National Aeronautics and Space Administration

NASA Space and Earth Science

Dr. Barbara Giles
Science Mission Directorate, NASA HQ

August, 2010

www.nasa.gov

NASA's Strategic Goals

U.S. Space Exploration Policy

- To advance U.S. scientific, security, and economic interests through a robust space exploration program

NASA's Mission

- To pioneer the future in space exploration, scientific discovery, and aeronautics research

Strategic Goals for the Science Mission Directorate

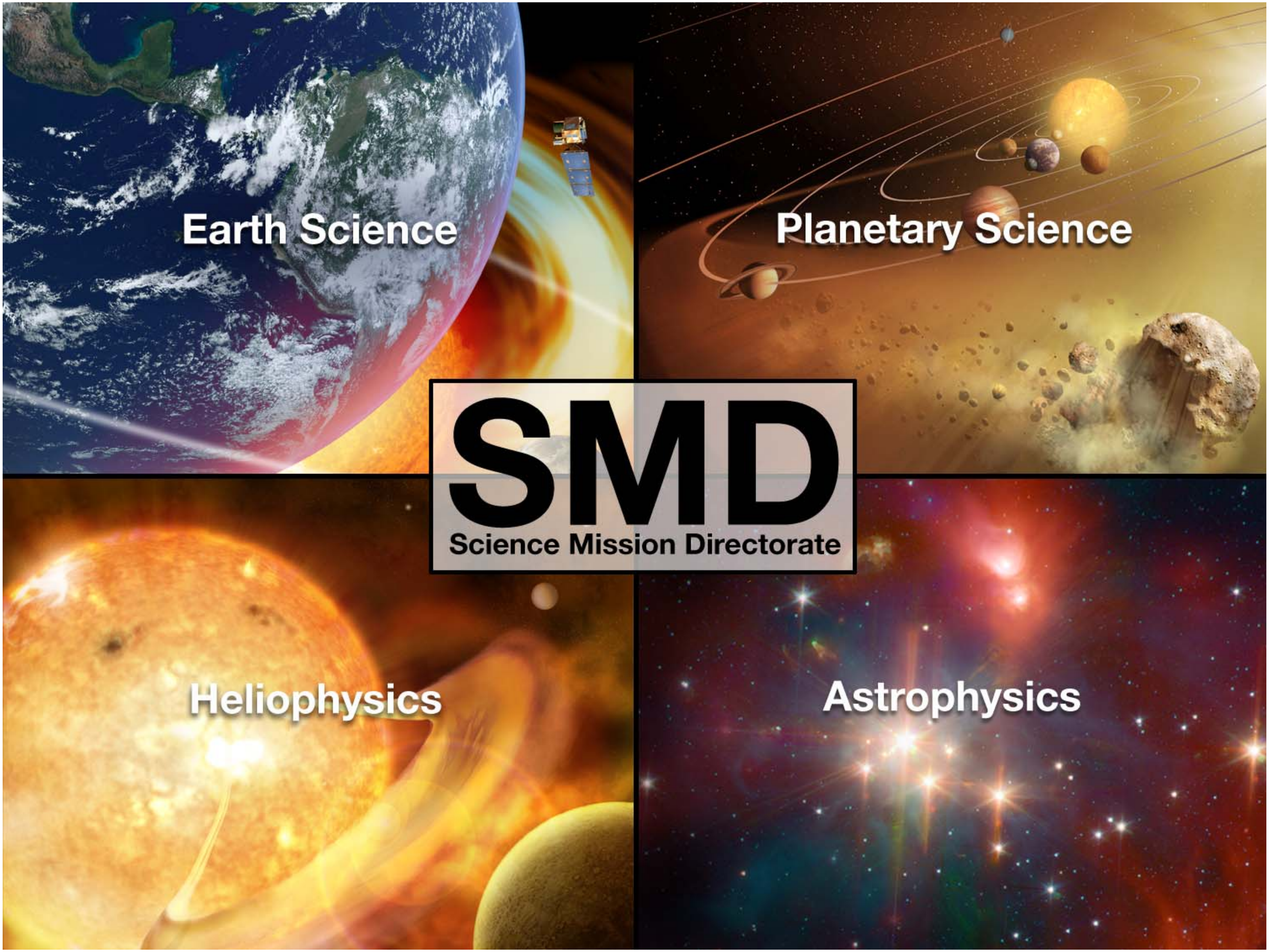
- Advance Earth System Science to meet the challenges of climate and environmental change
- Understand the Sun and its interactions with Earth and the solar system
- Ascertain the content, origin, and history of the solar system, and the potential for life elsewhere
- Discover how the universe works, explore how the universe began and evolved, and search for Earth-like planets

Science Mission Directorate Strategy

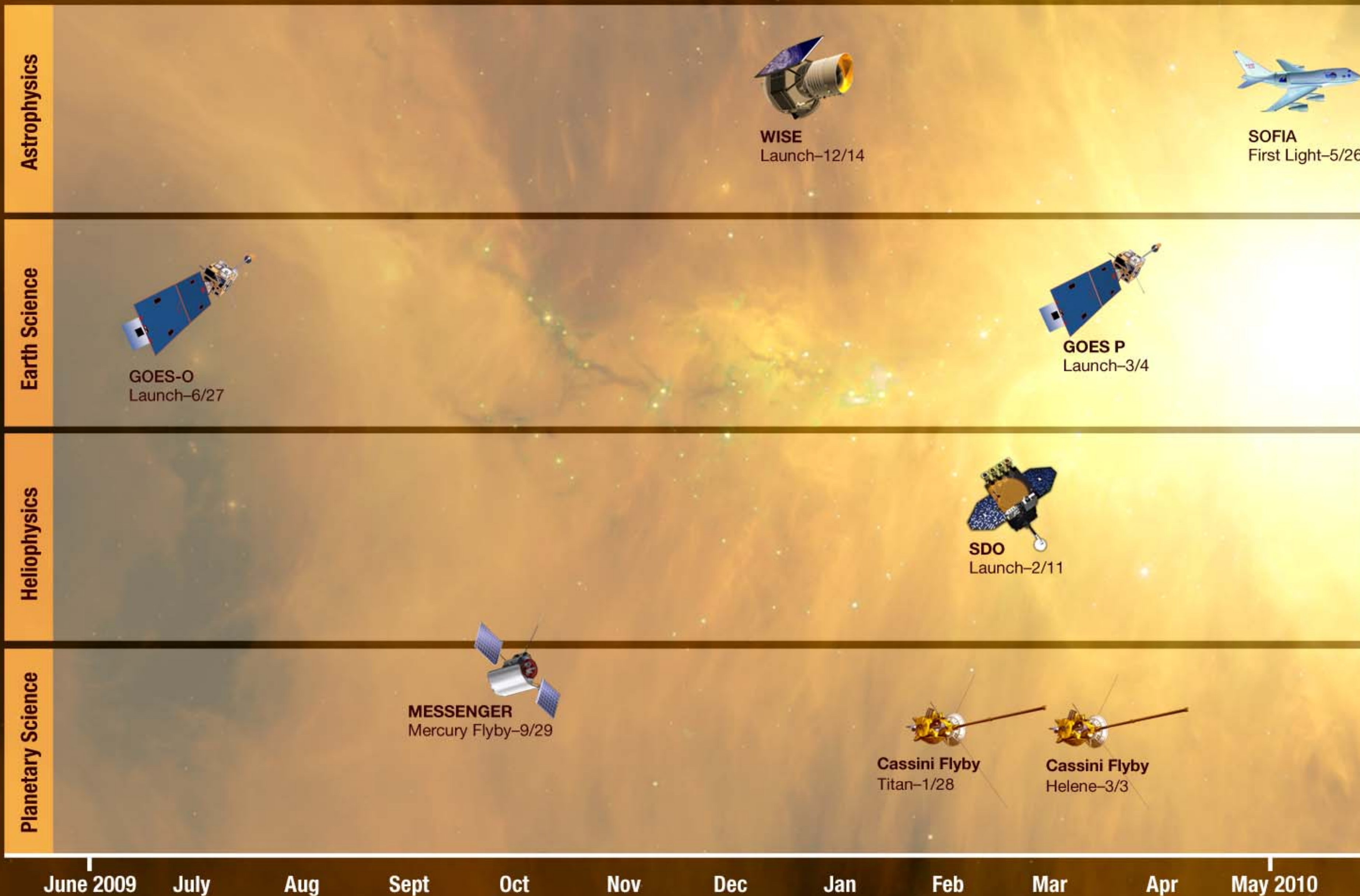
- **Pursue answers to big science questions** for which the view from space makes a defining contribution
- **Design programs that accomplish breakthrough science** and applications within the available budget.
- Partner with other nations' space agencies to pursue common goals
- Mature technologies through focused efforts prior to committing to implement missions that need them
- Share the story, the science, and the adventure of NASA missions and research to engage the public in scientific exploration and to improve science, technology, engineering, and mathematics (STEM) education nationwide

