SPACE WEATHER, VOL. 9, S03004, doi:10.1029/2011SW000663, 2011

Wang-Sheeley-Arge–Enlil Cone Model Transitions to Operations

Vic Pizzo, George Millward, Annette Parsons, Douglas Biesecker, Steve Hill, and Dusan Odstrcil

Published 9 March 2011.

Citation: Pizzo, V., G. Millward, A. Parsons, D. Biesecker, S. Hill, and D. Odstrcil (2011), Wang-Sheeley-Arge–Enlil Cone Model Transitions to Operations, *Space Weather, 9,* S03004, doi:10.1029/2011SW000663.

The National Weather Service's (NWS) Space Weather Prediction Center (SWPC) is transitioning the first large-scale, physics-based space weather prediction model into operations on the NWS National Centers for Environmental Prediction (NCEP) supercomputing system (see also C. Schultz, Space weather model moves into prime time, *Space Weather, 9,* S03005, doi:10.1029/2011SW000669, 2011). The model is intended to provide 1- to 4-day advance warning of geomagnetic storms from quasi-recurrent solar wind structures and Earth-directed coronal mass ejections (CMEs). A team has been put together at SWPC to bring an advanced numerical model—developed with broad participation of the research community—into operational status.

The modeling system consists of two main parts: (1) a semiempirical near-Sun module (Wang-Sheeley-Arge (WSA)) that approximates the outflow at the base of the solar wind; and (2) a sophisticated three-dimensional magnetohydrodynamic numerical model (Enlil) that simulates the resulting flow evolution out to Earth. The former module is driven by observations of the solar surface magnetic field accumulated over a solar rotation and composited into a synoptic map; this input is used to drive a parameterized model of the near-Sun expansion of the solar corona, which provides input for the interplanetary module to compute the quasi-steady (ambient) solar wind outflow. Finally, when an Earth-directed CME is detected in coronagraph images from NASA spacecraft, these images are used to characterize the basic properties of the CME, including speed, direction, and size. This input "cone" representation is injected into the preexisting ambient flow, and the subsequent transient evolution forms the basis for the prediction of the CME's arrival time at Earth, its intensity, and its duration (Figure 1).

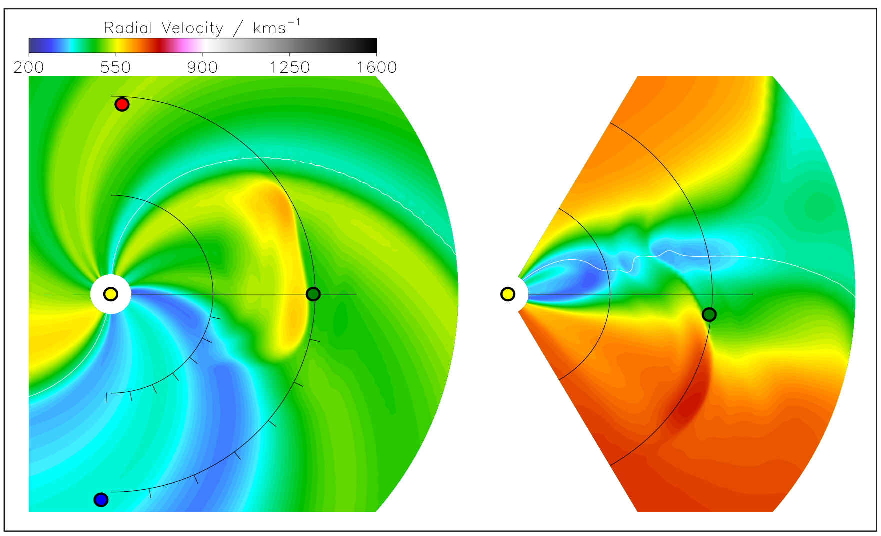

Figure 1. Sample output for Wang-Sheeley-Arge (WSA)–Enlil cone run for the 15 February 2011 multiple coronal mass ejection (CME) event. Graphic shows the velocity structure for three CMEs in the outburst at the time the largest CME was predicted to reach Earth, about 1500 UTC on 17 February. Image at left depicts the velocity structure in the ecliptic plane, looking down from above the solar north pole. Earth is the green circle to the right, and the positions of the two Solar Terrestrial Relations Observatory (STEREO) spacecraft (A, red circle; B, blue circle) are also shown; velocity is gauged by the color scale at top. Image at right shows a north-south cut along the Sun-Earth line. This model prediction proved to be a little early, with the main CME actually arriving at around 0100 UTC on 18 February.

Key aspects of the system being developed include the following:

- Automated, robust input data ingest from redundant sources, including synoptic magnetic maps for the ambient flow (via U.S. National Science Foundation–supported Global Oscillations Network Group (GONG) and Synoptic Optical Long-term Investigations of the Sun (SOLIS) instruments) and white-light CME images (via the Large Angle and Spectrometric Coronagraph (LASCO) and Solar Terrestrial Relations Observatory (STEREO) spacecraft, which are supported by NASA and the European Space Agency).

- Automated updating of the ambient solar wind flow several times per day.
- Direct participation of SWPC's Space Weather Forecast Office (SWFO)—the ultimate system operator—in the transition process. SWFO responsibilities include the recognition and characterization of Earth-directed CMEs and the preparation and dissemination of forecasts.
- A flexible database system to facilitate operations, support publicly accessible archival storage at the NOAA National Geophysical Data Center, and enable ongoing verification and validation efforts.

The system will be delivered to NCEP in fall 2011, to undergo a year of trial operation. During that time, potential improvements to the modeling system will be evaluated, and early assessments of its performance will be undertaken.

This transition draws upon contributions from many agencies and institutions, including the Center for Integrated Space Weather Modeling, Community Coordinated Modeling Center, Naval Research Laboratory, National Center for Atmospheric Research, Laboratory for Atmospheric and Space Physics, Office of Naval Research, Air Force Weather Agency (AFWA), and the Air Force Research Laboratory (AFRL). The long-term success of the system will hinge on training (collective experience), the quality of inputs (better interpretation, new observations), customer interactions, and the establishment of an effective operations-to-research (and the reverse) chain, which is critical to the continued improvement of the system.

Acknowledgment

We thank C. Nick Arge of AFRL for his essential contribution in the development and implementation of the WSA model.

***Vic Pizzo** is project scientist at NOAA SWPC, Boulder, Colo.; E-mail: vic.pizzo@noaa.gov. **George Millward** is the project technical lead at SWPC. **Annette Parsons** is the AFWA project administrator at SWPC. **Douglas Biesecker** is the project verification and validation lead at SWPC. **Steve Hill** is the development and transition section lead at SWPC. **Dusan Odstrcil** is the Enlil originator and a researcher at George Mason University, Fairfax, Va.*