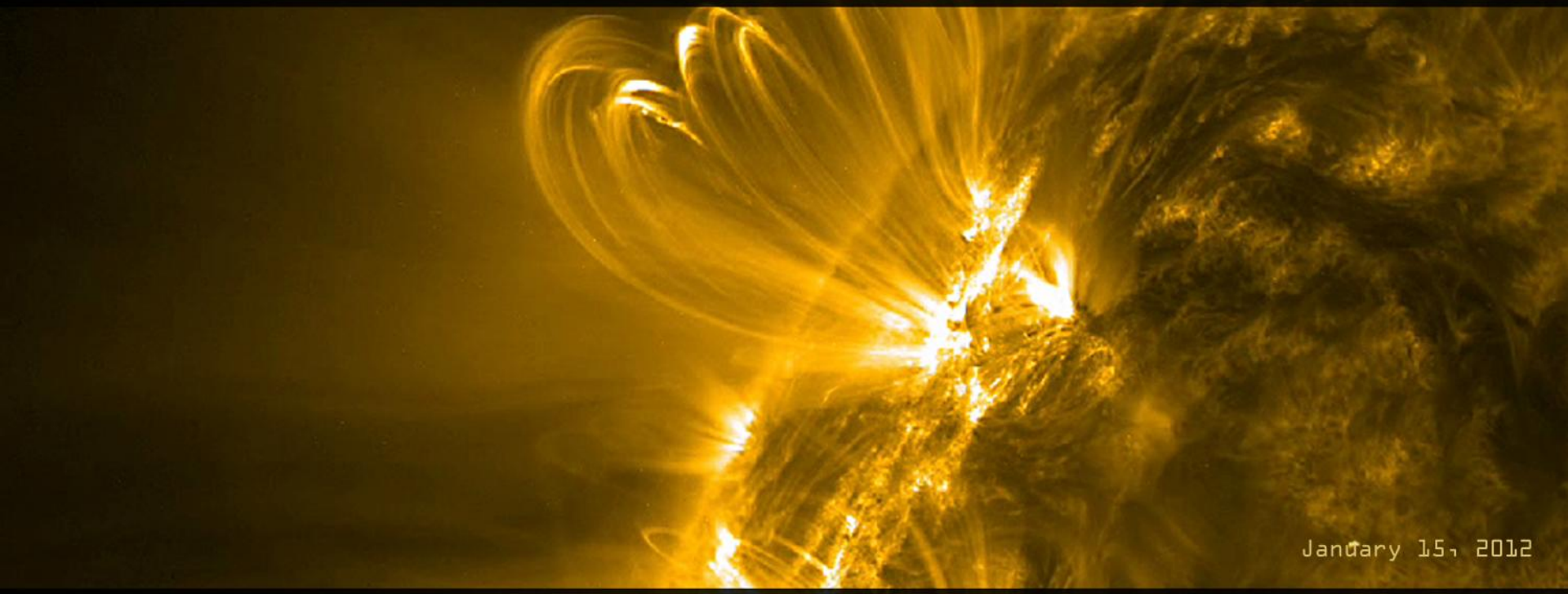
National Aeronautics and Space Administration



Heliophysics

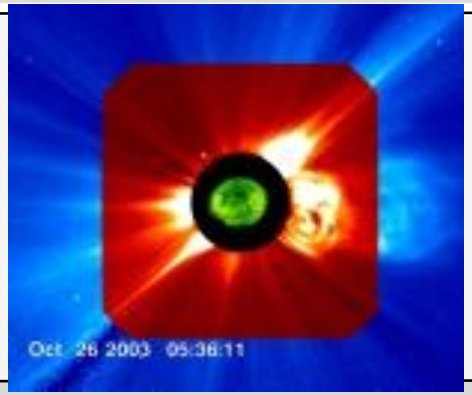
International Conference on Radiation Belts and Space Weather May 30, 2012 / Daejeon, Korea

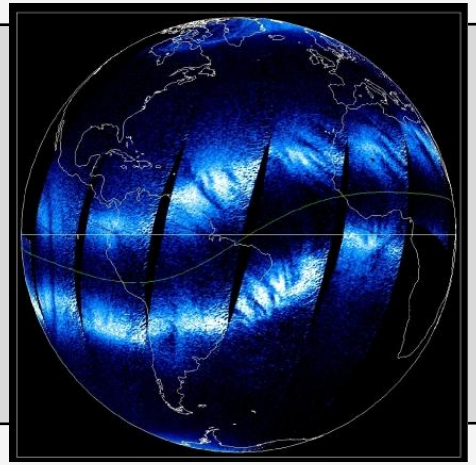
Dr. Barbara Giles
Director, Heliophysics Division, NASA Headquarters

Heliophysics: Understanding the Sun and its Interactions with Earth and the Solar System

Open the Frontier to Space Environment Prediction

Understand the fundamental physical processes of the space environment – from the Sun to Earth, to other planets, and beyond to the interstellar medium





Understand the Nature of Our Home in Space

Understand how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres.