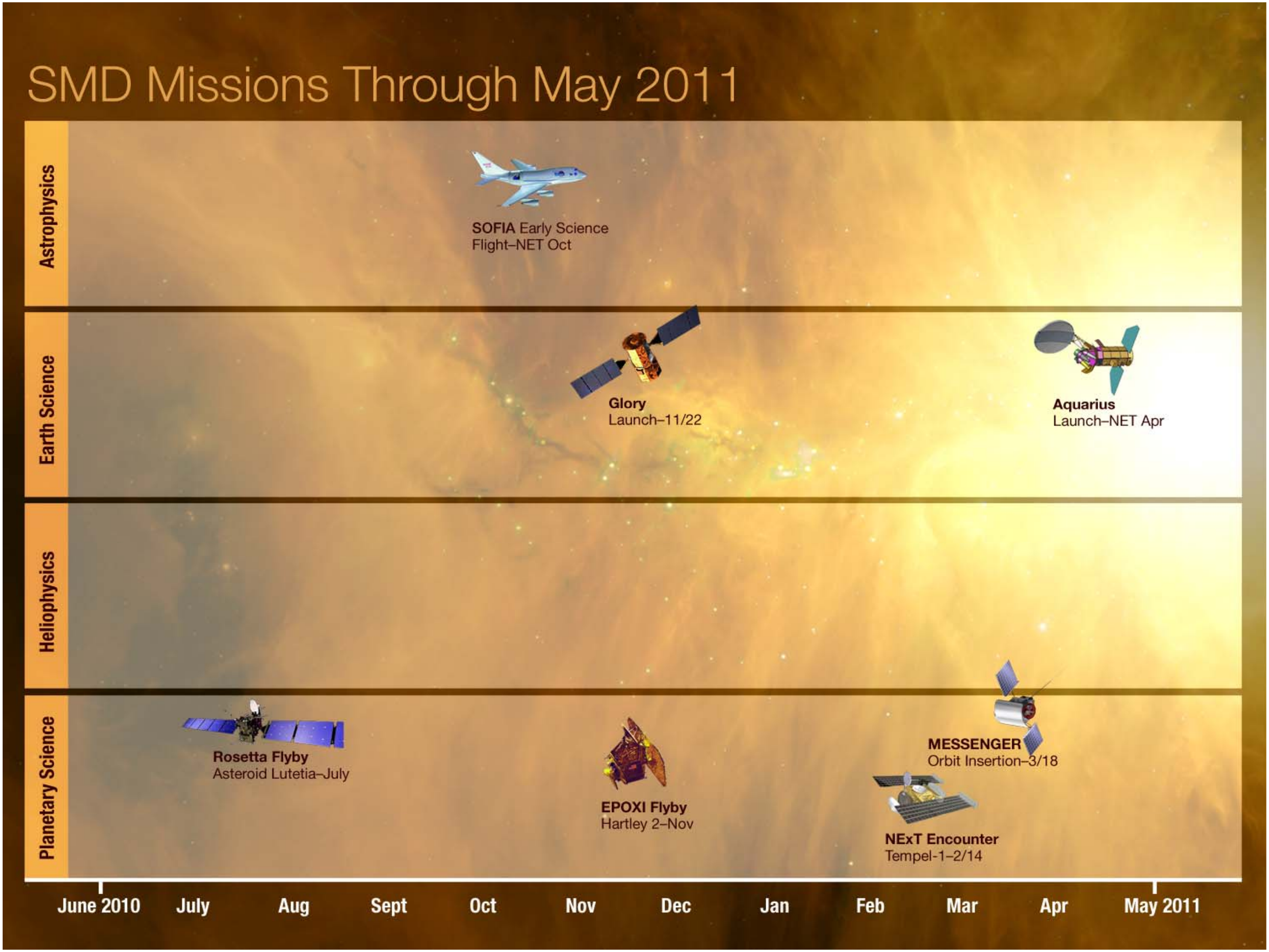
Science Mission Directorate Priorities

- **Substantial progress on NRC decadal surveys** in all four Science areas is the measure of success.
- **Investment choices are based on scientific merit** via peer review and open competition.
- Active participation by the research community beyond NASA is critical to success
- Effective international and interagency partnerships leverage NASA resources and extend the reach of our science results
- A balanced portfolio of space missions and mission-enabling programs sustains progress toward NASA’s science goals
- The NASA mandate includes broad public communication
- Accountability, transparent processes, accessible results, and capture of lessons learned are essential features of this Federal science enterprise.

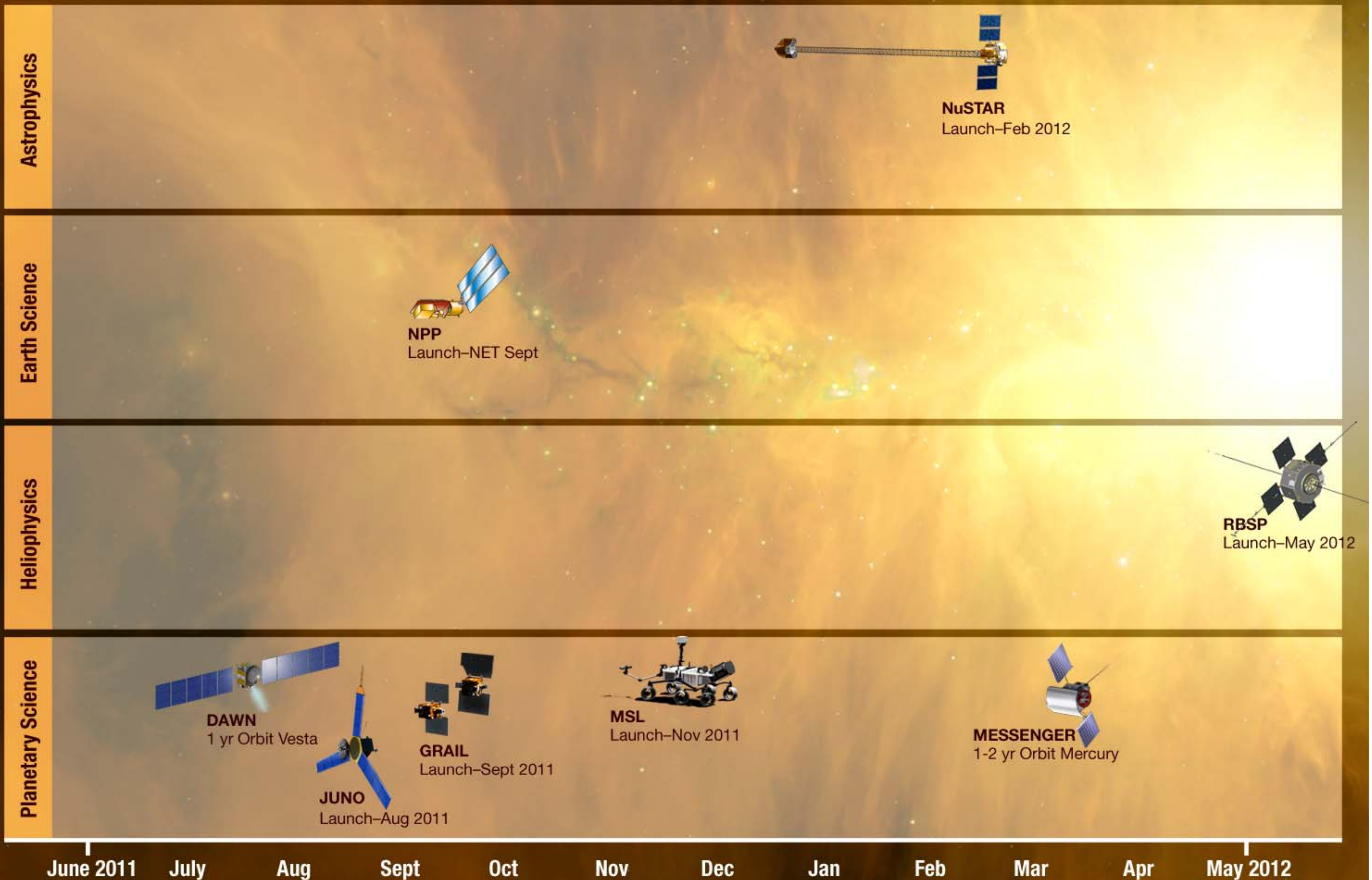

Earth Science
Planetary Science
SMD
Science Mission Directorate
Heliophysics
Astrophysics

SMD Missions Past 12 Months




SMD Missions Through May 2011
Astrophysics
Earth Science
Heliophysics
Planetary Science
SOFIA Early Science
Flight–NET Oct
Glory
Launch–11/22
Aquarius
Launch–NET Apr
Rosetta Flyby
Asteroid Lutetia–July
EPOXI Flyby
Hartley 2–Nov
MESSENGER
Orbit Insertion–3/18
NExT Encounter
Tempel-1–2/14
June 2010
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May 2011

SMD Missions Through May 2012



Science Mission Directorate Programs

Science Mission Directorate

Legend: Division / Program

- **Planetary Science Division**
  - New Frontiers
  - Mars Exploration
  - Discovery
  - Planetary Science Research
  - Outer Planets
  - Planetary Science Technology
  - Lunar Quest
- **Earth Science Division**
  - Earth System Science Pathfinder
  - Earth Systematic Missions
  - Applied Sciences
  - Earth Science Research
  - ESS Multi-mission Ops
  - Earth Science Technology
  - Earth Venture
- **Astrophysics Division**
  - Astrophysics Research
  - Cosmic Origins
  - Physics of the Cosmos
  - Exoplanet Exploration
  - Astrophysics Explorer
- **Heliophysics Division**
  - Living with a Star
  - Solar Terrestrial Probes
  - Heliophysics Explorer
  - Heliophysics Research

