of the dayside magnetosphere in soft X-rays, in situ plasma measurements, and UV auroral images, SMILE will measure the solar wind and its interaction with the magnetosphere. The launch date for SMILE was recently delayed by 1 year to the end of 2024. Scientific activities for SMILE are very active through the various working groups and the science working team.

Cluster

The Cluster mission has recently passed an important milestone, its 20th year anniversary, which is being celebrated by a special issue in JGR: Space Physics. The Cluster (launched July/August 2000) spacecraft continue to provide quality data and the mission was recently extended to 31 December 2022. Cluster 1 and 2 will de-orbit between 2023-2024 but there are plans for a final extension to the mission to operate Cluster 3 and 4 until the end of 2025. This would allow for a 1-year overlap with SMILE for conjunctive studies.

SWARM

The three SWARM spacecraft (launched 22 November 2013) continue to deliver high-quality data to study the Earth's magnetic field, ionosphere. At present the mission is extended through 2021. The spacecraft were recently used to show a Northern preference for terrestrial electromagnetic energy input from space weather.

Solar Orbiter

Solar Orbiter (SolO) was launched in February 2020 and has recently completed its first year of operations. SolO carries a suite of both in situ and remote sensing instruments and will investigate the solar wind processes and their connection to the Sun. Data is now freely available on the ESA Solar Orbiter archive (http://soar.esac.esa.int/soar/). To date, SolO has completed two perigees and one Venus flyby. The scientific activities are coordinated by the SolO working groups, which are open and free to all levels. Details on how to join the SolO working groups and take part in the scientific discussions is available on the ISWG webpage. The first results are to be published in a special issue of the journal of Astronomy and Astrophysics. Details of the instruments and scientific objectives can be found in another A&A special issue. All papers are open-access.

Daedalus

Following the selection of three Earth Explorer candidate missions to enter a first feasibility study in September 2018, ESA did not select the Daedalus mission. This was to be a low-flying spacecraft for the exploration of the lower thermosphere-ionosphere system.

Canada Liaison Report

John Manuel

This year, in response to a request from the Canadian Space Agency (CSA), the Canadian scientific community prepared a roadmap that identifies strategic directions and priorities for solar-terrestrial science in Canada. The 2020 Canadian Solar-Terrestrial Science Roadmap describes a path by which Canada, both independently and in partnership with other nations, will make strides toward the resolution of fundamental science questions relating to heliophysics, space weather, and the terrestrial and lunar space environments. The roadmap identifies the Geospace Observatory (GO) Canada initiative and the RADiation Impacts on Climate and Atmospheric Loss Satellite (RADICALS) mission concept as requiring immediate strategic investments.

1. Geospace Observatory (GO) Canada

The GO Canada initiative supports the operation of arrays of 120+ ground-based science instruments deployed across Canada's North. The instrument arrays include magnetometers (CARISMA, AUTUMN), riometers (U Calgary), ionosondes and GNSS monitors (CHAIN), radars (SuperDARN, ICEBEAR), and all-sky imagers (TREx). More than any other CSA initiative, GO Canada is recognized as being responsible for many of the national and international successes of the Canadian community. This year, a CSA opportunity provided ongoing support for the operations of many of these instruments. However, the CSA has announced that, in two years' time, it intends to significantly reduce the funds available for GO Canada and that PIs will need to secure funding from additional sources as a prerequisite for CSA funding of their projects. This may jeopardize the future of ground-based observations in Canada, including international partnerships; the Canadian community continues to discuss the potential impacts of this decision with the agency. The CSA also renewed its support for ground-based imaging and magnetometers operations in support of NASA's THEMIS mission.

2. RADiation Impacts on Climate and Atmospheric Loss Satellite (RADICALS)

The RADICALS mission is a low-Earth orbiting satellite concept targeting the transport and loss of energetic particles from the radiation belts into the atmosphere and the subsequent potential impact of high-energy particle precipitation on climate. The proposed instrument payload includes high-energy particle telescopes (U Alberta), X-ray instruments (U Calgary), fluxgate magnetometers (U Alberta), and a search coil magnetometer (U Alberta). The concept proposes to use a microsatellite bus from the UTIAS Space Flight Laboratory, making this an entirely Canadian mission. The PI, Ian Mann of U Alberta, has received partial funding from the Canada Foundation for Innovation and is currently seeking additional funding from the CSA and the province of Alberta, seeking to initiate mission development in 2021 for launch in 2025-26.

