

EXPLORE SOLAR SYSTEM & BEYOND NASA Heliophysics Space Weather Program

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NASA Heliophysics Objectives

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 including the interface with the interstellar medium.

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.

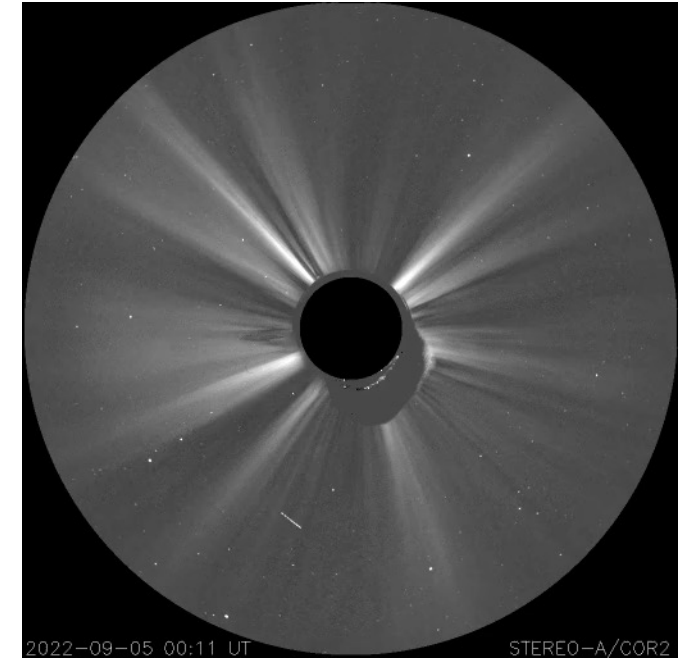
Understand the **nature of our home in space**: Advance our understanding of the connections that link the sun, the Earth, planetary space environments, and the outer reaches of our solar system.



NASA Space Weather Program (NSWx)

Space Weather Program Vision: Advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

- NASA plays a vital role in space weather research by providing unique, significant, and exploratory observations and data streams for theory, modeling, and data analysis research, and for operations.
- NASA's Heliophysics Division is uniquely poised to support needs of the National and International space weather enterprise and the Agency's Artemis.
- Various executive (NSW SAP) and legislative (PROSWIFT Act) mandates direct NASA to address research and application aspects of space weather which allows NASA to do what NASA does best – push the envelope by pursuing forward-leaning developmental activities.
- Making use of NASA's unique capabilities and directly addressing the legislative mandate, HPD has established the new NASA Space Weather Program, a national resource to unify space weather research and drive our understanding of its risks, impacts and mechanisms into new realms.



Heliophysics Missions

Heliophysics Mission Fleet

Heliophysics missions are strategically placed throughout our solar system, working together to provide a holistic view of our Sun and space weather, along with their impacts on Earth, the other planets, and space in general. NASA's heliophysics mission fleet includes 19 operating missions using 26 spacecraft, 13 missions in development, 1 mission under study, a robust sounding rocket program and a variety of CubeSat missions.

- ESA = European Space Agency
- JAXA = Japan Aerospace Exploration Agency

*Numbers in parentheses indicate how many spacecraft each mission includes.

● UNDER DEVELOPMENT

- AWE (ISS)
- Carruthers Geocorona Observatory
- ESCAPADE (2)
- EUVST (JAXA)
- EZIE (3)
- GDC (6)

