Global Environment Modeling

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The GEMstone

Notes from GEM Chair:
GEMstone Liaison Issue

Jacob Bortnik

The Geospace Environment Modeling (GEM) community is broad and far-reaching, a fact that could not be more aptly conveyed than in the current issue of the GEMStone publication, the so-called "liaison issue". The GEM liaisons represent our direct connections to the wider body of magnetospheric and space scientists, to sister organizations operating under the auspices of the National Science Foundation (NSF) such as CEDAR and SHINE, to US agencies such as NASA, NOAA, and USGS, to national defense interests (AFRL), and of course to the many international bodies and agencies that regularly contribute to, and benefit from, the GEM organization.

There are many important and interesting reports contained in this issue and I would encourage you read through them carefully. For the sake of brevity, I will highlight only a few items:

- For starters, please note the NSF's restructuring of GEM proposals which now do not have a set deadline and do not need to be explicitly tied to a particular Focus Group, a change which is designed to allow proposers greater flexibility to truly submit their most innovative ideas whenever they are ready.
- Space weather continues to be a strong motivating force in our community, expressed in part by the National Space Weather Strategy and Action plan, and perhaps best captured by SWPC's customer subscription numbers which ballooned to ~54,000 in March 2018. Space weather considerations drive important model developments such as AFRL's AE9/AP9-IRENE, and AF-DEPT models, the USGS IDEA model, and the various hazard maps created by the USGS, to name just a few.

Inside this issue

- The past year has seen a number of important launches including NOAA's new generation GOES-17 geosynchronous mission, NASA's GOLD mission, the Taiwanese FORMOSAT-5 mission, and (a bit further back) the Japanese Arase/ERG mission which published its findings on chorus scattering in the journal Nature earlier this year.
- We await with great anticipation the many exciting spacecraft and project launches that are scheduled for the next several months. These include NASA's (almost launched) ICON mission, the Parker Solar Probe, to be launched in the summer of 2018, coincident with the SHINE workshop; AFRL's DSX mission to launch later this year to study wave-particle interactions in the inner magnetosphere; KASI's NEXTSat-1 and GK-2A to be launched in Oct and Nov of this year, respectively; the joint Taiwanese/US mission FORMOSAT-7/COSMIC-2; and several cubeSats to be launched as part of the newly established Australian Space Agency. Further out, we have the joint ESA/JAXA BepiColombo mission to Mercury to be launched late this year, the ESA/CAS SMILE project to be launched in 2022-2023, and the new ESA exoplanet mission ARIEL, to be launched in 2028.

The liaisons, agency representatives, and many of our national and international colleagues will be in attendance at the upcoming GEM summer workshop, scheduled over the week of 17-23 June 2018 in sunny Santa Fe, New Mexico. This year's workshop will be held back-to-back with the CEDAR workshop (24-28 June 2018) with a CEDAR-GEM joint day scheduled for Saturday 23 June 2018. Please check the workshop website (http://www.cpe.vt.edu/gem/) for travel and accommodation information, as well as any late-breaking updates.

We look forward to seeing you all in Santa Fe in June!

Jacob Bortnik on behalf of the GEM steering committee

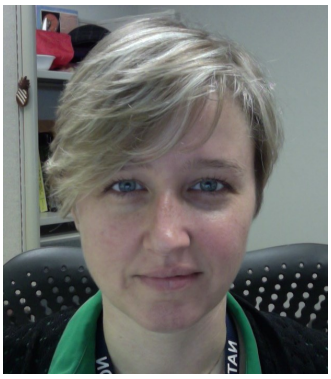
Venue for 2018 GEM Summer Workshop and GEM-CEDAR Joint Workshop

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

Editor's Note: The NASA Liaison (Dr. Mona Kessel) is currently on detail to Goddard and will provide a report next year.

Notes from Program Director

Carrie Black (NSF)



As I am sure you all are aware, Mike Wiltberger took over as the Geospace Science Section Head in August 2017. Under his management of Magnetospheric Physics, several important and difficult challenges were met. A special thank you to him for setting the program up for a successful and productive future. I have had the privilege of serving as Acting Magnetospheric Physics Program Director since August. I am thoroughly enjoying this assignment and hope that folks will not hesitate to reach out to me, while we await the announcement of a permanent PD.

Since the last GEMStone publication, the NSF GEM solicitation has been released (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5506). There are two major changes - 1) the deadline has been dropped so proposals may be submitted at any time and 2) the requirement for connection to the GEM Focus Groups has also been dropped. These changes are meant to provide greater flexibility for proposers. The program is still focused on modeling and I strongly encourage the community to continue to organize focus groups. This is one of the truly unique features of this community in no small part because it encourages innovation. We at NSF are frequently asked when the best time to submit a proposal is. The answer is quite honestly, when the idea is well formed. The budget cycle has been unpredictable, so I would encourage PIs to submit their work when they are happy with the quality of the proposal. There will be ample time to discuss these changes and more at the upcoming GEM meeting. In the meantime, please contact me with any questions.

After a series of continuing resolutions, the FY2018 budget for the federal government was passed in March. NSF programs have just recently the operating funds. Award decisions will be made in the coming weeks. I would encourage folks to please submit their annual reports, particularly if they are overdue, so that we may release increments and make new awards efficiently.

NSF's Big Ideas are beginning to take shape. (https://www.nsf.gov/news/special_reports/big_ideas/nsf2026.jsp) There are several Dear Colleague Letters out which have relevant content for Magnetospheric Physics. These are Harnessing the Data Revolution, Navigating the New Arctic, Growing Convergence Research, and Mid-Scale Research Infrastructure. Consider looking into these for potential future funding and for alignment with NSF priorities.

Please reach out if you have any questions or concerns. I can be reached via email (cblack@nsf.gov) or phone (703)292-2426. See you all in Santa Fe, NM for the next GEM meeting.

CEDAR Liaison Report

Yue Deng (University of Texas Arlington)

The Chair of CEDAR is Jonathan Makela, the CEDAR workshop Organizers are Astrid Maute and Barbara Emery, the Conference Administrators are Kendra Greb and Michelle McCambridge, and the NSF CEDAR Program Directors are Irfan Azeem, Ruth Lieberman and John Meriwether.

The 2017 CEDAR workshop was held at Keystone Resort, Colorado, June 18 - 23. A total of 325 participants from 86 different institutions and 12 different countries registered. The traditional Sunday student workshop was guided by the theme "Modeling and Data Analysis Synergy". The students organized a very diverse set of presentations highlighting the challenges combining data and modeling to study the atmosphere-ionosphere-magnetosphere system, including tutorials about empirical model, theoretical model and data-assimilated model, FPI, superDARN coherent scattered Radar, sounding rockets and CubeSats. The student workshop ended with a professional development presentation about effective communication, and the student soccer game.