3. Ultraviolet Imager for the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)

SMILE is a joint European Space Agency (ESA) and Chinese Academy of Sciences (CAS) science mission that will observe solar wind-magnetosphere coupling via simultaneous in situ plasma and magnetic field measurements, X-ray images of the magnetosheath and magnetic cusps, and global ultraviolet images of the northern hemisphere aurora. Canada is providing a UV imager that will be capable of identifying the polar cap boundary of the auroral oval at all local times, even on the sunlit side of the Earth, for up to 40 hours per orbit at a cadence of 1 minute and resolution of 150 km. The PI is Eric Donovan of U Calgary.

As well as identifying priorities for solar-terrestrial science missions and projects, the Canadian community also responded strongly to a CSA announcement of opportunity for analyses and modelling of data being acquired by Canadian ground- and space-based instruments, and supported by international data. The 13 CSA-funded projects will develop and advance a wide variety of empirical and physical models of geospace. For each project, model development will be informed by coordinated data analyses aimed at capturing the new knowledge and insight in code for use in later research projects. Through its support of these projects, the CSA hopes to advance understanding of the physical processes that generate space weather, particularly as it affects Canadians.

ISAS, Japan Liaison Report

Yoshizumi Miyoshi

This report only concerns "GEM-related news" regarding major and recent ISAS missions.

Currently-running space-physics satellites of ISAS is GEOTAIL and ARASE (ERG)

1 – GEOTAIL

GEOTAIL has been approved for operation through at least the end of March 2022. GEOTAIL project is planning to take a mission extension review in fall 2022 in order to extend GEOTAIL operation at least for 3 years. NASA is continuously supporting GEOTAIL (tracking by DSN (Deep Space Network), and making level-1 data). NASA's support for GEOTAIL operation until 2023 was approved at NASA Heliophysics 2020 Senior Review contingent on the JAXA mission extension. THEMIS-GEOTAIL conjunction, MMS-GEOTAIL conjunction observations are continuing. Conjunction events of GEOTAIL, THEMIS, and MMS can be found at a website called CEF (Conjunction Event Finder): http://darts.isas.jaxa.jp/stp/cef/cef.cgi. GEOTAIL digital data are open to the public at a website called DARTS at http://darts.isas.jaxa.jp/stp/index.html.en. When you used the GEOTAIL data in your paper, please tell that to ISAS, for the record. The DARTS website shows where to contact. Requests of GEOTAIL digital data that are not found at DARTS are to be sent to both Dr. Hiroshi Hasegawa (Project Scientist): hase AT stp.isas.jaxa.jp and Dr. Yoshifumi Saito (Project Manager): saito AT stp.isas.jaxa.jp

2 – Arase (ERG)

Arase (ERG) satellite has been observing the Earth's inner magnetosphere with the full operation mode since March 2017. We have already organized various conjugate observations between Arase and Van Allen Probes, MMS, DSX, and ground-based observations. More than 500 conjunction events between Arase and Van Allen Probes had been observed until October 2019, and ~50 conjunction operations between Arase and DSX until May 2021 have been realized. Any requests and suggestions about further conjugate observations with Arase are highly welcome.

CDF files of the calibrated science data obtained by each instrument are available and data analysis software, which is a SPEDAS plugin, is also found in the ERG science center webpage (https:// ergsc.isee.nagoya-u.ac.jp/). Any request to the Arase (ERG) science data is welcome. If you have any questions on the Arase satellite, please contact Dr. Yoshizumi Miyoshi (Project Scientist): miyoshi AT isee. nagoya-u.ac.jp, Dr. Iku Shinohara (Project Manager): iku AT stp.isas.jaxa.jp and PIs of each instrument.

