

EARTH SCIENCE



HELIOPHYSICS



PLANETARY SCIENCE



ASTROPHYSICS

NAC SCIENCE COMMITTEE REPORT

Eugene H. Levy
11 December 2013

Science Committee Members

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Carle Pieters, (Vice Chair), Brown University

Maura Hagan, NCAR, Chair of Heliophysics

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The header features a horizontal strip of five rectangular panels. From left to right, the panels show: a blue and white image of Earth from space, a bright yellow and orange image of a star or nebula, a white and grey image of a nebula, a purple and blue image of a nebula, and a grey image of a nebula.

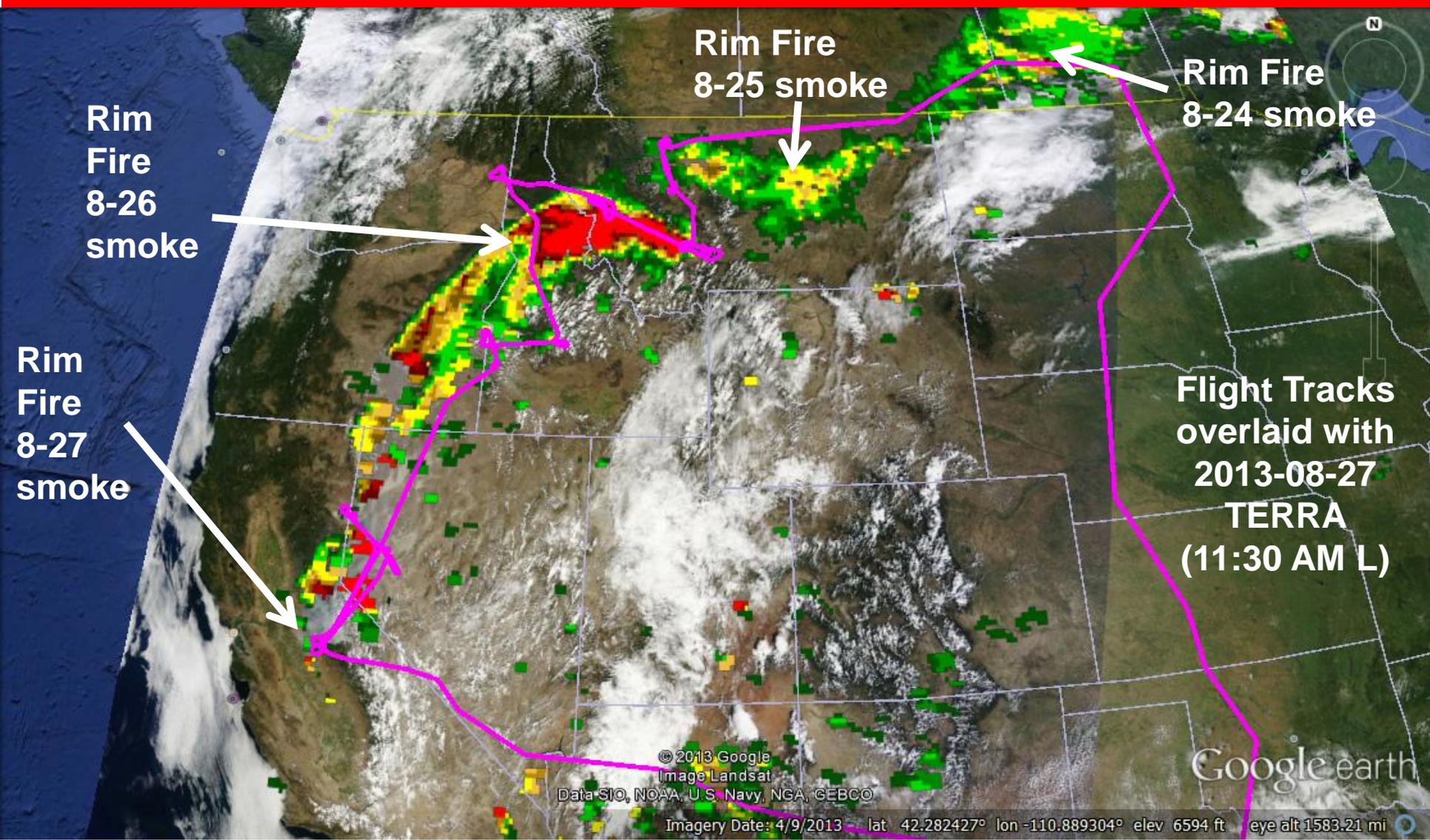
Outline

- **Science Results**
- Programmatic Status
- Findings & Recommendations

SEAC⁴RS – A study in the fungibility of NASA acronyms

~~Southeast Asia Composition, Cloud, Climate Coupling Regional Study~~

~~Studies of Emissions, Atmospheric Composition, Clouds & Climate Coupling by Regional Surveys~~

