

National Aeronautics and Space Administration



# Heliophysics

*U.S. Government Efforts: Research, Operations and Preparedness  
Department of State Space Weather Forum  
04 April 2016  
Steven W. Clarke, Director*

National Aeronautics and Space Administration



# Science Mission Directorate



HELIOPHYSICS



EARTH SCIENCE



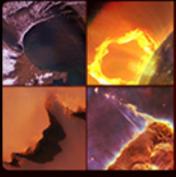
PLANETARY SCIENCE



ASTROPHYSICS



An Integrated Program of Science



# NASA Heliophysics

Strategic Goal: Understand the Sun and its interactions with Earth and the solar system, including space weather

## Solar Terrestrial Probes



Strategic Mission  
Flight Programs

*Solve the fundamental physics mysteries of heliophysics:* Explore and examine the physical processes in the space environment from the sun to the Earth and throughout the solar system.

*Build the knowledge to forecast space weather throughout the heliosphere:* 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.

## Living With a Star



Strategic Mission  
Flight Programs

*Understand the nature of our home in space:* Advance our understanding of the connections that link the sun, the Earth, planetary space environments, and the outer reaches of our solar system.

## Explorers



Smaller flight programs,  
competed science topics,  
often PI-led

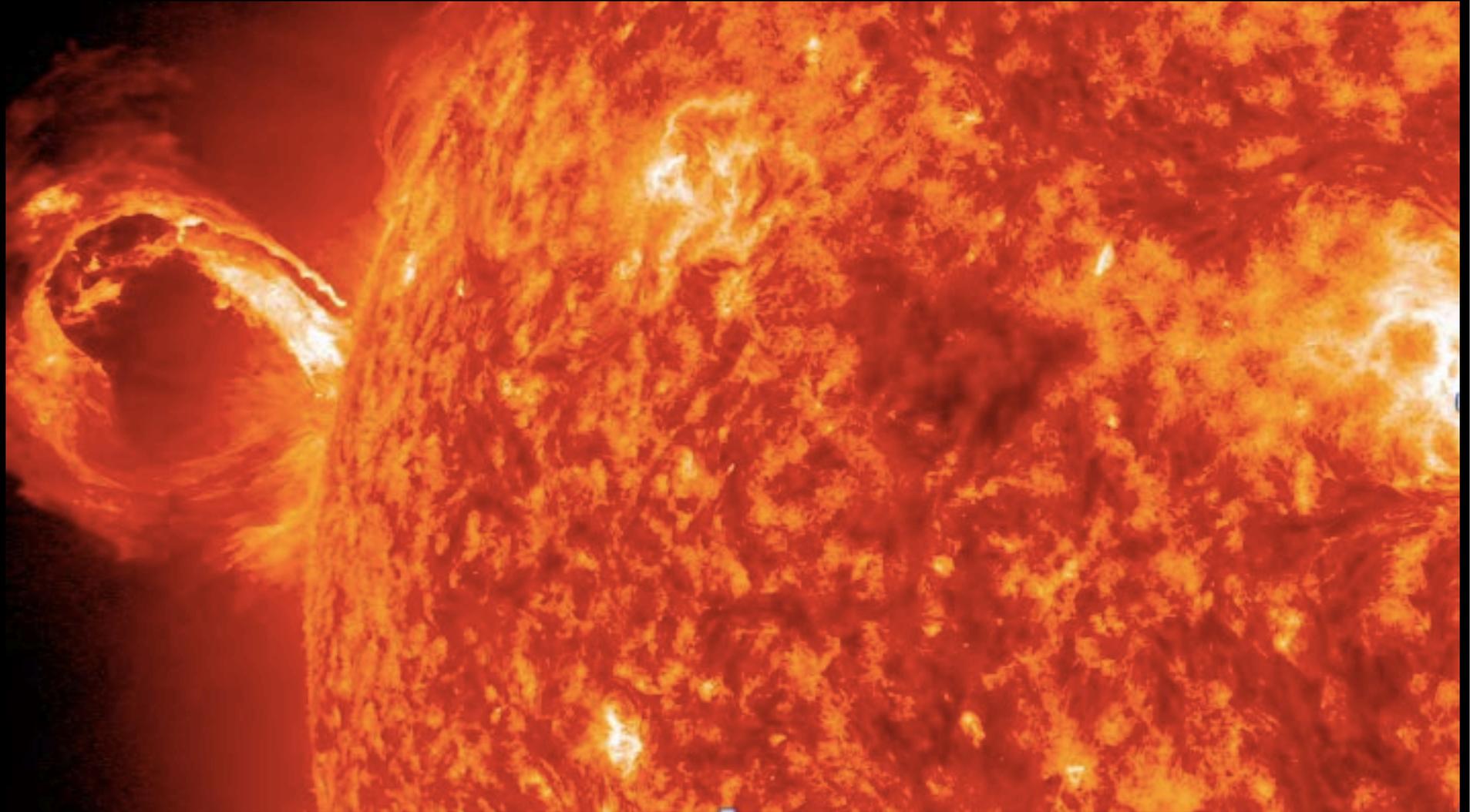
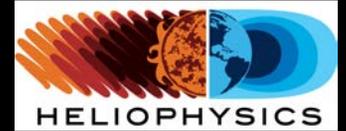
## Research



