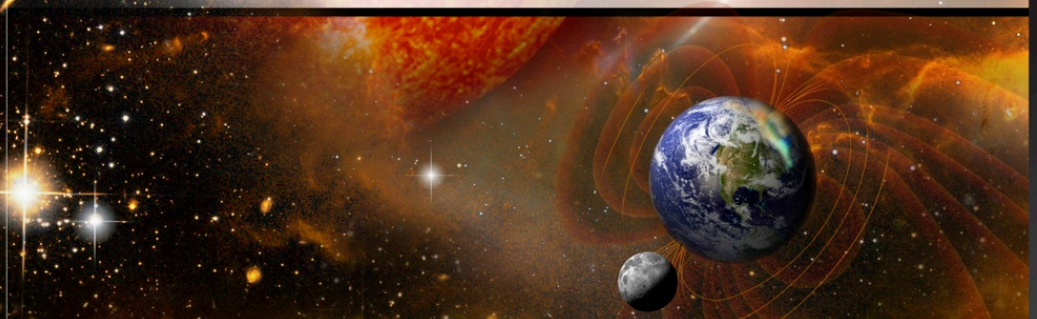
National Aeronautics and Space Administration

NASA Heliophysics: The Science of Space Weather

HELIOPHYSICS DIVISION



Space Weather Enterprise Forum
21 October 2015
Steven W. Clarke, Director
Heliophysics Division
Science Mission Directorate, NASA Headquarters

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

Living With a Star

Strategic Mission Flight Programs

Solve the <u>fundamental physics</u> 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.

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

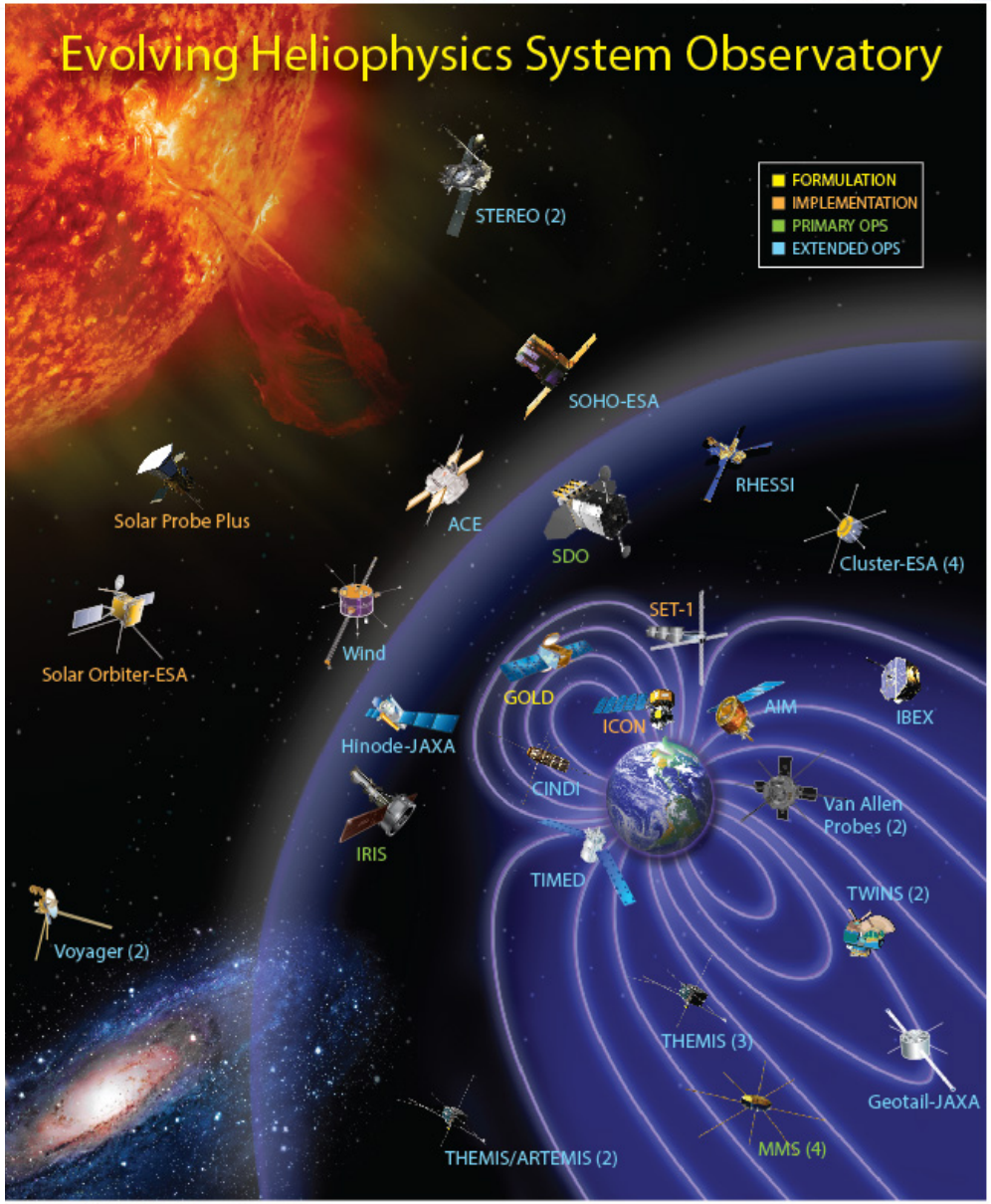
Smaller flight programs, competed science topics, often PI-led