Solicitations: nspires.nasaprs.com/ and https://www.fbo.gov/

Legend: Astrophysics; Earth Science; Heliophysics; Planetary Science

Total Missions / Spacecraft
87 / 100

1/20/10

Formulation 12 / 11

- **JPL 1**: SMAP
- **GSFC 8/7**: ICESat-II, IRIS, *Solar Orbiter*, Solar Probe +, BARREL (1/0), GEMS, *Astro H (NEXT)*, MAVEN
- **MSFC 3**: LADEE, NF-3, *Strofio*

Implementation 17 / 20

- **JPL 6**: NuSTAR, ST-7, *Aquarius*, MSL, JUNO, GRAIL
- **GSFC 10/14**: JWST, LDCM, GPM, GOES-P, Glory, NPP, SDO, SET-1, RBSP (2), MMS (4)
- **DFRC 1/0**: SOFIA(1/0)

Primary Ops 18 / 18

- **JPL 10**: WISE, *Herschel*, *Planck*, Spitzer, Kepler, OSTM, *Rosetta*, DAWN, EPOXI*, NExT*
- **GSFC 6**: Fermi, Aura, TWINS-A, CINDI, TWINS-B, IBEX
- **MSFC 2**: MESSENGER, New Horizons

Extended Ops 40 / 51

- **LaRC 1**: CALIPSO
- **JPL 12/15**: GALEX, Cloudsat, ACRIMsat, GRACE (2), Jason-1, QuikSCAT, Voyager (2), *Mars Express*, Mars Odyssey, MER (2), Cassini, MRO
- **GSFC 25/33**: HST, *Suzaku*, *Integral*, RXTE, WMAP, XMM, SWIFT, Aqua, SORCE, EO-1, ICEsat, Terra, TRMM, Landsat 7~, THEMIS (5), STEREO (2), AIM, *Cluster-2 (4)*, RHESSI, SOHO, TIMED, TRACE, WIND, ACE, GEOTAIL
- **MSFC 2**: Chandra, *Hinode*

In concept development:

JDEM, SIM-Lite, LISA, Con-X, *Mars 2016/ExoMars*, ILN, OPF, CLARREO, DESDynI, GPM-LIO, OCO-2

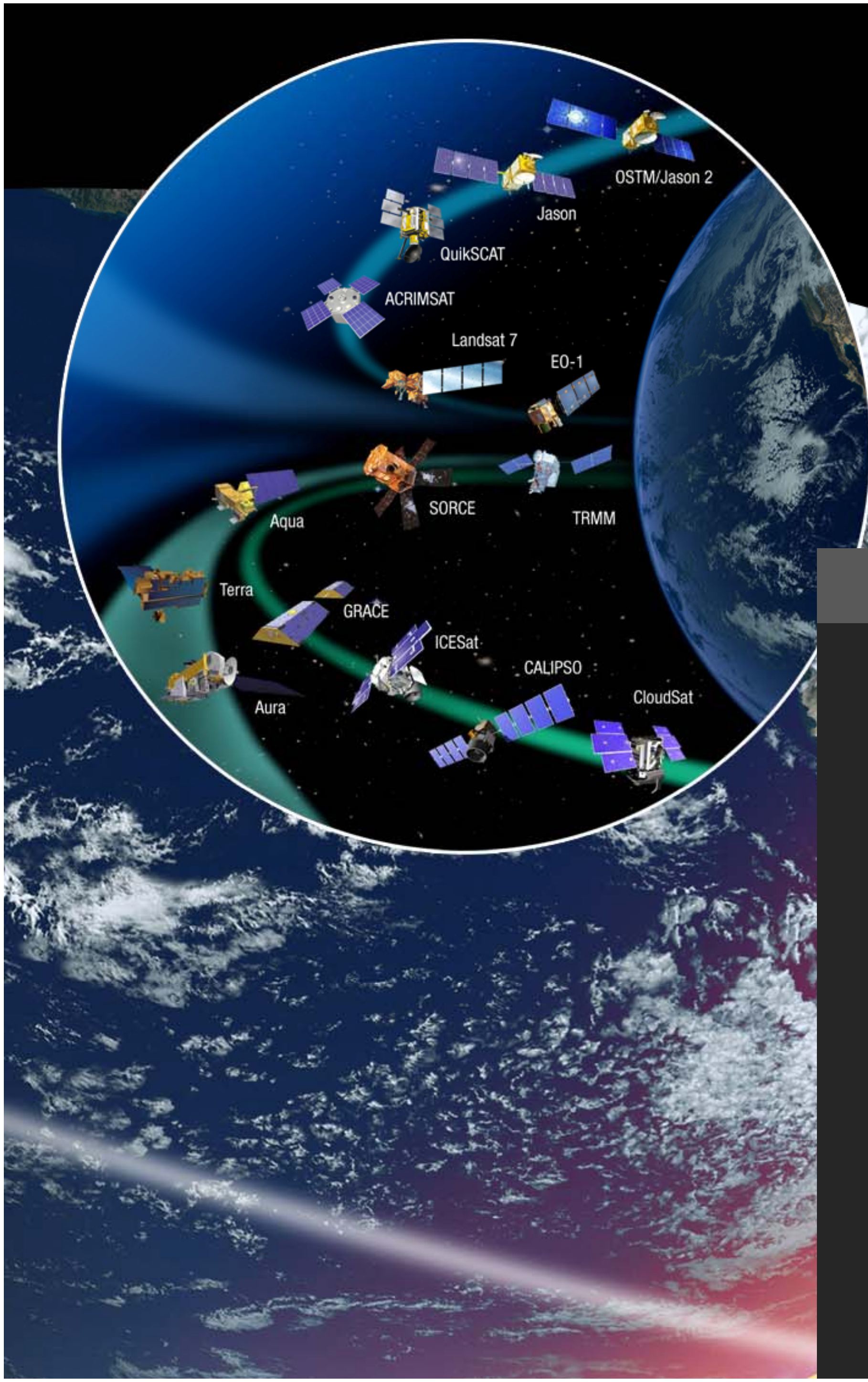
SOFIA and BARREL are mission projects but do not add spacecraft

Italics = US instruments on foreign mission

X / Y = # of missions / # of spacecraft

* New missions for Deep Impact and Stardust, respectively

~ Operated by USGS



Earth Science

Questions

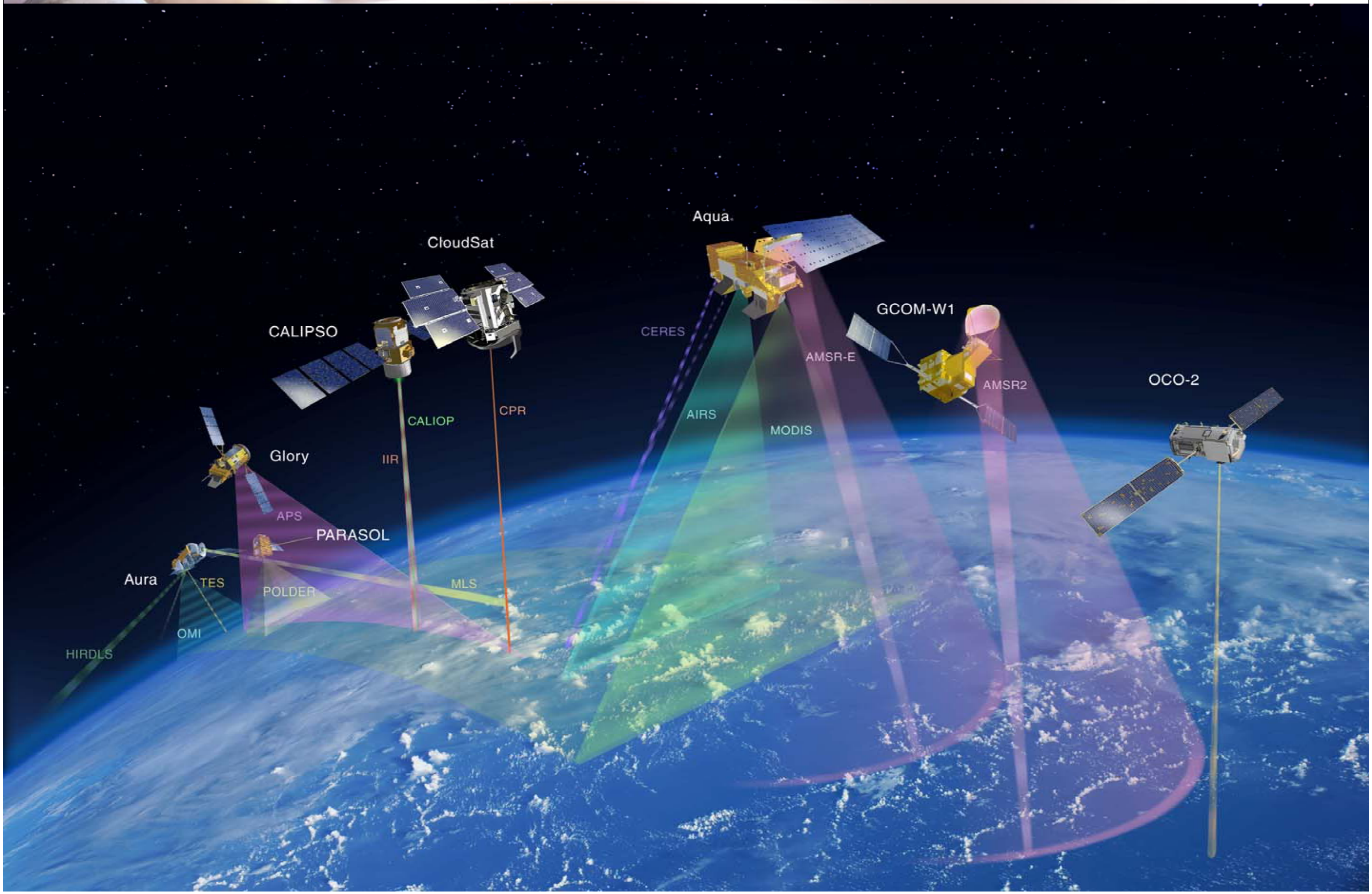
How is the global Earth system changing?