The CEDAR meeting included 31 sessions, covering a range of themes as proposed by the community. Details about these sessions can be found on the CEDAR workshop webpage http://cedarweb.vsp.ucar.edu/wiki/index.php/2017_Workshop:Main. Three of these were Grand Challenge topics, which were "MLT-X: Frontiers in Science and Sensing", "High Latitude System Frontiers" and "Storms and Substorms Without Borders (SSWB)". Over the past several years, CEDAR has been organically moving toward initiatives that combine space-based and ground-based measurement of the coupled "geospace system," in line with the community's 2012 strategic planning document, "CEDAR, The New Dimension." The 2017 workshop included several related science highlights, which covered the topics of using a Constellation of Cubesats to Conduct Thermospheric Science: The QB50 mission, Lagrangian coherent structures in the thermosphere, Waves and Turbulence Dynamics above the Andes, Solar Eclipse 2017, Thermosphere data from acceleration measurements by Swarm and other satellites, and Medium Range Thermosphere Ionosphere Storm Forecasts. Delores Knipp presented the Nitric Oxide cooling effect on the thermosphere in the "CEDAR Prize Lecture" and Art Richmond talked about perspectives on ionospheric electrodynamics in the "CEDAR Distinguished lecture ".

The next CEDAR workshop will go back to Santa Fe, NM during June 24-29, 2018. Since 2018 GEM workshop will be hold at the same location one week before CEDAR, one day CEDAR-GEM joint workshop on June 23, 2018 has been proposed and planned. Discussions continue on a sustainable strategy for exploiting deep synergies between the GEM and CEDAR communities in different ways.

Photos at 2017 CEDAR Workshop

SHINE Liaison Report

Joe Borovsky

The Chair of SHINE is Georgia De Nolfo, the SHINE Workshop Coordinator is Noe Lugaz, the Conference Administrator is Umbe Cantu, and the NSF SHINE Program Director is Ilia Roussev.

The 2017 SHINE Conference was held in St. -Sauveur, Quebec, Canada in July of 2017. The 2018 SHINE Conference will be held July 30 - August 3 2018 in Cocoa Beach, Florida. The SHINE Conference sessions rely heavily on audience discussion. There are also poster sessions for more-formal presentations.

There are 27 sessions at the upcoming SHINE Conference, dealing with physics of the Sun, the solar wind, reconnection and turbulence, acceleration and transport of energetic particles, etc. Some of the sessions will be addressing the physics issues that will be explored with the upcoming NASA Parker Solar Probe, scheduled to be launched at about the time of the 2018 SHINE Conference.

Eight sessions that will be held at the 2018 SHINE Conference in Cocoa Beach are of particular interest to the GEM community (for magnetospheric physics and for space weather): "Observational Signatures of Star-Planet Interactions", "Global implications of kinetic-scale particle acceleration throughout the heliosphere", "Using PSP to Probe Magnetic Reconnection at the Sun", "Suprathermal ions and electrons in interplanetary space: Properties and Roles", "Predicting solar energetic particles: community campaign", "Coupled heliospheric and solar energetic particle models", "Advancing Solar Activity Forecasts Through Observations, Data Assimilation and Machine Learning", "How do small-scale effects feedback on reconnection global dynamics, and vice versa?". Details about these sessions (and who to contact to participate) can be found on the SHINE Workshop webpage http://shinecon.org/CurrentMeeting.php.

NOAA Liaison Report

Howard Singer (NOAA Space Weather Prediction Center)

This brief report describes recent highlights and future plans related to NOAA's space weather activities that are relevant to the Geospace Environment Modeling (GEM) community. As described below, driven by the growth and needs of customers, there are numerous recent accomplishments in the provision of space weather services, and plans for future models and observations. NOAA's Space Weather Prediction Center (SWPC) is also guided, in part, by recent national imperatives for meeting societal needs and advancing space weather understanding and services as presented in the National Space Weather Strategy and Action Plan and through working with our interagency, international, academic, and commercial service partners.

Solar cycle 24, peaking in April 2014, was one of the smallest solar cycles on record; however, as we head toward solar minimum, customer growth in space weather continues to increase. This is illustrated by SWPC's customer subscription service, which climbed to 53,864 at the end of March 2018. This is only one of several ways SWPC delivers services, but it is a good indicator of growing customer needs. At the same time that we experience a weak solar cycle, and rapidly advance towards solar minimum, it is useful to remember that some of the largest geomagnetic storms have occurred during these smaller cycles. (**Figure 1** shows the International Space Environment Services Sunspot and Solar Cycle Progression as described on SWPC web page https://www.swpc.noaa.gov/products/solar-cycle-progression).

During the past year, NOAA space weather observations, many of which are used frequently by the GEM community, have been sustained, or improved, and new observations are planned. NOAA's Deep Space Climate Observatory (DSCOVR) (carried out in partnership with NASA and DOD) continues to provide real-time solar wind observations from the L1 Lagrange location and during the past year software modifications have been implemented that improve the quality of solar wind velocity, density and temperature provided by the Faraday Cup. At the same time, efforts are underway in NOAA for expanded capabilities at L1 with a notional launch in 2024 of the Space

