2025 Workshop: GIC-GMD

Long title
Understanding the causes of geomagnetic disturbances in geospace for hazard analysis on geomagnetically induced currents
GEM-only session
Conveners
Xueling Shi
Dogacan Ozturk
Zhonghua Xu
Mark Engebretson
Josh Erin Rigler
Chigomezyo Ngwira
xueling7@vt.edu
Description

Geomagnetic disturbances (GMDs) have long been used to derive global geomagnetic activity indices (e.g., Kp, AE, and Dst), remote sense the magnetosphere-ionosphere (M-I) currents and plasma waves, and as inputs to geoelectric field/GIC models. The sources of GMDs are directly related to various M-I currents and plasma waves which can be attributed to various drivers in the solar wind-magnetosphere-ionosphere-ground coupled system. Despite extensive research, questions still remain regarding the common sources and driving mechanisms of GMDs. Many studies have focused on the association of GMDs with large-scale geomagnetic activity including storms and substorms. Several more recent statistical studies have analyzed the association of nighttime GMDs with global inputs (IMF and solar wind) and geomagnetic indices, and case studies have focused on more local phenomena such as overhead ionospheric currents and auroras. The M-I currents that drive nighttime GMDs appear to be linked to mesoscale disturbances in the magnetotail, and their association with substorms and/or intervals of negative IMF Bz suggests the influence of magnetotail reconnection. Recent studies have demonstrated connections between nighttime GMD events and specific magnetotail disturbances, such as dipolarizing flux bundles in the nighttime transition region. However, direct geoelectric field measurements remain scarce, and GIC data are often not publicly available. As a result, many studies rely on dB/dt or ΔB as proxies, yet it remains unclear whether these metrics

reliably represent GICs or under what conditions GMDs lead to extreme geoelectric fields and hazardous GICs. Addressing these gaps requires an interdisciplinary, community-wide effort involving space science data analysis, space weather modeling, magnetotelluric (MT) studies, and power system engineering. The GIC FG aims to address the following questions: What are the drivers of the formation and evolution of space weather significant GMDs? To what extent can different models predict GMDs and what are the immediate missing components to improve GMD prediction? What is the most important input the GEM community could provide to those who study geoelectric fields and GICs?

Agenda

1. Tue 10:00-12:00 (Rm. 307): GIC: Discussion Session on Current FG Efforts and Future FG Ideas

- Xueling Shi: Summary of GIC Focus Group Activities
- Zhonghua Xu: Review Ground Magnetometer Network
- Bhagyashree Waghule, Shane Coyle, Gabby Nowak, Shibaji Chakraborty: Students and Early Career Scientists Led Open Discussion on Future Focus Group Ideas

2. Wed 10:00-12:00 (Rm. 307): GIC: Modeling Challenge Session

- Dogacan Ozturk: Opening Remarks
- Daniel Welling: Challenges, Considerations, and New Paradigms for Extreme Event Modeling
- Scott Thaller: Examining the Quantitative Connection Between Field-Aligned Current and Geomagnetic Field Variability Using Swarm Data
- Pauline M. Dredger: Solar Wind Input and Its Effect on SWMF Predictions of GMDs
- Michael Wiltberger: MAGE Simulation of GMDs during the Gannon Storm
- Michael Liemohn: GIC challenge input:Consider a “Prediction Efficiency” Skill Score for Event Detection
- Masha Kuznetsova: CCMC tool for ground magnetic field perturbations
- Panel Discussion on Modeling Challenges

3. Thu 10:00-12:00 (Rm. 309-310): GIC-GMAG Joint Session

- Zhonghua Xu: Opening Remarks
- Marc Lessard: Search Coil Updates
- Eframir Franco-Diaz: Magstar Array Update and Future Ideas
- Mike Hartinger: IPY update and campaigns
- Mark Engebretson: MACCS network update
- Delores Knipp: Causes of GICs and Penetrating Electric Fields during the 12 May 2021 G3 Storm
- Lucas Jia: Extreme Event SML Modeling - IRANNA
- Open Discussion on Future of Ground Magnetometers