3 – NASA-ISAS Sounding Rocket Experiment : LAMP

LAMP is a sounding rocket project led by NASA, which is dedicated for understanding the generation mechanisms of sub-relativistic, microburst electron precipitations under the activities of pulsating aurorae. ISAS with several Japanese universities are developing one of the instrument packages to be onboard LAMP. LAMP will be launched from Porker Flat Research Range in Fairbanks, Alaska after the integration testing at NASA Wallops Flight Facility. Japanese team will also contribute to ground-based supporting observations at Alaska during the launch campaign. Launch of LAMP will be early 2022.

4 – BepiColombo Mio

BepiColombo Mio was launched on 20 October 2018. Commissioning of the onboard instruments was completed by autumn 2019. After the Earth Flyby in April 2020, science observations during interplanetary cruise and Venus flyby were successfully operated, and conjugate observations between BepiColombo, the solar-telescope satellite Hinode, and Venus orbiter Akatsuki were performed for radio occultation measurements of the solar wind. After arriving at Mercury in December 2025, Mio will make a comprehensive observation of Mercury's magnetosphere together with ESA' s Mercury Planetary Orbiter (MPO). If you have any questions on Mio, please contact Dr. Go Murakami (Project Scientist): go AT stp.isas.jaxa.jp.

UK Liaison Report

Tom Elsden & Jasmine Sandhu

This brief report serves as an update to the GEM community on key missions and research areas with significant funding in the UK.

1. Solar Orbiter

Since launch in February 2020, Solar Orbiter has flown two perihelia to 0.5 AU and had one Venus flyby. Data from all instruments is excellent and with higher downlink rates than expected, the remote sensing instruments are able to run for a larger fraction of the time than had been planned. A first results special issue of Astronomy and Astrophysics is planned for publication later in 2021.

2. SuperDARN

SuperDARN is a global network of over 30 HF coherent scatter radars. The UK have run radars at Halley Bay, Hankasalmi, Finland, Pykkvibear, and Stokkseyri, Iceland, and the Falkland Islands. Currently the two radars in Iceland are being replaced by two new systems funded by NSF, while the Finland radar is being upgraded to an imaging radar, funded by NERC, to operate in conjunction with NASA's upcoming mission, TRACERS. Radars provide line of sight velocity measurements in the ionosphere, used to study solar wind-magnetosphere-ionosphere coupling and MHD waves, and also make measurements of gravity waves and meteor winds.

3. EISCAT

The European Incoherent Scatter Scientific Association (EISCAT) operates radars in Northern Fennoscandia; magnetosphere-ionosphere coupling is an area where EISCAT has made significant contributions over the years. Ionospheric plasma data are freely available from the MADRIGAL database, while higher-level 'raw' data is available to Associates and Affiliate members. The UK is an Associate member and affiliate institutes include JHUAPL. Construction of the new EISCAT 3D radar has begun and it is anticipated that it will begin operations at the start of 2023. This will be the most advanced ISR in the world, providing volumetric imaging and rapid, multi-vector resolution.

4. SMILE

The Solar wind Magnetosphere Ionosphere Link Explorer, joint mission by ESA and the Chinese Academy of Sciences (CAS), is in Phase B-C and is due for launch at the end of 2024. SMILE carries a Soft X-ray Imager (University of Leicester PI) which will map the solar wind charge exchange X-rays in the magnetosheath and the cusps, the UltraViolet Imager (University of Calgary, Canada) and an in-situ package comprising a Light Ion Analyser and a Magnetometer, both CAS responsibility, as is the spacecraft. Instruments and spacecraft development is progressing well with payload and mission Critical Design Review planned in stages for 2022.

5. RadSat

The goal of the Rad-Sat project is to determine the acceleration, transport and loss of high energy electrons and use them in state-of–the-art modelling and forecasting of space weather events to protect satellites. The project is led by the British Antarctic Survey in collaboration with the Universities of Sheffield, Northumbria, Reading, Mullard Space Science Lab and Imperial College London. Satellite operators, underwriters, the UK Met Office, and USAF are included as stakeholders. Our research on wave-particle interactions, ULF waves and AI methods of forecasting has led to major improvements in the BAS Radiation Belt Model now used by the European Space Agency to help protect satellites. https://rad-sat.ac.uk

6. SWIMMR (Space Weather Instrumentation, Measurement, Modelling and Risk)

SWIMMR is a £20M space weather programme, in association with the Met Office Space Weather Operations Centre (MOSWOC), supported by three government ministries. It comprises eleven projects, with nine already in operation. Six concern the development of models for use at MOSWOC, including modelling of the solar wind, radiation belts, atmospheric radiation, ionosphere, thermosphere and ground magnetic effects. Another project is developing a framework to transition models from research to operational use. The final two projects are developing instruments and test facilities for radiation monitoring and resilience. Applications for a new project to develop neutron monitoring capabilities are currently under review.