Scientific research projects  
utilizing existing data plus  
theory and modeling

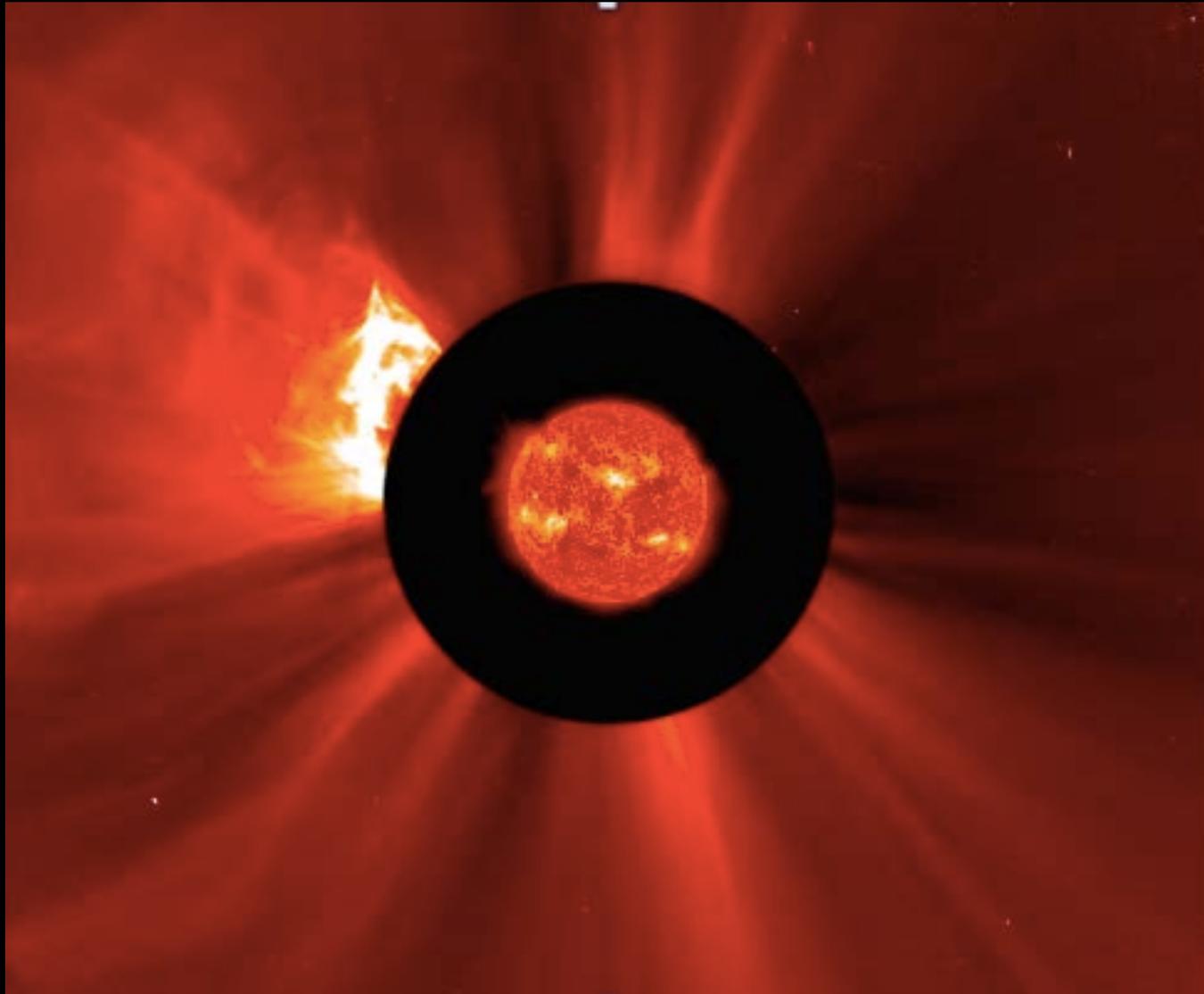