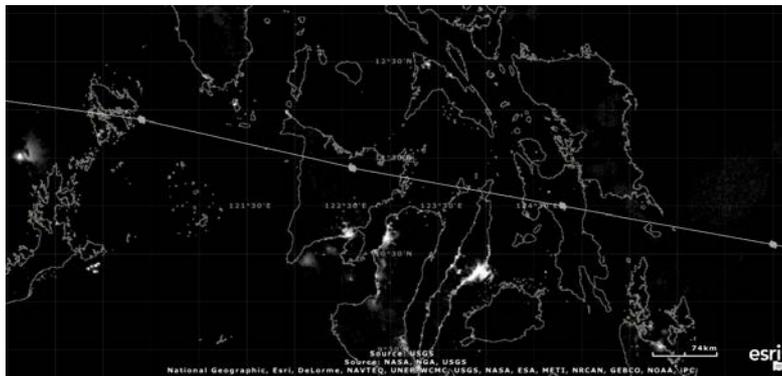
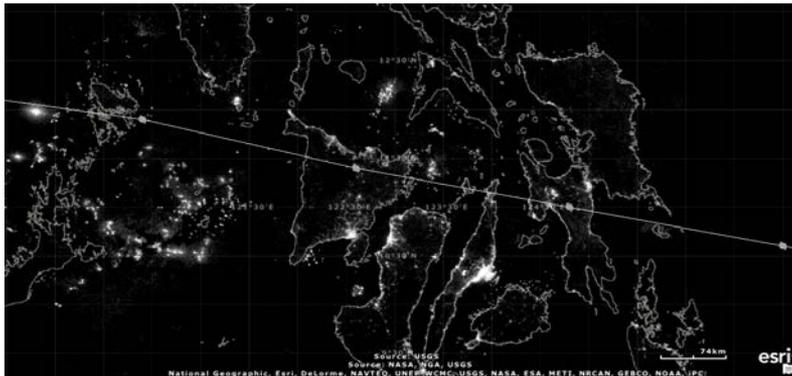
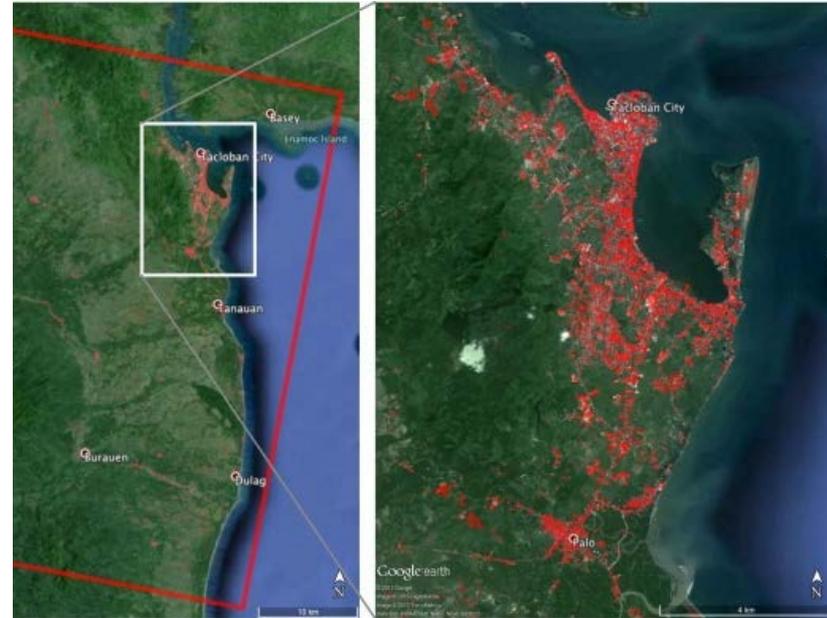