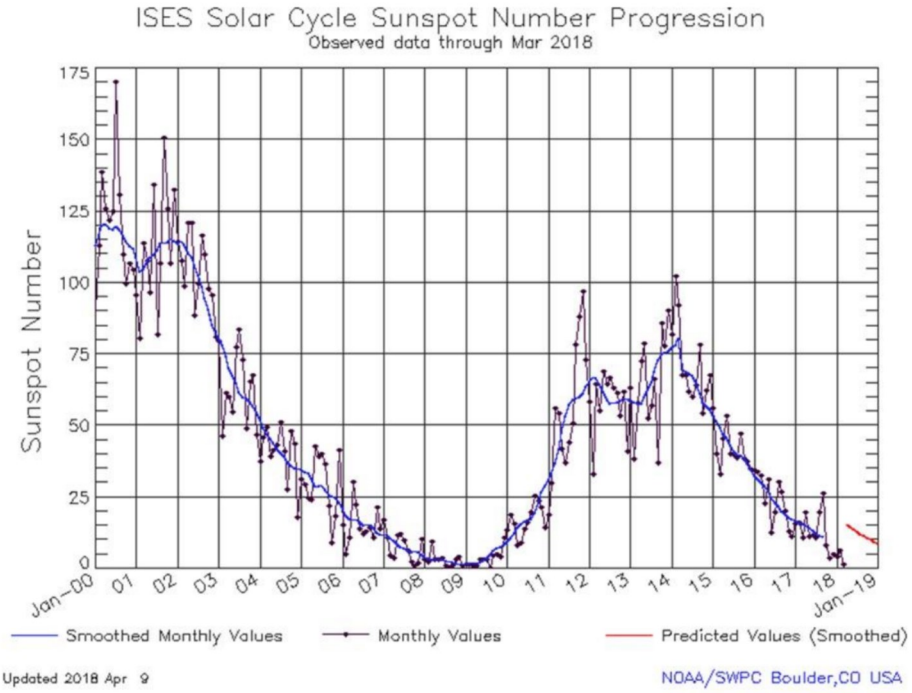


***Figure 1**. The International Space Environment Services Sunspot and Solar Cycle Progression as described on SWPC web page https://www.swpc.noaa.gov/products/solar-cycle-progression).*

Weather Follow On (SWFO). NOAA's first planned operational coronagraph, the Naval Research Laboratory's Compact CORonagraph (CCOR), is under development and scheduled for preliminary design review this coming fall. SWPC is also working with international partners to coordinate their proposed measurements from L5 with the NOAA observations at L1.

Currently GOES-14 and -15 are the operational geosynchronous satellites providing in-situ energetic particle and magnetic field data and solar observations, both for space weather operations and to support GEM scientists and others. Recently, on March 12, 2018, GOES-17, the second of a new series of four GOES geosynchronous spacecraft was launched. For this new series of satellites, in addition to continuing magnetic field, integrated X-ray and EUV observations, and an extensive range of energetic particle measurements; the satellite will host new observing capabilities, including: ions and electrons down to 30 eV; heavy ions from 10-200 MeV/nucleon; improved energetic particle energy resolution; ultraviolet solar imagery for improved solar feature characterization with wavelength bands comparable to SDO/AIA; and a faster sampling rate for the magnetometer (10 Hz). Following testing and evaluation, the new GOES real-time data will become available through SWPC and archived with the National Centers for Environmental Information (NCEI, formerly known as NGDC). SWPC is also preparing to utilize data from the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2) satellites after their launch, which is planned for Fall 2018. Also, through collaboration with NSF and the National Solar Observatory (NSO), SWPC is providing support for data processing activities for Global Oscillation Network Group (GONG) data that are used in operations as well as by the science community.

Modeling the space environment is a significant challenge that will lead to major benefits for those impacted by space weather. Since October 2016, the University of Michigan's Geospace model has been used in operations with initial products that provide forecasters and web-based users with regional predictions of geomagnetic disturbances. During the past year, the model had its first upgrade to version 1.5 which includes some minor physics improvements, new output parameters, increased model robustness, changes to handling input data outages, and a switch to a different operational high-performance computer (Cray). There is also an increased emphasis on model validation. SWPC, in partnership with NASA's Community Coordinated Modeling Center and the AF, is also working on model improvements to the Wang-Sheeley-Arge Enlil Cone model for predicting the background solar wind, and the impact of coronal mass ejections. For predicting dynamics in the ionosphere and thermosphere, work is continuing on the Integrated Dynamics in Earth's Atmosphere (IDEA) model.

Another major activity for SWPC, and other national agencies, this year was related to carrying out actions that were defined in the National Space Weather Strategy and Action Plan. The Space Weather Action Plan (SWAP) identifies many efforts that are needed by the Nation for "improving understanding of, forecasting of, and preparedness for space-weather events." As one of the actions in SWAP, during the past year, SWPC engaged Abt Associates to produce a report on the Social and Economic Effects of Space Weather and they are now conducting a comprehensive user survey of space weather data and product requirements. Also this year, SWPC has partnered with NASA and NSF to fund an Operations to Research/Research to Operations (O2R/R2O) pilot project to improve space weather services and held several meetings to gather community input on future plans for O2R-R2O. Finally, another successful and exciting Space Weather Workshop was held in Westminster, CO in April 2018. The workshop, organized by the University Corporation for Atmospheric Research, is co-sponsored by NOAA, NASA and NSF and brought together the broad space weather focused communities, composed of government, commercial and academic sectors for a week of presentations, posters and panel discussions. The workshop hosted over 300 participants, with representation from 18 nations as well as student contributions. Next year's Space Weather Workshop is scheduled for April 1-5, 2019.

AFRL Liaison Report

James McCollough (Air Force Research Laboratory)

The Air Force Research Laboratory (AFRL) supports science to better understand the space environment. This science is leveraged to extract information about specific populations and phenomena that have practical effects on things like satellites, communications, etc. AFRL's role is to perform in-house R&D and leverage community data, models, and advancements to address AF needs. This includes a variety of topics of interest to GEM: Ground- and space-based environment monitoring; Spacecraft charging and space weathering; and the anticipated launch of the DSX spacecraft. We would like to highlight two others here: radiation belt climatology modeling and solar energetic particle forecasting.

International Radiation Environment Near Earth (IRENE)

AFRL is continuing to develop AE9/AP9-IRENE, a model suite addressing particle radiation hazards in near-Earth space for satellite design and mission planning. V1.5 was released in late 2017 and added electron and proton data sets from Van Allen Probes. In early 2019 a V1.6 update will add additional Van Allen Probes data.

The model stores flux maps in invariant space (e.g. K, Φ, and E) and spans energies from hot plasma to radiation belts. It provides Monte Carlo scenarios capturing spatio-temporal variability. Of interest to modelers, it can serve to supply multiple, realistic boundary conditions for global simulations, or to provide priors for sensor data inversion and data assimilation.

There are several areas where we expect community modeling will inform future development. The next major version, V2.0, will involve an architecture overhaul to support additional degrees of freedom in existing components (e.g., MLT variation for plasma and longitude variation for radiation belt electrons), plus the ability to incorporate new component models such as ones for solar protons and auroral electrons. In particular, it will add a sample solar cycle as a fly-through option for designers, capturing realistic dynamics on a range of timescales up to a solar cycle. This will entail having a full solar cycle reanalysis covering a broad range of energies for users to interrogate. These results along with other physics-based modeling may also inform approaches to filling gaps in the existing proton, electron, and plasma models.