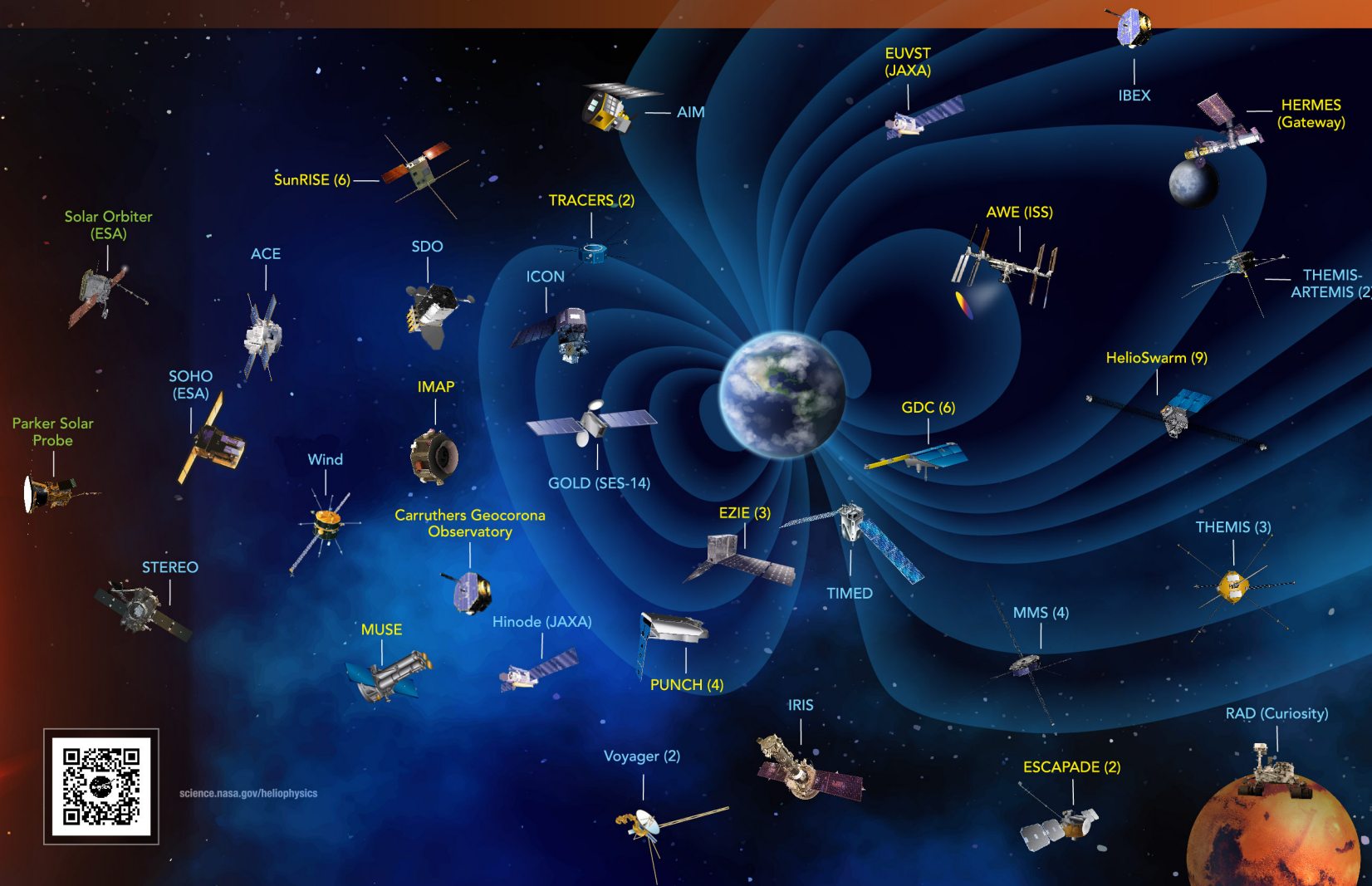
- HelioSwarm (9)
- HERMES (Gateway)
- IMAP
- MUSE
- PUNCH (4)
- SunRISE (6)
- TRACERS (2)

● PRIMARY OPERATION

- Parker Solar Probe
- Solar Orbiter (ESA)

● EXTENDED OPERATION

- ACE
- AIM
- GOLD (SES-14)
- Hinode (JAXA)
- IBEX
- ICON
- IRIS
- MMS (4)
- RAD (Curiosity)
- SDO
- SOHO (ESA)
- STEREO
- THEMIS-ARTEMIS (2)
- THEMIS (3)
- TIMED
- Wind
- Voyager (2)



science.nasa.gov/heliophysics



Space Weather Program Activities

Flight Missions

HERMES & Gateway

- The NASA space weather instrument suite, led by HPD, will observe solar particles and the solar wind. A second scientific payload is a radiation instrument package, built by the European Space Agency.
- Serves as a pathfinder mission for future missions to establish an earth-independent space weather capability for long duration missions beyond the earth-moon system
 - NASA Suite: HERMES (Heliophysics Environmental and Radiation Measurement Experiment Suite)
 - ESA Suite: ERSA (ESA Radiation Sensors Array)
 - ESA/JAXA Suite: IDA (Internal Dosimeter Array)

GDC

- Near real-time space weather data

IMAP

- I-ALiRT

Artemis Program

- Ongoing conversations with potential international partnerships

NOAA/Interagency Partnerships

- R2O2R Framework and Quad-Interagency Agreement



Space Weather Program Activities Cont.

Competed Research

Small Business Innovation Research (SBIR)

- NASA's SBIR program seeks to transform scientific discovery into products and services through innovations that have the potential for infusion into NASA programs and missions, the potential for commercialization into NASA relevant commercial markets, and that have a societal benefit.

Space Weather Pipeline Instruments (TBI)

Space Weather and Science Agile Platforms (SWAPS) RFI

Research to Operations to Research (R2O2R)

- One ROSES-23 focused topic:
 - Data Assimilation for Neutral Density Forecasting
 - ROSES-23 *Open Call*

Centers of Excellence

- Provide significant long-term investment in research and infrastructure development to address major challenges in space weather in an integrated multidisciplinary fashion

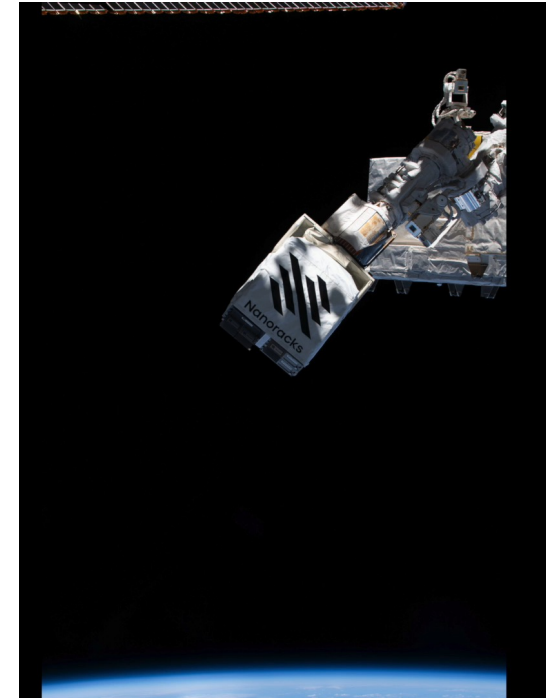
Space Weather Grand Challenge (TBI)

- Identify the next low-latency data stream that would significantly advance space weather forecasting capability to meet national needs.

