Project Details

ROSES ID: NNH17ZDA001N
Selection Year: 2017
Program Element: Focused Science Topic

Topic: Toward a Systems Approach to Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere

Project Title:
New Insights into SEP Sources, Acceleration, and Propagation: An Integrated Observation-Modeling Approach

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Summary:
Science Goals: Solar energetic particle (SEP) events can be a significant hazard to humans and technological infrastructure in space; predicting their intensity, location, and impacts is an imperative. Despite years of study, true predictive capabilities for SEP events continue to be hampered by open fundamental questions regarding their genesis close to onset from low in the corona, and how they populate the heliosphere. Studies combining the observations of SEPs near Earth (using, e.g., ACE, SOHO, and GOES) with those from the twin STEREO spacecraft have revealed longitudinal distributions that defy our general understanding of energetic particle transport, and point to the importance of magnetic field structure, coronal mass ejection injection and structure. Events such as 3 November 2011 indicate that SEPs can fill the inner heliosphere in ~30 minutes, much faster than expected. Statistical surveys of multi-spacecraft events show that the longitudinal distributions of SEPs vary substantially from event to event and the characteristics are, surprisingly, not clearly organized by rigidity but do depend on energy. Interpreting these observations requires an integrated approach that combines state-of-the-art analysis of SEP, solar, and interplanetary measurements with cutting-edge simulations starting from the Sun and extending through the low corona and inner heliosphere. By studying both individual events as well as general characteristics determined from survey studies, we will investigate key questions, including the role of coronal mass ejections (CMEs) and low-coronal shock formation in the acceleration of SEPs, the effect of field line connectivity on SEP transport, and the mechanisms that influence various SEP characteristics observed at 1 AU, such as rise time, longitudinal spreading, and compositional variation.

Methodology: Our proposed work leverages a new simulation tool that couples realistic, three-dimensional (3D) magnetohydrodynamic (MHD) simulations of CME events with 3D solutions of the focused transport equation. Versions of this new tool (SPE Threat Assessment Tool, or STAT) will have been delivered to the CCMC by the start of the proposed work; the tool combines the Predictive Science CORHEL (Corona-Heliosphere) MHD modeling suite with the University of New Hampshire Earth-Moon-Mars Radiation Environment Module (EMMREM) and can provide particle flux, fluence, and dose-rate predictions for different points in the heliosphere. We will perform detailed flare/CME event simulations for events carefully selected from recently catalogued SEP events observed by STEREO, ACE, and GOES to elucidate the underlying source locations and mechanisms of SEP acceleration/transport as well as test and improve the models. The models will be used to gain new insights into the recent observation of a general energy dependence of SEP longitudinal distributions (and lack of rigidity dependence) and investigate the influence of the shock/compression properties, its surrounding environment, and the conditions of the inner heliosphere on the characteristics of the SEP event observed at 1 AU. These models will significantly aid the interpretation of Parker Solar Probe observations when they become available and connect them to 1 AU observations.

Proposed Contributions to the Focused Team Effort: As part of a larger systems approach to understanding SEPs, we will work with other selected teams to study events through modeling and observational analysis. We will provide simulation and data analysis results as well as useful visualizations to the whole FST team. We will provide our expertise in modeling and SEP analysis to other team members and will capitalize on the additional expertise, particularly in the analysis of solar and solar wind observations, that other members will bring to the team effort.

Publication References:

no references