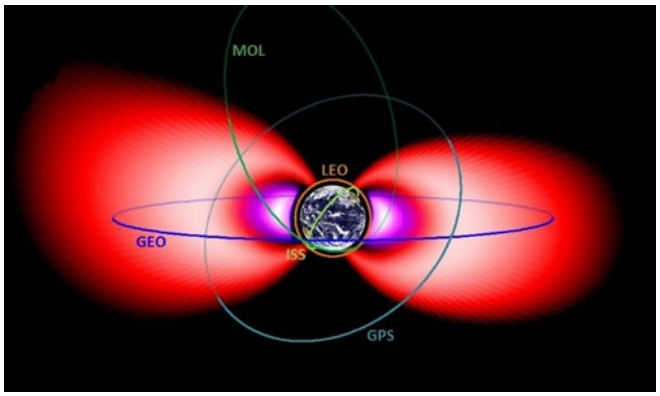


Figure 2. *IRENE specifies electron (red) and proton (blue) climatological flux levels (indicated by saturation) throughout geospace. Several orbits are plotted for context.*

Air Force Dynamic Energetic Particle Tool (AF-DEPT)

This is an automated 3-step SEP forecast system that leverages community models to provide information before and during a solar event. The goal is to forecast solar energetic particle (SEP) events defined as periods when the interplanetary flux I of >10 MeV protons exceeds 10 pfu (see **Figure 3**).

AF-DEPT will forecast:

- P_E: probability of an event occurring in a 24 -hour window

- I_p: peak interplanetary flux
- t_O and t_R: onset and rise times
- $P(t)$: time-dependent SEP-event occurrence probabilities

Once a SEP-event occurs, forecasting the time profile as a function of energy becomes necessary and will be the subject of on-going research.

AF-DEPT utilized the MAG4 model developed by NASA to provide P_E before any solar event. Once a solar flare (M2 class or larger) occurs, the NOAA Protons model utilizes a database of GOES X-Ray and SEP events and a custom time dependent factor to provide $P(t)$ and forecasts of I_P *and* t_R. Once flux increases are observed, the UMASEP model (U. Malaga) is employed to provide a dynamic forecast of I_P and t_O. Current work involves possibly replacing this last step with an in-house model that will provide forecasts of I_P, t_O, and t_R.

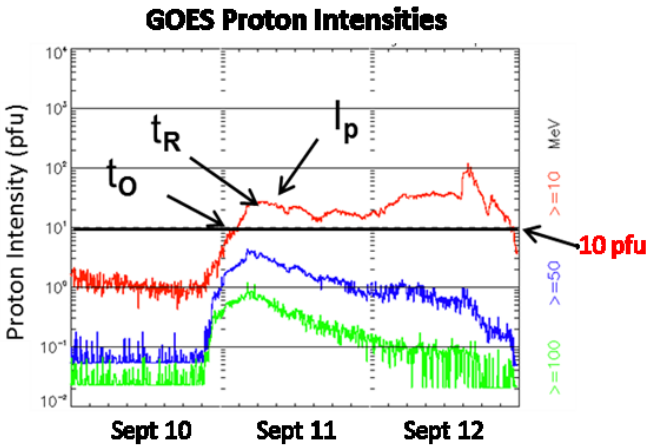


Figure 3. *The goal of AF-DEPT is to forecast: the probability of an event occurring in a 24-hour window; peak intensities I_P; onset and rise times t_O and t_R; and time-dependent SEP event occurrence probabilities P(t).*

USGS Liaison Report

E. Joshua Rigler (USGS Geomagnetism Program)

The following is a brief summary of operations and research undertaken at the United States 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.

Data Services

The USGS Geomagnetism Program monitors the Earth's magnetic field with high accuracy, (time) resolution, and reliability. It manages 14 magnetic observatories distributed across the United States and its territories. "Preliminary" magnetometer data are minimally processed, but 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. INTERMAGNET recently deployed a public FTP service to facilitate downloading considerably larger chunks of data than was previously possible (ftp://ftp.seismo.nrcan.gc.ca/intermagnet/).

The USGS recently initiated geoelectric field monitoring at the Boulder, Colorado observatory. These data are available in near real time. Presently, no post-processing is performed on these data beyond basic quality checks. This project serves as a template for geoelectric monitoring at other observatories, should future funding allow.

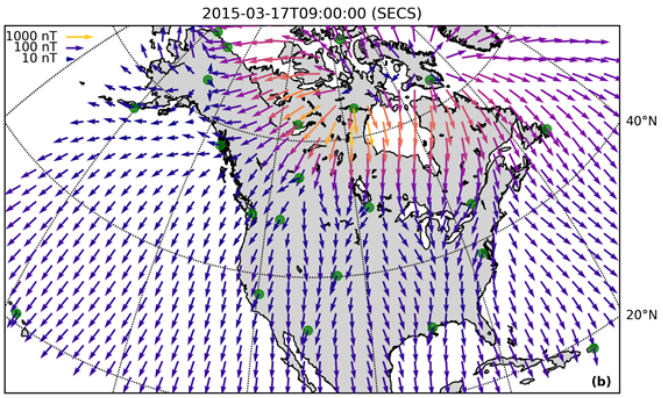
"Adjusted" geomagnetic data are near real time, automatically generated versions of traditional, and manually intensive, Quasi-definitive and Definitive data products. A beta version has been under evaluation for over a year, and it will become the USGS' default real time product starting in FY19. All derived real time geomagnetism products (e.g., USGS 1-minute Dst) will then use Adjusted data as input, thus improving their accuracy and reliability.

Targeted Research

Research within the USGS Geomagnetism Program is concentrated on analysis of geomagnetic and geoelectric data for the assessment of related natural hazards.

Geomagnetic Disturbance Maps

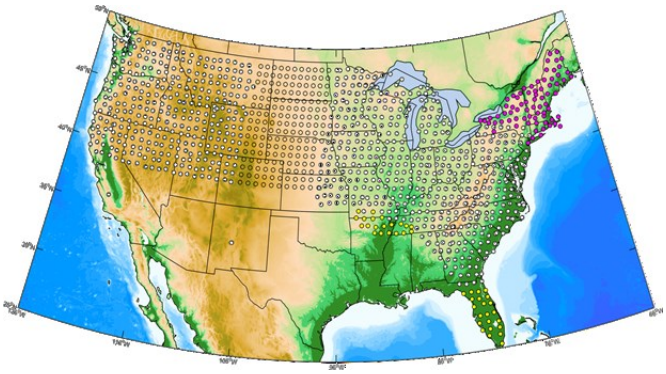
As part of a multi-agency collaboration with NASA and NOAA, the USGS has developed a real time operations-oriented open-source software package that employs the well-known spherical elementary current system (SECS) inversion technique to interpolate surface magnetic perturbations given sparse geomagnetic observations (github.com/usgs/geomag-imp). NOAA's



Space Weather Prediction Center (SWPC) incorporated this software into their gridded geoelectric field maps for the continental United States (CONUS) using near real time data from the USGS and Natural Resources Canada (NRCan) as input.

