Project Details

ROSES ID: NNH13ZDA001N
Selection Year: 2013
Program Element: Focused Science Topic

Topic: Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system

Project Title:
Modeling of Storm-Time Magnetosphere-Ionosphere-Thermosphere Dynamics

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Summary:
Thermosphere is an integral part of the tightly coupled ionosphere-thermosphere-magnetosphere (ITM) system. Response of the global thermospheric winds to geomagnetic activity depends on the driving forces of magnetospheric origin, and it strongly influences ionospheric dynamics during storms. As thermospheric changes in circulation modify ionospheric electron density distribution at auroral and subauroral latitudes, these changes are expected to provide magnetospheric feedback. The two main objectives of this project are to develop a first-principles numerical model of the ITM system, and to use it to understand how storm-time changes in the thermospheric winds affect magnetosphere-ionosphere coupling, by addressing these science questions:

1. How do storm-time changes in the thermospheric winds at auroral latitudes modify ionospheric conductances and how do these neutral wind driven conductance changes affect ring-current dynamics?

2. What is the thermospheric and ionospheric response to Subauroral Polarization Stream (SAPS) events during geomagnetic storms?

3. What is the role of the neutral wind flywheel effect in modifying the ionospheric state?

4. What are the relative roles of the disturbance wind dynamo and magnetospheric prompt penetration electric fields on ionospheric electron density redistributions?

We will develop a first-principles numerical model of the ITM system that includes realistic magnetosphere-ionosphere coupling at auroral and subauroral latitudes, is able to describe storm-time changes in the ionospheric electron densities and thermospheric wind pattern, and has sufficiently high spatial resolution in the ionosphere on magnetic field lines that map out to the inner magnetosphere (ring current and plasmasphere). Our methodology will be:

(1) We will develop a new model of the ITM system by starting with the GITM (Global Ionosphere-thermosphere model), RCM (Rice Convection Model of the inner magnetosphere), and BATS-R-US (global MHD magnetosphere) physics-based models. Most of the required coupling is already in place as part of the Space Weather Modeling Framework (SWMF) (for example, within SWMF, RCM and BATS-R-US are already coupled, and GITM can also be driven by BATS-R-US). We will add necessary coupling between the three models, by providing auroral precipitation from the RCM to GITM, and using GITM-modeled conductances and neutral winds in the RCM. We will increase the spatial resolution of GITM at auroral and subauroral latitudes to match it to the RCM resolution. We will test the model with numerical experiments.

(2) We will conduct event simulations and will do extensive model-data comparisons. During this stage of work, we expect extensive collaborations within the focused science team (FST), by taking advantage of datasets and empirical models developed as part of the collaborative FST work. We will contribute to the team by providing our simulations results to other interested members of the FST.

(3) We will conduct a series of idealized simulations by including or excluding various elements of the model, in an attempt to understand how various processes affect the response of the coupled system. In designing these idealized simulations, we will be guided by the science questions listed above.

Publication References:

Summary: no summary

Reference: Huba, J. D.; Sazykin, S.; Coster, A.; (2016), SAMI3-RCM simulation of the 17 March 2015 geomagnetic storm, Journal of Geophysical Research: Space Physics, Volume 122, Issue 1, pp. 1246-1257, doi: 10.1002/2016JA023341