A. SAGE

'SWIMMR Activities in Ground Effects' (SAGE) is one of the SWIMMR programme projects funded by the UK government (2020-2023). SAGE will provide operational nowcasting and forecasting services in space weather hazard to ground-based technology, specifically the hazard to power and gas transmission and railway signaling networks. SAGE will leverage results and insights gained under the SWIGS project and deliver real time products via the Met Office Space Weather Operations Centre. The ground impact models will be driven by real-time or forecast solar wind data, via several physics-based and empirical magnetospheric models, to provide forecast diversity and the quantification of uncertainties.

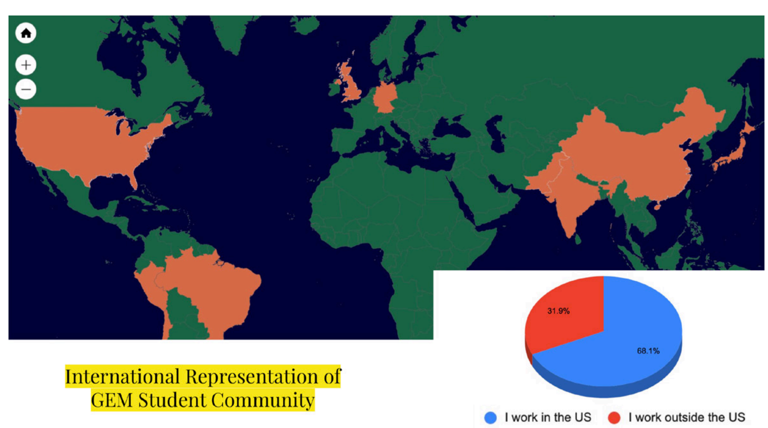
B. Sat-Risk

Sat-Risk is one of the SWIMMR projects funded by UKRI to transition the British Antarctic Survey Radiation Belt Model into an operational forecast system for the UK Met Office. The objective is to develop a real-time system to forecast radiation exposure to satellites for a range of different orbits and quantify the risk of damage or degradation. Led by the British Antarctic Survey, Sat-Risk includes the same Groups as in Rad-Sat and the UK MOD as an additional stakeholder. Research from the Rad-Sat project feeds directly into Sat-Risk and is extended further to include the proton radiation belt, MHD modelling of extreme events and radiation effects on satellites.

7. SWIGS (Space Weather Impact on Ground-based Systems)

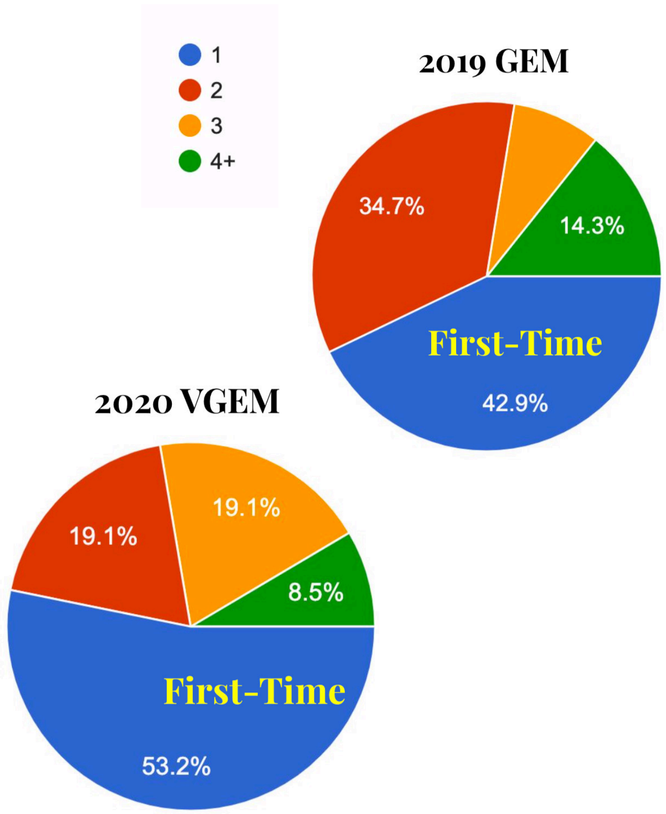
The UK Natural Environment Research Council funds a ten-institute consortium to study the 'Space Weather Impact on Ground-Based Systems' (SWIGS). SWIGS is due to complete this calendar year, having improved our understanding of magnetospheric-ionospheric processes and how these couple via the solid Earth to drive Geomagnetically Induced Currents in conducting, Earthed systems, such as power transmission, gas pipeline and railway signalling networks. SWIGS recently led a Royal Astronomical Society specialist discussion meeting on ground-based impacts, inviting several international experts. SWIGS science is also the subject of a special issue of AGU Space Weather (closing date for submissions is September: https://agupubs.onlinelibrary.wiley.com/hub/journal/15427390/features/call-for-papers).

