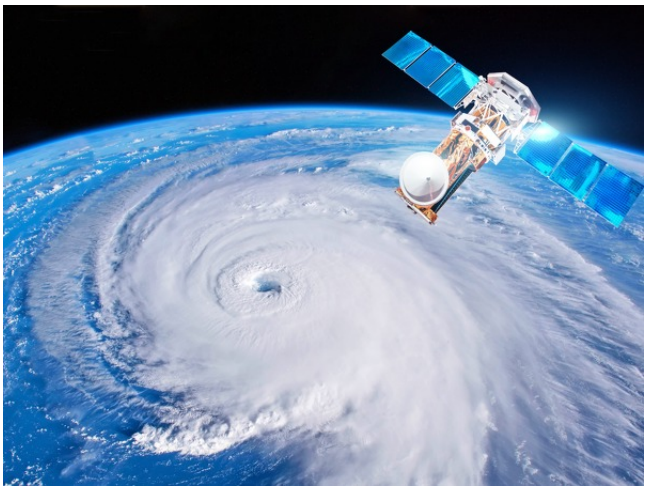
INNOVATION PARTNERSHIPS
UNIVERSITY OF MICHIGAN

Space Weather Modeling Framework Software

TECHNOLOGY NUMBER: 3386



OVERVIEW

Physics-based framework for predicting and analyzing complex space weather phenomena

- Improves space weather forecasting with integrated, multi-scale, high-performance modeling capabilities
- Satellite protection, astronaut safety, navigation reliability, power grid management, aerospace planning

BACKGROUND

Space weather refers to variable conditions in space driven by solar phenomena, Earth's magnetosphere, and atmospheric layers, which can drastically impact technological systems on Earth and in orbit. Traditional approaches to understanding space weather relied on empirical data, statistical forecasting, or partial-physics-based models, often falling short in predicting extreme events or capturing the interconnected dynamics between space environments. The growing dependence on space-based technologies for communication, navigation, and energy distribution has increased vulnerability to harmful space weather effects, from satellite failure and navigation drift to power grid blackouts. Limitations of existing models included a lack of integration between components and slow, resource-heavy computation, which restricted timely and accurate forecasts. Thus, there is a critical need for comprehensive, high-fidelity, and scalable predictive systems to inform mitigation strategies and safeguard essential infrastructure.

Technology ID

3386

Category

Software
Software & Content
MOSS - Michigan Open Source Support

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INNOVATION

The Space Weather Modeling Framework (SWMF), developed by the Center for Space Environment Modeling at the University of Michigan, represents a major technical advance in predictive space weather modeling. SWMF integrates diverse, physics-based simulation components—such as models for the Sun, solar wind, magnetosphere, and ionosphere—into a unified, high-performance computational framework. This modular architecture facilitates real-time coupling and feedback among system components, enabling multi-scale, first-principles-based simulations that more accurately predict space weather events and their effects. The SWMF's flexibility allows researchers to adapt, control, and extend models to address evolving scientific questions and operational needs. Its applications are broad and essential, including protecting satellites, forecasting astronaut exposure, preventing GPS disruptions, and supporting the resilience of electric power grids and global communications infrastructure.

ADDITIONAL INFORMATION

PROJECT LINKS:

- SWMF Project Site
- SWMF Github

DEPARTMENT/LAB:

- Tamas Gombosi, Aerospace Engineering

LICENSE:

- Apache 2