Project Details

ROSES ID: NNH14ZDA001N
Selection Year: 2014
Program Element: Focused Science Topic

Topic: Prediction of the Interplanetary Magnetic Field Vector Bz at 1AU

Project Title:
Observer global shock connectivities inferred from ENLIL runs and SEP measurements

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- Fry, Dan James; Collaborator; NASA / Johnson Space Center
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Summary:
SCIENCE GOALS: Coronal Mass Ejections (CMEs) that drive coronal and interplanetary shocks are known to produce the larger, gradual SEP events. However, understanding these types of events well enough to forecast their properties at a given location requires a realistic picture of the global background solar wind through which the shocks and SEPs propagate. The goal of the proposed work is to use the combination of ENLIL heliospheric modeling and multipoint SEP observations to address the following science questions: (1) What is the importance of observer-shock magnetic connectivity in determining the occurrence of a SEP event, including the time profile and longitudinal extent? (2) Which SEP event characteristics are primarily a consequence of their shock connection and heliospheric field geometries? Are multiple shock connections and/or heliospheric reflections common occurrence? (3) How are SEP anisotropies, including bi-directionality, related to the observer-shock connection(s)? (4) How important is the magnetic cloud in altering a SEP event profile? METHODOLOGY: This study will investigate the above questions and others using a large set of ENLIL models and SEP observations. We will apply a proposed multiple shock detection routine for ENLIL output processing in order to tackle periods with multiple CMEs, a quite common occurrence during active periods. The topology of observer-connected magnetic field lines and plasma and shock properties along the field lines that will be compared against SEP profiles and anisotropies at various observer locations. Starting with the CME parameters and lessons learned from the existing database of short-duration (~6 days) CCMC WSA-ENLIL+Cone runs, we will extend these runs by performing new, long-duration (~month), higher cadence output model runs at CCMC, which also use a larger outer boundary radius (5.5 AU) and employ the proposed necessary multiple shock detection routines. These new simulations will provide a variety of realistic interplanetary field realizations for which the shock geometries relative to any inner heliosphere observer can be examined. The in-situ monitors at STEREO, MESSENGER, near-Earth (ACE, SOHO, GOES), and MAVEN measure SEPs whose behavior will be related to observer shock connections and the global heliospheric setting at the time. Data from these combined multipoint spacecraft observations is essential for studying the longitudinal extension of SEP events. To understand the complexities of these events it is crucial to have an understanding of the heliospheric setting. For example, comparing SEP observations with ENLIL modeling will address the question of how the longitudinal extent is related to single and merged, or multiple shocks in the model. RELEVANCE: This proposal is relevant to NASA's LWS Science goals and specifically addresses Focused Science Topic #2 ("Physics-based methods to predict connectivity of SEP sources to points in the inner heliosphere, tested by location, timing, and longitudinal separation of SEPs") of LWS Targeted Investigations. This individual proposal will provide a global context of magnetic topologies and shock properties from state of the art (ENLIL) heliospheric models, along with necessary SEP profile analysis, including anisotropies and the role of magnetic clouds, in support of potential focused science team collaborations. Our applications of ENLIL runs will also provide additional SEP-related ``model data'' products that will be of useful to others in the larger community for SEP event modeling and forecasting tools. This proposed research is of fundamental importance to the focused science team goal of producing "model(s) that predict the longitudinal spread of SEPs, with statistical quantification of the uncertainty."

Publication References:

Summary: .

Reference: Bain H. M.; Mays M. L.; Luhmann J. G.; Li Y.; Jian L. K.; Odstrcil D.; (2016). Shock Connectivity in the August 2010

and July 2012 Solar Energetic Particle Events Inferred from Observations and ENLIL Modeling. Astrophysical Journal, 825, 1, doi: 10.3847/0004-637X/825/1/1

- **Investigation Type:** Data Model Comparison
- **Names of models being tested or validated:** ENLIL
- **Datasources:** SOHO:LASCO STEREO A:COR2 STEREO A:IMPACT STEREO A:PLASTIC STEREO B:COR2 STEREO B:IMPACT STEREO B:PLASTIC

Summary: SSA-3, SSA-6

Reference: Luhmann J. G.; Mays M. L.; Li Y.; Lee C. O.; Bain H.; Odstrcil D.; Mewaldt R. A.; Cohen C. M. S.; Larson D.; Petrie G.; (2018). Shock Connectivity and the Late Cycle 24 Solar Energetic Particle Events in July and September 2017. Space Weather, 16, 557-568, doi: 10.1029/2018SW001860

- **Investigation Type:** Data Model Comparison
- **Names of models being tested or validated:** SEPMOD
- **Datasources:** ACE:EPAM GOES:EPS SDO:AIA NSO:GONG SOHO:LASCO STEREO A:COR2 STEREO B:COR2