NASA Damage Map Helps in Typhoon Disaster Response

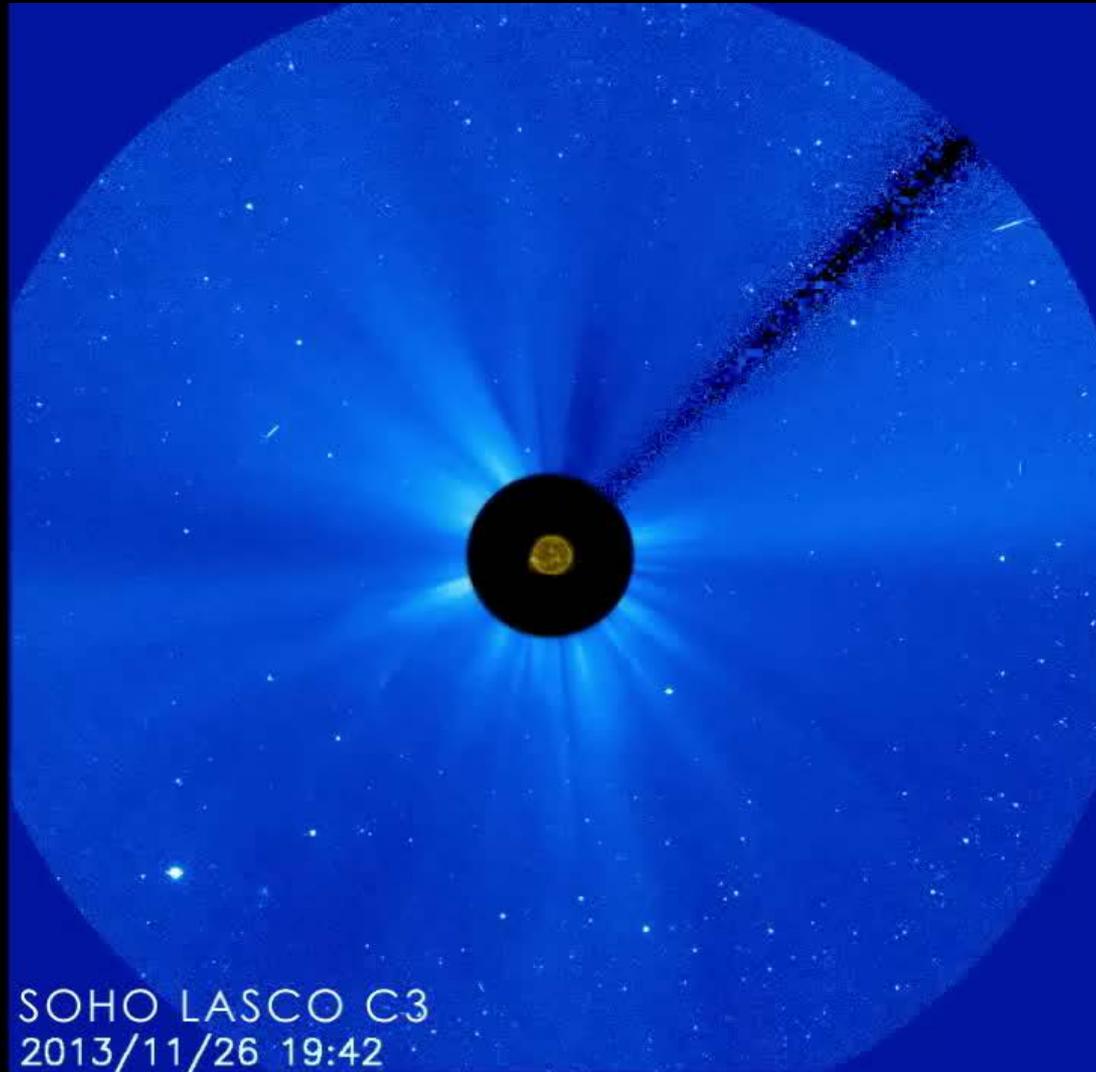
NASA data provided to the Disaster Response Coordinator at USGS EROS, and made publicly available through the Hazards Data Distribution System (HDDS)

Haiyan will be known as a historic storm, making landfall in the central Philippines November 8 as perhaps the most powerful tropical cyclone to ever make landfall with sustained winds estimated at 195 mph. So far, over 2300 people are confirmed to have been killed by the storm, and the number is likely to climb higher with many still missing and not all areas unaccounted for. The most deadly flooding from Super Typhoon Haiyan was caused by the storm surge, which was reported to be up to ~17 feet in Tacloban. The images below identify regions post-landfall (bottom) that are suffering power outages, using the highly sensitive day/night band on the Suomi-NPP VIIRS instrument.



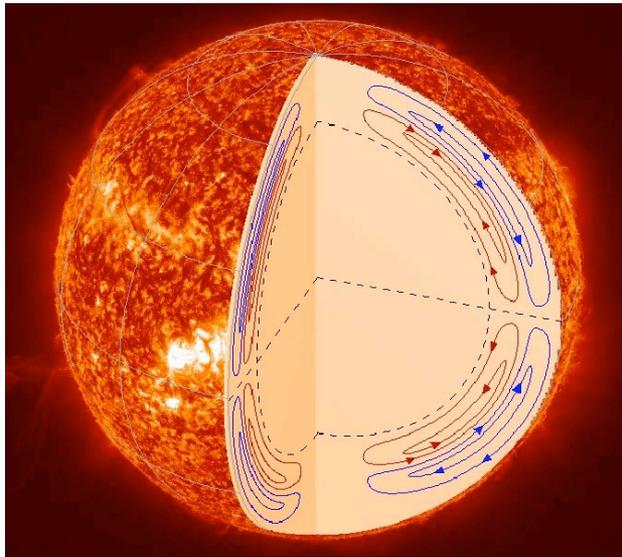
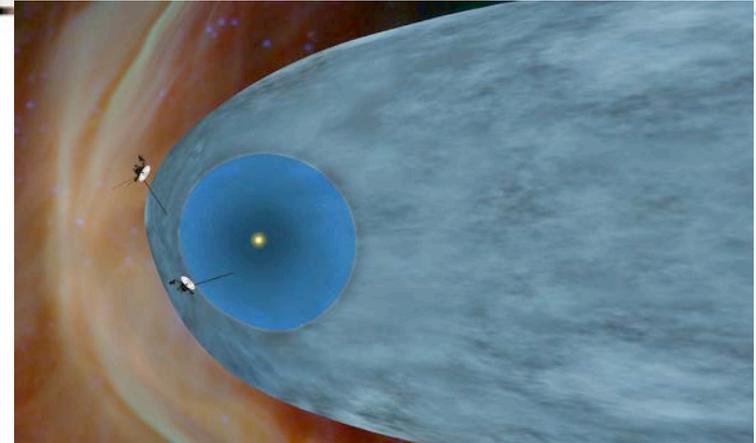
NASA's Jet Propulsion Laboratory in collaboration with the Italian Space Agency, generated the above image of the storm's hardest-hit regions, depicting its destruction. The 40-by-50 kilometer damage proxy map, near Tacloban City, where the massive storm made landfall, was processed by JPL's Advanced Rapid Imaging and Analysis (ARIA) team using X-band interferometric synthetic aperture radar data from the Italian Space Agency's COSMO-SkyMed satellite constellation. The technique uses a prototype algorithm to rapidly detect surface changes caused by natural or human-produced damage. The assessment technique is most sensitive to destruction of the built environment. When the radar images areas with little to no destruction, its image pixels are transparent. Increased opacity of the radar image pixels reflects damage, with areas in red reflecting the heaviest damage to cities and towns in the storm's path. The time span of the data for the change is Aug. 19--Nov. 11, 2013. Each pixel in the damage proxy map is about 30 meters across.