What are the sources of change in the Earth system and their magnitude and trends?

How will the Earth system change in the future?

How can Earth system science improve mitigation of and adaptation to global change?

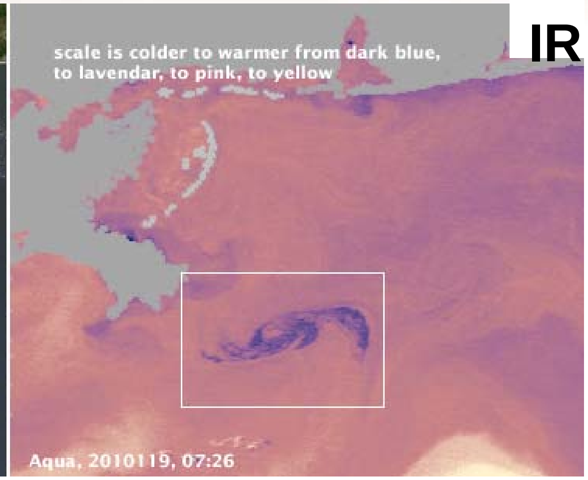
Earth Science A-Train



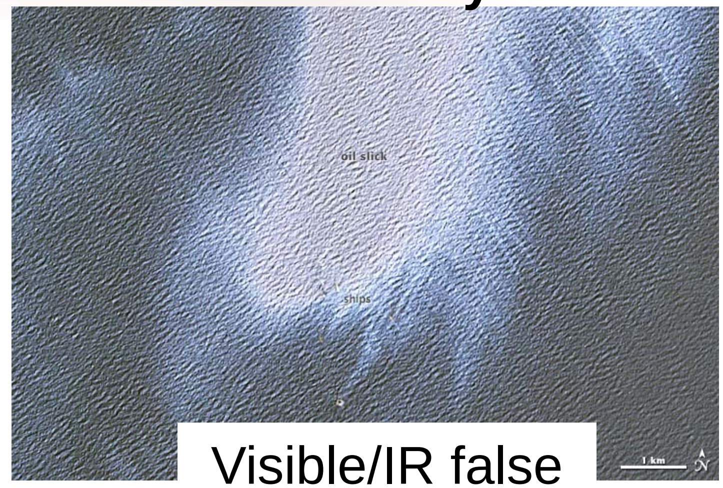
Response to Gulf Oil Spill (GOSpill)

Visible **MODIS views on 29 April 2010**

IR



ASTER 1 May 2010



Visible/IR false color

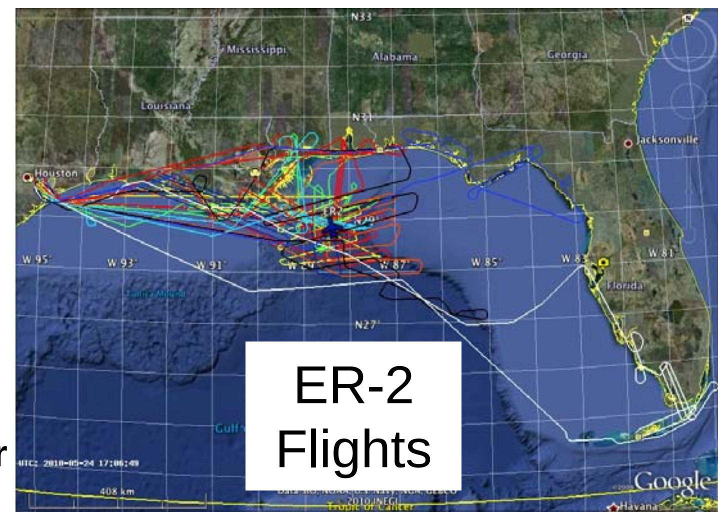
Satellite instruments: continually monitoring the extent of the spill

- Terra & Aqua / MODIS – visible and infrared daily synoptic
- Terra / ASTER – visible, near IR and thermal IR high res
- EO-1 / Advanced Land Imager and Hyperion – highest res
- Terra / MISR
- CALIPSO / CALIOP

Airborne instruments: measuring extent and volume of the spill

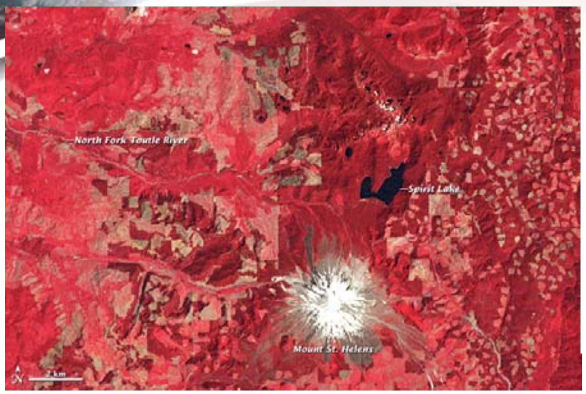
- ER2 / AVIRIS and DCS– 6, 10, 11, 13, 17-20, 23-25 May
- B200 / HSRL– 10-11 May; two FOO; CALIOP studies
- UAVSAR– to be deployed last week of May

Data and products being provided to USGS distribution center for use by first responders to position equipment and for analysis of slick volumes. NOAA using radiances to initialize trajectory model

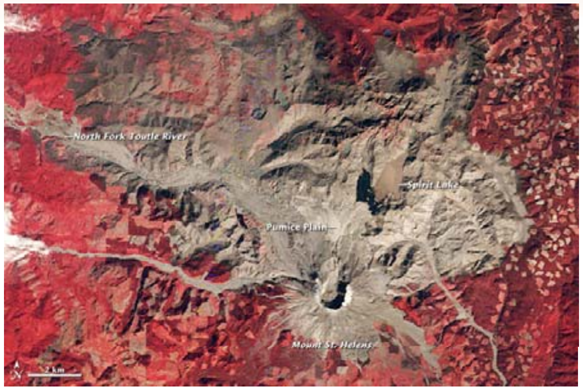


ER-2 Flights

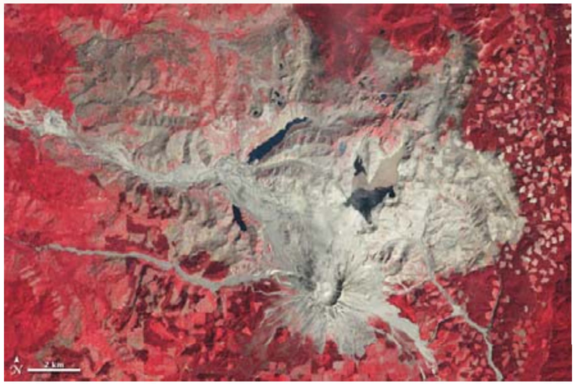
30th Anniversary of Mt. St. Helen’s Eruption: Recovery as Viewed from Space



1979



1980



1982

1986

1998

2009

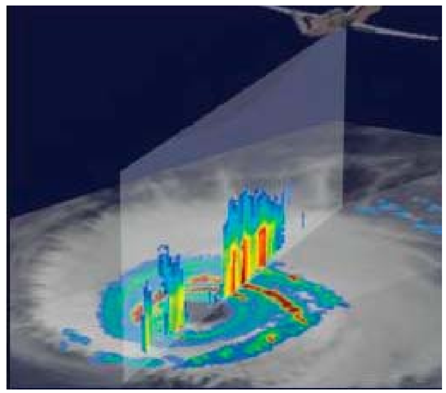
Landsat imagery of Mt. St. Helen’s area before and after May 18, 1980 – earlier years use false color imagery (vegetation red); images from Earth Observatory Web Site - http://earthobservatory.nasa.gov/Features/WorldOfChange/sthelens.php)

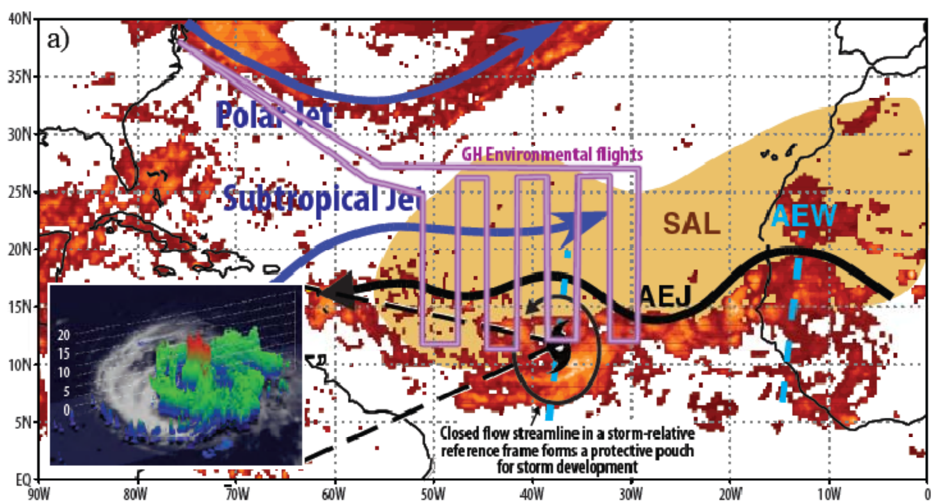
Earth Venture-1
Hurricane and Severe Storm Sentinel (HS3)