Safeguard the Journey of Exploration

Maximize the safety and productivity of human and robotic explorers by developing the capability to predict the extreme and dynamic conditions in space

Heliophysics Research and Space Weather Components

DATA

- Heliophysics System Observatory (HSO)
- Virtual Observatories
- Low Cost Access to Space

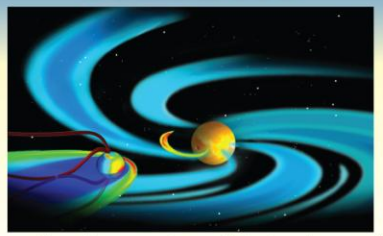
HELIOPHYSICS: An Integrated Program

MODELS

COMMUNITY COORDINATED MODELING CENTER

- Enabling Research to Operations
- Community Coordinated Modeling Center (CCMC)
- NASA / NSF SW Modeling Partnership
- integrated Space Weather Analysis

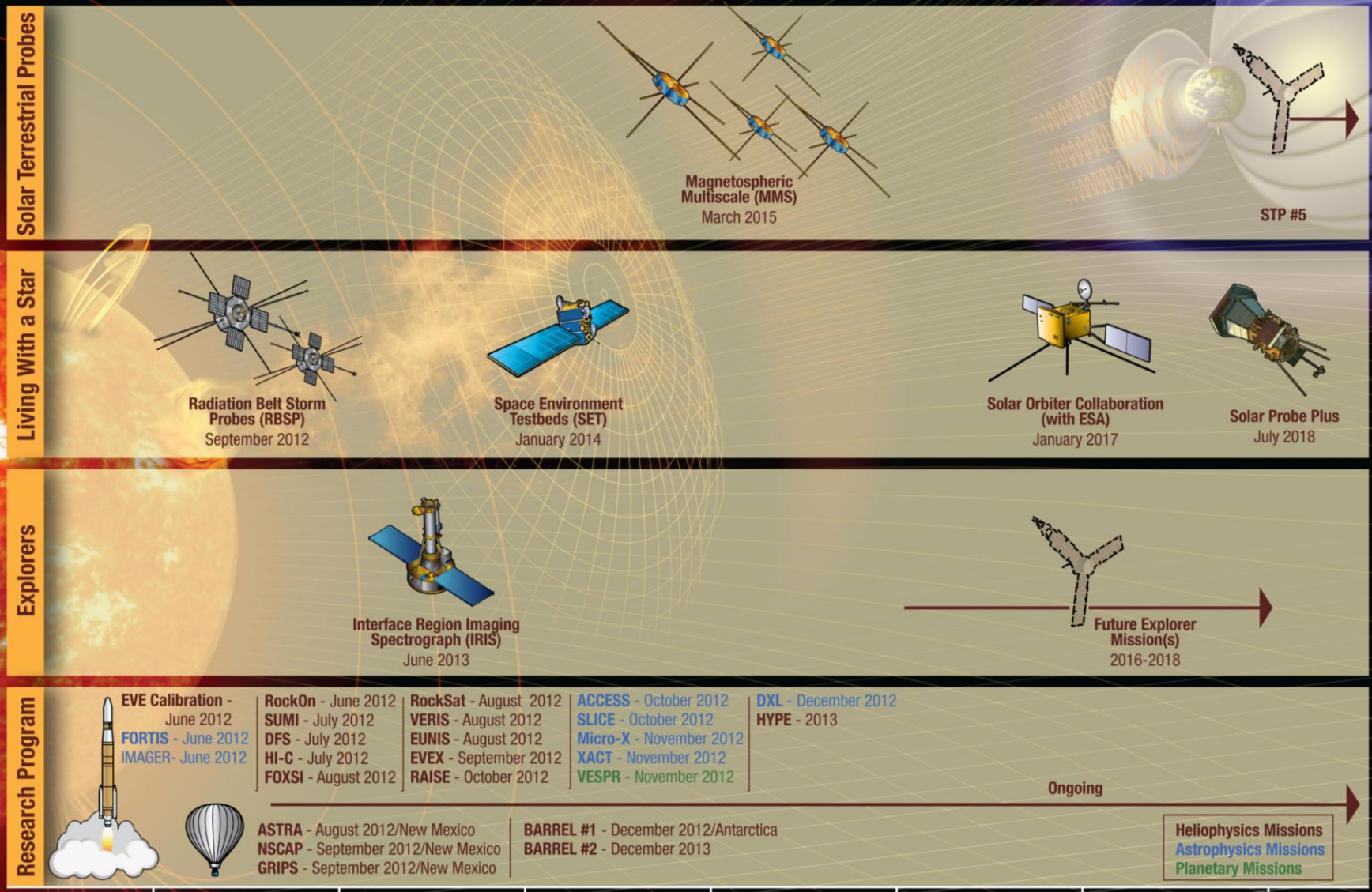
THEORY



- Supporting Research and Technology - $26M
- Targeted Research and Technology - $14.6M
- Research and Analysis
- Guest Investigator Program - $9M
- Theory Program - $4M

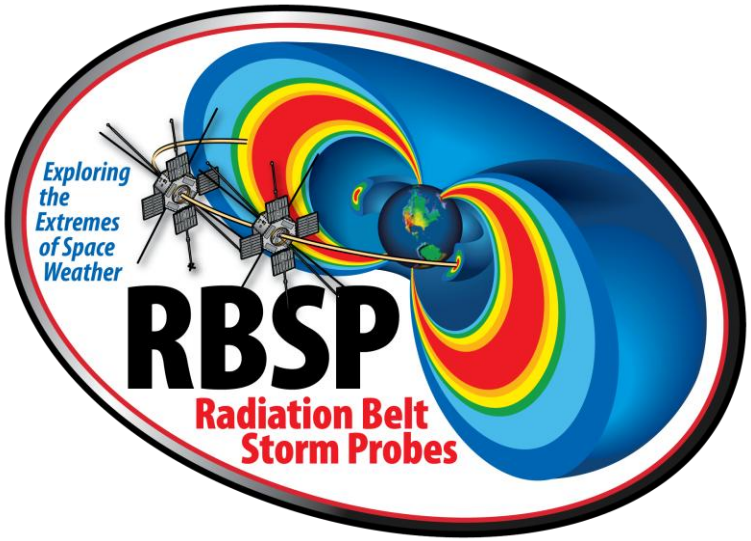
** Funding levels listed in FY11 dollars*

Heliophysics Program 2012-2018

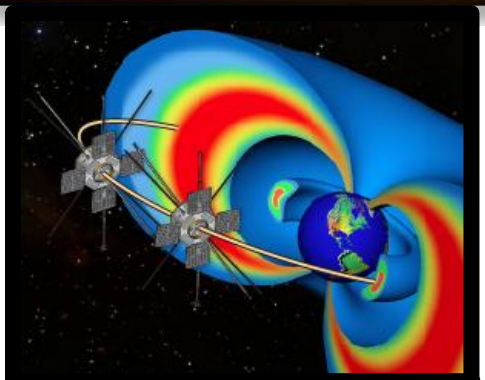


