Project Details

ROSES ID: NNH22ZDA001N-LWS
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:
Advanced Statistical Analysis of the Solar Wind Control of Magnetospheric Activity and Magnetospheric Particle Populations

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Summary:
OBJECTIVES_x000D_
The objectives of this LWS FST Investigtion are (1) To determine what solar-wind variables (and their time history) control geomagnetic activity and various magnetospheric particle populations and their response lag times. (2) To explore the upstream-turbulence effect and determine if it has a causal explanation or if the upstream-turbulence amplitude is acting as a statistical proxy for another physical variable. (3) To explore the possibility that polar-cap-potential saturation is not a post-reconnection coupling phenomena but rather is caused by an inadequate description of the true solar wind driving of the magnetosphere. (4) To work with other Focus Science Teams to develop statistical analysis methods for simulation outputs that can be used to statistically test codes against real solar-wind/magnetosphere data. In previous works the investigators have identified many correlations between solar wind properties (v, B, n, fluctuation amplitude, Mach number, strahl intensity) and magnetospheric properties (convection, auroral activity, polar-cap currents, substorm occurrence, plasma sheet, substorm-injected electrons, radiation belt electrons), and now will further explore the causality (rather than coincidence) of these and other statistical connections._x000D_
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METHODS_x000D_
Two main statistical tools used will be canonical correlations analysis (CCA, vector-vector correlations) and information transfer. This will extend existing statistical methodologies to gain more information about causality rather than simple correlations. CCA work in the past has been focused on examining the modes of reaction of the magnetosphere to the solar wind, here we will use CCA to focus on the solar wind properties that drive Earth. Information transfer goes beyond the standard correlations to examine liner and nonlinear cause and effect statistical connections. We will exploit this specifically for Objective 2. We will merge CCA and information transfer to create a vector-vector analysis methodology based on transfer entropy or mutual information rather than on Pearson linear correlations. The merged technique will be used to determine the causal relationships and response modes and time scale. To determine time lags, an evolutionary (genetic) algorithm will be used that runs the vector-vector analysis tool. Further, the new dynamic canonical correlation tool will be introduced to heliophysics._x000D_
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SIGNIFICANCE_x000D_
This LWS FST Investigation will deliver extensive knowledge of solar-wind/magnetosphere coupling informed by collaboration with other groups. This FST Investigation directly supports all five FST#2 objectives: (1) identifying the parameters controlling the transfer of energy through dayside magnetopause reconnection, (2) establishing the role of ionospheric and magnetospheric plasmas in solar wind magnetosphere coupling, (3) investigating the physical processes controlling non-reconnection coupling, (4) understanding the role of solar wind fluctuations in the coupling of the solar wind to the Earth, and (5) understanding the post-reconnection reconfiguration of the magnetosphere and ionosphere system in response to extreme solar wind magnetosphere coupling. Outstanding questions about the upstream-turbulence effect and about polar-cap potential saturation will be addressed. The system-science tools that will utilized are quite general and can be applied to datasets from other FST subteams. This could be the glue of the FST Team. One desire of this FST subteam is to develop and test a system-science methodology to gauge simulation codes by statistically analyzing simulation outputs and comparing with statistical analysis of actual system measurements. With collaborations with other subteams, we will compare the information flow in the simulated system and with the information flow in the real M-I-T system.

Publication References:

no references