Research

Scientific research projects utilizing existing data plus theory and modeling

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 has 19 operating missions with 33 spacecraft: Voyager, Geotail, Wind, SOHO, ACE, Cluster, TIMED, RHESSI, TWINS, Hinode, STEREO, THEMIS/ARTEMIS, AIM, CINDI, IBEX, SDO, Van Allen Probes, IRIS, MMS**

  (Missions in red contribute to operational Space Weather in conjunction with the NOAA Space Weather Prediction Center)

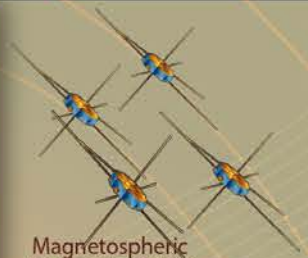
- **5 missions are in development:**

  SET, ICON, GOLD, SPP, and SOC

Heliophysics Program 2015-2024

* Notional

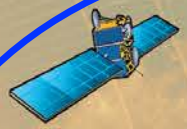
Solar Terrestrial Probes



Magnetospheric Multiscale (MMS)
March 2015

STP #5
2023*

Living With a Star

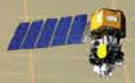


Space Environment Testbeds (SET)
October 2016

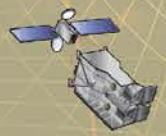
Solar Probe Plus
July 2018

Solar Orbiter Collaboration (with ESA)
October 2018

Explorers



Ionospheric Connection Explorer (ICON)
October 2017



Global-scale Observations of the Limb and Disk (GOLD)
April 2018

Heliophysics MO
2020*

Heliophysics SMEX
2022*

Heliophysics MO
2022*

Heliophysics MIDEX
2024*

Heliophysics MO
2024*

Research Program

Solar/Heliospheric - September 2015
UV/Optical Astrophysics - November 2015
Geospace - November 2015
Geospace - November 2015

Solar/Heliospheric - December 2015
High Energy Astrophysics - December 2015
UV/Optical Astrophysics - December 2015