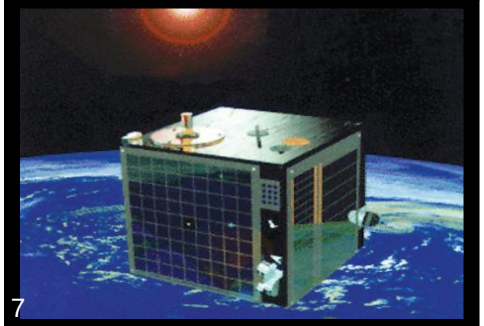
Radiation Belt Storm Probes (RBSP)

- The Radiation Belt Storm Probes (RBSP) mission is being designed to help us understand the Sun's influence on Earth and Near-Earth space by studying the Earth's radiation belts on various scales of space and time.
- Each RBSP spacecraft will also be equipped with a Space Weather Beacon that will enable research to operations by transmitting key space weather measurement parameters to anyone willing to receive them. Strengthening the technical teamwork between the U.S. and our international partners permits activities and advancements that could not be achieved separately.
- The Korea Astronomy and Space Science Institute (KASI) has completed the RBSP receiving antenna system as part of their Space Weather Prediction Center (SWPC) project.
- NASA is looking forward to continued collaboration and partnership with KASI in order to improve our understanding of space weather events and the connected Sun-Earth system.



