Project Details

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Program Element: Focused Science Topic

Topic: Ion Circulation and Effects on the Magnetosphere and Magnetosphere - Ionosphere Coupling

Project Title:
Investigations of Magnetosphere-Ionosphere Coupling with RAM-SCB-E

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Summary:
The main research goals of this investigation are to provide better understanding and improved predictive capability of energetic ion dynamics in the coupled magnetosphere-ionosphere system. In particular, we will investigate 1) how are heavy ions transported from the ionosphere and what is their distribution in the magnetosphere, and 2) how does the ionospheric conductivity vary with space and time and what is the feedback on the global E field and ion circulation. These are key objectives of this NASA/LWS solicitation, Focused Science Topic (FST) (3) "Ion Circulation and Effects on the Magnetosphere and Magnetosphere-Ionosphere Coupling".

The methodology includes a combination of several physics-based models used to study the coupled magnetosphere-ionosphere system driven by solar activity, and analysis of space-borne and ground-based observations. First, we will simulate the ion outflow from the ionosphere using a newly developed at LANL large-scale particle tracing model (PTM) driven by dynamic electric and magnetic fields from state-of-the-art models described below. The supply of heavy ions to the magnetosphere as a function of source location, solar and geomagnetic activity will thus be investigated. Second, a unique transport code, a ring current-atmosphere interactions model with self-consistent magnetic field and (recently added) self-consistent electric field (RAM-SCBE) will be used to simulate the subsequent injection of particles (H+, He+, O+ ions and electrons) from the plasma sheet into the inner magnetosphere and their precipitation to the ionosphere. Third, we will couple RAM-SCBE with a two-stream electron transport code (GLOW) to compute the height-dependent electric conductivity, given the electron precipitation from the ring current model. This will allow for a self-consistent calculation of the ionospheric conductance (the height-integrated electric conductivity) that is crucial in regulating both the ionospheric electrodynamics and the magnetospheric dynamics. We will simulate geomagnetic storms of various strengths with the newly coupled modeling framework (PTM/RAM-SCBE/GLOW) and compare results with the traditional empirical approach, which is commonly used in global simulations, to evaluate the effects of the self-consistent feedback and answer the science questions listed above. In order to validate the predictive capabilities of our model and identify where improvements are needed, simulation results will be compared with in situ and ground-based measurements at many stages of the modeling cycle. Van Allen Probes will thus be used for validation of magnetospheric particle fluxes, DMSP and NOAA satellites for particle precipitation, and ground-based ionospheric measurements for validation of the ionospheric parameters.

This research is highly relevant to the strategic goals of the NASA/LWS and the National Space Weather programs to develop predictive models of energetic particle dynamics and electrical current systems, and to be able to forecast adverse activity that could be dangerous to technologies and humans in space and on ground. RAM-SCBE extends an inner magnetosphere model (RAM-SCB) that has a proven history as a component in the Space Weather Modeling Framework (SWMF), and therefore this proposal can directly lead to an improved configuration of the operational SWMF that is currently used to predict ground magnetic perturbations at NOAA/SWPC.

This project will result in an improved understanding of magnetosphere-ionosphere coupling and a comprehensive model with space weather applications. The main contributions to the FST will include sharing the scientific results and simulation outputs (e.g., ion distributions and ionospheric conductance maps) from our model with the other researchers from the FST team, as well as help with the organization and active participation in the FST team meetings. All products from this research will be

shared with the space science user community.

Publication References:

no references