Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Focused Science Topic

Topic: Use Inner Heliospheric Observations to better constrain Coronal Mass Ejection (CME) and Solar Energetic Particle (SEP) Event models.

Project Title:
Understanding Interplanetary Shock Dynamics in the Inner Heliosphere with New Observations and Modeling Techniques

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Summary:
Using archival observations and the ENLIL model at the Community Coordinated Modeling Center (CCMC), we propose to evaluate several new methods of predicting interplanetary (IP) shock location and strength throughout the inner heliosphere. Shocks accelerate energetic particles, and coronal mass ejection (CME) driven shocks are the primary cause of severe geomagnetic storms. These new prediction techniques appear to be superior to those presently in use by NASA s Space Radiation Analysis Group (SRAG) and NOAA s Space Weather Prediction Center (SWPC) for predicting shock arrival time at Earth. Our goals are two-fold: to provide observational validation of the ENLIL model in the inner heliosphere and to improve the prediction of shock arrival times at 1 AU .

We have discussed the project with Dr. M. Hesse (CCMC Director), and a letter of support from him is included with this proposal. To insure that the results are immediately useful to SRAG and SWPC we have enlisted Dr. Neal Zapp and Mr. W. Murtagh as collaborators in this work. Although the proposed work is initially based on archival data, the study is timely because the STEREO space weather beacon now provides the real-time coronagraph images as well as the low-frequency radio measurements needed in the new techniques described below.

The first new prediction method is an empirical technique based on the kilometric wavelength interplanetary Type II radio emissions described by Cremades, et al., 2007 (hereafter called "kmTII" technique). The second technique is based on the empirical shock arrival (ESA) model described by Gopalswamy et al. (2005a) based on CME speeds measured in SOHO LASCO. Xie et al. (2006) extended the ESA technique to include a correction for projection effects by a "cone model" (described below). A third technique is an extension of these two, where CME deceleration is included in the corrected ESA model and synthesized with kmTII-derived shock velocities. Promising initial results have been reported recently by Xie et al. (2008).

These empirical techniques will be evaluated against ENLIL driven by a "cone model" of halo CMEs. The ENLIL model developed by Dr. D. Odstrcil (e.g., Odstrcil and Pizzo, 1999) is well-known in the solar-helio community, and ENLIL version 2.3a is currently available to users at the CCMC. Odstrcil is a collaborator on the proposed work. The cone model that is used at the CCMC to drive interplanetary disturbances through the inner heliosphere via ENLIL was developed by a co-investigator to this proposal (Xie et al., 2004).

Space weather forecasters are keen to understand differences between the coronagraphic, the radio and the ENLIL techniques:

-How do these techniques compare to those presently in use at SRAG and SWPC?

-Is one technique superior for all/some CME-driven shocks?

-Are there CME characteristics (e.g., size, speed, mass, event repetition, morphology, etc.) that distinguish when one technique is superior?

-Can the techniques, or aspects of the techniques, such as definition of a more realistic interplanetary density model--be used together to improve the forecast?

The PI, Co-I's, and collaborators are uniquely-qualified to undertake the proposed work, as they have a published track-record of recent, relevant, significant results in this topic. The requested funding resources are modest, and the anticipated gain is significant. The work proposed here directly supports the NASA Strategic Goals. In particular, it supports Subgoal 3B: Understand the Sun and its effects on Earth and the solar system; as well as NASA Research Objectives: 3B.2 Understand how human society, technological systems, and the habitability of planets are affected by solar variability and planetary magnetic fields, and 3B.3 Develop the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers.

Publication References:

Summary: no summary

Reference:
Rouillard, A. P.; Odstr?cil, D.; Sheeley, N. R.; Tylka, A.; Vourlidas, A.; Mason, G.; Wu, C.-C.; Savani, N. P.; Wood, B. E.; Ng, C. K.; Stenborg, G.; Szabo, A.; St. Cyr, O. C.; (2011), Interpreting the Properties of Solar Energetic Particle Events by Using Combined Imaging and Modeling of Interplanetary Shocks, The Astrophysical Journal, Volume 735, Issue 1, article id. 7, 11 pp, doi: 10.1088/0004-637X/735/1/7