Project Details

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Program Element: Focused Science Topic

Topic: Advances Toward a Near Real Time Description of the Solar Atmosphere and Inner Heliosphere

Project Title:
Magnetic Data Driven Global Model for Simulating the Solar Atmosphere and Inner Heliosphere in Real Time

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Summary:
Science Goals and Objectives. The Sun's atmosphere and solar wind play a critical role in space weather. Understanding of the global state of the inner heliosphere to 1 AU underlies LWS Strategic Science Areas, especially ``Physics-based Solar Energetic Particle Forecasting Capability''.

We will develop a magnetic data driven global model to simulate the time-dependent state of the inner heliosphere - from the top of chromosphere to 1 AU. The model will use AWSoM-R global MHD model developed at the University of Michigan (see I.V. Sokolov et al. arXiv:1609.04379 (2016)) which has already achieved the faster than real time performance. This effort will lead to improved predictions of the solar wind in the heliosphere and at 1 AU, which is vital for CIR and CME simulations. The background wind is vital for CME propagation travel time. Magnetic field vector data driving will significantly improve the accuracy of predictions of the magnetic connectivity of active regions to the Earth, which is vital for the SEP predictions.

The time-dependent coronal modeling will include such effects as quasi-periodic streamer blowouts and the accumulation and expelling of the magnetic helicity. The latter study requires vector magnetic field data to be incorporated into the model.

Methodology. To improve a prediction of the solar atmosphere and solar wind we will innovatively use of sequences of magnetograms and/or synoptic (Carrington rotation) magnetic maps in combination with other data products. High-cadence (about 2 hours) and high-quality magnetograms will be provided by a software package MAGIC (developed at the CCMC) and employed as a dynamical boundary condition for the AWSoM-R model. As an alternative we will also use new synoptic map data products recently developed at the NSO including synoptic (Carrington rotation) maps of vector magnetic field. This new data product will benefit the modeling of coronal magnetic field, interplanetary magnetic field and solar wind properties by better representing true radial component of magnetic field as compared with currently used pseudo-radial magnetograms, which are derived under a restrictive assumption that field is radial in the photosphere. Integer Carrington rotation and near-real time (NRT) synoptic maps for more recent data will be produced as the part of the proposed work.

A non-linear force free field (NLFFF) model will be applied to describe the state of the low solar corona using the vector magnetograms as low boundary condition. The model was previously tested on selected vector data from SOLIS and HMI (e.g., T. Tadesse et al, Solar Physics, 289, 4031 (2014) and references therein). NLFFF provides a better representation to global magnetic connectivity in the corona. It will also be used to derive new parameters (e.g., distribution of free magnetic energy with height in solar corona), which will allow us to quantify the flare activity of the Active Regions. The application of vector magnetograms as well as the NLFFF model with non-zero free energy would allow a critical evaluation of uncertainties in modeling outcome based on traditional assumptions. The developed model will be validated both with the observations from the existing missions and with the WSA model predictions for the solar corona and inner heliosphere.

Contributions to the team effort. We propose a global model simulating the solar atmosphere and inner heliosphere to incorporate all contributions from other modelers and to compare the model predictions with the observational data. Among the model outputs there will be the predictions of heliospheric MHD quantities at 1 AU and the magnetic free energy in the solar corona. We will also provide the magnetogram data products (MAGIC, vector synoptic maps, NLFFF) for the use by the focused topic team. The team will evaluate the advantages/disadvantages of vector synoptic maps and develop approaches to mitigate potential shortcomings.

Publication References:

no references