Project Details

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Selection Year: 2022
Program Element: Focused Science Topic

Topic: FST #2: Coupling of the Solar Wind Plasma and Energy to the Geospace System

Project Title:
Effects of Foreshock and Magnetosheath Kinetic Structures on the Global Magnetosphere

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Summary:
Science Goals and Objectives: _x000D_
It is well established that the Bz and By components of the IMF are geoeffective, and many study have exclusively focused on them when studying the variance of geomagnetic indices. However, these two IMF components are not always dominant, and the radial component has been recognized to play an increasingly important role in the solar wind-magnetosphere interaction. A radial IMF displaces the foreshock region from the dawn side to cover almost the dayside region, favors the generation of foreshock waves and foreshock cavities, and causes a highly fluctuating magnetosheath. While these fluctuations have been shown to cause magnetopause boundary indentations, trigger magnetopause reconnection, and excite ultra-low frequency waves, whether and how they affect the macroscale dynamics of the magnetosphere is poorly understood. The overarching goal of the proposal is to understand how foreshock and magnetosheath kinetic structures affect macroscale magnetosphere-level dynamics. This will be accomplished through addressing the following questions:_x000D_
1. How do foreshock and magnetosheath kinetic structures incident upon the magnetosphere impact measures of global dynamics such as polar cap index, auroral electrojet indices, and Kp?_x000D_
2. What disturbances in the magnetosphere do the kinetic structures drive that contribute to the variances of the measures of global dynamics? _x000D_
3. How do varying solar wind conditions (e.g., IMF Bz, IMF By, speed, Mach number) support or suppress the geoeffectiveness of the kinetic structures?_x000D_
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Methodology: _x000D_
The project will employ a comprehensive set of observations of the solar wind-magnetosphere-ionosphere system, and a state-of-art MHD-AEPIC model that two-way couples the Hall-MHD model BATS-R-US and the semi-implicit PIC code FLEKS through the Space Weather Modeling Framework (SWMF). For the observations, the project will conduct both statistics and case study analysis. The statistical analysis will assess the statistical similarities and differences in the measures of global dynamics when foreshock and magnetosheath kinetic structures are present versus absent. The case study analysis will focus on events with multi-point observations that can validate the model results and illuminate the sequence of events that lead to changes in the global state of the magnetosphere. For example, we will use ACE, WIND, and Geotail for the pristine solar wind, MMS, THEMIS, CLUSTER, Van Allen Probes, and GOES for the dayside (including the shock and magnetosheath), nightside, and inner magnetosphere, and ground-based radars and magnetometers for plasma convection and magnetic perturbations. For the simulation, the domain covered by the PIC code will be varied to cover (exclude) the foreshock and magnetosheath so that the kinetic effects of the upstream will be assessed for a given pristine solar wind. BATS-R-US coupled with RCM handles the rest of the simulation domain and simulates the dynamics of the magnetosphere. _x000D_
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Significance and Relevance: _x000D_
The proposed study directly addresses the scientific objectives of the Focused Science Topics (FST) #2 of the NASA Living with a Star (LWS) Program, which is to identify the parameters controlling the transfer of energy through dayside magnetopause reconnection and to understand the role of solar wind fluctuations in the coupling of the solar wind to the Earth. It is also directly relevant to the LWS program goal #2, which is to understand how the Earth and planetary systems respond to dynamic external and internal drivers. The proposing team has expertise in numerical simulation and observations of the coupled solar wind-magnetosphere-ionosphere system, and the collaborative efforts are expected to contribute substantially to the FST team efforts.

Publication References:

no references