Comet ISON Slingshots Around the Sun



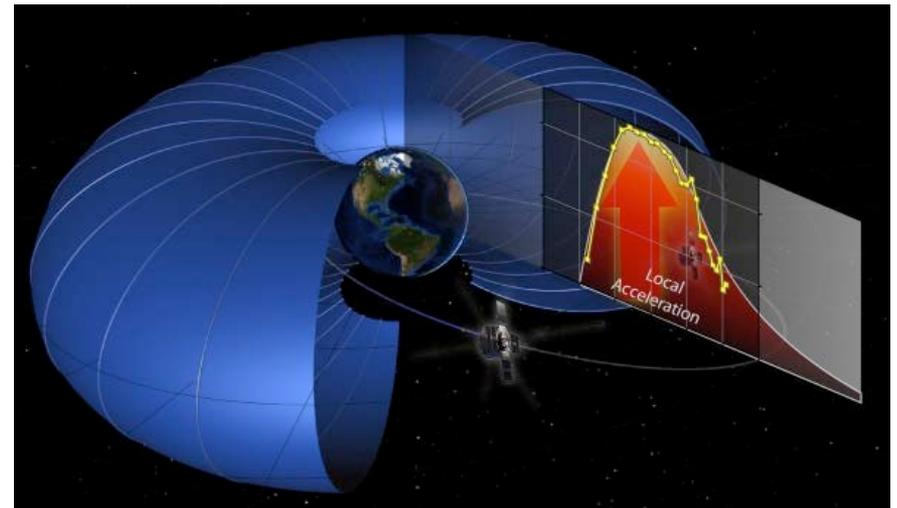
Recent Major Accomplishments – Heliophysics

Sept. 12, 2013 – Voyager 1 Embarks on a Historic Journey into Interstellar Space: Voyager 1 is officially the first human-made object to venture into interstellar space. New data indicate Voyager 1 has been traveling for about one year through the interstellar plasma. Voyager 2 is expected to exit in ~3 more years.