# Observations



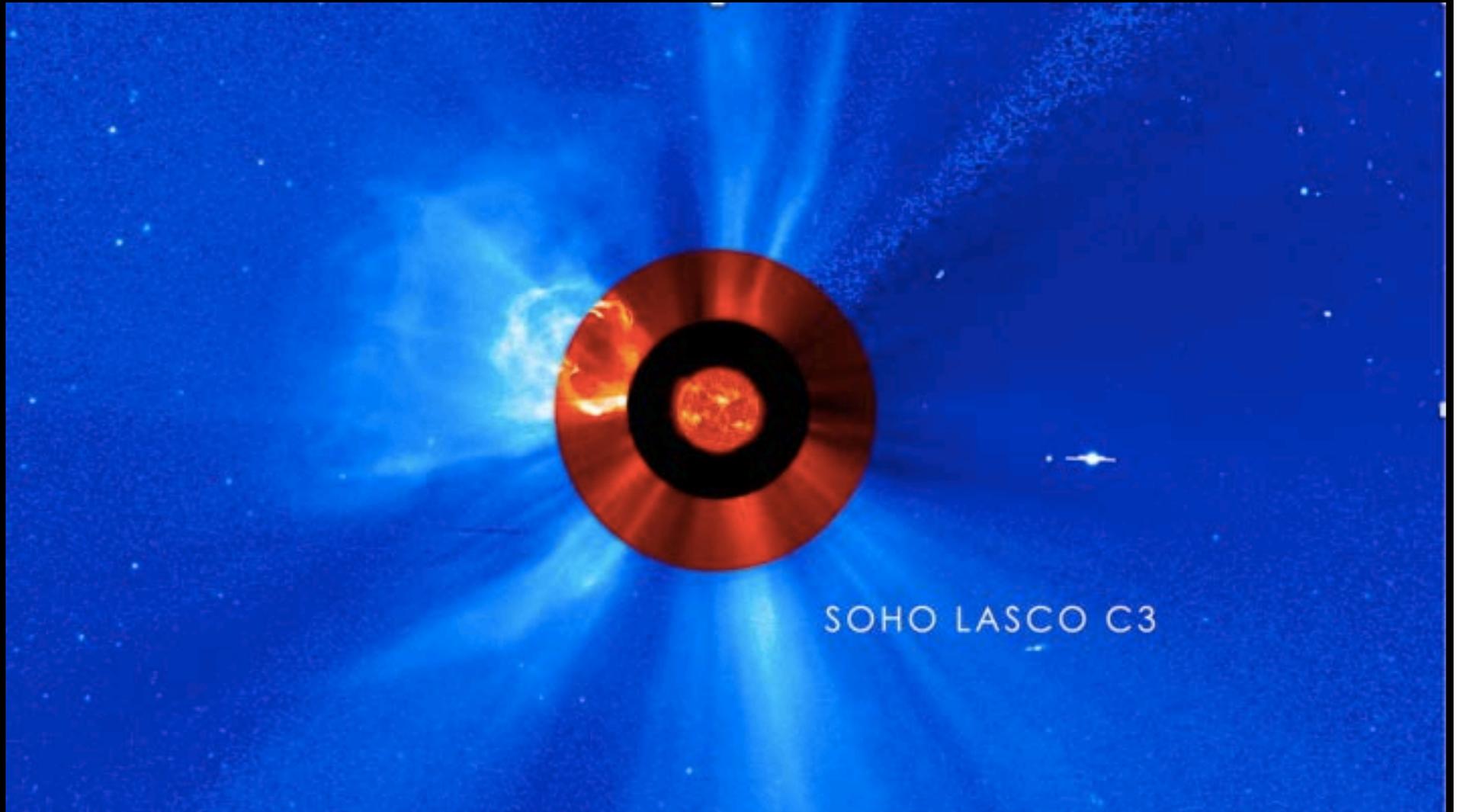


# Observations



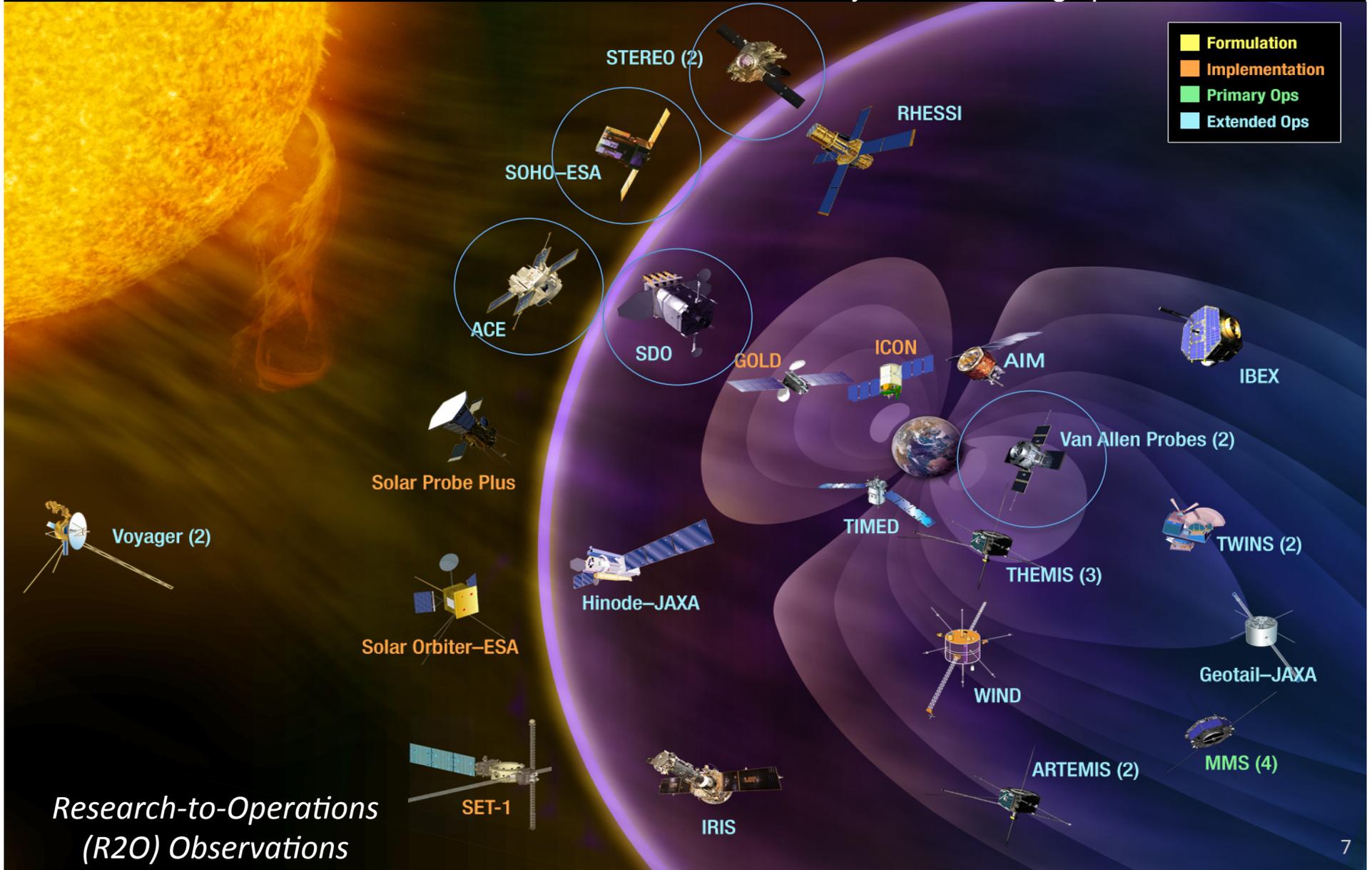