GEM Student Survey



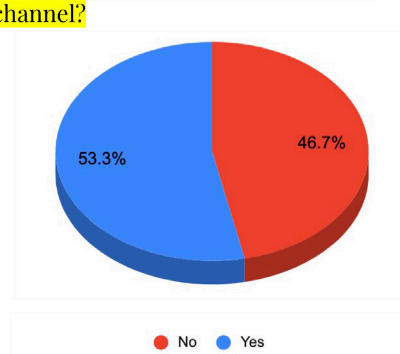
International Representation of GEM Student Community

How many GEM have you attended?

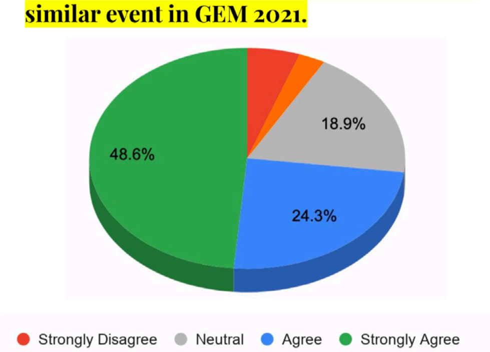


DEI/Mental Health

Have you browsed through #**support-each-other** in VGEM slack channel?



Opinion Poll: #support-each-other makes me **aware of mental health and we should have similar event in GEM 2021.**



In Memoriam

Sam Bingham

Chris Mouikis and Ian Cohen

On July 4, 2020, we tragically lost Sam Bingham, a young member of our community. Sam (1988-2020) was a bright and promising early career scientist and a genuinely caring person. Sam belonged to the "Van Allen Probes generation". His PhD work, at the University of New Hampshire, was based on analyzing data from the Van Allen Probes mission, focusing on understanding the ring current, source electron and EMIC and chorus wave activity responses to CME and CIR driven storms. After successfully defending his thesis in the Spring of 2019, Sam began a postdoctoral fellow position in the Solar & Space Physics Group at The Johns Hopkins Applied Physics Laboratory (APL). There, he worked as a member of the MMS Energetic Particle Detector (EPD) investigation, focusing primarily on the study of energetic ion charge-state determination and energization processes in Earth's magnetotail. His publication output was very impressive, having published several first-author papers in a short time period.

Sam was humble, gracious, and funny with a dry humor and exceptionally quick wit. He was known to go out of his way to help others. Sam loved sports and the outdoors, with both passions coming together most profoundly in his affection for skiing, at which he was an expert. He grew up skiing with his family and continued enjoying traveling and skiing all over the world as an adult. He was also raised with multiple Corgi dogs, and Sam carried that love into his adulthood as well, most recently as the proud and doting owner of his dog, Pisgah.

The news of Sam's passing caused an outpouring of awareness and action in the GEM community that brought discussions on DEI and mental health to the forefront. The GEM workshop will honor Sam's dedication to others' well-being by introducing new facets to our traditional GEM workshop activities that focus on the well-being of the members of our community as part of the "Sam Bingham Community Cares Initiative".

