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:
Quantifying solar wind-magnetosphere-ionosphere response to extreme driving conditions

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Summary:
The proposal will seek to understand and quantify the solar wind-magnetosphere-ionosphere response for extreme driving conditions using the 3D multifluid MHD code (BATS-R-US) coupled to the inner magnetosphere module (CIMI), the module of ionospheric electrodynamics and the outflow module. Historical data available for extreme geomagnetic storms will be compared with the simulations when available.

Scientific objectives:

A few scientific topics are selected for detailed analysis, including the response of the coupled magnetosphere-ionosphere system to Carrington-type events, paying attention to the role of ring current population, and the role of ionospheric effects, and the role of solar wind drivers. The proposal will study physical mechanisms that could explain unusually fast recovery rate for the Carrington event. These processes include elevated O+ outflow and faster rate of charge-exchange losses, ionospheric effects, magnetopause losses, wave-particle interactions. In relation to the applications of space weather, we will also examine the response of electrons in the energy range 5-50 keV in the inner magnetosphere and along GEO orbit. The response of the electron fluxes will be studied as a function of the strength of the storms, in order to find optimal conditions for formation of intense electron fluxes.

Methodology:

To achieve scientific objectives, we will model the global coupled system for some extreme historical geomagnetic storms, including the Carrington event. The modelling tools will include the coupled MHD-ring current code (CIMI-BATS-R-US) and the standalone version of CIMI model. As a reference, a few moderate/big storms (with |Dst| ~ 200-300 nT) will be considered, and the output of the model will be compared to that of modern data sets from Geospace fleet. We will quantify the similarities/differences between the model and the response observed in Dst/SYMH indices, particle fluxes and magnetic fields (if available). Quantifying the differences between observations and the model results for moderate/big storms will help to understand and predict the differences between the model and the actual magnetosphere for extreme conditions, as well as will allow to estimate model errors and limitations.

Importance of the proposed work:

The proposed work will provide a better description of extreme geomagnetic storms, including Carrington type events, and fill some critical gaps in the current understanding of extreme activity. We will address the fast recovery rate observed for the Carrington event, exploring different proposed physical processes, and simulate these processes with the state of the art global models of magnetosphere/ionosphere. Electron fluxes in the 5-50 keV energy range are responsible for surface charge/discharge phenomena. It is important to understand that current results show the existence of some optimal level of activity in order to form the most intense electron fluxes. Quantifying the response of electron population to different geomagnetic storms will help to develop mitigation strategies for the worst-case scenarios. The expected outcome will also allow more accurate modelling representation of extreme geomagnetic storms and help to understand key processes that occur during such events.

Publication References:

no references