# Observations



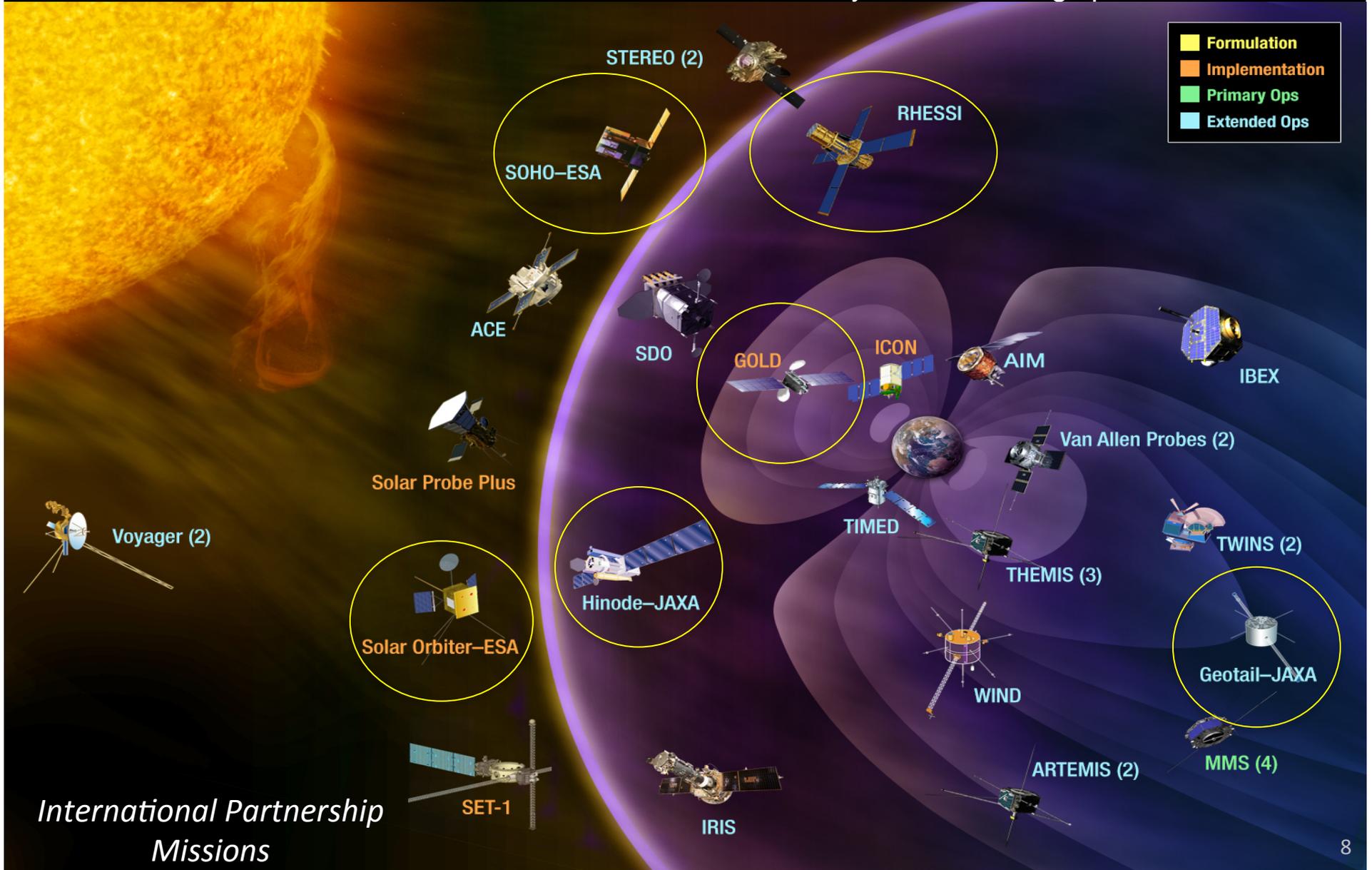
# Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system, including space weather