Principal Investigator: Scott Braun
NASA Goddard Space Flight Center

Project Manager: Marilyn Vasques
NASA Ames Research Center

Cost: $29.7M over five years (2010-2015)





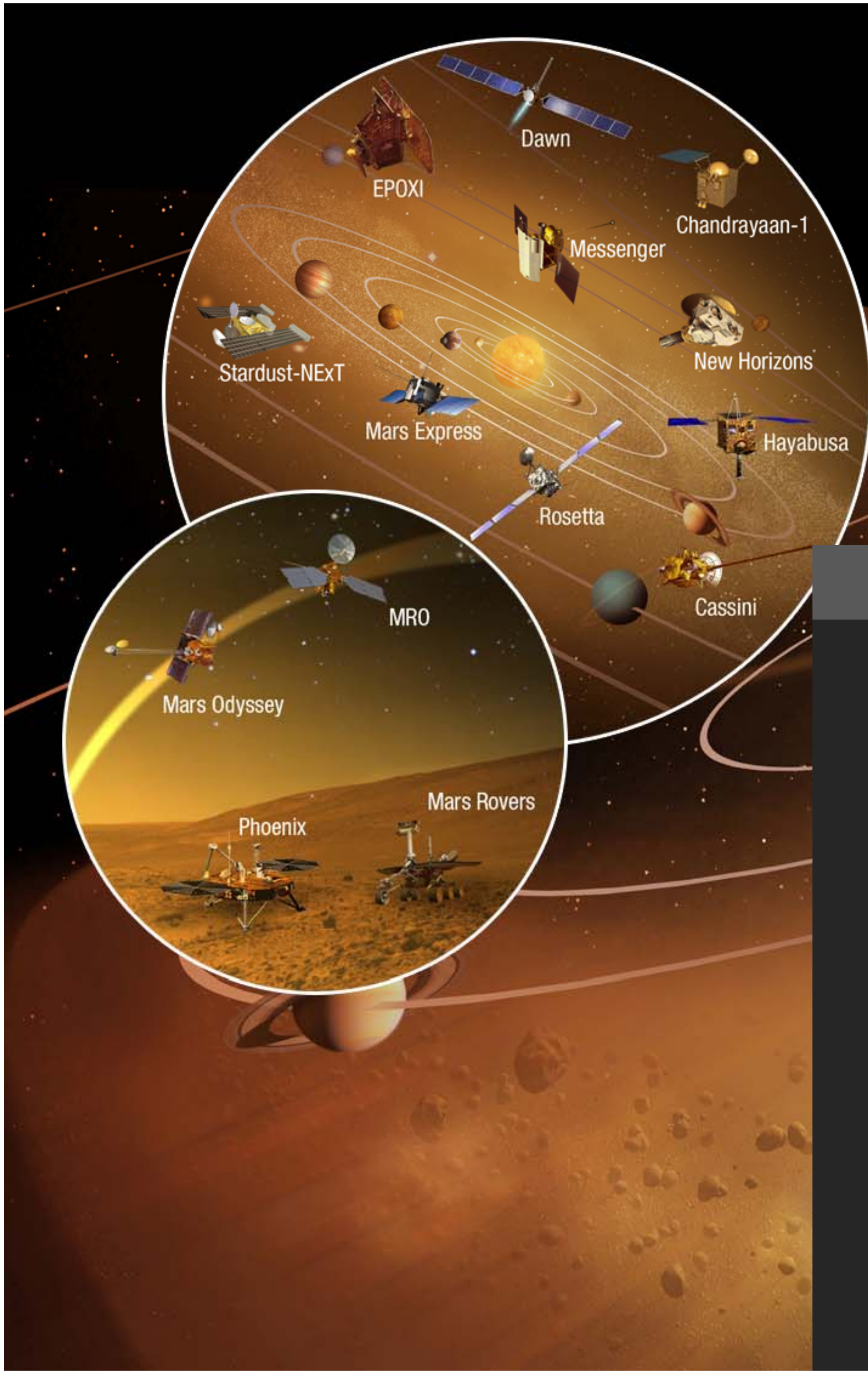
Summary

The Hurricane and Severe Storm Sentinel (HS3) is a five-year mission targeted to enhance our understanding of the processes that underlie hurricane intensity change in the Atlantic Ocean basin. HS3 will determine the extent to which the environment and processes internal to the storm are key to intensity change.

Implementation

The investigation objectives will be achieved using two Global Hawk Uninhabited Aerial Systems (UAS) with separate comprehensive environmental and over-storm payloads. The high Global Hawk flight altitudes allow overflights of most vertical storm convection and sampling of upper-tropospheric winds. Deployments from NASA's Wallops Flight Facility and 30-hour flight durations will provide access to unrestricted air space, coverage of the entire Atlantic Ocean basin, and on-station times up to 10-24 hours depending on storm location. Deployments will be from mid-August to mid-September 2012-2014, with ten 30-hour flights per deployment, providing an unprecedented and comprehensive data set for approximately nine to twelve hurricanes.

Planetary Science



Questions

What is the inventory of solar system objects and what processes are active in and among them?

How did the Sun's family of planets, satellites, and minor bodies originate and evolve?

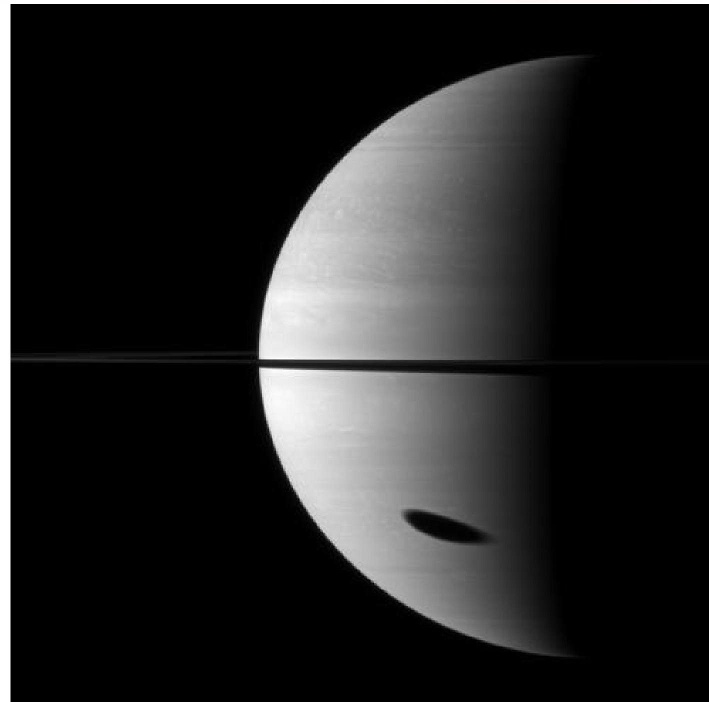
What are the characteristics of the solar system that lead to habitable environments?

How and where could life begin and evolve in the solar system?

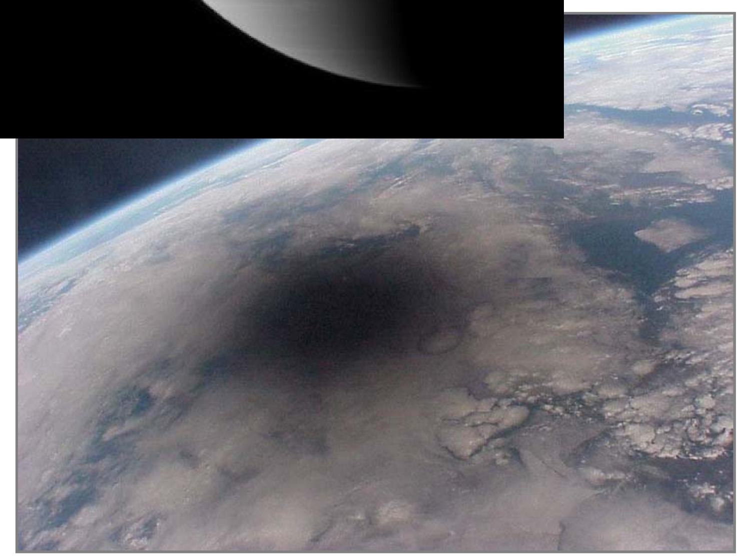
What are the characteristics of small bodies and planetary environments that pose hazards or provide resources?

Titan’s Enormous Elongated Shadow

This view looks toward the northern, sunlit side of the rings from just above the ring plane. The picture was taken by the Cassini spacecraft in November of 2009 as it continues or orbit Saturn and collect amazing amount of science data about the ringed planet.