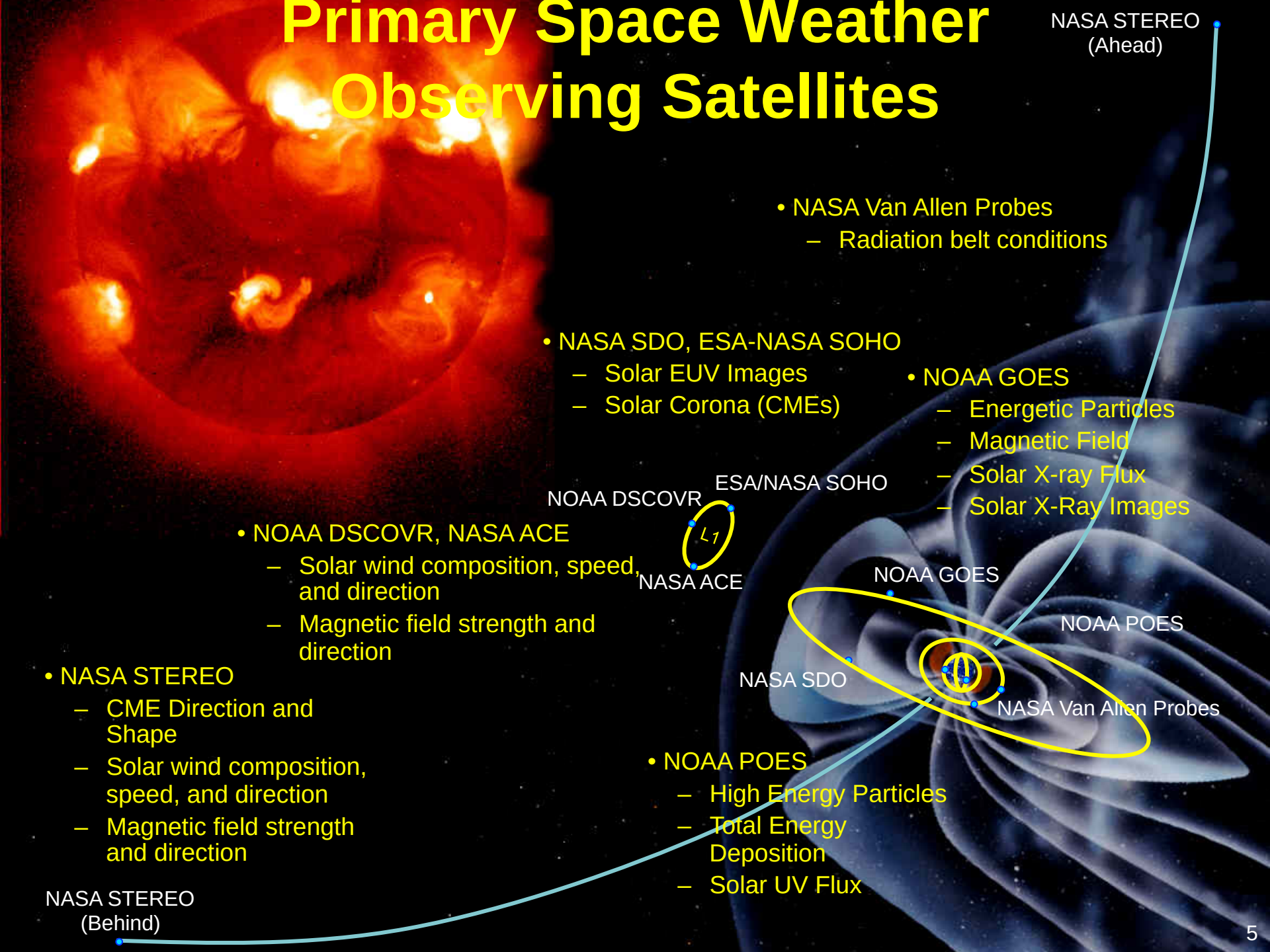
HASP - September 2015
RAD-X - September 2015
GRIPPS - December 2015