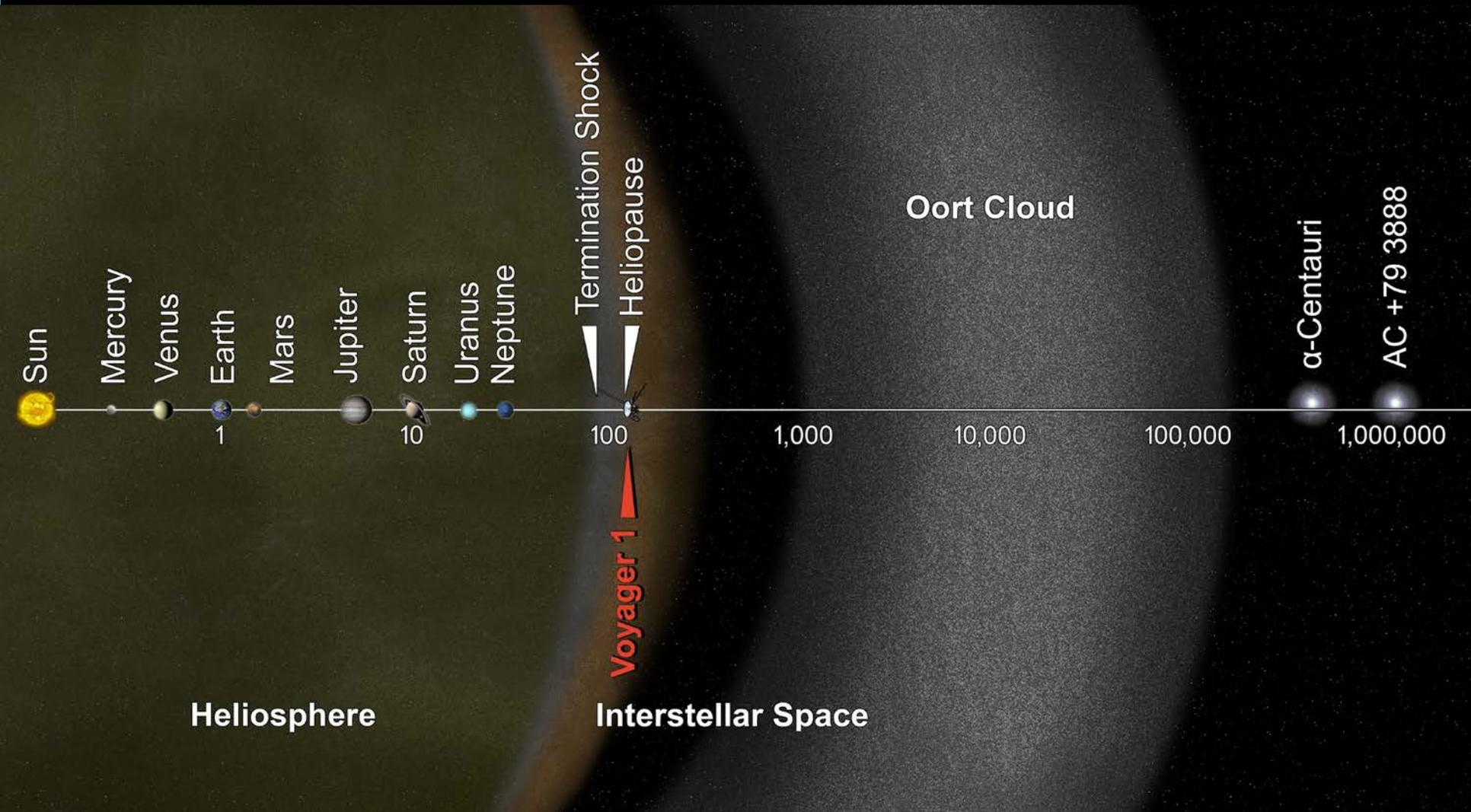


SDO Untangles the Motion Inside the Sun: Using the Helioseismic and Magnetic Imager (HMI) on NASA's Solar Dynamics Observatory, scientists have mapped out the flow of the material inside the sun. Recent results reveal a double layer of circulation, with two cycles of flow on top of each other

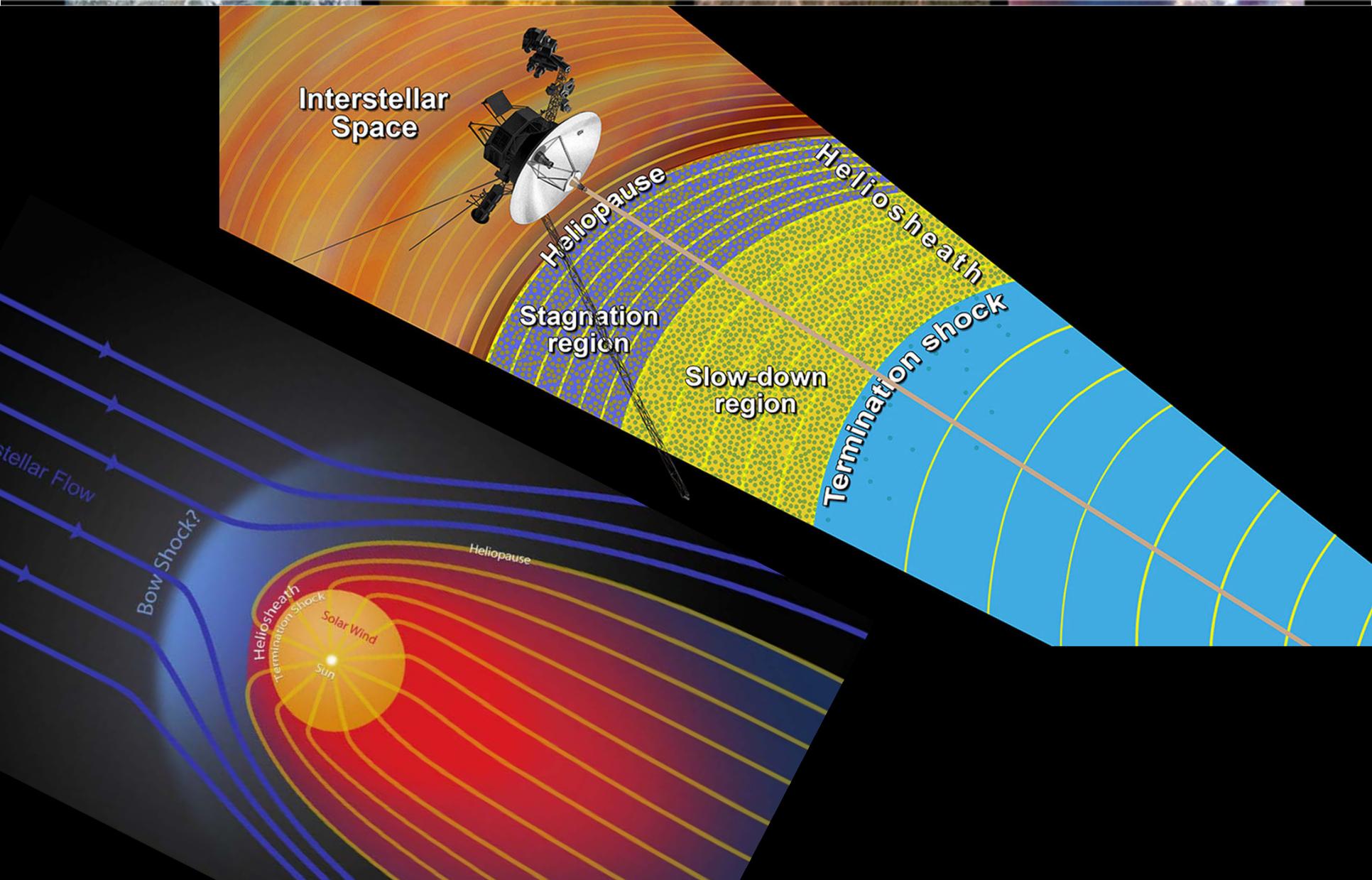
July 25, 2013 – Van Allen Probes Discover Particle Accelerator in the Heart of Earth's Radiation Belts: New results from the Van Allen Probes show that acceleration energy comes from within the belts themselves rather than a more global process.