Living With a Star (LWS) Program





• **Radiation Belt Storm Probes (RBSP):**
The RBSP mission will provide insight into the dynamics of particle acceleration within the radiation belts and give scientists the data they need to make predictions of changes in this critical region of space. Two spacecraft will orbit the Earth and sample the harsh radiation belt environment where major space weather activity occurs and many spacecraft operate. The goal is to understand how particle acceleration mechanisms operate in both space and time.
Launch: August 23, 2012

• **Balloon Array for RBSP Relativistic Electron Losses (BARREL):**
BARREL is a balloon-based mission to augment the measurements of the RBSP mission. There will be two campaigns of five to eight long-duration balloons aloft simultaneously over a 1-month period to provide measurements of the extent of relativistic electron precipitation and allow an estimate of the total electron loss from the radiation belts.
Launch: BARREL #1 December 2012, BARREL #2 December 2013.

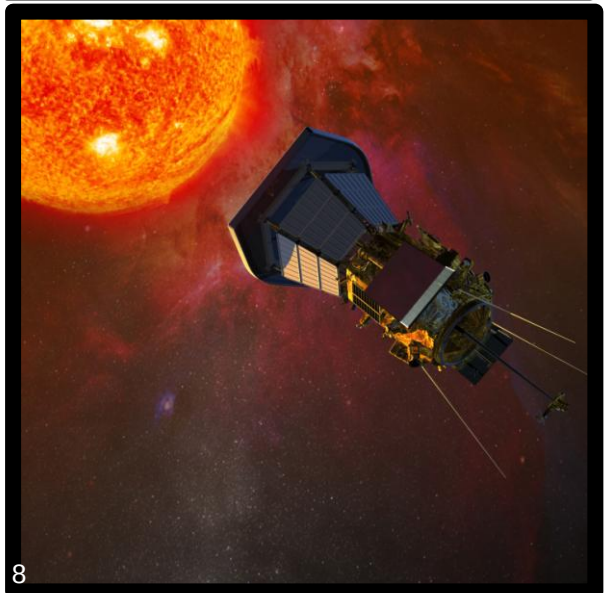
• **Space Environment Testbeds (SET):**
SET will fly as a piggyback payload on the U.S. Air Force Deployable Structures Experiment (DSX) mission. SET will perform flight and ground investigations to characterize the space environment and its impact on hardware performance in space.Launch: January 2014

Living With a Star (LWS) - *Continued*

• **Solar Orbiter Collaboration (SOC):**
SOC will unravel how solar transients alter the plasma and magnetic field structure of the inner heliosphere and measure the solar polar magnetic fields for the first time using a combination of in-situ and remote sensing instruments.

Solar Orbiter will approach the Sun within the orbit of Mercury and using multiple Venus encounters its orbit will be cranked up to above 40 degrees solar latitude giving an unprecedented view of the solar poles to its remote sensing instruments. Launch: No earlier than 2017

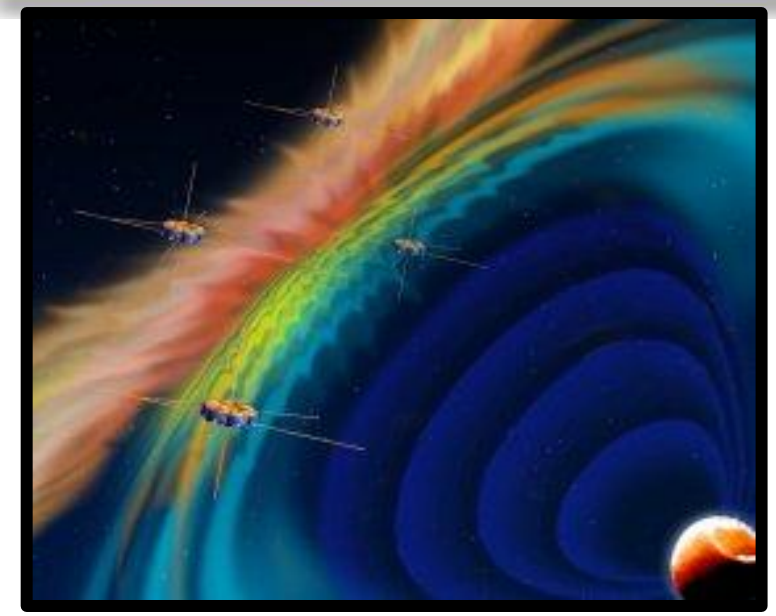
NEWS: On Oct. 8, 2011, ESA selected Solar Orbiter as its first M-class mission.



