Project Details

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Program Element: Focused Science Topic

Topic: Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures

Project Title:
Kinetic modeling of the impact of solar wind structures on the dayside magnetosphere

PI Name: Jean P. Berchem
PI Email: jberchem@igpp.ucla.edu
Affiliation: University of California, Los Angeles
Project Member(s):
- Escoubet, C. Philippe;Collaborator;ESA
- Lapenta, Giovanni;Co-I;Space Science Institute
- Wing, Simon;Co-I;The Johns Hopkins University
- Richard, Robert L;Co-I;University of California at Los Angeles

Summary:
We propose to use large-scale implicit particle-in-cell (PIC) simulations embedded in global magnetohydrodynamic (MHD) simulations to improve our understanding of the response of the dayside magnetosphere to the impact of solar wind structures. The main science objectives of the study will be to investigate how these structures affect kinetic processes at the magnetopause and how this is manifested in the entry of electrons and ions in the dayside magnetosphere. In particular, we will use both generic/idealized discontinuities with different field and plasma parameters (e.g. fast rotations of the interplanetary magnetic field (IMF), density enhancements, embedded current sheets, interplanetary shocks) and event studies to investigate how the impact of solar wind discontinuities can affect reconnection processes and the precipitation of low-to high energy particles in the cusps. Simulation results will be used to understand and tabulate characteristic precipitation signatures driven by the impact of different types of solar wind structures. By comparing these signatures with spacecraft observations and correlating them with the state of the magnetosphere observed after the discontinuities have affected the entire magnetosphere will allow us to associate dayside precipitation signatures with the geoeffective responses to different types of solar wind structures.

The methodology of the research will be based on carrying out a series of large-scale iPic3D simulations that will use global MHD simulations to determine their initial and evolving boundary conditions. While the investigation will be based on actual events using observations from the MMS, Cluster, THEMIS, and DMSP spacecraft, a key element of the study will be to first use a series of idealized forms of the solar wind input that include the fundamental characteristics of the discontinuities of interest. This approach will allow us to grasp the primary physical processes involved before using actual solar wind measurements to obtain quantitative assessments of the simulation results by comparing them to observations. In particular, case studies for intervals when the spacecraft provide suitable conjunctions in the ionosphere, magnetosphere, and near Earth solar wind will be used to evaluate how uncertainties in the input data and the simulation assumptions affect the results of the model.

The proposal will address directly the science objectives targeted by the Focused Science Topic (FST) # 3 of the ROSES-2018 LWS program (Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures). By improving the quantitative assessment of the kinetic effects associated with the impacts of solar wind structures on the dayside magnetopause, our proposed research will advance the development of the next generation of models to forecast the effects of geoeffective disturbances. In addition, the results of the investigation could motivate the discovery of new features occurring as solar wind structures interact with the dayside magnetosphere.

Publication References:

no references