Voyager Has Left the Solar System



“Leaving the Solar System” can have several different meanings . . .

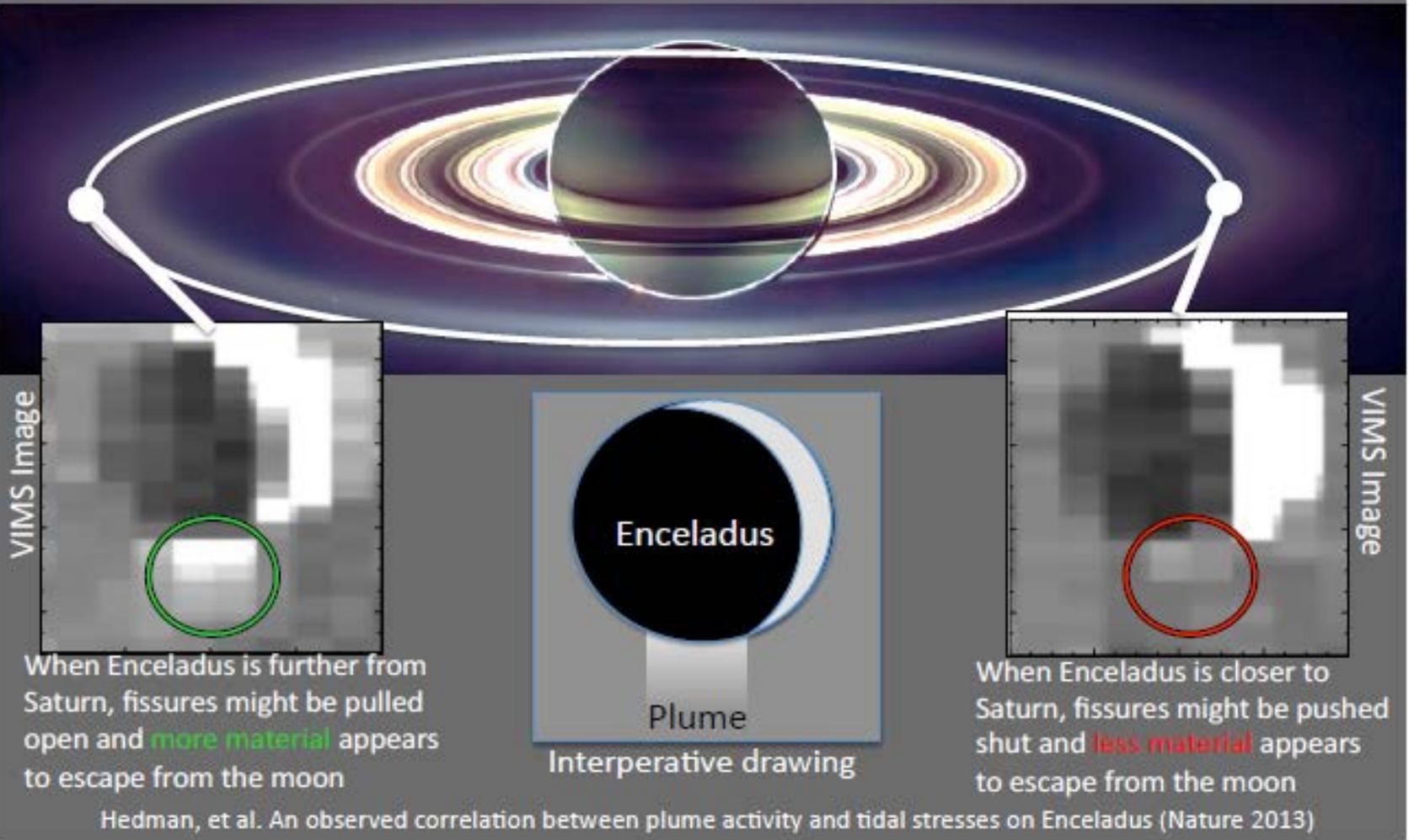


Ed Stone receiving the Distinguished Public Service Medal



Cassini Finds Tidal Forces Controlling Enceladus' Jets

Enceladus' geological activity varies systematically as moon moves around its elliptical orbit

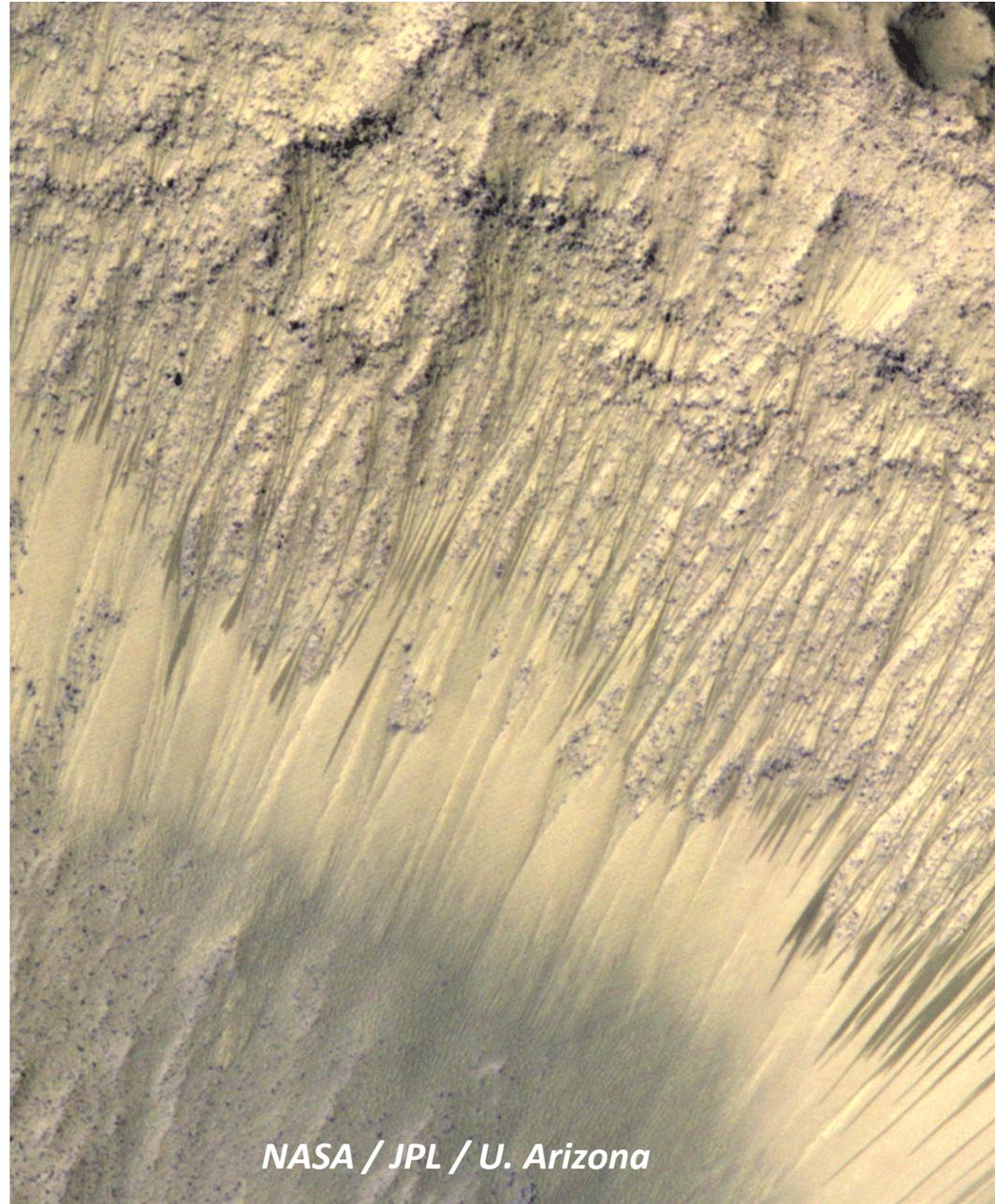


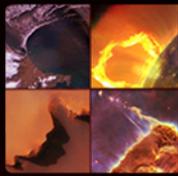


Recurring Slope Lineae (RSL) in Equatorial Regions of Mars

A.S. McEwen et al. , Nature Geoscience, *web release 12/10/13* ←

- RSL are dark flows up to a few meters wide on steep, rocky slopes.
- They behave like salty water flows in terms of temperature dependence, seasonality, and growth patterns, but origin of water is not known.
- Previously reported in southern middle latitudes during the warm seasons.
- Now known to be abundant in equatorial regions, as well, especially deep in Valles Marineris.
- They follow the sun: active on N-facing slopes when subsolar latitude is to the north; active on S-facing slopes when sun is to the south.
- *Implication*: Shallow water may be surprisingly abundant near the surface in equatorial regions of Mars.
- *Key issue*: To understand present-day Mars for future human explorers.