Magnetotelluric Surveys

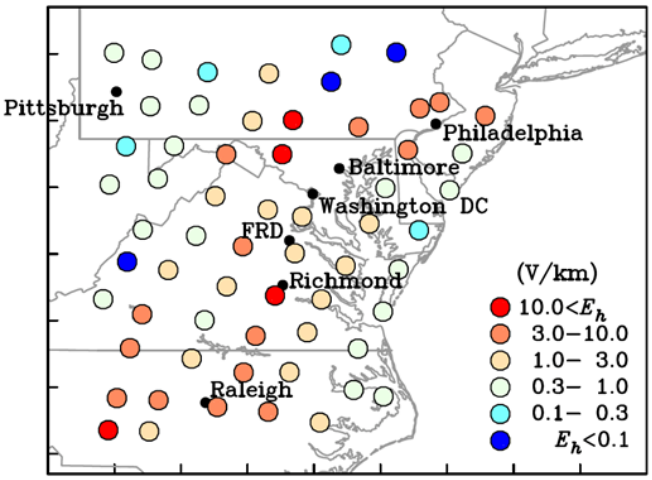
The USGS is closely involved with NSF's Earthscope USArray program, run out of Oregon State University (OSU), to perform a gridded magnetotelluric (MT) survey of the continental United States, and to assist with archiving this and related data in a publicly accessible online database (ds.iris.edu/spud/emtf). USArray covers the Pacific Northwest, the Upper Midwest and Great Lakes, Appalachia, and recently completed New England. The USGS has sponsored and conducted its own smaller-scale regional magnetotelluric surveys that augment USArray coverage and support specific industry needs, most notably in Florida, southern Missouri, northern Arkansas, and western Tennessee.



Geoelectric Field and Geoelectric Hazard Maps

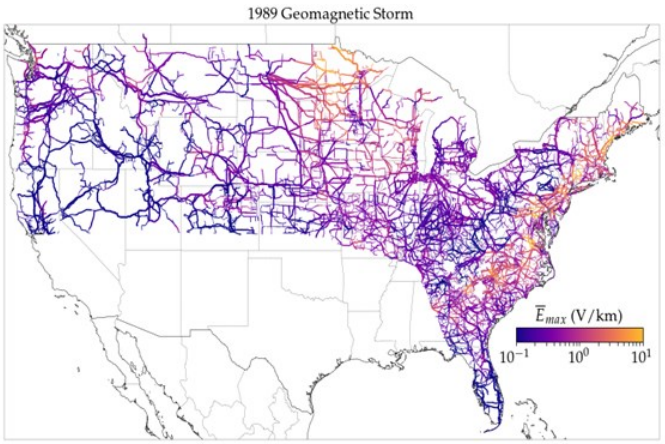
The USGS is a lead agency working in collaboration with NOAA, NASA, and Los Alamos National Laboratory to map time-varying geoelectric fields and evaluate geoelectric hazards that are of concern for the power-grid industry. While geoelectric fields can be measured directly, they are more practically estimated using magnetotelluric (MT) impedances and modeled or measured geomagnetic disturbance.

This approach is used for NOAA SWPC's geoelectric field maps, mentioned previously. It was also used to calculate induced geoelectric fields over extended historical periods for which USGS geomagnetic data were available, using the dense distribution of USArray measured impedances. This allowed relatively complete spatio-temporal distributions to be constructed, and extreme event statistics to be calculated for regions of CONUS with dense populations and sensitive technological infrastructure (e.g., Eastern seaboard). Finally, geoelectric fields were integrated along real electric power grid geometries to provide industry-relevant induction hazard scenario maps.



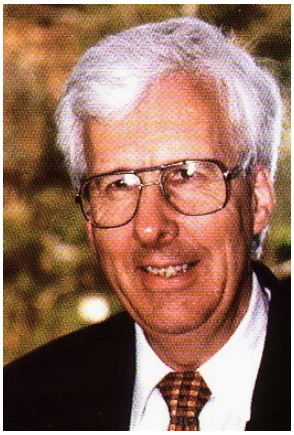
Regional, Continental, and Global Ground Conductivity

Synthetic impedances can be estimated on uniform spatial grids by using MT measurements to constrain geophysically self-consistent conductivity models. The USGS is using magnetotelluric survey data collected across the U.S. to generate such conductivity models and is investigating the effects of scaling and distortion on synthetic impedance grids. To date, these efforts have been regional in scope, but ongoing research promises more continental-scale models that will be directly applicable to the GIC hazard problem.



Australia Liaison Report

Brian Fraser (University of Newcastle)



1) Organisation under way for COSPAR 2020 which will be held in Sydney: http://www.cospar2020.org/

2) On 8 May 2018, as part of the 2018-19 Budget, the Australian Government announced the establishment of an Australian Space Agency with ongoing funding starting at $26 million over the next four years.The Agency will also be able to draw on a pool of $15 million, from 2019-20, to invest in specific international space projects which are considered to be beneficial to Australia. Dr Megan Clark, former head of CSIRO will be interim Head of the Agency, due to commence on July 2018. The initial funding level is at the low end of expectation, but other agencies funding totalling more than $260M is available initially, to support critical national infrastructure. Location of the Agency yet to be determined. Mainly based on establishing space industry, there is little mention of space science. https://www.industry.gov.au/INDUSTRY/IndustrySectors/SPACE/Pages/default.aspx

3) Development and launch of a number of cubesats for various R&D projects (including defence):

- http://sydney.edu.au/inspire-cubesat/
- https://www.itnews.com.au/news/first-unsw-cubesat-launched-into-orbit-478479
- http://www.acser.unsw.edu.au/QB50
- https://www.airforce-technology.com/news/newsus-developed-biarri-point-satellite-launched-into-orbit-5876701/

4) Establishment of an R&D training centre at U Sydney for cubesats and UAVs: http://www.arc.gov.au/australia-re-enter-space-business-cubesats

5) BAE systems wins $1B contract for phase 6 upgrade of the JORN OTHR facility, to extend life beyond 2042: https://www.defenceconnect.com.au/key-enablers/1986-bae-systems-australia-lands-1-billion-jorn-upgrade-contract

