

2025 Workshop: Whole Geospace Modeling and Validation

Long title

Modeling of whole Geospace Coupling and Validation

CEDAR-GEM

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Description

The geospace system, which includes the mesosphere, thermosphere, ionosphere and magnetosphere, is a strongly coupled, nonlinear dynamic system. To understand the structure and variability of this system and its response to external driving conditions, the chain of physical processes from solar wind-magnetosphere interaction, magnetosphere ionosphere and thermosphere coupling to lower atmosphere wave precondition of the thermosphere and ionosphere response to storms has to be simulated not only with first principles models of each sub system of the geospace, but also the coupling among these sub systems with fully coupled whole geospace models. The model simulations are also needed to be validated with observations to ensure the fidelity of the coupled model for both research and space weather applications. The recent advances in coupled models of the whole geospace system and its component sub system, as well as new ground and space observations, enables the community to gain new insights into the cross-scale, internal dynamics of the system, as well as the response of the geospace, as a whole system, to varying external driving conditions. This workshop invites modeling, model-data comparison, and data analysis presentations that include but not limited to: 1) quantifying energy and momentum inputs into, flows through and impacts on the geospace due to disturbed solar irradiance and solar wind conditions, and forcing from lower atmospheric waves including gravity waves, tides and planetary waves; 2) investigating regional and global mesoscale and large-scale processes generated under such conditions and the cross-scale coupling between

these processes, and 3) comparing model and data, revealing model-data discrepancy, and guiding model improvement.

Justification

The whole geospace system (mesosphere, thermosphere ionosphere and magnetosphere) is an open, nonlinear, dynamic and strongly coupled system that is greatly influenced by external solar radiation, solar wind and lower atmospheric weather conditions. For instance, at high latitudes, Joule heating, particle precipitation, and ion drag - each varying across different temporal and spatial scales - are imposed on the thermosphere-ionosphere system by solar wind-magnetosphere interaction and internal magnetospheric dynamics. These processes not only alter local neutral and plasma density, temperature, and velocity but also generate local mesoscale and large-scale structures that propagate globally, redistributing energy and momentum across regions and causing global perturbations to the I-T system. Waves from the lower atmosphere also deposit energy and momentum in the I-T modifying its global circulation, composition and dynamo electric fields and thereby its local and global structures. Furthermore, transient solar events of flares and eclipse also affect photochemical processes of the I-T system and feedback to the magnetosphere affecting its dynamics. To understand the effects of external forcings from above and below and their coupling with internal processes requires both first principles models of the coupled geospace system that can accurately represent the dynamic variability of multi-scales and data to validate models and guide model development. This is critical to understanding the fundamental physics within the geospace system and better predicting the space weather events that affect human space activity.

Related to CEDAR Science Thrusts:

Encourage and undertake a systems perspective of geospace

Explore exchange processes at boundaries and transitions in geospace

Explore processes related to geospace evolution

Fuse the knowledge base across disciplines in the geosciences

Manage, mine, and manipulate geoscience/geospace data and models

Workshop format

Short Presentations

Include a virtual component?

Yes

Keywords

Geospace system dynamics, space weather, whole geospace modeling, cross-scale coupling

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