• **Solar Probe Plus (SPP):**
SPP will approach as close as nine solar radii from the surface of the Sun, repeatedly sampling the near-Sun environment. By directly probing the solar corona, this mission will provide essential knowledge and understanding of coronal heating and of the origin and acceleration of the solar wind, critical questions in heliophysics that have been ranked as top priorities for decades.

By making the first direct, in situ measurements of the region where some of the most hazardous solar energetic particles are energized, SPP will make a fundamental contribution to our ability to characterize and forecast the radiation environment in which future space explorers will work and live. Launch: No earlier than 2018

Solar Terrestrial Probes (STP) Program



• **Magnetospheric Multiscale (MMS):**
The MMS mission will use Earth's magnetosphere as a laboratory to study the microphysics of magnetic reconnection, a fundamental plasma-physical process that converts magnetic energy into heat and the kinetic energy of charged particles.

These processes — magnetic reconnection, particle acceleration, and turbulence — occur in all astrophysical plasma systems but can be studied in situ only in our solar system and most efficiently in Earth's magnetosphere, where they control the dynamics of the geospace environment and play an important role in space weather. Launch: No later than March 2015

• **Solar Terrestrial Probe #5:**
STP #5 will be defined by the 2012 Decadal Survey. Mission planning activities will start upon receipt of the Decadal Survey.

Left: Fit check of MMS FPI sensors on Spacecraft Deck #1

Explorers Program

Left: IRIS Final Frame Inspection

• **Interface Region Imaging Spectrograph (IRIS):**
Understanding the interface between the photosphere and corona is a fundamenta challenge in solar and heliospheric science. The IRIS mission opens a window into this crucial region by tracing the flow of energy and plasma through the chromosphere and transition region into the corona and solar wind using spectrometry and imaging. IRIS will contribute to our fundamental understanding of the solar energy transport, will increase our ability to forecast space weather, and will provide an archetype for all stellar atmospheres.
Launch: No later than June 2013

• **U.S. Participating Investigator (USPI):**
The 2010 Explorer Program AO solicited proposals for U.S. Participants on missions being built and flown by an agency other than NASA. Three of these proposals were selected for funding:

- **J. Forbes**: USPI-GOCE: U. of Colorado: Middle Thermosphere Variability due to Sources From Above and Below

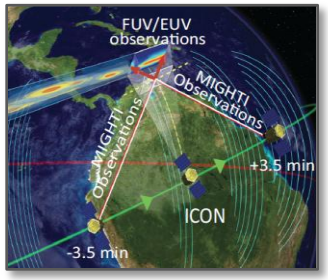
-**J.D. Moses**: Naval Research Laboratory: US Participation in the Solar Orbiter Multi Element Telescope for Imaging and Spectroscopy (METIS)

- W. Peterson: U. of Colorado: Investigations of the mid-latitude thermospheric response to variations in solar irradiance and geomagnetic activity using photoelectron and other observations from the Canadian ePOP Mission

Explorers Program - *Continued*

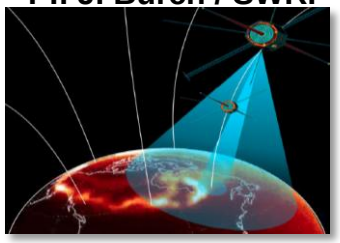
Explorer Mission Selections

ICON: ***Ionospheric Connection Explorer***
PI: T. Immel UC Berkeley



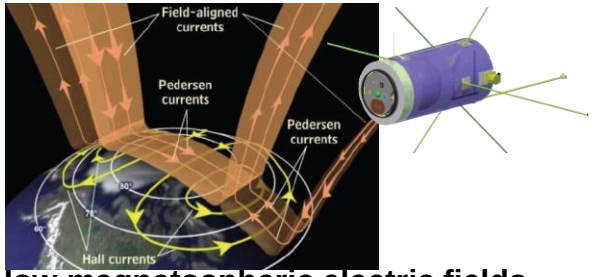
- How neutral atmosphere affects the ionosphere & How solar wind and magnetosphere affect the ionosphere

OHMIC: ***Observatory for Heteroscale Magnetosphere–Ionosphere Coupling***
PI: J. Burch / SWRI



- How magnetospheric EM energy flows downward to power aurora&How ion outflows are initiated and modify the underlying ionosphere

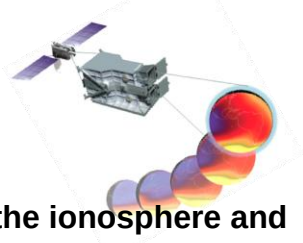
ASTRE: ***Atmosphere-Space Transition Region Explorer***
PI: R. Pfaff / GSFC