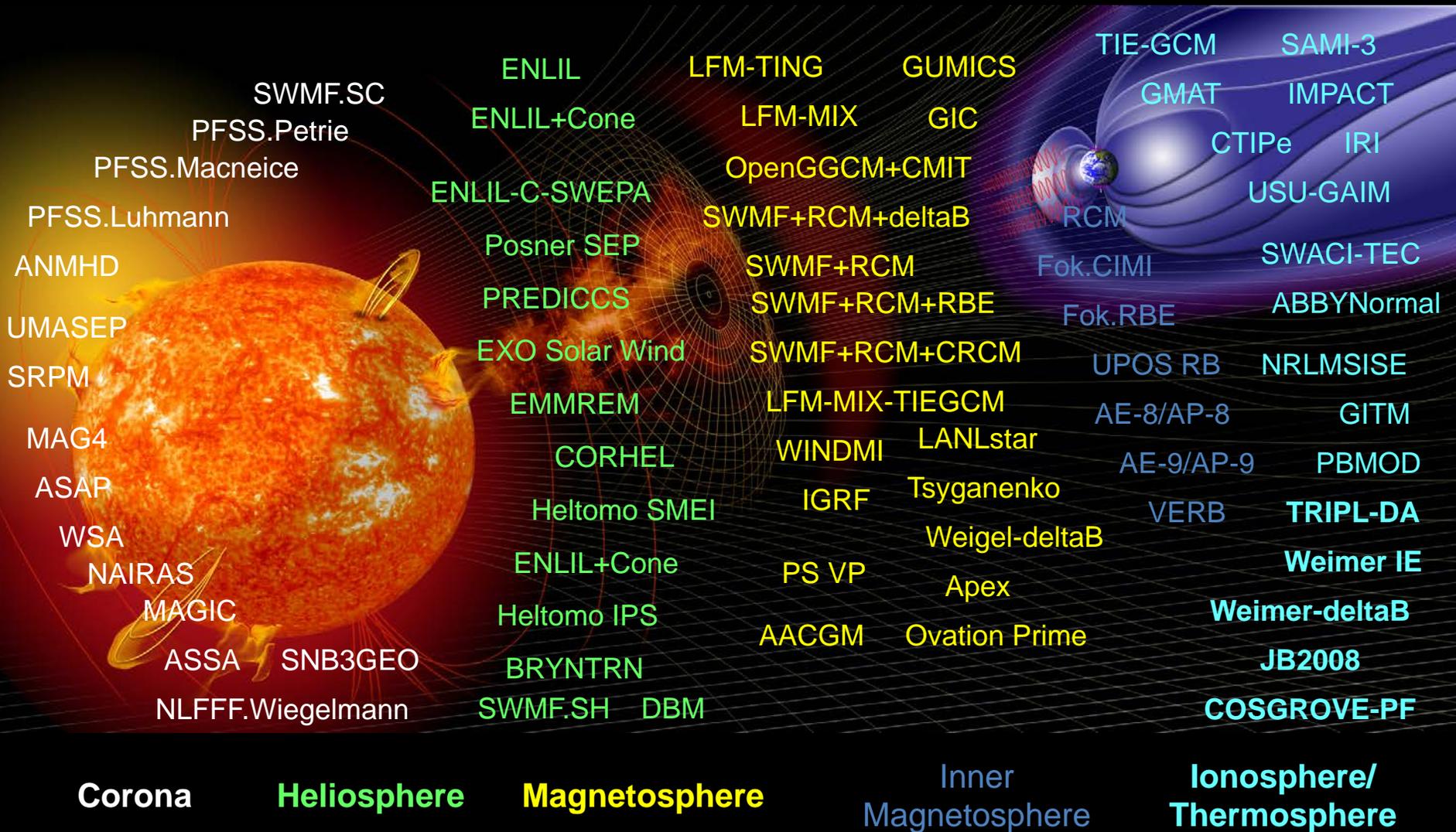
# Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system, including space weather