Ongoing

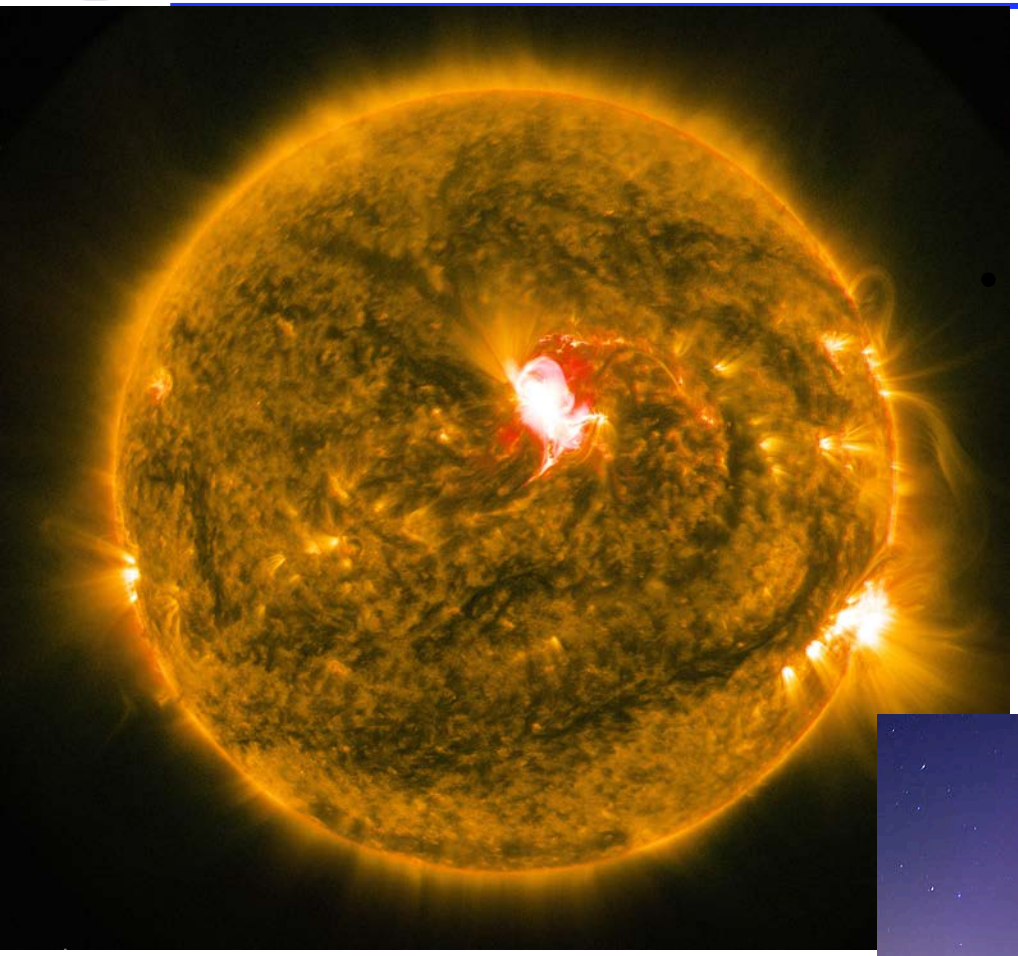
Heliophysics Missions
Astrophysics Missions
Planetary Missions

2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Primary Space Weather Observing Satellites



