Project Details

ROSES ID: NNH17ZDA001N
Selection Year: 2017
Program Element: Focused Science Topic

Topic: Understanding Physical Processes in the Magnetosphere--Ionosphere / Thermosphere / Mesosphere System During Extreme Events

Project Title:
Physics-based modeling of the magnetosphere-ionosphere-thermosphere-mesosphere system under Carrington-scale solar driving: response modes, missing physics and uncertainty estimates

PI Name: Antti A Pulkkinen
PI Email: antti.a.pulkkinen@nasa.gov
Affiliation: NASA Goddard Space Flight Center
Project Member(s):
- Welling, Daniel;Co-I;University Of Michigan, Ann Arbor
- Ngwira, Chigomezyo;Co-I;Catholic University Of America
- Glocer, Alex;Co-I;NASA Goddard Space Flight Center
- Schuck, Peter W;Co-I;NASA Goddard Space Flight Center
- Cash, Michele;Collaborator;National Weather Service, Camp Springs

Summary:
This proposal will address the Focused Science Topic "Understanding Physical Processes in the Magnetosphere--Ionosphere / Thermosphere / Mesosphere System (M-ITM) during Extreme Events." We will investigate the global physics-based modeling of the magnetosphere-ionosphere (M-I) system under extreme solar driving conditions such as those experienced during the Carrington storm of 1859. The specific focus of the proposed work is to advance global modeling of the ground magnetic field (delta-B) variations under extreme solar driving conditions. To this end, we will provide quantifiable advancements in modeling of the spatiotemporal delta-B structures. The delta-B focus provides a direct connection to the global M-I dynamics as the field variations on the ground are an aggregate of all the electric currents that operate in the geospace environment. Delta-B variations are also the primary driver of geomagnetically induced currents (GIC) that flow in long ground-based technological conductor systems such as power grids. Our work thus directly supports national space weather needs via improved understanding of the phenomena that cause GIC.

Two target phenomena of specific high-interest to space weather will be the focus of this work:

i) Auroral boundary expansion during extreme events. Auroral boundaries determine the locations that are exposed to the most extreme delta-B fluctuations and GIC.

ii) Spatiotemporal localization during extreme events. Spatiotemporally localized delta-B are perhaps the most significant cause for large-amplitude GIC.

The target phenomena are used to address three key science goals:

1) Quantification of model uncertainty under extreme driving conditions. The uncertainties and variability are some of the most important and yet poorly addressed characteristics of any space weather modeling effort. We will develop methodologies for quantifying the M-I modeling and specifically delta-B uncertainties. Methodologies for both normal storm conditions and extreme storm conditions not seen in modern observations are explored.

2) Key missing physics in modeling extreme storms. We will identify possible missing physical elements in our modeling of the M-I system under extreme driving conditions.

3) Changes in fundamental system response modes. With information from goals 1) and 2), we will explore possible changes in the M-I dynamics under extreme Carrington-scale solar driving not seen in modern delta-B observations.

The work is carried out using a large number of M-I simulations and analysis of the corresponding modeled and observed delta-B variations. Careful coordination between the goals 1-3 in the context of the target phenomena allows new light to be shed on the physical processes behind important GIC-related phenomena. Our work will also generate quantifiable evidence of progress toward more accurate simulation of extreme space weather events. Our team will be integrated with the Focused Science Team (FST) Effort via provision of delta-B simulations capacity and recommendations for further model development efforts by the other FST teams. All simulations carried out in the project will be made publicly available via Community Coordinated Modeling Center (CCMC). Further, we will coordinate our work with NOAA Space Weather Prediction Center (SWPC) to ensure that operational considerations are take into account in addressing the delta-B features (operations-to-research) and to allow transition of the new information back into operational implementation of the M-I models at SWPC (research-to-operations).

Publication References:

no references