More details on his life's celebration can be found at https://www.memoryofsambingham.com/, along with recordings of previous tributes (including the one from

Virtual GEM 2020).

Stan Sazykin

Bela Fejer, Tom Hill, Pat Reiff, Bob Spiro, Frank Toffoletto, Dick Wolf, Jian Yang

Stan Sazykin died suddenly and unexpectedly on May 4, 2021, at the age of 49.

After completing his B. S. at Moscow Institute of Physics and Technology, he earned a Ph.D. from Utah State University. Stan came to Rice in 2000 as a postdoc, rising through the ranks to Associate Research Professor. He was a distinguished computational physicist and a highly respected member of the space plasma physics community. He was also one of the smartest people any of us have ever encountered, with a rigorous and penetrating mind.

As a graduate student, Stan reprogrammed much of the Rice Convection Model (RCM) of the Earth's inner magnetosphere. At Rice, Stan led the continued development and use of the code. He was always the person that people went to with questions about the RCM and its use.

Much of Stan's research dealt with magnetospherically driven electric fields, and their ionospheric effects. Using the RCM he played a major role in showing how the magnetosphere can cause strong ionospheric electric fields just equatorward of the auroral zone and also to all low latitudes. He also worked on the magnetosphere of Saturn and on understanding data from the Magnetospheric Multiscale mission.

Stan was a very active member of the GEM community. He served for years as a member of the GEM Steering Committee and often chaired meetings and focus groups, always with good humor and penetrating comments.

Stan will be sorely missed by his wife Ying Ye and his three young sons, as well as many members of the magnetospheric and ionospheric space physics communities. For additional information on Stan's life and contributions, see the May 8 and May 21 issues of the GEM Messenger. See also https://gofund.me/06094fbf.

Richard Mansergh Thorne

Jacob Bortnik and Wen Li

Richard Mansergh Thorne, a distinguished Professor Emeritus at the University of California, Los Angeles, passed away peacefully on 12 July 2019, at the age of 76. Over the course of his career, Richard made numerous pioneering and highly significant research contributions to the fundamental understanding of wave-particle interactions in the field of space plasma physics. He was an active member of the GEM community and a chair of numerous GEM focus groups. In addition to his outstanding research accomplishments, Richard will be remembered for his incredible mentorship that has meant so much to so many of us. He was also a terrific colleague, and a true friend to many of us from all over the world. A longer article of "In Memoriam: Richard Mansergh Thorne" is published at https://ieeexplore.ieee.org/document/8956148.

GEM Steering Committee

NSF GEM Program Director
- Lisa Winter

Steering Committee (Voting Members)
- Vania Jordanova (Chair, 2020 - 2022)
- Adam Kellerman (Vice Chair, 2020 - 2022)
- Ian Cohen (2021 - 2025)
- Allison Jaynes (2018 - 2022)
- Yihua Zheng (2019 - 2023)
- Lynn Kistler (2019 - 2023)
- Research Area Coordinators (see below)
- Meeting Organizers (see below)

Steering Committee (Liaison Members)
- Shasha Zou (Liason to CEDAR)
- Joe Borovsky (Liaison to SHINE)
- Masha Kuznetsova (Liaison to CCMC)
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- Howard Singer (Liaison to NOAA)
- James McCollough (Liaison to AFRL)
- Josh Rigler (Liaison to USGS)
- Andrew Dimmock (Liaison to Europe)
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- Yoshizumi Miyoshi (Liaison to ISAS, Japan)
- Jaejin Lee (Liaison to Korea)
- Xochitl Blanco-Cano (Liaison to Mexico)
- Lou Lee (Liaison to Taiwan)
- Thomas Elsden (Liaison to MIST/UK)
- Lutz Rastaetter (Liaison for Metrics and Validation)

Meeting Organizers
- Chia-Lin Huang and Chris Mouikis (2018 -)

Student Representatives
- Agnit Mukhopadhyay (2019 - 2021)
- Mei-Yun Lin (2020 - 2022)

Research Area Coordinators

Solar Wind - Magnetosphere Interaction (SWMI, previously known as Dayside)
- Steve Petrinec (2015 - 2022)
- Brian Walsh (2018 - 2024)