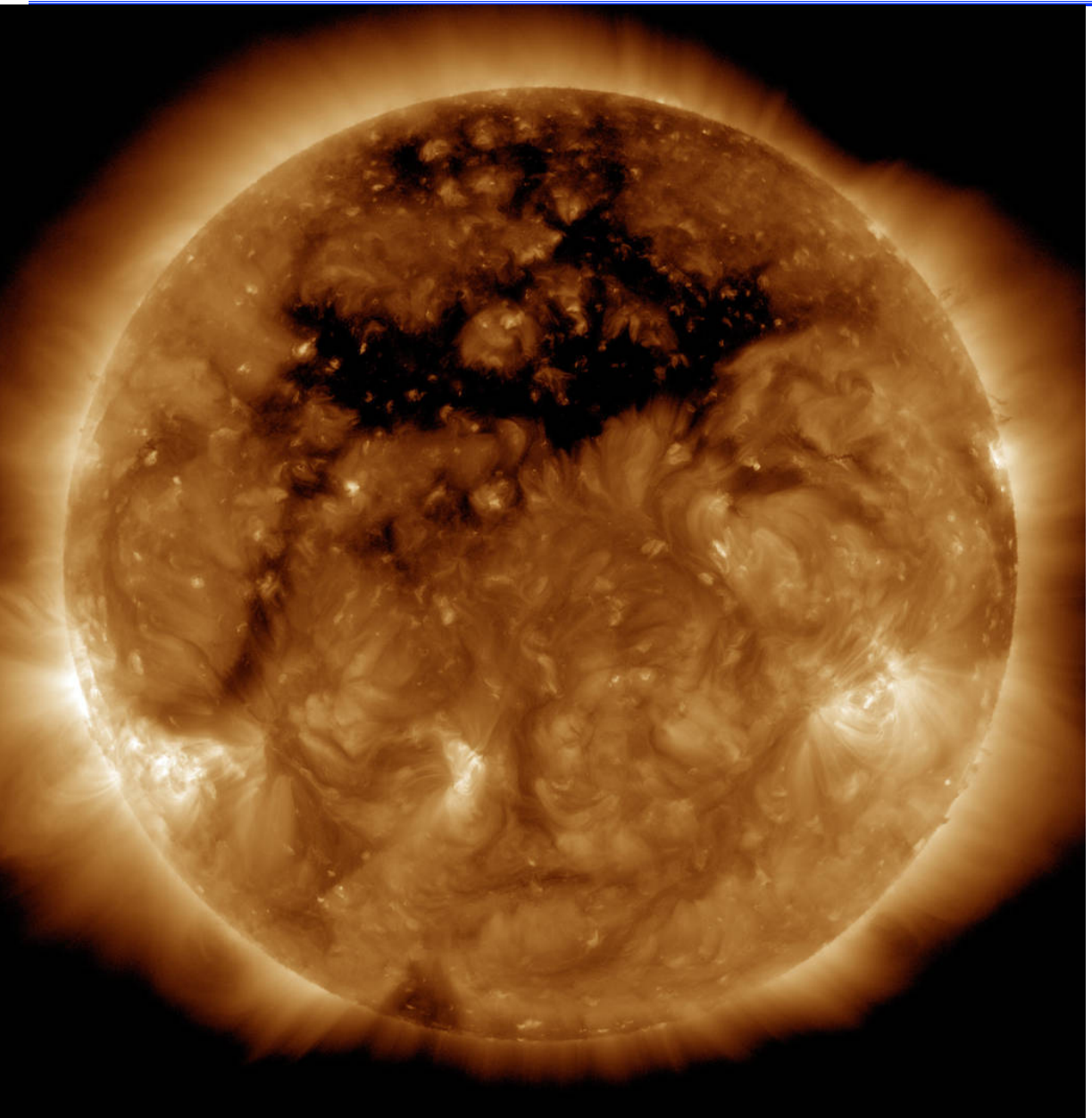
NASA's Solar Dynamics Observatory (SDO)



