Project Details

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Topic: Magnetospheric and Ionospheric Processes Responsible for Rapid Geomagnetic Changes

Project Title:
Advances in numerical simulations for resolving multi-scale geomagnetic disturbances

PI Name: Yue Deng
PI Email: yuedeng@uta.edu
Affiliation: University of Texas Arlington
Project Member(s):
- Anderson, Brian J;Co-I/Institutional PI;Johns Hopkins University
- Welling, Daniel;Co-I;University Of Texas, Arlington
- Sheng, Cheng;Co-I;University Of Texas, Arlington
- Morley, Steven K;Co-I/Institutional PI;Triad National Security, LLC

Summary:
Geomagnetically induced currents (GICs), which are strongly related to the change rate of geomagnetic field, pose a large hazard to the important infrastructures, such as powerlines and pipelines, especially during geomagnetic super storms. It is essential to understand the magne- tospheric and ionospheric processes responsible for the geomagnetic disturbances (GMD) during space weather events in order to improve the preparedness of society to the space weather impact. Recently significant progresses have been made in both observations and simulations to improve the description and understanding of GICs. A wide range of spacecraft and ground datasets has been utilized to analyze GICs and their correlation with drivers. Meanwhile, both first-principles physical models (MHD model coupled with ionosopheric electrodynamic model) and empirical models have been applied to the calculation of the geomagnetic perturbations. The ground con- ductivity model, which plays a crucial role to estimate the geoelectric field from geomagnetic disturbance (GMD), has been improved from 1-D to 3-D. However, a comprehensive understand- ing of the impact of different processes on the multi-scale geomagnetic disturbances is lacking, yet it remains fundamental to correctly interpret and specify GICs. Further, it is clear that small spa- tial scale magnetic perturbations with large amplitudes are a contributor to the GIC problem, but the underlying physics of these localized effects remains unclear [Ngwira and Pulkkinen, 2019]. The goal of this project is to examine the relative significance of different forcing terms in driving the multi-scale variations of geomagnetic disturbances through magnetosphere-ionosphere coupled simulations. Specifically, we will address the following three science questions (SQ):

(1) What is the role of the ionospheric and thermospheric processes in producing geo- magnetic disturbances on the ground? Proposed study: use MHD-GCM numerical models with expanded coupling that includes thermospheric processes such as the neutral dynamo to examine disturbance generation and to compare with observations.
(2) How does the combined M-I system produce geomagnetic disturbances of different spa- tial and temporal scales? Proposed study: With high resolution MHD-GCM coupled model, explore processes leading to different scales of disturbances, including solar wind conditions, con- ductance and neutral-wind perturbations driven by atmospheric waves.
(3) How do magnetic perturbations manifest as geoelectric fields, and how much does the Earth conductivity model affect this conversion? Proposed study: examine the frequency depen- dence of geoelectric field conversion, decompose the geoelectric field by its contributions from different geospace regions, and convolve numerical results with 1D and 3D models of Earth s conductivity.

This investigation will make significant contributions to the scientific objectives of the NASA LWS Focus Science Topic 3: Magnetospheric and ionospheric processes responsible for rapid geomagnetic changes. Specifically, it will improve modeling of geomagnetic disturbances and geoelectric field during disturbed periods and to improve understanding of the role of solar wind, magnetosphere, ionosphere and thermosphere in driving geomagnetic variation and geoelectric field. Furthermore, this investigation will make important contributions to science questions from the Heliophysics Roadmap and Decadal Survey. We would intend to interact with space physicists in the team to work on problems of overlapping interest that may be identified.

Publication References:

no references