- How magnetospheric electric fields drive neutral atmospheric motions &How neutral-ion transition region regulates the magnetosphere

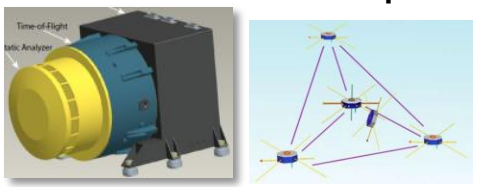
Mission of Opportunity Selections

GOLD: ***GlobalScale Observations of the Limb and Disk***
PI: R. Eastes / U. Central Florida



… how the ionosphere and thermosphere respond to geomagnetic storms, solar radiation, and upward propagating atmospheric tides

IMSA on SCOPE: ***IonMass Spectrum Analyzer***
PI: L. Kistler / U. New Hampshire

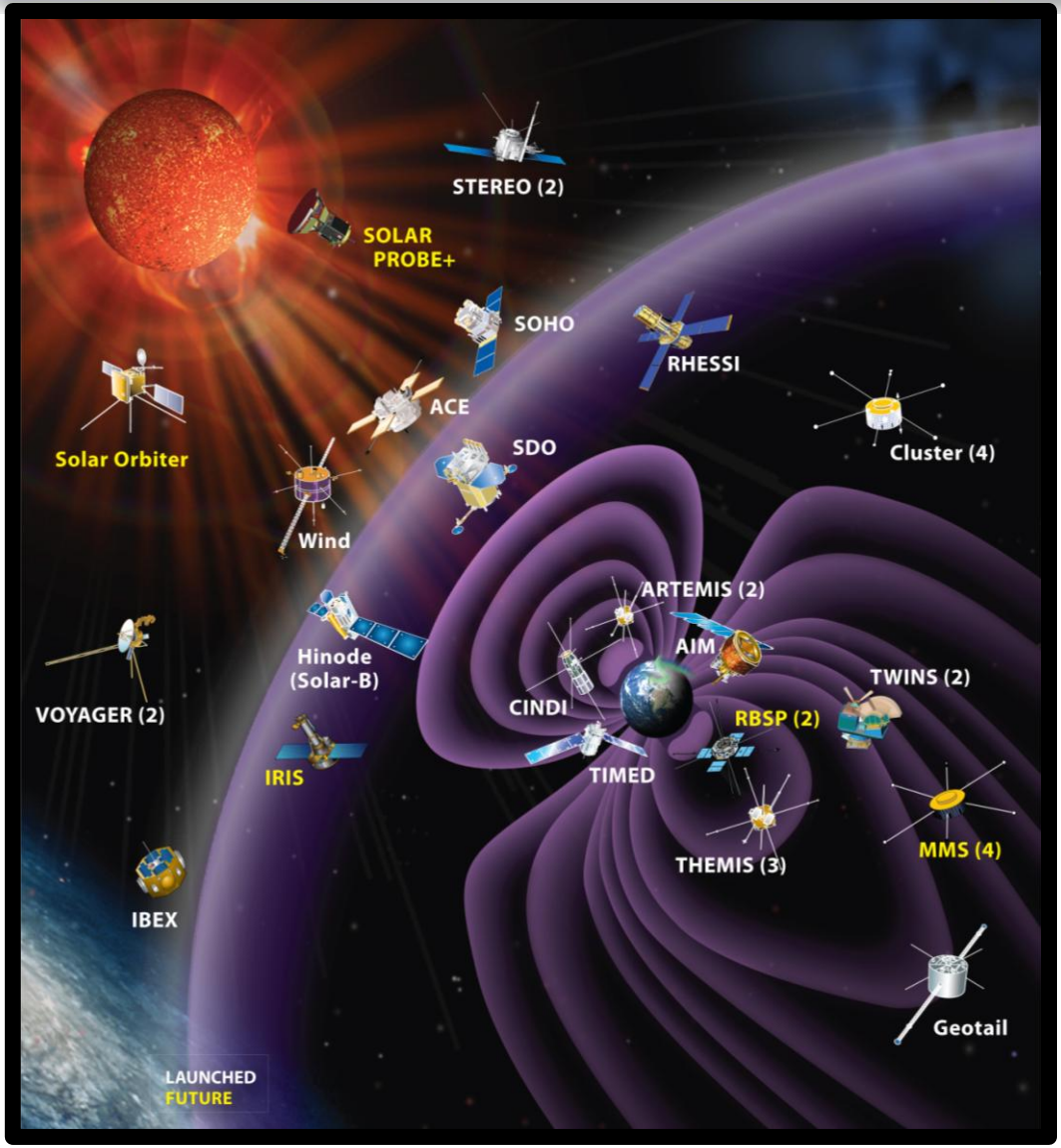


… fundamental processes of reconnection, particle acceleration, and turbulence … focused on the feedback mechanisms between ion and electron scale lengths