Magnetotail and Plasma Sheet (MPS, previously known as Tail)
- Matina Gkioulidou (2015 - 2021)
- Chih-Ping Wang (2018 - 2023)

Inner MAGnetosphere (IMAG, previously known as IMS)
- Seth Claudepierre (2015 - 2021)
- Raluca Ilie (2018 - 2023)

Magnetosphere – Ionosphere Coupling (MIC)
- Shin Ohtani (2015 - 2021)
- Hyunju Connor (2018 - 2023)

Global System Modeling (GSM, previously known as GGCM)
- Alex Glocer (2015 - 2022)
- John Lyon (2018 - 2024)

GEMstone Editor
- Allison Jaynes

GEM Online

GemWiki: https://gem.epss.ucla.edu/mediawiki/index.php/Main_Page

GEM Workshop Website: https://gemworkshop.org/

GEM Messenger (Electronic Newsletter):
- To subscribe, post announcements or read back issues: https://gem.epss.ucla.edu/mediawiki/index.php/GEM_Messenger

GEM Virtual Workshop 2021:
https://gem.epss.ucla.edu/mediawiki/index.php/2021_Virtual-GEM_Workshop

GEM Chair's Chat Blog:
https://gemchairschat.home.blog/

GEM Focus Groups

Focus Group	Duration	Co-Chairs	Associated Research Areas				
			SWMI	MPS	IMAG	MIC	GSM
Merged Modeling & Measurement of Injection Ionospheric Plasma into the Magnetosphere (M^3I^2) and Its Effects -- Plasma Sheet, Ring Current, Substorm Dynamics	2016 - 2021	Shasha Zou, Barbara Giles, Rick Chappell				*	
ULF wave Modeling, Effects, and Applications (UMEA)	2016 - 2021	Michael Hartinger, Kazue Takahashi, Alexander Drozdov, Maria Usanova, Brian Kress, Xueling Shi					*
Dayside Kinetic Processes in Global Solar Wind-Magnetosphere Interaction (DAYS)	2016 - 2021	Heli Hietala, Xochitl Blanco-Cano, Gabor Toth, Andrew Dimmock, Ying Zou	*				*
Magnetotail Dipolarization and Its Effects on the Inner Magnetosphere (DIP)	2017 - 2023	Christine Gabrielse, Matina Gkioulidou, Slava Merkin, Drew Turner, David Malaspina		*	*		
3D Ionospheric Electrodynamics and Its Impact on the Magnetosphere-Ionosphere-Thermosphere Coupled System (IEMIT)	2017 - 2022	Hyunju Connor, Doğacan Öztürk, Gang Lu, Bin Zhang				*	*
Magnetic Reconnection in the Age of the Heliophysics System Observatory (RX)	2018 - 2024	Rick Wilder, Shan Wang, Michael Shay, Anton Artemyev					*
Interhemispheric Approaches to Understand M-I Coupling (IHMIC)	2018 - 2023	Hyomin Kim, Robert Lysak, Tomoko Matsuo			*	*	
System Understanding of Radiation Belt Particle Dynamics through Multi-spacecraft and Ground-based Observations and Modeling (RB)	2019 - 2024	Hong Zhao, Lauren Blum, Sasha Ukhorskiy, Xiangrong Fu			*		
Particle Heating and Thermalization in Collisionless Shocks in the MMS Era (BSH)	2019 - 2024	Lynn Wilson III, Li-Jen Chen, Katherine Goodrich, Ivan Vasko	*				
The Impact of the Cold Plasma in Magnetospheric Physics (CP)	2020 - 2025	Gian Luca Delzanno, Natalia Buzulukosva, Barbara Giles, Roger Varney, Joe Borovsky			*		
Self-Consistent Inner Magnetospheric Modeling (IMM)	2020 - 2025	Cristian Ferradas, Chao Yue, Jacob Bortnik, Qianli Ma			*	*	

Links to Focus Group pages and past Focus Groups can be found here:
https://gem.epss.ucla.edu/mediawiki/index.php/GEM_Focus_Groups

†MMV is now a Standing Resource Group led by Mike Liemohn, Lutz Rastaetter, Alexa Halford and Josh Rigler

* - Primary research area
* - Secondary research area