- *Mid-level Coronal Mass Ejection (CME) captured by SDO on June 20, 2015*

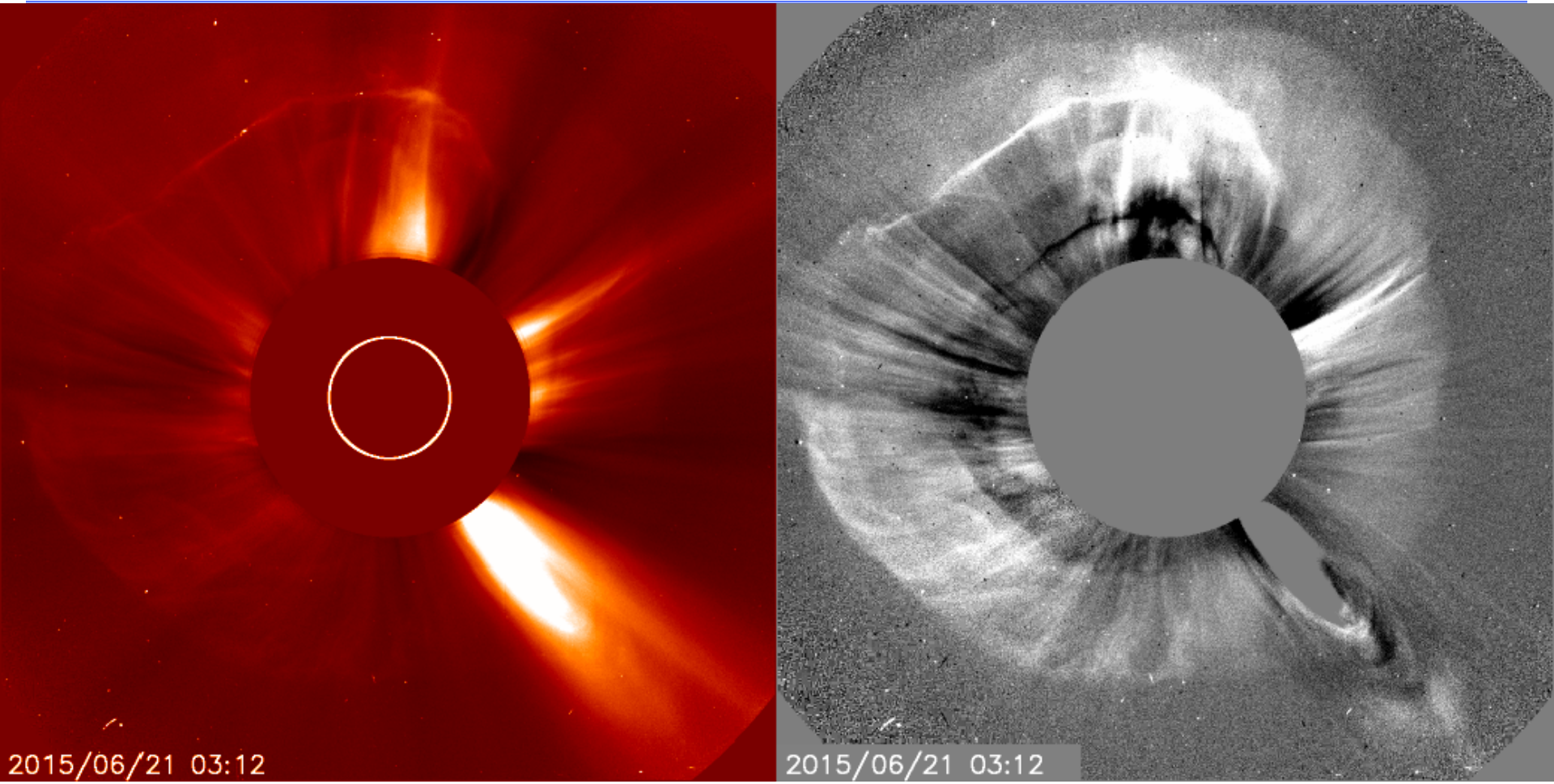
Aurora captured west of Philadelphia

NASA's Solar Dynamics Observatory (SDO)