6) A very successful International Astronautical Congress held in Adelaide attracts over 5000 delegates, half from Australia. Keynote address was by Elon Musk: http://www.iafastro.org/events/iac/iac-2017/

China Liaison Report

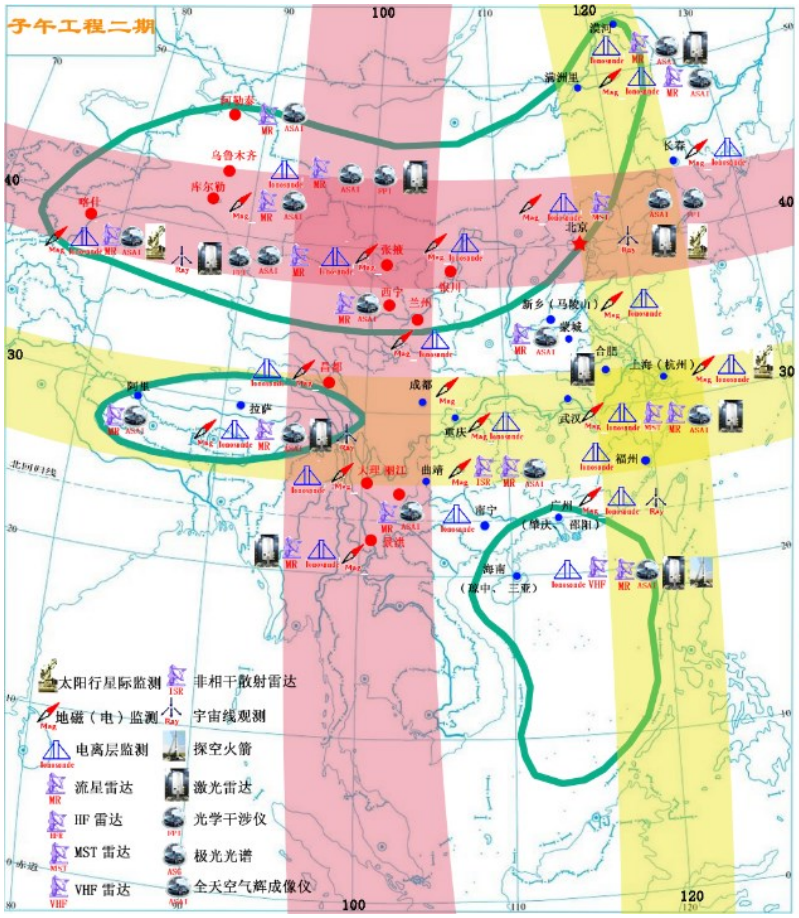
Chi Wang (National Space Science Center, Chinese Academy of Sciences)

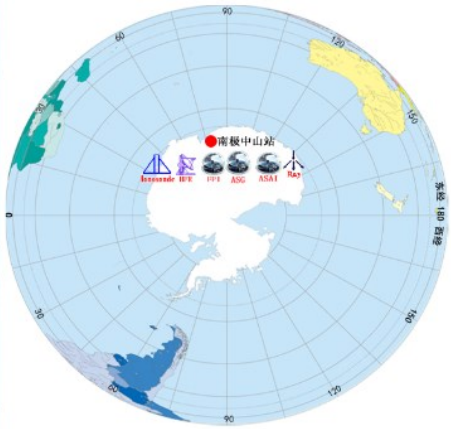
Meridian Project II

The Chinese Meridian Space Weather Monitoring Project (Meridian Project) is a ground-based geospace monitoring chain in China. It consists of 15 ground-based observation stations located roughly along 120°E longitude and 30°N latitude. Each observatory is equipped with multiple instruments to comprehensively measure key parameters such as the baseline and time-varying geomagnetic field, as well as the middle and upper atmosphere and ionosphere from about 20 to 1000 kilometers. Chinese Meridian Project started collecting data from 2011, part of data is made public via the website http://data.meridianproject.ac.cn.

For the current Meridian Project, as limited by a small budget, no solar observation capability was built, a large area of China's territory is not covered, distances between adjacent stations are too large for study of medium to small scale phenomenon, and the capability of the ordinary instruments adopted by the current project is still relatively weak. A major upgrade to the current Meridian Project is strongly demanded, and Phase II of Chinese Meridian Project has been proposed and has been approved.

Meridian Project II will add to the current project two observatory chains, one along 100°E and another along 40°N. Together with the current 120°E and 30°N chains, a two-cross network configura-



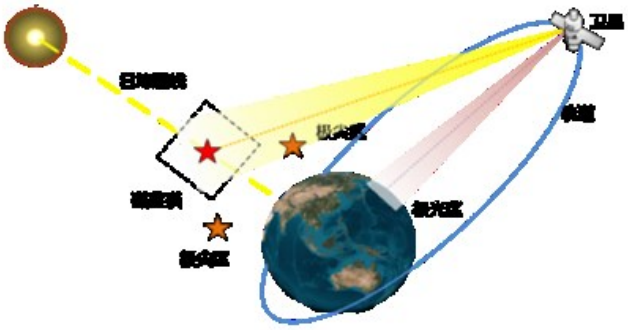


tion will be formed to cover nearly the whole territory of China in a sense of monitoring medium scale phenomenon, and distances between adjacent stations will be as small as 100km in some critical regions. The construction is scheduled to start at end of 2018 and complete in 2022.

SMILE

The SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) mission is a novel self-standing mission to observe solar wind-magnetosphere coupling via simultaneous in situ solar wind/magnetosheath plasma and magnetic field measurements, X-Ray images of the magnetosheath and magnetic cusps, and UV auroral images of global auroral distributions defining system-level consequences. The Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) will complement all solar, solar wind and in situ magnetospheric observations, including both space- and ground-based observatories, to enable the first -ever observations of the full chain of events that drive space weather.

SMILE mission is an international cooperation project of space science exploration jointly leaded by CAS and ESA, and it is a new milestones of comprehensive and deep cooperation among scientists from both parties. CAS is responsible for the study and development of satellite Platform (PF), TC/TM(CLTC), Science Application System (SAS) as well as Ground Support System (GSS),



and is also responsible for the study of MAGnetometer (MAG) and Light Ion Analyzer (LIA) from NSSC, CAS. ESA is responsible for the study and development of Payload Module (PLM), Launch Vehicle, Launch Site and Science Operation Center (SOC), station support and service when it is necessary from the Chinese part, and is also responsible for the study of Soft X-ray Imager (SXI) from Leicester University, UK. and Ultra-Violet Imager (UVI) from University of Calgary, Canada.