Space Weather Program International Activities

Current International Collaborations

- Vigil: ESA
 - ESA Led mission to L5
 - ERSA on Lunar Gateway
 - ESA led counterpart to HERMES
- AOM: CSA
- SPORT: NASA/AEB
 - Launch Nov. 26th 2022. Deployed from ISS on Dec. 29, 2022
- SNIPE: KASI
- Aditya: ISRO



Credits: ISS/JAXA Koichi Wakata

Space Weather and Human Exploration

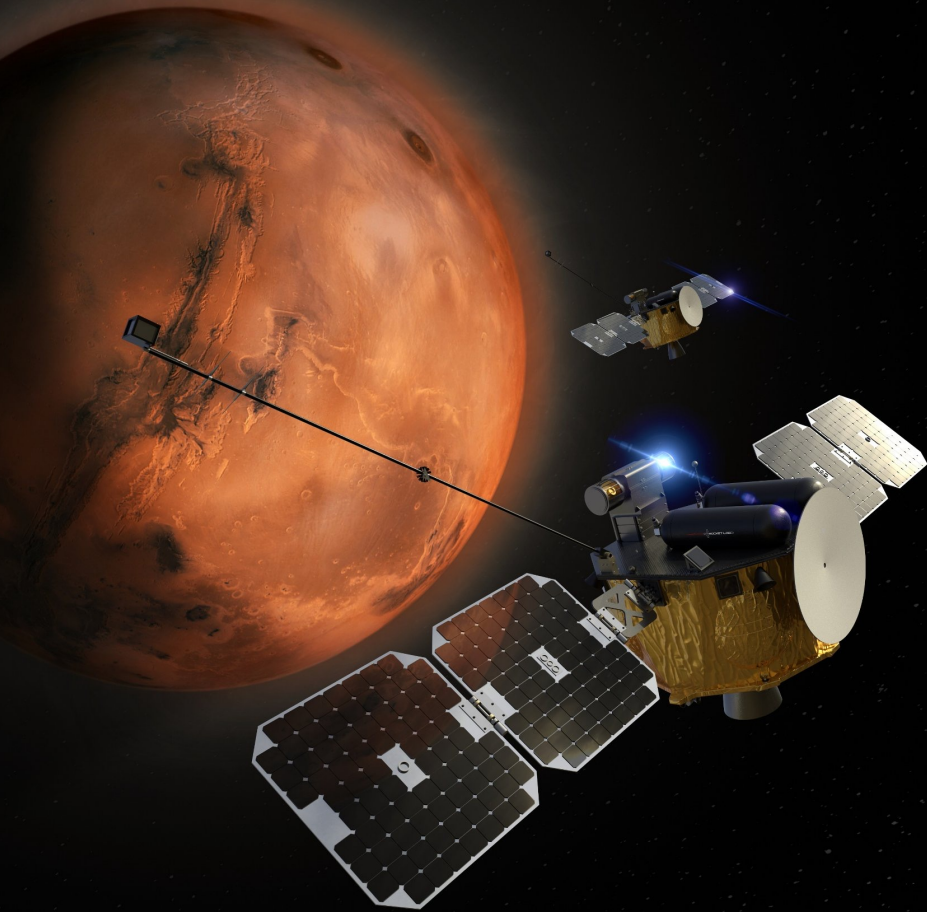


In the context of current plans for human exploration of deep space, the abilities to track, understand, and predict space weather become increasingly important. As astronauts venture beyond low Earth orbit, to the Moon and beyond, both the potential hazards and the level of variability of space-weather phenomena increase. Crew vessels will need dedicated monitors to provide alerts of dangerous conditions and to provide input for predictive space-weather models to forewarn astronauts of impending events.

HERMES: NASA's First Science Payload on Gateway



Space Weather and Mars Exploration



- Concern: We currently have observational gaps (e.g., Mars-Sun L1) that limit our ability to monitor and predict space weather at Mars.
- M2M Space Weather Analysis Office and MAVEN* mission team are collaborating to develop data products for analysis and validation of space weather predictions at Mars
- Expansion of the Heliophysics fleet at Mars: RAD (Curiosity rover) and ESCAPEDE (image to left)
- Next Heliophysics Decadal may provide recommendations on this topic
- What does an “*Earth-independent space weather capability*” look like?

* MAVEN (Mars Atmosphere and Volatile Evolution) mission in SMD/Planetary Science Division