# Numerous Community Research Models

## [List of those hosted at Community Coordinated Modeling Center (CCMC)]



*Focus is on research - despite quantity of excellent models few are applicable to operational needs.*

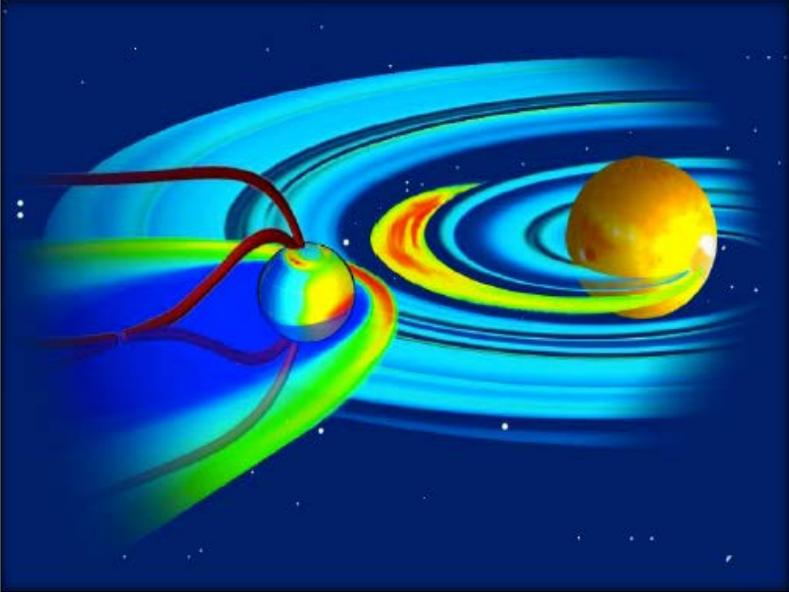


# NSF/NASA LWS Strategic Capability Space Weather Modeling (2013-2018)



8 continuing awards, \$1.5M/yr (NSF), \$2.5M/yr (NASA) for 5 years:

Collaborative Space Weather Modeling



*A Model of Community Coordinated Modeling Center (CCMC)*

NASA NSF Partnership for Collaborative Space Weather Modeling supports large-scale space weather modeling efforts that require collaborative community teamwork. This joint effort has been significantly enhanced by our capabilities in the modeling and prediction of solar eruptions, particle acceleration in the corona and solar wind, small scale physics effects in global magnetosphere models, and upper atmosphere dynamics.

- Fisher; UC Berkeley, Stanford, Lockheed; [Coronal global evolutionary model](#)
- Schunk; Utah State, JPL, U of Southern CA, [1<sup>st</sup> principles-based data assimilation model for the global ionosphere](#)
- Bhattacharjee, Princeton, GSFC, LANL, UCSD; [Kinetic Effects in Global Magnetosphere Models](#)
- Mansour, [Real-time heliospheric space weather modeling](#)
- Odstroil, UMD, GMU, UCB; [Magnetic flux emergence and transport](#)
- Antiochus; UMich, NASA, NRL; [Modeling of flares, coronal mass ejections \(CMEs\) and their interplanetary impacts](#)
- Mannucci; JPL; [IT storm fronts](#)
- Schwadron; [Energetic particle acceleration](#)

