Project Details

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Program Element: SCOSTEP/VarSITI

Project Title:
Storm-time magnetosphere: Specification and prediction using a global MHD model with empirical ring current pressure

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Summary:
Goals and objectives

A rich set of magnetic field measurements made by historic and current NASA missions goes largely unused by first-principles predictive global models of the geospace environment. These data have been intelligently mined and integrated into empirical magnetic field models of the Tsyganenko family with the most recent incarnation (TS07D) providing unprecedented spatial resolution. This empirical model gives access to the wealth of observational information that is critical in supplying the missing physics to global magnetospheric models. In particular, the hot pressure in the inner magnetosphere is created by physical processes that are beyond the magnetohydrodynamic (MHD) approach commonly used. In this project we propose to extract the equilibrium magnetic pressure from the empirical TS07D model and use it to augment our global MHD model thus yielding a predictive global model of the storm-time geospace environment. The specific tasks include: (i) Derive the equilibrium pressure from TS07D model for a number of selected storm events during the Van Allen Probe (VAP) era and compare with VAP data; (ii) Modify the equation of state in the global MHD model using the empirical plasma pressure; (iii) Perform coupled empirical pressure-global MHD simulations for the previously selected storm events; (iv) Validate the simulations with VAP data.

These transformative modeling capabilities will lead to resolution of fundamental outstanding issues of magnetospheric physics. In particular, our science investigation will address the following questions: What are the global effects of the inner magnetosphere hot plasma pressure in the storm-time evolution of the magnetosphere? How does the distribution of plasma in the plasma sheet influence the formation and evolution of ring current? Due to the limited scale of the project, we will restrict our detailed investigation to global effects in the night-side magnetosphere. However, the effects of the inclusion of hot plasma pressures will be much more far going and may include the magnetosphere-ionosphere coupling, saturation of the polar cap potential, boundary instabilities, and global magnetospheric properties such as the magnetopause standoff distance.

Methodology

We will use the TS07D empirical model of the magnetospheric magnetic field to derive equilibrium pressures in the inner magnetosphere. These will be used to modify the equation of state in the Lyon-Fedder-Mobarry (LFM) global MHD model of the magnetosphere. The resulting global MHD model with empirical pressure corrections will be used to perform simulations of geomagnetic storms, which will be validated with Van Allen Probes data, and used to address the science questions posed.

Relevance to SCOSTEP/VarSITI

This project is an ideal fit for the SPeCIMEN theme of the VarSITI program. In particular, it addresses directly all four aspects emphasized in ROSES B.6 as it elaborates and attacks the following science targets: (i) help understand the response of the inner magnetosphere as a coupled system to solar wind and interplanetary magnetic field forcing; (ii) improve predictive capabilities with specific emphasis on model integration; (iii) couple different magnetospheric regions affecting the state of the inner magnetosphere; (iv) fuse empirical and first-principles approaches. Model development will constitute only a minor part of the proposed effort with emphasis placed on storm-time magnetosphere simulations and addressing the science questions in concert with VAP observations. , '

Publication References:

Summary: no summary

Reference: Sitnov, M. I.; Merkin, V. G.; (2016), Generalized magnetotail equilibria: Effects of the dipole field, thin current sheets, and magnetic flux accumulation, Journal of Geophysical Research: Space Physics, Volume 121, Issue 8, pp. 7664-7683, doi: 10.1002/2016JA023001

Summary: no summary

Reference: Merkin, V. G.; Sitnov, M. I.; (2016) Stability of magnetotail equilibria with a tailward Bz gradient, Journal of Geophysical Research: Space Physics, Volume 121, Issue 10, pp. 9411-9426, doi: 10.1002/2016JA023005

Summary: no summary

Reference: khorskiy, A. Y.; Sitnov, M. I.; Merkin, V. G.; Gkioulidou, M.; Mitchell, D. G.; (2017), Ion acceleration at dipolarization fronts in the inner magnetosphere, Journal of Geophysical Research: Space Physics, Volume 122, Issue 3, pp. 3040-3054, doi: 10.1002/2016JA023304