CPI on the ISS: ***Coronal Physics***

…processes that heat and accelerate the plasma components of the slow and fast solar wind

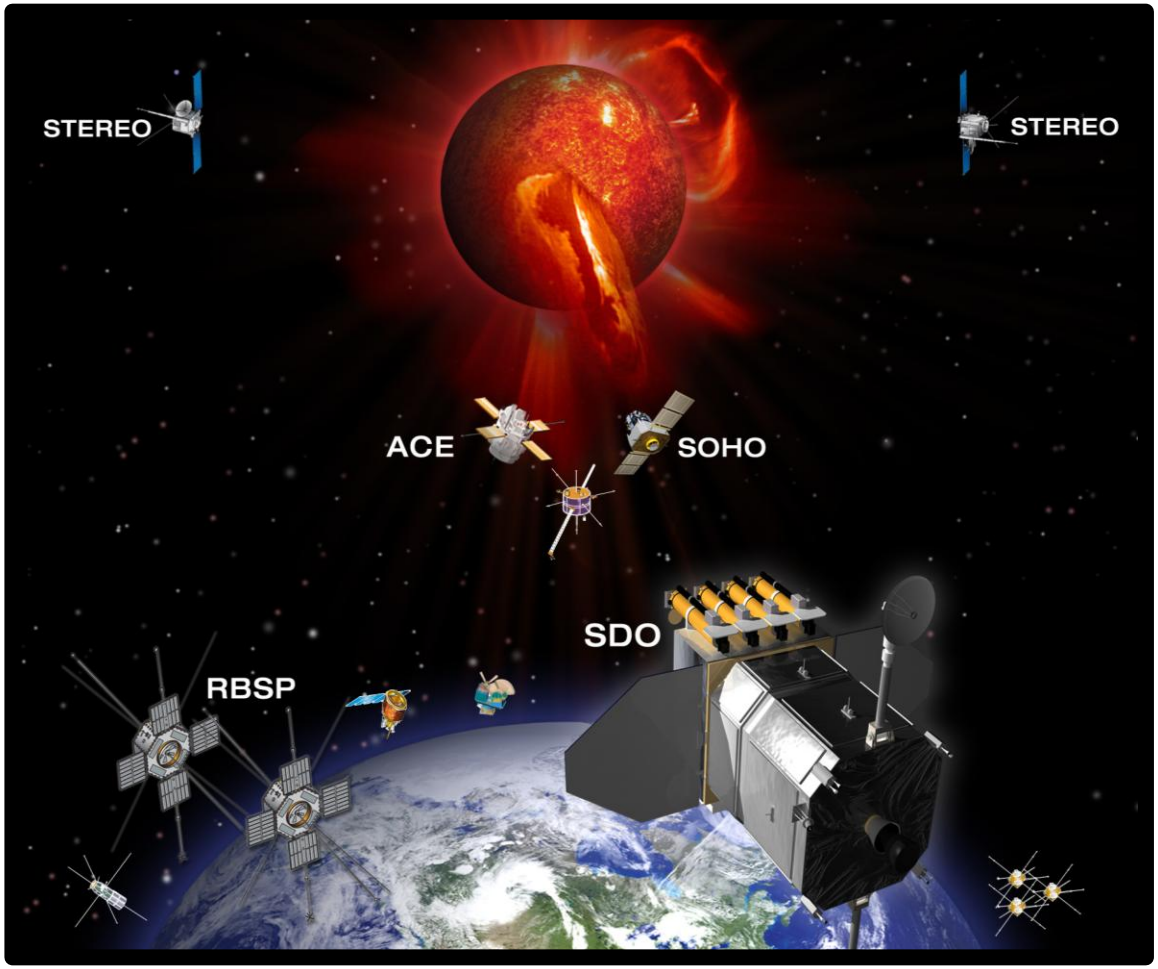
Heliophysics System Observatory (HSO)



The Heliophysics System Observatory (HSO) utilizes the entire NASA fleet of solar, heliospheric, geospace, and planetary spacecraft as a distributed observatory to discover the larger scale and/or coupled processes at work throughout the complex system that makes up our space environment.