From the Chinese side, SMILE has been fully supported. For the ESA side, the mission was selected by SPC in November 2015, and the final mission adoption by SPC is currently scheduled in November 2018. The launch date is scheduled in 2022 – 2023.

ESA Liaison Report

Benoit Lavraud (IRAP, Toulouse, France)

This report only concerns "GEM-related news" regarding recent ESA missions and programmatic calls.

1. Cluster

Cluster got preliminary extended for 2019-2020 at the ESA science programme committee meeting in March 2018. If nothing major happens in the next few months on the spacecraft, the extension should be confirmed in November. The science case for a further extension in 2021 and 2022 will be built during the next few months.

2. SWARM

The three spacecraft SWARM mission (launched on 22 November 2013), dedicated to the study of Earth's interior, magnetic field and ionosphere, continues to provide great results. In November 2017 ESA approved the extension of SWARM until the end of 2021.

3. Small-size S2 mission

The SMILE mission, selected in 2015 as a joint European and Chinese small mission, is still under development as planned. SMILE will be launched into a highly inclined, elliptical orbit to a third of the way to the Moon. From this orbit it will make images and movies of the magnetopause, the polar cusps, and the auroral oval for the first time based on X-ray imaging from afar.

4. Medium-size M4 mission selection

Following 2-year phase A studies, ESA recently selected the ARIEL (exoplanets) mission as the next M-class mission, with a launch scheduled now for 2028. The THOR (space plasma turbulence) mission, of interest to the GEM community, was unfortunately not selected. This mission was made of a single spacecraft dedicated to the study of solar wind and magnetosheath turbulence at kinetic scales, with unprecedentedly high resolution wave and particle measurements (beyond MMS).

5. Medium-size M5 mission selection

Recently, ESA announced the selection of three missions for a two-year phase A study, but unfortunately none of them concerns the GEM community (or even the broader heliospheric plasma community). The selected missions are: ENVISION (Venus radar mapping), SPICA (SPace Infrared telescope for Cosmology and Astrophysics; mission of opportunity with JAXA) and THESEUS (Transient High Energy Sky and Early Universe Surveyor). The candidate missions of interest to the GEM community which were not selected are:

- JANUS. Exploration of the asymmetric magnetosphere, with a dual spacecraft mission design on Molnya type orbits, dedicated primarily to continuous/simultaneous auroral imaging.
- ESCAPE: European SpaceCraft for the study of Atmospheric Particle Escape: a single satellite on rather low-Earth orbit to study escape processes to the Earth's magnetosphere, with strong emphasis on composition measurements (Nitrogen/Oxygen).
- ALFVEN: A dual spacecraft mission in rather low Earth Orbit to study particle acceleration in strongly magnetized plasmas.

6. Next ESA opportunities

The ESA programme is somewhat volatile these days. As of now, it appears that there will be no M6 mission, owing to financial planning issues. Yet, ESA is currently discussing the opportunity of what they call an M* mission, as well as an F1 mission. The contours of these opportunities remains unclear and so no further details may be given at this time.

ISAS Liaison Report

Yoshi Miyoshi (Nagoya University, Japan)

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

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

1. GEOTAIL

GEOTAIL operation will continue at least until the end of March 2019. The GEOTAIL project is planning to take a mission extention review in fall 2018 in order to extend GEOTAIL operation at least until the end of Mar. 2021. NASA is continuously supporting GEOTAIL (tracking by DSN (Deep Space Network), and making level-1 data). NASA's support for GEOTAIL operation until 2020 was approved at NASA 2017 Heliophysics Senior Review. THEMIS-GEOTAIL conjunction, MMS-GEOTAIL conjunction observations are continuing. When you analyze THEMIS or MMS data, please also use simultaneous GEOTAIL data. You can easily browse data plots of GEOTAIL, THEMIS, and MMS at a website called CEF (Conjunction Event Finder): http://darts.isas.jaxa.jp/stp/cef/cef.cgi. At CEF, GEOTAIL data can be browsed about two weeks after the acquisition of the data. (To be more specific, magnetic field data, electric field data, and low-energy plasma data, can be browsed.) GEOTAIL digital data are open to public at a website called DARTS at http://darts.isas.jaxa.jp/stp/index.html.en. When you use 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@stp.isas.jaxa.jp and Dr. Saito (Project Manager): saito@stp.isas.jaxa.jp.

2. Arase (ERG)

Arase (ERG) satellite has observed the inner magnetosphere with the full operation mode since March 2017. We organized four campaign observations between Arase and ground-based conjugate observations in 2017. Besides these campaign observations, conjugate observations between Arase and ground-based observations have been continuouslly operated. During the conjugate periods, Arase operates the burst mode observations to mesaure waveforms at VLF/ELF frequency range. Moreover, conjugate observations between Arase and Van Allen Probes are operated since June 2017, and more than 100 conjugate observations between two satellites were realized. The information of the science instruments onboard the Arase satellite were published in the special issue of Earth, Planets and Space. The first scentific result on the pitch angle scattering by chorus waves was reported in Nature, 2018, and the GRL special issue is now going. CDF files for the orbit and related software, tools are also found in the science center webpage (https://ergsc.isee.nagoya-u.ac.jp), and the Level-2 science data will be opened to the public in this year. If you have any questions on the Arase satellite, please contact Dr. Shinohara (Project Manager): iku@stp.isas.jaxa.jp and Dr. Miyoshi (Project Scientist) : miyoshi@isee.nagoya-u.ac.jp.

3. BepoiColombo MMO

In addition to Earth-orbiting missions GEOTAIL and Arase, BepiColombo MMO [Mercury Magnetospheric Orbiter] will be launched in autumn this year. After arriving at Mercury in December 2025, MMO will make comprehensive observation of Mercury's magnetosphere together with ESA' s Mercury Planetary Orbiter (MPO).

