2025 Workshop: Electrodynamic coupling of the ITM

Long title

Electrodynamic Coupling of the Thermosphere, Ionosphere and Magnetosphere from High to Low Latitudes

CEDAR-GEM

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Description

Recent observations from the two largest geomagnetic storms have challenged our understanding of the main magnetospheric and neutral-wind-driven processes responsible for disturbances in the middle- and low-latitude ionosphere-thermosphere (I-T) system and of the electrodynamic associated due to impulsive Joule heating events that generated Medium Scale Travelling Atmospheric and Ionospheric Disturbances and its interaction with Disturbance Dynamo Electric Fields, magnetospheric effects like Substorms and Subauroral Polarization Stream (SAPS) effects observed at the magnetic equator and at other latitudes. On the other hand, disturbances of ionospheric observations during a Sudden Stratospheric Warming event have been observed to distribute plasma density up to protonosphere altitudes. These challenging observations at different regimes are only possible thanks to the unprecedented datasets from spaceborne sensors aboard ICON, GOLD, COSMIC-2, GRACE-FO, Van Allen probes, Arase, DMSP along with enhancements, expansions and upgrades of ground-based assets such as ISRs, regional FPI networks, GNSS receivers, and ionosondes. These advancements continue to reveal the highly coupled nature of the I-T-M system during both quiet and storm conditions leading to refinements in the existing theories and improvements in current modeling. This workshop aims to bring together CEDAR and GEM experts to advance understanding of electrodynamics from high to low latitudes, with a focus on contributions from the inner magnetosphere, thermospheric wind dynamo, and lower atmospheric forcing.

Agenda

1. **D. Billet**, University of Saskatchewan, *Unravelling meso- vs large-scale dynamics using ground and space-based observations*

2. **R. Itani**, University of Alaska Fairbanks, *Investigations on the Role of Local Electrodynamics on High-latitude F-region Neutral Winds*

3. **Y Zou**, Johns Hopkins University Applied Physics Laboratory (JHU/APL), *Extreme Auroral Electrojets during May 2024 Geomagnetic Storm*

4. **K. Davidson**, Boston University, *Data-Model Comparison of High-Latitude Ionosphere Thermosphere Coupling during the 17 March 2013 Storm*

5. **S. Bao**, Rice University, *Electrodynamic Pathways to Ionospheric Super-Depletions: MAGE Simulation of the September 2017 Storm*

6. **Q. Wu**, High Altitude Observatory (HAO/NCAR), *Penetrating and disturbed electric fields observed by ICON and simulated by MAGE*

7. **K. Laundal**, University of Bergen, *A new approach to modeling global magnetosphere-ionosphere coupling*

8. **K. Pham**, National Center for Atmospheric Research (NCAR), *Ionospheric Response to the May 2024 Storm Simulated by MAGE*

9. **S. Walton**, University of California Berkeley, *Energetic Electron Transport in the Inner Radiation Belt as a Source of Low-Latitude Precipitation*

10. **A. Prakash**, Department of Aerospace Engineering Sciences, University of Colorado (CU, SWx-TREC), *Geomagnetic Storms vs Equatorial IT Anomalies*

11. **X. Li/Y. Mei**, Laboratory for Atmospheric and Space Physics, University of Colorado (LASP), *"Zebras stripes" of Relativistic Electrons Unveiled by CIRBE/REPTile-2 Measurements and Their Physical Implications*

12. **L. Navarro**, Space Weather Technology, Research and Education Center, University of Colorado (SWx-TREC), *Thermosphere disturbance effects during the May 2024 Geomagnetic storm*

For virtual participation, please use the login details below:

https://alaska.zoom.us/j/81524127801

Justification

Electrodynamic response at different latitudes is known to be disturbed at different time scales during geomagnetically active conditions. These disturbances have been widely studied, and they have been attributed to interactions of the solar-wind/magnetosphere dynamo with the high-latitude ionosphere. The main processes are the ionospheric disturbance dynamo and the penetration of magnetospheric electric fields. The ionospheric disturbance dynamo is triggered by energy deposition into the high-latitude thermosphere producing thermospheric winds disturbances and leading to large and long-lasting departures of the middle- and low-latitude thermospheric winds and ionospheric electric fields. The electric fields of magnetospheric origin can penetrate into the low latitude ionosphere following sudden changes in the high-latitude convection electric field. These large changes occur as a result of an imbalance in the high-latitude field-aligned current system. This imbalance is produced by the solar wind-magnetosphere dynamo which is driven by the southward/northward turnings of the interplanetary magnetic field. These magnetospheric electric fields produce short-lived, global disturbances that affect the ionosphere and the thermosphere through enhanced ion drag, disturbed neutral circulation, and resulting composition changes. Similarly, the terrestrial weather effects into the upper atmosphere such as Stratospheric Warming effects have become increasingly important as their effects are longer lasting than geomagnetic storms as they modulate the tidal spectra of intrinsic atmospheric drivers such as electric fields and neutral winds which ultimately lead to composition changes affecting the I-T coupling at different latitudes.

Despite extensive historical observations of the ionosphere and thermosphere, recent upgrades in ground-based and spaceborne instrumentation continue to refine our understanding of the magnetosphere-ionosphere-thermosphere (M-I-T) system. Fundamental questions remain, including the nonlinear interactions between competing processes, the geographic extent of penetration electric fields, and the influence of magnetospheric phenomena such as substorms, IMF By effects, solar wind pressure variations, sub-auroral polarization streams (SAPS), medium-scale traveling ionospheric disturbances (MSTIDs), and their relationship with disturbance dynamo electric fields. Many of these aspects are typically studied from an aeronomy perspective, often overlooking the role of inner magnetospheric processes. However, research suggests that the prior state of the inner magnetosphere influences ionospheric responses during geomagnetic storms, potentially affecting the geoefficiency of the effects in the thermosphere and ionosphere across all latitudes. Yet, this remains insufficiently explored. The CEDAR/GEM meeting provides a unique platform to address these knowledge gaps by bringing together experts in magnetospheric, ionospheric, and thermospheric physics to foster interdisciplinary discussions and advance our understanding of near-Earth space dynamics.

Related to CEDAR Science Thrusts:
Explore exchange processes at boundaries and transitions in geospace
Fuse the knowledge base across disciplines in the geosciences
Workshop format
Short Presentations
Keywords
inner magnetosphere, MIT coupling, electrodynamics
Focus Group and Group Leader

Mesoscale drivers of the nightside transition region: ionospheric and magnetotail evaluations (MESO-FG)
Bea Gallardo-Lacourt

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