The HSO consists of 17 operating missions: Voyager, Geotail, Wind, SOHO, ACE, Cluster, TIMED, RHESSI, TWINS, Hinode, STEREO, THEMIS, AIM, CINDI, IBEX, SDO, ARTEMIS

Heliophysics Research Missions with Space Weather Utility



Every day we watch the Sun for signs of flares and coronal mass ejections with SDO, STEREO, ACE, Wind, and other solar sensing satellites. We monitor the effects on Earth's near space environment with AIM, THEMIS, CINDI and other Sun-Earth connection satellites.

Heliophysics research provides Theory, Data, and Modeling development services to national space weather efforts including the Community Coordinated Modeling Center (CCMC), a multi-agency partnership to enable, support and perform the research and development for next-generation space science and space weather models.

NASA Roles In Space Weather Infrastructure

Internal to NASA

Research:
- Solar Terrestrial Probes, Living With a Star, Explorer Flight Programs
- Community Coordinated Modeling Center
- Integrated Space Weather
- Online Integrated Space Weather Analysis System

Operations:
- Tracking and Data Relay Satellite System
- Robotic and Air Fleet
- Nowcast of Atmospheric Ionizing Radiation System (LRC)
- Space Radiation Analysis Group(JSC): Models, EVA, ISS Drag

Engineering:
- Design and Specification
- Models (MSFC

National

Research:
- GIC Forecast Model
- SEP Forecast Model
- Interplanetary CME model

Operations:
- Real-time Beacon Data
- SDO and STEREO Near Real-time Data
- Space Weather Theory, Data, Models (available online)

Governance:
- Committee on Space Weather: (NOAA, NASA, NSF, DoD, + 7 others)
- National Space Weather Program Council
- Unified National Space Weather Capability

International

Research:
- International Living With a Star Program
- United Nations / Committee on the Peaceful Uses of Outer Space
- International Heliophysical Year

Operations:
- International Space Weather Initiative: Instrument Deployment, Data Analysis, and Modeling

Bilateral Agreements:
- Korea and Brazil (anticipated)

Consultation:
- ESA, Sweden, United Kingdom, Germany, and France

International Space Weather Activities

International Space Weather Initiative (ISWI) Reaches More Than 100 Countries:

• The International Heliophysical Year (IHY) provided a successful model for outreach and the deployment of arrays of small scientific instruments in new and scientifically interesting geographic locations. The ISWI was designed to build on this momentum to promote the observation, understanding, and prediction space weather phenomena, and to communicate new scientific results to the public.

• Recently with the help of the United Nations Basic Space Science Program, the ISWI has reached a new milestone with **close to 1,000 instruments deployed in more than 100 UN member states around the world.** These instruments include magnetometers, radio antennas, GPS receivers, all-sky cameras, particle detectors, etc. that provide global measurements of heliophysics phenomena. As a result of this program, scientists from many countries now participate in the instrument operation, data collection, analysis, and publication of scientific results, working at the forefront of science research.

International Living With a Star (ILWS):

•ILWS (http://ilwsonline.org/) has very broad international participation: 28 member agencies, working groups with scientists from all over the world, and workshops that provide a forum for the scientific community.

• Significant opportunities have been created from ILWS partnerships, including missions, workshops, and data and modeling activities.

- New mission opportunities: Cross-Scale, EQUARS, Solar-C
- New scientific coordination opportunities: ISWI and NOAA

NASA Participates UN Sustainability Framework:

•With delegate on the Expert Working Group (EWG) on Space Weather for the Working Group on Long-Term Sustainability of Space Activities as part of United Nations Committee on the Peaceful Uses of Outer Space.

Heliophysics Decadal Survey and Roadmap Response

Heliophysics Decadal Survey:

- The Space Studies Board has organized a broadly-based assessment of the scientific priorities of the U.S. solar and space physics research enterprise for the period 2013-2022.

  See Progress At: http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_056864

- Anticipated Completion Date for the Survey: Spring 2012

Roadmap Response:

- The Heliophysics 2012 Roadmap will provide the implementation response to the Decadal Survey. It will present both long-term goals and nearer-term objectives. The Roadmap is the product of, and is periodically revised by, the science community at large.
- Roadmap focus:
  - Align the science strategy developed by the Decadal with the Heliophysics Program over the next 10 years
  - Extend the strategy out to 2033
  - Present science priorities with a flexible mission implementation approach consistent with the current (FY13) budget profile
  - Identify needed Technology development
- Goal: Roadmap rollout Dec. 2012

Heliophysics: The Science of Space Weather