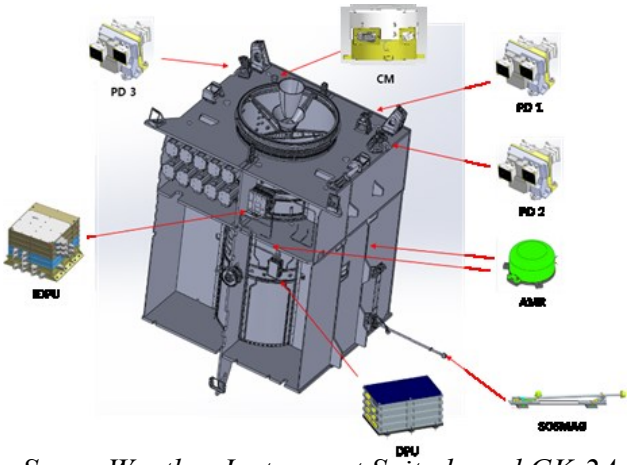
South Korea Liaison Report

Jaejin Lee (Korea Astronomy and Space Science Institute)

1) The Magnetosphere-Ionosphere joint workshop, similar to the GEM/CEDAR joint meeting, was successfully held last summer in Daejeon. This workshop aims to share scientific interests and discuss the future direction of the Korean space physics community. About 83 researchers and students attended the workshop.

2) KASI (Korea Astronomy and Space Science Institute) is designing the SNIPE (Small-scale magNetospheric and Ionospheric Plasma Experiment) mission, which consists of four nanosatellites of ~10 kg. The SNIPE mission, planned to be launched in Oct. 2020, will perform formation flying in low earth orbit (~500 km) to investigate ionospheric plasma irregularities and electron precipitation with sophisticated instruments, a Langmuir Probe, Solid State Detectors, and Magnetometers. The SNIPE passed an SDR (System Definition Review) in Nov. 2017 and will be reviewed as to preliminary design (PDR) in Jul. 2018.

3) GK-2A, a Geosynchronous meteorological satellite funded by KMA (Korea Meteorological Administration) is scheduled to be launched in Nov. 2018 into a longitude of 128.2° E. Kyunghee University has developed space weather instruments (KSEM; Korea Space Environment Monitor) composed of three detectors, Particle Detectors, Spacecraft Charging Monitor, and Magnetometer.



Space Weather Instrument Suit aboard GK-2A

4) Prof. Min at KAIST (Korea Advanced Institute of Science and Technology) is waiting for the launch of NEXTSat-1 on which the ISSS (Instruments for the Study of Space Storms) have been loaded. The ISSS is an instrument suite consisting of five space plasma detectors; High Energy Particle Detector (HEPD), Medium Energy Particle Detector (MEPD), Langmuir Probe (LP), Retarding Potential Analyzer (RPA) and Ion Drift Meter (IDM). The NEXTSat-1 is a Korean scientific satellite (~ 100 kg) scheduled to be launched in Oct. 2018 into the low earth (~ 600 km) polar orbit.

Magnetosphere and Ionosphere Workshop Attendees

Taiwan Liaison Report

Lou Lee (Academia Sinica)

There are two satellites from Taiwan, one was launched in 2017 and the other will be launched in 2018. These two satellite missions can make contributions to space weather study.

1. FORMOSAT-5 Mission (Launch August 25, 2017)

As a FORMOSAT-2 follow-on mission, National Space Organization in Taiwan (NSPO) has self-reliantly finished developing FORMOSAT-5 program to mainly provide 2-m resolution panchromatic and 4-m resolution multi-spectral imagery with capability of two-day revisit and global coverage. In addition, an advanced ionospheric probe (AIP) with the heritage of FORMOSAT-1 Ionospheric Plasma and Electrodynamics Instrument is also onboard FORMOSAT-5 satellite. AIP, an all-in-one plasma sensor with up to 8192 Hz sampling rate, will provide the measurements of ionospheric plasma concentrations, velocities, and temperatures over a wide range of spatial scales to study the Earth's ionosphere and contribute to space weather study. During FORMOSAT-5 early orbit checkout phase, it is shown there is no significant hysteresis on measured current-voltage curves. It indicates that the AIP grids are almost free of contamination and could make an accurate measurement of ionospheric plasma parameters. Currently AIP measures in night-side orbits with a geographic latitude coverage from -60° to 60° and can be used to identify ionospheric plasma density irregularity distributions at low latitudes. Furthermore, mid-latitude electron density enhancement, equatorial plasma depletion bay, and non-migrating tide (wave-4) can be observed from synthesized global ion density maps every two days. The AIP in-situ measurement data can also benefit the research of ionospheric seismic precursor and eventually to mitigate the loss of earthquake disasters.

2. FORMOSAT-7/COSMIC-2 Mission (Launch 2018)

The FORMOSAT-7/COSMIC-2 is a collaborative program between Taiwan and the U.S. following the success of FORMOSAT-3. The program will launch a cluster of 6-satellites into low-inclination orbits in 2018. Each satellite is equipped with three payloads, Radio Occultation receiver (TGRS), Ion Velocity Meter (IVM), and RF Beacon (RFB). The TGRS is capable of tracking up to 4,000 high-quality profiles per day. The IVM directly measures the ion temperature, velocity in the path of each satellite. The RFB measures the irregularity of electron densities in the ionospheric layer. The FORMOSAT-7/COSMIC-2 mission will provide a revolutionary increase in the number atmospheric and ionospheric observations operationally. The operational ionospheric observations with 30-45 min time latency will benefit the ionospheric space weather monitoring and forecast. In the FORMOSAT-3/COSMIC era, global ionospheric maps are built in a monthly basis, which could only be applied for climatological study. For the FORMOSAT-7/COSMIC-2, increasing numbers and advances in data assimilation techniques will provide global ionospheric maps on a 2-hour basis. The 2-hour basis global ionospheric maps will be applied for real space weather monitoring. In the meantime, new ionospheric forecast model has been developed and it is expected to provide short-range forecast (hours).

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- Lou Lee (Liaison to Taiwan)

Meeting Organizer
- Robert Clauer (2005-2018)
- Chia-Lin Huang, Chris Mouikis (2018-)

Student Represenatives
- Suzanne Smith (2016 - 2018)
- Ryan Dewey (2017 - 2019)

Research Area Coordinators

Solar Wind-Magnetosphere Interaction (SWMI)
- Katariina Nykyri (2012-2018)
- Steve Petrinec (2015-2021)

Magnetotail and Plasma Sheet (MPS)
- Andrei Runov (2014-2018)
- Matina Gkioulidou (2015-2021)

Inner MAGnetosphere (IMAG)
- Scot Elkington (2013-2018)
- Seth Claudepierre (2015-2021)

Magnetosphere-Ionosphere Coupling (MIC)
- Marc Lessard (2012-2018)
- Shin Ohtani (2015-2021)

Global System Modeling (GSM)
- Frank Toffoletto (2012-2018)
- Alex Glocer (2015-2021)

Communications Coordinator
- Peter Chi (2014 - 2019)

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