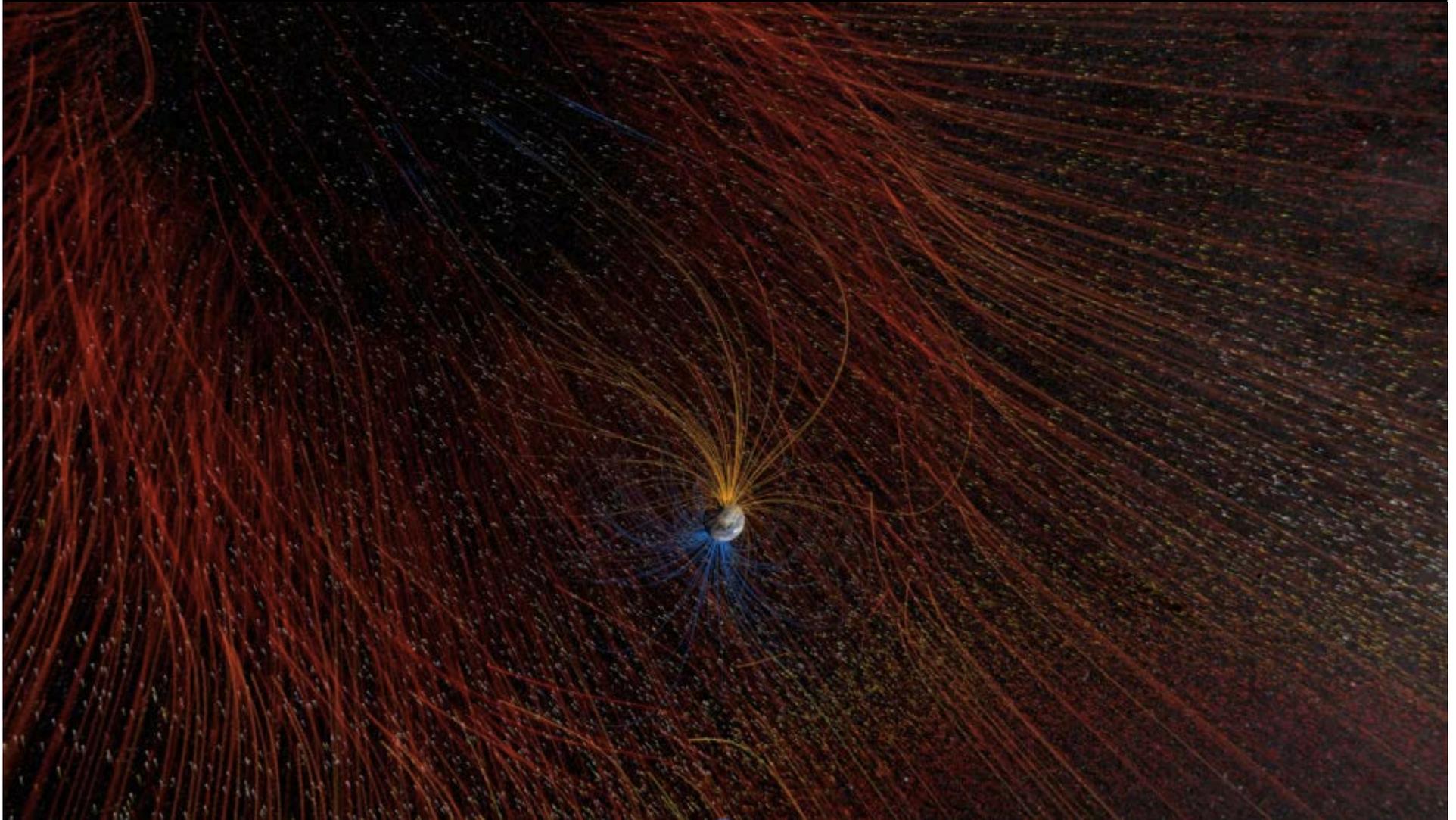
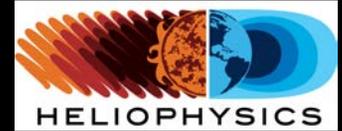


# Coronal Mass Ejection Simulation





# Coronal Mass Ejection Simulation





# Aurora as seen from the ISS



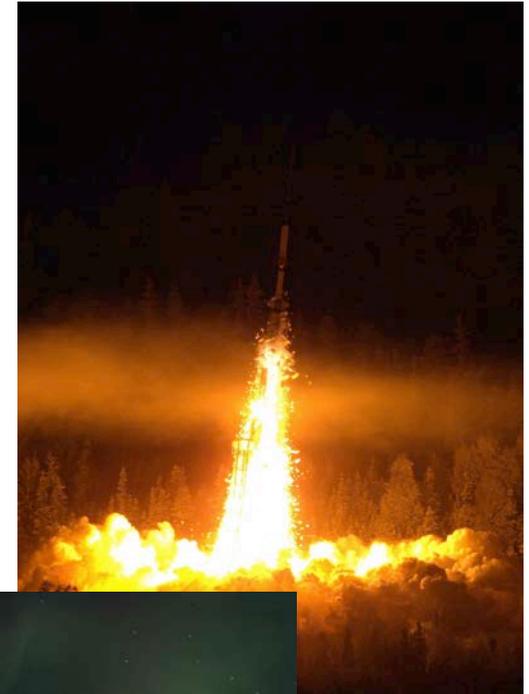


# Heliophysics Research Grants



NASA Heliophysics implements a program to achieve three overarching science goals through research grants for flight data analyses, theory and modeling:

- *Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system*
- *Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system*
- *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*

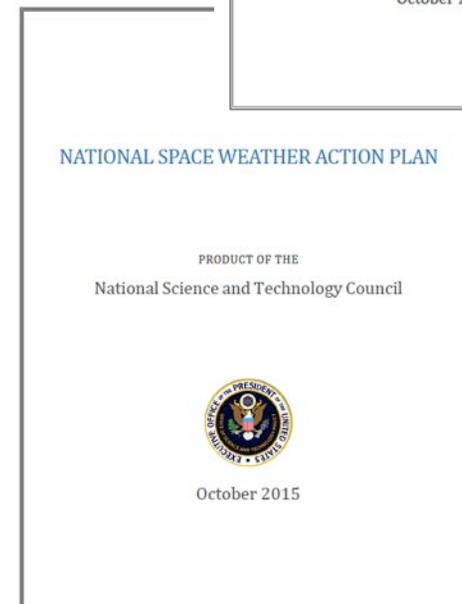
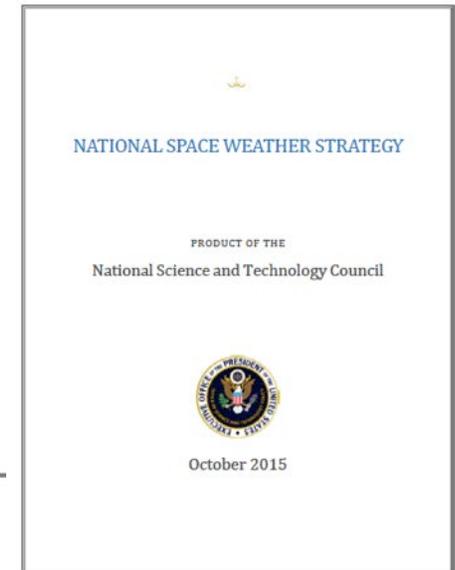