Coronal hole imaged by NASA's Solar Dynamics Observatory on October 10, 2015

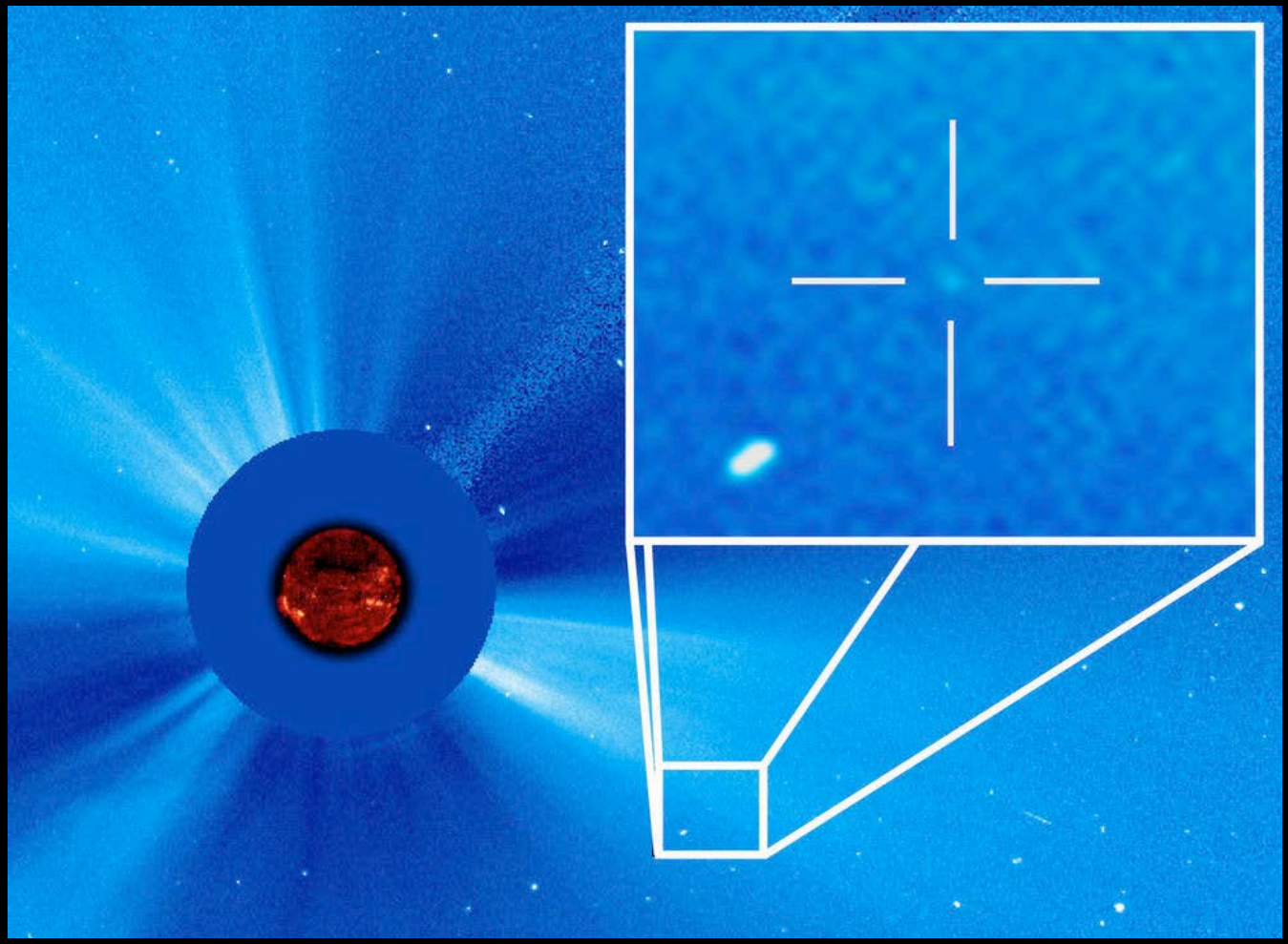
ESA-NASA Solar and Heliospheric Observatory (SOHO)



Halo coronal mass ejection (CME) as captured by the SOHO spacecraft on June 21, 2015

ESA-NASA Solar and Heliospheric Observatory (SOHO)

SOHO Discovers Its 3,000th Comet!



- On Sept. 13, 2015, citizen scientist Worachate Boonplod, of Samut Songkhram, Thailand used data from the Solar and Heliospheric Observatory (SOHO) to discover its 3,000th comet.

- Prior to the 1995 launch of SOHO, only a dozen or so comets had ever even been discovered from space, while some 900 had been discovered from the ground.

- SOHO's great success as a comet finder is dependent on the people who sift through its data – a task open to the world as the data is publicly available online in near-real time. The result: 95 percent of SOHO comets have been found by these citizen scientists.

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.

Summary

- NASA formulates and implements a national research program for understanding the Sun and its interactions with the Earth and the Solar System and how these phenomena impact life and society.

- NASA fields a coordinated and complementary fleet of spacecraft to understand the Sun and its interactions with Earth and the solar system, including space weather.

- NASA's space weather research contributions continue to provide positive societal benefits, leveraging inter-Agency and international collaborations.