Project Details

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Topic: A model of CME evolution and impact on the inner heliosphere

Project Title:
DYNAMCS: A DYNAmically evolving Model of CMEs and SEPs

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Summary:
Coronal mass ejections (CMEs) are remarkable displays of solar variability, and are the leading cause of space weather effects at Earth. Major solar energetic particle (SEP) events are closely associated with CMEs. Measurements of the Heliophysics System Observatory (HSO) provide us with an unprecedented view of CMEs and SEPs.
Exploiting these data to further our quantitative understanding of these fundamental phenomena requires advanced physics-based models. Such models can also become prototypes for eventual operational space weather models. We propose a four-year program to create a DYNAmically evolving Model of CMEs and SEPs (DYNAMCS) and deliver it to the CCMC for runs-on-demand. Our proposed program strongly leverages and builds on our present modeling capabilities from MAS/CORHEL and EPREM/EMMREM.

Our first major goal and delivery milestone is to seamlessly link ambient corona/solar wind, CME initiation, and SEP acceleration/transport models to produce comprehensive simulations of CME-SPE events for runs-on-demand.
Recognizing that the notion of a quasi-steady background corona that is perturbed by an event is too simplistic for many real-world situations, our second major goal and milestone is to deliver an evolving background coronal and solar wind magnetohydrodynamic (MHD) model, capable of running continuously, to the CCMC. This model will be driven by magnetic maps that assimilate available magnetograms and farside data to continuously update the ambient structure of the solar corona and inner heliosphere.

Finally, as the effects of multiple flares/CMEs are poorly understood, yet may have important space weather consequences, our third goal/milestone is to allow multiple eruptions to be introduced into the continuously-running model, providing a near-real time description of the solar corona and inner heliosphere.

When completed, DYNAMCS will address key target objectives, including:
(1) Combining data assimilation and simulations
to successfully span multiple spatial scales and improve the understanding of CME evolution in the corona and inner heliosphere;
(2) Incorporating new capabilities to study the evolution, magnetic properties, and substructure of CMEs as they transit the corona and inner heliosphere and interact with the solar wind;
(3) Incorporating new techniques or simulation capabilities that can eventually lead to improved forecasts of the space weather impact on the Earth system as a result of improved understanding of CMEs and their evolution through the corona and inner heliosphere; and
(4) Providing a broad combination of models and observations for detailed understanding of the propagation of CME/flare-generated particles from the Sun to 1 AU.

DYNAMCS will provide post-processing of the results for innovative diagnostics and validation, so that fundamental science questions can be addressed, including:

(1) How does evolution of the ambient corona and solar wind affect CME evolution, propagation, magnetic-field properties, and geo-effectiveness?
(2) How does this evolution affect magnetic connectivity in the inner heliosphere and the subsequent propagation of SEPs?
(3) How do multiple eruptions affect CME evolution, propagation, magnetic-field properties, and geo-effectiveness?
(4) How do multiple eruptions affect SEP acceleration and transport?

These questions are relevant to the three Heliophysics Science Objectives: (1) Explore and characterize the physical processes in the space environment from the Sun to the heliopause and throughout the universe; (2) Advance our understanding of the Sun's activity, and the connections between solar variability and Earth and planetary space environments, the outer reaches of our solar system, and the interstellar medium; and (3) Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Publication References:

no references