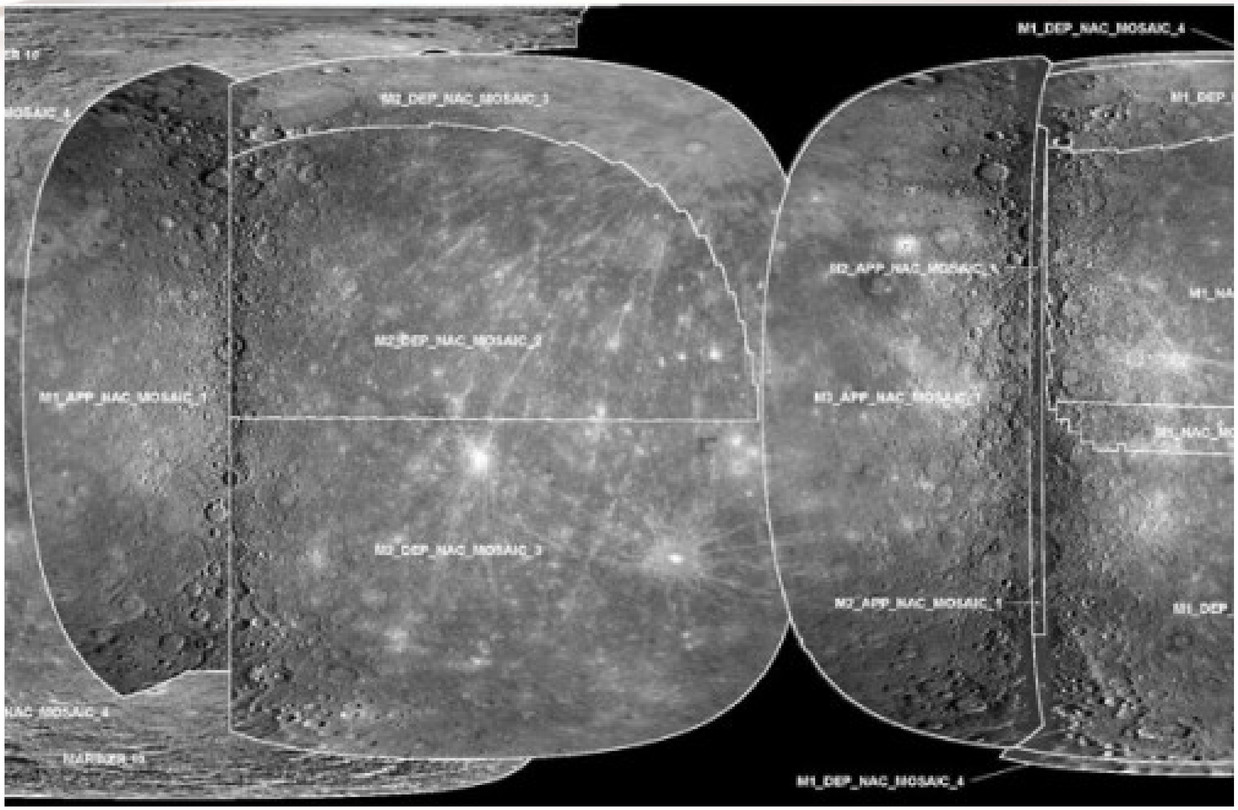


The shadow of Saturn's largest moon, Titan, darkens a huge portion of the gas giant planet (top image). Titan (5,150 kilometers, or 3,200 miles across) is not pictured here, but its shadow is elongated in the bottom right of the image. Titian is at ~20 R_S distance from Saturn.



The same phenomenon (a solar eclipse) occurs on Earth too. The bottom picture is a picture of a solar eclipse taken from MIR in 1999. The shadow on the earth is roughly 200 km in diameter. Titan’s shadow on Saturn is 25 times larger despite the fact that Titan is only 50% larger than our moon. This difference is caused by the Saturn’s distance from the sun, since the sun appears to be much, much smaller at Saturn, a smaller body can block out more sun.

MESSENGER Maps Mercury



- The MESSENGER mission just released the first global map of Mercury
- In three flybys of the planet, MESSENGER has seen 90% of the planet
  - Mariner 10, the last mission to mercury, only captured 45%.
- Using all of the MESSENGER data and portions of the Mariner data to fill in holes, the MESSENGER team was able to create a global map of Mercury that covers 97.7% of the surface (missing only the polar regions)
- This map will help scientists with focus their scientific observations when MESSENGER enters orbit around Mercury in 2011

MRO Captures Image of Phoenix Lander

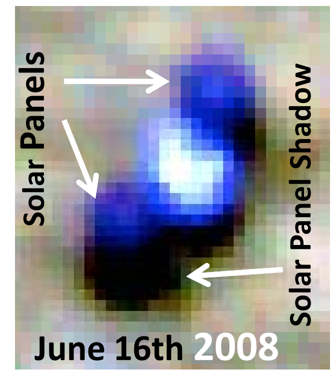
In Nov 2008, Phoenix was encased in CO_2 ice as the winter expansion of the northern Polar Cap of Mars covered the Phoenix landing site.

It was hoped that as spring came in 2010 that Phoenix would start to communicate again thanks to increased power since it would get more sun. However in over 150 overflights of Phoenix, the Mars Odyssey spacecraft was unable to hail it.

Recent pictures taken of Phoenix (lower right) by yet another Mars asset, MRO, show what appears to be significant damage to the solar arrays, and a vehicle covered in Martian dust when compared to a picture of Phoenix taken in 2008 shortly after landing (upper right)

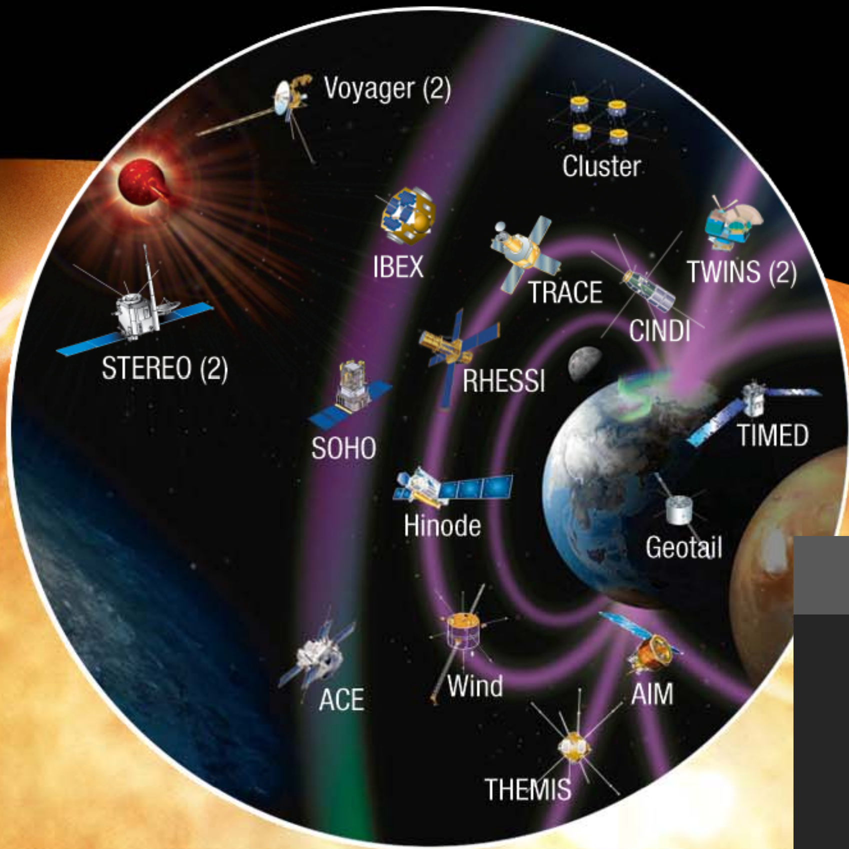
Initial interpretations of the new image conclude that one solar array is lying completely on the ground and the other is perhaps folded over.

As a result of this damage, engineers do not expect to hear from Phoenix.




Artist's concept of Phoenix after landing on Mars. The solar arrays are clearly visible and casting shadows.

Heliophysics



Questions

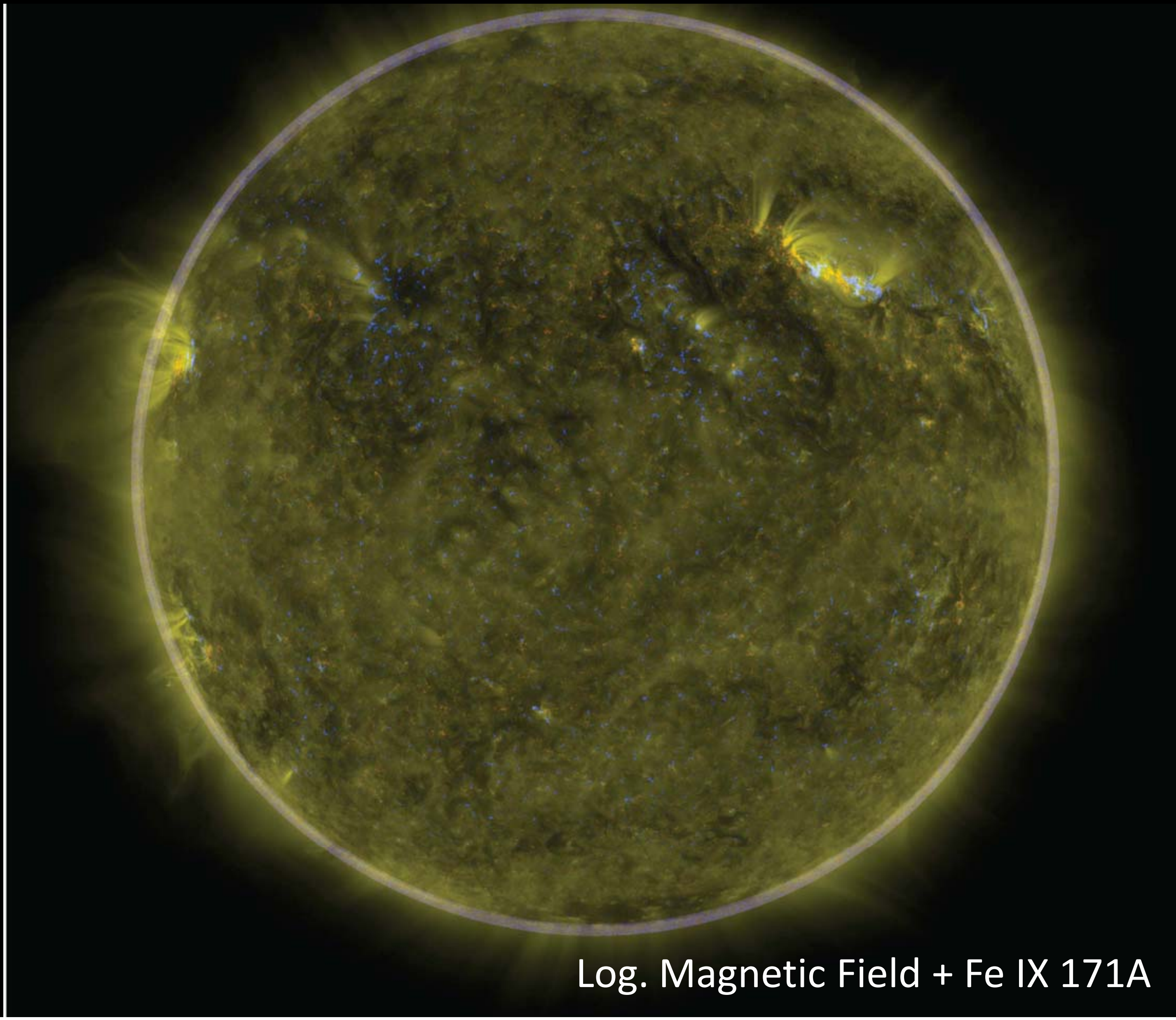
What causes the Sun to vary?

