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:
Understanding the Thermosphere-Ionosphere Response to Extreme Solar Events

PI Name: Tim Fuller-Rowell
PI Email: tim.fuller-rowell@noaa.gov
Affiliation: University of Colorado, Boulder
Project Member(s):
- Maruyama, Naomi;Co-I/Science PI;University Of Colorado, Boulder
- Emmert, John T;Co-I/Institutional PI;Naval Research Lab
- Codrescu, Mihail V.;Collaborator;Space Weather Prediction Center
- Viereck, Rodney;Collaborator;National Weather Service, Camp Springs
- Fedrizzi, Mariangel;Co-I/Science PI;University Of Colorado, Boulder
- Fang, Tzu-Wei;Co-I/Science PI;University Of Colorado, Boulder

Summary:
The objective of this proposal is to understand how the thermosphere-ionosphere system responds to an extreme space weather event, such as the Carrington storm of 1859 or the solar wind conditions experienced by STEREO-A when a CME struck the spacecraft on July 23rd, 2012. These solar wind conditions provide a reasonable scenario for a once in a 100-year extreme solar storm impacting Earth. By targeting extreme events, we will address the needs of the Space Weather Action Plan, and in addition improve our understanding of the how the physical system responds to events at the level of the Halloween (October, 2003) and Bastille (July, 2000) geomagnetic storms.

With the obvious lack of observations, the physical models cannot be used blindly, but the model simulations will have to be carefully interpreted to address the following fundamental science questions: 1) How does the ionospheric plasma redistribution respond to the combination of the overly expanded magnetospheric convection to mid-latitudes and the strong penetration electric field to low latitudes? 2) How does the thermospheric circulation and neutral composition respond to Joule heating expanded well into mid latitudes, rather than the typical location at higher latitudes during storms? 3) Does the disturbance dynamo still play a significant role given the magnitude and possible dominance of magnetospheric convection? 4) How severe is plasmasphere erosion in response to the polar cap boundary and plasma escape well into mid-latitudes? 5) Do both positive and negative phases both still have a significant contribution in the response of the ionospheric plasma density and total electron content? 6) What is the level of thermal expansion and increase of neutral, and plasma density, at high altitude contributing to satellite drag? 7) Does the auroral NO production and radiative cooling cause the upper atmosphere expansion to saturate?

We will use the newly developed and tested ionosphere-plasmasphere-electrodynamics (IPE) model, with self-consistent electrodynamics, to simulate the ionospheric response, and the well-tested thermospheric component of the coupled thermosphere-ionosphere-plasmasphere model (CTIPe) for the thermospheric expansion and neutral density response. The models will be driven by the estimated or simulated response to extreme solar wind drivers from either empirical magnetospheric convection models or from MHD model simulations.

This simulation study will contribute to the Proposed Contributions to the Focused Science Team Effort by providing state-of-the art models as powerful tools for the investigation. In addition, the personnel will provide understanding of the physical system. Since there are no observations of the response to a Carrington-level event, understanding the physical processes and interpreting the model simulations is the only way we can be sure the extrapolation of the response of the physical system is likely to be realistic. The proposers also have close collaboration with the MHD magnetospheric modeling groups, such as the OpenGGCM and Michigan Geospace model, and we are able to leverage and reinforce our on-going interactions with these groups and contribute to simulations of the two-way interactions and feedbacks between the magnetosphere and thermosphere-ionosphere systems.

In addition, in this proposal we will address the impact of an extreme space weather event on operational systems, including: How do changes in ionospheric plasma density impact satellite communications and navigation? What are possible perigee height changes due to the likely neutral density enhancement, and what part of the catalog would be de-orbited? How would in-track orbit uncertainties grow, and what are potential impacts on collision avoidance? By quantifying the impact on operational system, we will enable operators, planners, and decision makers to make appropriate choices to implement mitigation strategies.

Publication References:

no references