4. Fri 13:30-15:30 (Rm. 307): GIC: Gannon Storm Session

- Dogacan Ozturk: Opening Remarks
- Masha Kuznetsova: Community Portal for Great Helio Storms
- Yu Hong: Impacts of Neutral Wind-induced Currents on Geomagnetic Disturbances and Magnetospheric Dynamics During the May 2024 Gannon Storm
- James Weygand: GMD and GICs during the Gannon storm
- Bhagyashree Waghule: NERC GIC
- Ying Zou: Extreme auroral electrojet during May Gannon Storm
- Lucy Wilkerson: GIC-Related Observations During the May 2024 Geomagnetic Storm in the United States
- Shibaji Chakraborty: Validating SCUBAS-forecasted electrical surges in submarine cables during superstorms using observations reported in historical studies
- Open Discussion

Justification

For the 2025 GEM-CEDAR joint summer workshop, the GIC FG requests four sessions overall. These sessions are designed to promote large-scale, collaborative, community initiatives. Furthermore, the proposed sessions aim to address one of the five ground-based projects that will move the magnetospheric community forward as identified by the 2024 Heliophysics Decadal Survey.

The session information and goals are as follows.
1. Discussion Session on Current FG Efforts and Future FG Ideas
Session structure: Open discussion led by early career scientists
Session description: As we approach the conclusion of our FG, this session will focus on summarizing past FG activities, shaping future research directions, and finalizing any outstanding efforts. We aim to identify key areas of interest for future FG initiatives and address any unresolved discussions. Early career scientists interested in leading future FG efforts will play a central role in guiding the conversation. Participants are encouraged to contribute ideas and engage in discussions on the next steps for the community.

2. Ground Magnetic Field Perturbation Modeling Challenge Session
Session description: This session will focus on planning and implementing a community-wide modeling challenge centered on ground magnetic field perturbations and geomagnetically induced currents (GICs). Modeling challenges have been a cornerstone of the GEM community, providing a quantitative, systematic, and transparent evaluation of models developed by members of our community. Since the initiation of the GEM Global Geospace Circulation Model (GGCM) modeling challenge in 2008, significant advancements have been made in numerical models' ability to characterize ground magnetic disturbances and their underlying drivers. These improvements stem from:
a) Enhanced physical process modeling leading to more accurate representations of geospace dynamics.
b) Increased computational performance enabling higher-resolution simulations.
c) Growing datasets allowing for more robust model validation and uncertainty quantification.
d) Advancements in the accessibility of machine learning algorithms, improving predictive capabilities.

In recent years, NASA has supported multiple Drive Centers and Centers of Excellence, fostering innovation in modeling and forecasting. Additionally, the Community Coordinated Modeling Center (CCMC) has played a crucial role in hosting and evaluating previous modeling challenges, providing an established infrastructure to facilitate a new challenge event. Given these advancements, it is timely to launch a new modeling challenge aimed at:
a) Assessing the current state of ground magnetic field perturbations, geoelectric field variations, and GIC modeling.

b) Identifying strengths and areas for improvement in existing models.
c) Encouraging collaboration between model developers, data providers, and operational users.

By building on lessons learned from previous challenges, this initiative will not only quantitatively evaluate model performance but also assess their ability to characterize key drivers, spatial and temporal extents, and impacts of identified phenomena, while helping end users take mitigating actions ahead of predicted GMDs/GICs. Through broad collaboration across the GIC research community, this challenge will drive innovation, improve predictive capabilities, and strengthen our collective understanding of space weather effects.

3. GIC-GMAG Joint Session
Session description: This session will feature important updates from ground-based array PIs, along with a key discussion on developing a ground-based magnetometer facility as a "one-stop service center." We aim to keep this as an interactive, workshop-style session with short talks and group discussions.

4. Gannon Storm Session
Research Update and Group Discussion Session
Session description: The Gannon storm, which occurred between the 10th and 13th of May 2024, was one of the strongest geomagnetic storms in recent history. Due to the large-scale efforts of the scientific community, geomagnetic perturbations related to the Gannon storm were captured globally. This session, led by the Focus Group with community contribution, will review our current understanding of ground magnetic field variability, geoelectric field determination, and their relevance to GIC. We welcome 2-3 slide presentations on studies of Gannon Storm.

Related to CEDAR Science Thrusts:
Fuse the knowledge base across disciplines in the geosciences
Workshop format
Short Presentations
Round Table Discussion
Keywords
geomagnetic disturbances, geomagnetically induced currents, geoelectric fields
Focus Group and Group Leader

Understanding the causes of geomagnetic disturbances in geospace for hazard analysis on geomagnetically induced currents, Xueling Shi

View PDF