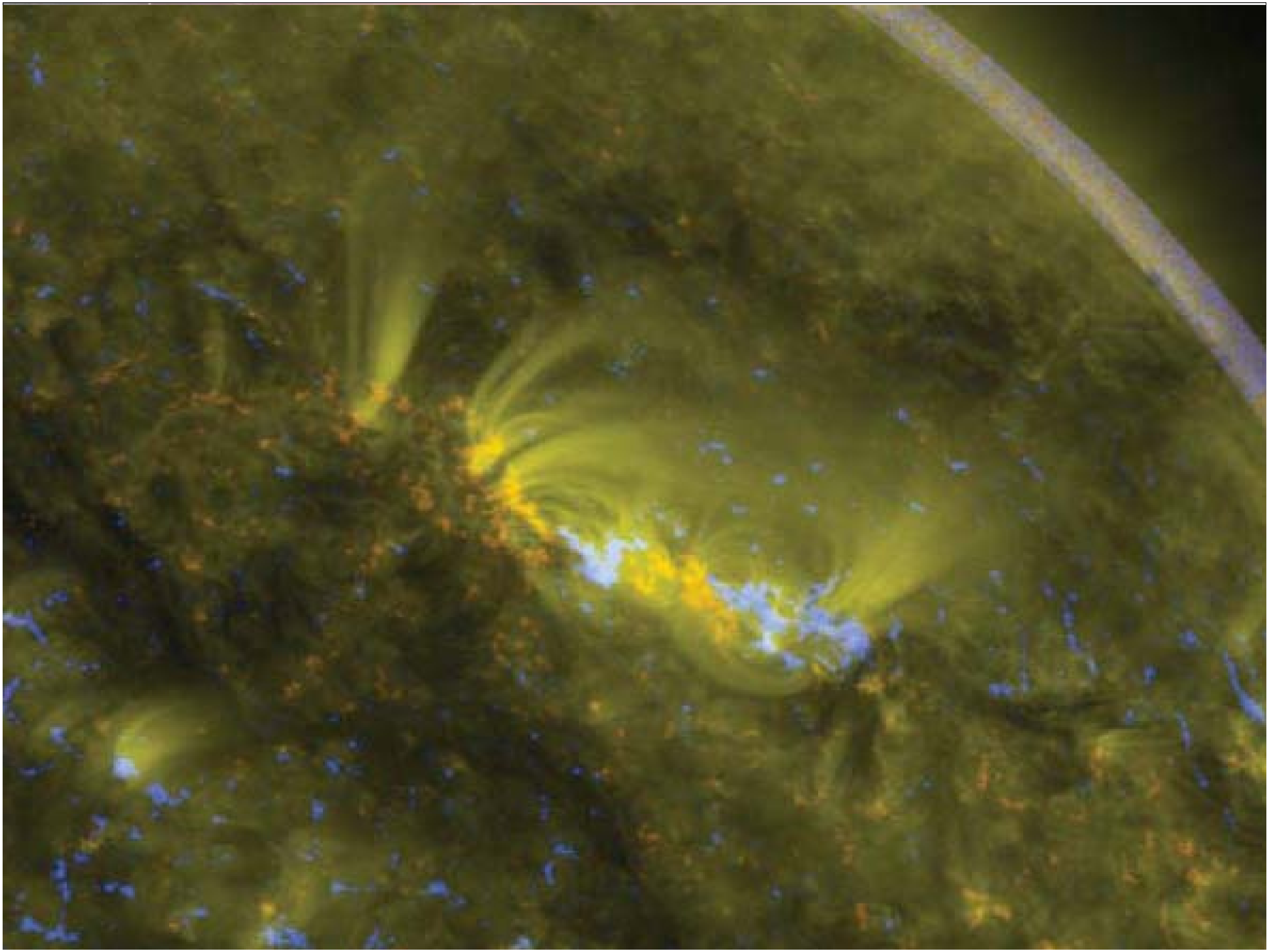
How do the Earth and Heliosphere respond?

What are the impacts of space weather on humanity?

Solar Dynamics Observatory

http://sdowww.lmsal.com/sdomedia/SunInTime/2010/06/23/f_HMImag_171.jpg





As the Sun Awakens, NASA Keeps a Wary Eye on Space Weather

- Earth and space are about to come into contact in a way that's new to human history. To make preparations, authorities in Washington DC held The Space Weather Enterprise Forum at the National Press Club on June 8th.

- Many technologies of the 21st century are vulnerable to solar storms. The Sun is waking up from a deep slumber, and in the next few years we expect to see much higher levels of solar activity. At the same time, our technological society has developed an unprecedented sensitivity to solar storms.

- The National Academy of Sciences focused on the problem two years ago in a report entitled "Severe Space Weather Events Societal and Economic Impacts." It noted how people of the 21st-century rely on high-tech systems for the basics of daily life. Smart power grids, GPS navigation, air travel, financial services and emergency radio communications can all be knocked out by intense solar activity.

- Much of the damage can be mitigated if we know a storm is coming. Putting satellites in 'safe mode' and disconnecting transformers can protect these assets from damaging electrical surges. Preventative action, however, requires accurate forecasting.

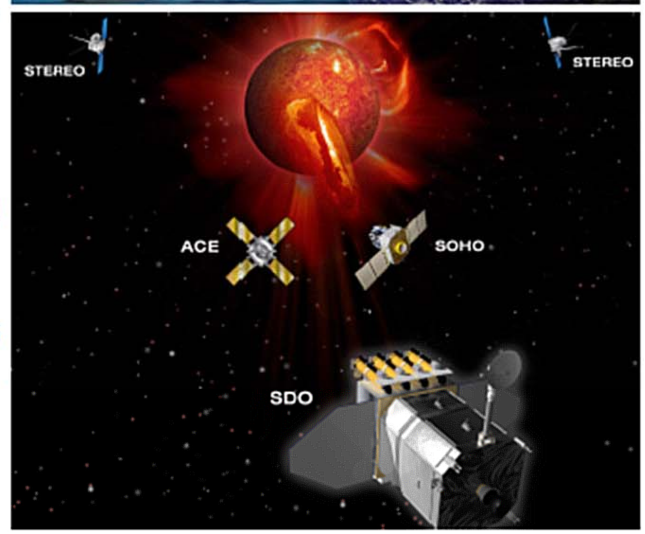
- NASA's fleet of Heliophysics research spacecraft provides us with up-to-the-minute information about what's happening on the Sun. Three spacecraft of special significance are ACE, STEREO, and SDO.

- The Advanced Composition Explorer (ACE), launched in 1997, is a solar wind monitor sitting upstream between the Sun and Earth, detecting solar wind gusts, billion-ton CMEs, and radiation storms as much as 30 minutes before they hit Earth.

- STEREO (Solar Terrestrial Relations Observatory), launched in 2006, is a pair of spacecraft stationed on opposite sides of the Sun with a combined view of 90% of the stellar surface. In the past, active sunspots could be on the Sun's farside, invisible from Earth, and then suddenly emerge over the limb casing flares and CMEs. STEREO makes such surprises impossible.

- SDO (the Solar Dynamics Observatory) is the newest addition to NASA's Heliophysics System Observatory. Launched in February 2010, it is able to photograph solar active regions with unprecedented spectral, temporal and spatial resolution. Researchers can now study eruptions in exquisite detail, raising hopes that they will learn how flares work and how to predict them. SDO also monitors the sun's extreme UV output, which controls the response of Earth's atmosphere to solar variability. On April 19, 2010, SDO observed one of the most massive eruptions in years.

