VOL. 98 • NO. 7 • JUL 2017

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Predictive Capability for Extreme Space Weather Events

Workshop on Modeling and Prediction of Extreme Space Weather Events
College Park, Maryland, 22–24 August 2016

Space weather research is motivated by the quest to understand the effects of solar activity on the near-Earth space environment and the severe impacts these effects can have on infrastructure systems and technologies in space and on Earth. As this sensitive infrastructure grows, so does the vulnerability of our society to solar storms. The growing importance of extreme space weather events underscores the need to develop modeling and predictive capabilities for these low-probability but high-impact events.

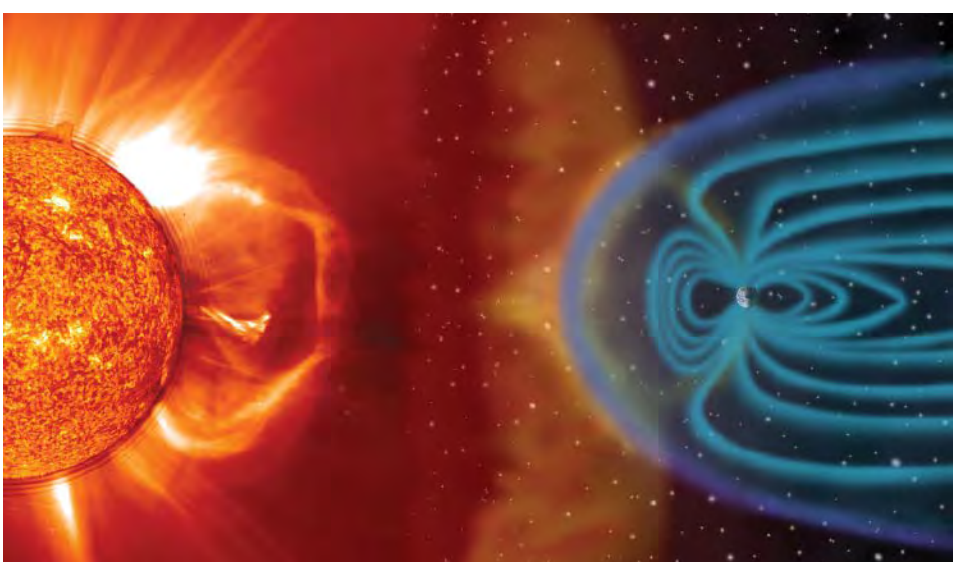
A workshop last August brought together participants from universities, research centers, and federal agencies. Participants assessed current capabilities in modeling severe space weather events, and they addressed potential approaches for developing capabilities that can facilitate preparedness and transition from research to operational forecasting.

A Developing Response to an Established Risk

The famous solar storm referred to as the Carrington Event of 1859 illustrates the potential consequences of space weather events for everyday life on Earth. This event sparked auroras as far south as the Caribbean and blew out telegraph systems. A comparable storm today would be devastating.

Several recent intense geospace storms also serve as a warning. In particular, the 23 July 2012 solar storm, which had a magnitude comparable to the Carrington Event, narrowly missed Earth but provided clear evidence of the likelihood of such intense events.

The U.S. government has provided a strong impetus to study space weather. In October 2015, the White House Office of Science and Technology Policy released the National Space Weather Strategy (see http://bit.ly/space-weather-strategy) and an accompanying action plan (see http://bit.ly/space-weather-action). A 13 October 2016 presidential executive order calls for space weather preparedness and efforts to minimize the extent of economic loss and human hardship from space weather (see http://bit.ly/space-weather-EO).



Artist's representation of the Sun-Earth connection. When storms on the Sun emit solar flares and coronal mass ejections, the effects can extend to electrical grids and telecommunications systems on Earth. At a workshop last August, experts looked at current capabilities for modeling severe space weather events and discussed how they could develop ways to help with preparedness and forecasting for such events. Credit: NASA/GSFC/SOHO/ESA, CC BY 2.0 (http://bit.ly/ccby2-0)

Workshop participants noted that despite major developments in space weather models, space weather forecasting is still in an early stage. One of the challenges they discussed is the dearth of spacecraft monitoring the solar wind between Earth and the Sun. At present these are limited to the L1 point, where Earth's and the Sun's gravities balance out and where several spacecraft are stationed (Advanced Composition Explorer (ACE), Deep Space Climate Observatory (DSCOVR), Wind, and Solar and Heliospheric Observatory (SOHO)).

Because of this dearth of data, a strategy for integrating data and modeling is essential, attendees noted. They agreed that the example of terrestrial weather forecasting provides compelling guidance: Data assimilation and ensemble forecasting have produced dramatic improvements in predictions. Such a strategy should aim to overcome the "valley of death"—the difficulties in the transition from research to operations that infamously claim so many promising ideas.

A Need for Advanced Modeling Capabilities

At the workshop, participants discussed challenges in modeling and prediction of extreme events in general. However, they agreed that the severe consequences of such events require developing strategies or frameworks that combine the capabilities of first principles and data-driven approaches. Data-driven modeling is based on complexity science and does not require modeling assumptions, so it is an important framework that has provided methods to quantify uncertainty. In space weather, such approaches are very relevant, especially considering the current state of numerical models.

Workshop participants identified the need for increasing open access to models in space weather research. To move toward forecasting, testing and validating models are essential, which requires that models be readily accessible to the community. As in the case of terrestrial weather, there is a fundamental need for open-access numerical models to accelerate model development and their transition from the research community to operational use.

This workshop was funded by NSF/PREEVENTS grant AGS 1638499.

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