2026 Workshop: Multi-scale M-I-T Dynamics

Long title
Multi-scale Dynamics in the M-I-T System
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Description

Determining the effects of energy deposition and transport across regions during disturbed times, such as storms and substorms, is a crucial objective in the mid- and high-latitude Magnetosphere-Ionosphere-Thermosphere (M-I-T) system. Coupling across scales presents a significant challenge, as observation and modeling capabilities for bridging these scales are limited. Recent advancements in high-resolution radar observations and numerical simulations of multi-scale convection have yielded substantial progress. This workshop will feature a panel discussion on recent advances in multi-scale convection. Panelists will present the current understanding, latest results, and future challenges of convection across scales in the magnetosphere-ionosphere system, as well as its connection to other key processes, such as precipitation and ion-neutral coupling. The panel discussion will be followed by open discussion with attendees and, if time allows, a small number of short contributed talks.

Agenda

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High Spatial and Temporal Resolution of SuperDARN Convection Patterns

1. Daniel Billett, Small, short-lived Joule heating events dominate the high-latitude ionosphere – how much does it matter? (Virtual)

2. Bill Bristow, Progress toward incorporating the covariance matrix in SuperDARN convection estimation
3. Toshi Nishimura, High-Time-Resolution Observations of Plasma Convection in the Nightside High-Latitude Ionosphere
4. Larry Lyons, 2-D SuperDARN flows reveal possible new features of polar cap convection and substorm growth phase
5. Cheng Sheng, Transient features of SuperDARN ion convection and their impacts on the I-T system

Other Observations and Simulations

6. Doug Rowland, Multi-scale Dynamics in the Context of Satellite Observations
7. Yue Deng, Inter-hemispheric asymmetry in the geomagnetic forcing and its impacts on the I-T system
8. Spencer Hatch, Multi-scale MIT coupling via data assimilation
9. Sreelakshmi Jayaraman, Large-scale simulated convection patterns during 83 Geomagnetic storms
10. Leslie Lamarche, Heterogeneous Observations of Multi-Scale Velocities in the Auroral Zone

Discussions

Justification

High-resolution network observations by distributed sensors have revealed the existence of strong, localized, and transient structures, ranging from a few tens to a few hundreds of kilometers in size and lasting several minutes. These meso-scale structures have potentially significant impacts on the ionosphere-thermosphere (I-T) system. Multi-scale phenomena (large, meso, and small) are ubiquitous throughout the global ionosphere, including the cusp, auroral oval, mid-latitudes, and equatorial regions. For example, flows and precipitation imposed by the magnetosphere at high latitudes tend to be more intense at the meso-scale than at the large-scale. Neutral wind has also been shown to exhibit strong responses to such meso-scale energy input. Localized fast flows and density structures propagate across regions as flow channels and waves, leading to coupling across latitudes and longitudes, and between regions. Meso-scale structures are also significant energy sources, often more intense than large-scale background fields. Small- scale (<~10 km) dynamics are recognized as critical components for conductance and energy dissipation. Coupling across multiple scales remains a critical challenge, as observational and

modeling methodologies for bridging different scales and between regions are currently lacking. Recent advancements in observations, such as SuperDARN and ISRs, as well as high-resolution numerical simulations, have enabled the resolution of flow structures with significantly higher fidelity than previously possible. This session will bring together experts to discuss the current understanding and future challenges of multi-scale physics, with a particular focus on convection.

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Workshop format
Short Presentations
Panel Discussion
Round Table Discussion
Keywords
magnetosphere-ionosphere-thermosphere coupling, convection, multi-scale dynamics
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