# National Space Weather Strategy



- National Space Weather Strategy and Space Weather Action Plan were officially released on 29 October 2015
- 6 Strategic Goals in the Action Plan
  - Establish Benchmarks for Space-Weather Events
  - Enhance Response and Recovery Capabilities
  - Improve Protection and Mitigation Efforts
  - Improve Assessment, Modeling, and Prediction of Impacts on Critical Infrastructure
  - Improve Space-Weather Services through Advancing Understanding and Forecasting
  - ***Increase International Cooperation***
- Action Plan details the activities, outcomes and timelines that will be undertaken by Federal departments and agencies for the Nation to make progress toward the strategic goals

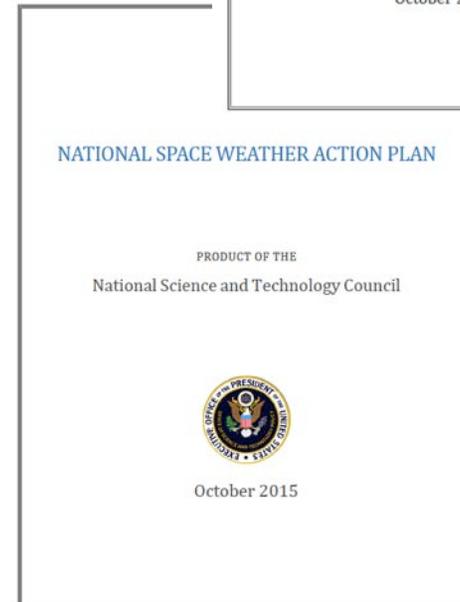
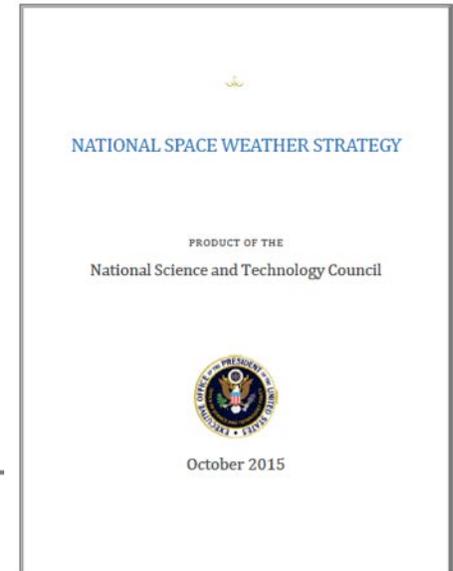




# National Space Weather Strategy



- Goal 6 – Increase International Cooperation
  - 6.1: Build International Support at the Policy Level for Acknowledging Space Weather as a Global Challenge
  - 6.2: Increase Engagement with the International Community on Observation Infrastructure, Data Sharing, Numerical Modeling, and Scientific Research
  - 6.3: Strengthen International Coordination and Cooperation on Space-Weather Products and Services
  - 6.4: Promote a Collaborative International Approach to Preparedness for Extreme Space-Weather Events



**NASA is leveraging existing international partnerships and developing new partnerships that will support the National Space Weather Strategy goals.**

# International Space Weather Activities



## International Space Weather Initiative (ISWI)

- Program of international cooperation to advance the space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments in conjunction with space data, and communicate the results to the public and students



## International Living With a Star (ILWS)

- Stimulate, strengthen, and coordinate space research to understand the governing processes of the connected Sun-Earth System as an integrated entity



## United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS)

- Review the scope of international cooperation in peaceful uses of outer space, to devise programmes in this field to be undertaken under United Nations auspices, to encourage continued research and the dissemination of information on outer space matters, and to study legal problems arising from the exploration of outer space



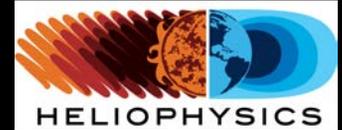
## Coordination Group for Meteorological Satellites (CGMS)

- International forum for the exchange of technical information on geostationary and polar orbiting meteorological satellite systems



## COSPAR/ILWS roadmap towards advanced space weather science

- COSPAR and the steering committee of the ILWS program tasked a multi-disciplinary, international team with the development of a roadmap with the goal of demonstrably improving our observational capabilities for, scientific understanding of, and ability to forecast the various aspects of space weather



*Long-term interagency, international and public-private collaboration is critical to successful global space weather preparedness.*

*Thank You!*