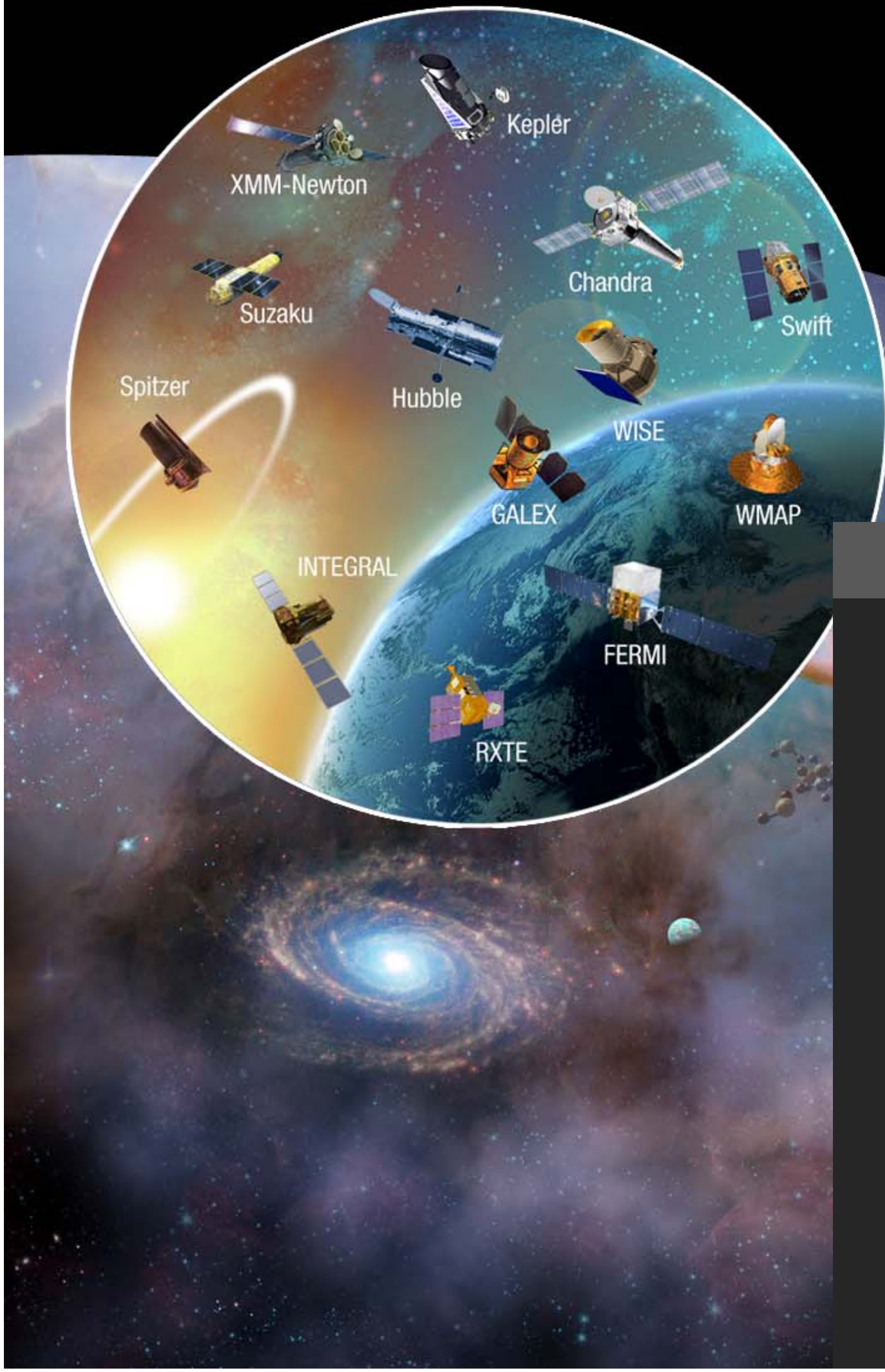
For more information on Heliophysics and space weather, see: http://science.nasa.gov/heliophysics/



NASA space weather assets. Credit: NASA

Astrophysics

Astrophysics

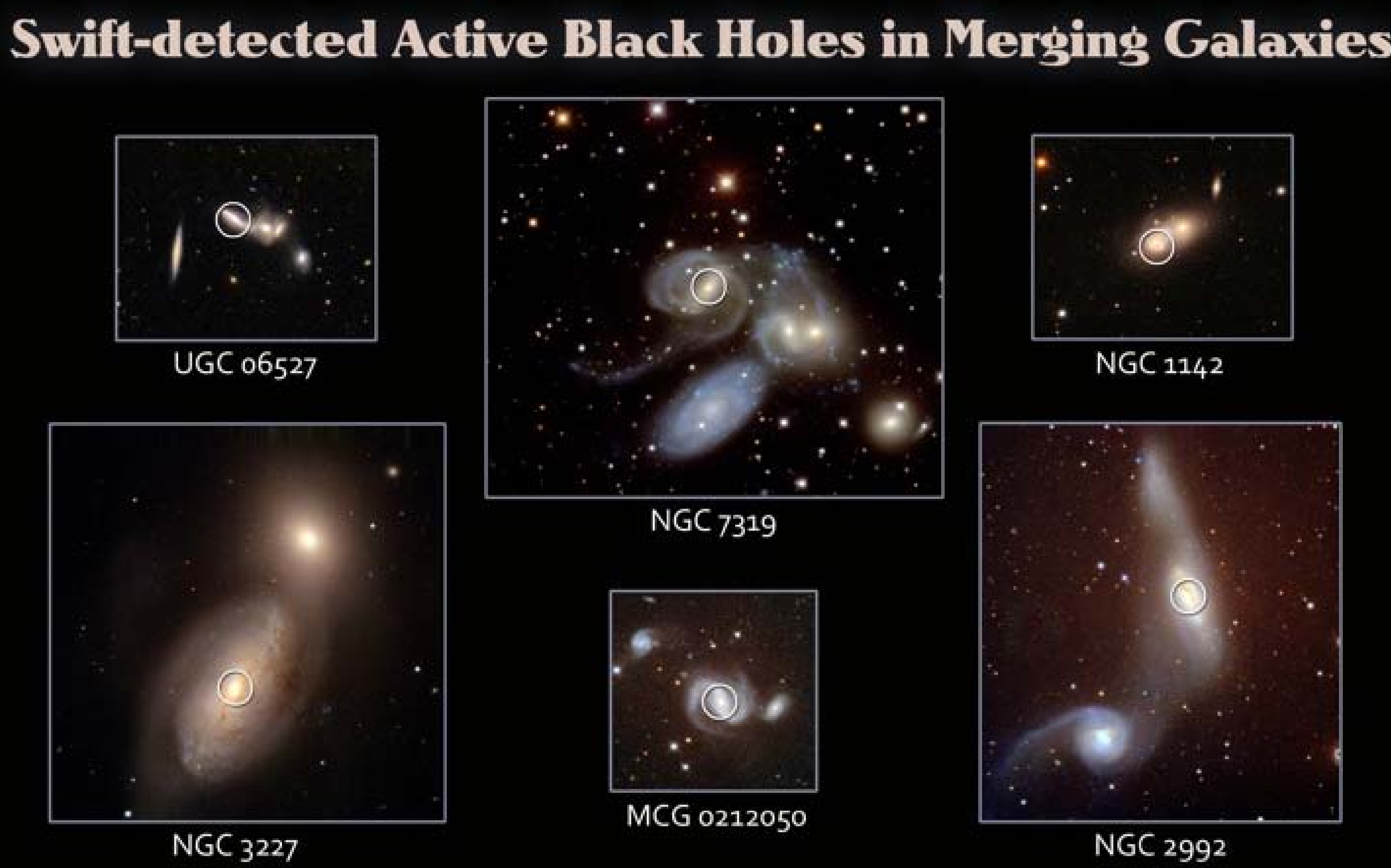


Questions

How do matter, energy, space and time behave under the extraordinary diverse conditions of the cosmos?

How did the universe originate and evolve to produce the galaxies, stars, and planets we see today?

What are the characteristics of planetary systems orbiting other stars, and do they harbor life?



Credit: NASA/Swift/NOAO/Michael Koss and Richard Mushotzky (Univ. of Maryland)

GALEX Galaxy Evolution Explorer

Ultraviolet + Visible/GALEX + SDSS   Visible/SDSS

Ultraviolet Tail of Galaxy IC 3418

NASA/JPL-Caltech

GALEX • FUV • NUV
Sloan Digital Sky Survey

CH Cyg

Credit: X-ray: NASA/CXC/SAO/M.Karovska et al; Optical: NASA/STScI; Radio: NRAO/VLA]; Wide field [Optical (DSS)

SMD Research Program

- Research is an essential part of SMD, and research is a part of every budget line
- Research is an integral part of missions:
  a) Development (including PI-led mission development and PI-led instrument development);
  b) Operations (including science operations and data processing);
  c) Science Teams (including participating scientists and interdisciplinary scientists); and
  d) Data Analysis (DA) (including guest observer/investigator programs)
- Individual investigator-led research is base of program:
  a) Supporting Research and Technology (SR&T);
  b) Suborbital Investigations (e.g., Aircraft, Balloon, Sounding Rockets); and
  c) Research and Data Analysis (R&DA)

Workforce Development, Education, & Public Outreach

SMD Science Plan

- The SMD Science Plan is accessible on-line and in print form
- A summary version is also available on-line and in print form
- Look for the updated 2010 Plan to be posted by the end of summer

http://nasascience.nasa.gov/about-us/science-strategy