Hubble Traces Subtle Signals of Water on Hazy Worlds

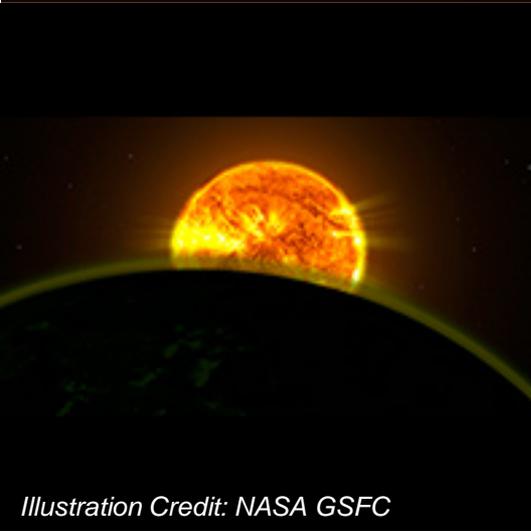


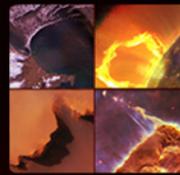
Illustration Credit: NASA GSFC

- Using NASA's Hubble Space Telescope, two teams of scientists have found faint signatures of water in the atmospheres of five distant planets.
- The presence of atmospheric water was reported previously on a few exoplanets orbiting stars beyond our solar system, but this is the first study to conclusively measure and compare the profiles and intensities of these signatures on multiple worlds.
- The five planets — WASP-17b, HD209458b, WASP-12b, WASP-19b and XO-1b — orbit nearby stars. The strengths of their water signatures varied. WASP-17b, a planet with a specially puffed-up atmosphere, and HD209458b had the strongest signals. The signatures for the other three planets, WASP-12b, WASP-19b and XO-1b, also are consistent with water.

Ubiquity of water ???

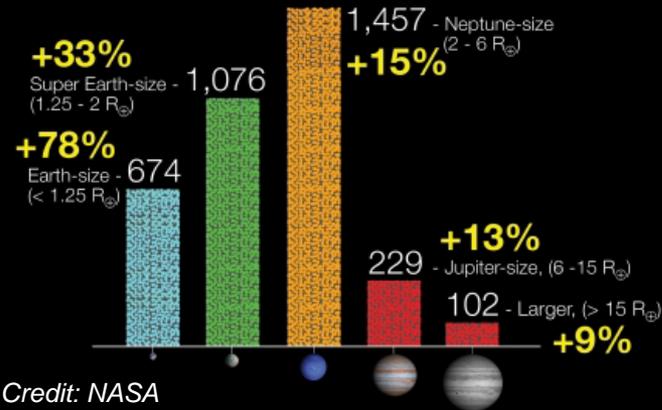
- The scientists used Hubble's Wide Field and of Depth camera to explore the details of absorption of light through the planets' atmospheres. The observations were made in a range of infrared wavelengths where the water signature, if present, would appear. The teams compared the shapes and intensities of the absorption profiles, and the consistency of the signatures gave them confidence they saw water.
- The water signals were all less intense than expected, and the scientists suspect this is because a layer of haze or dust blankets all of the five planets. This haze can reduce the intensity of all signals from the atmosphere in the same way fog can make colors in a photograph appear muted. At the same time, haze alters the profiles of water signals and other important molecules in a distinctive way.
- The five planets are hot Jupiters, massive worlds that orbit close to their host stars. The researchers were initially surprised that all five appeared to be hazy, but other researchers are finding evidence of haze around exoplanets.

Some Results from the 2nd Kepler Science Conference



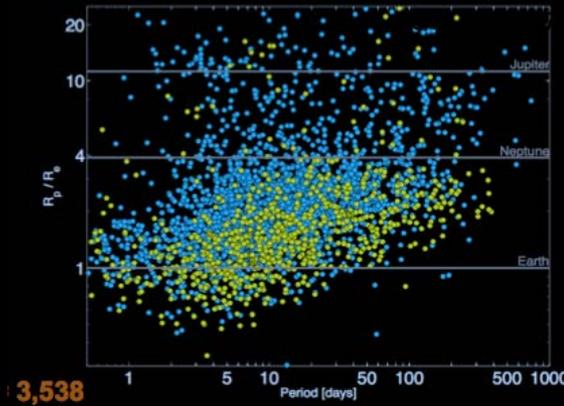
Sizes of Planet Candidates

Totals as of November, 2013



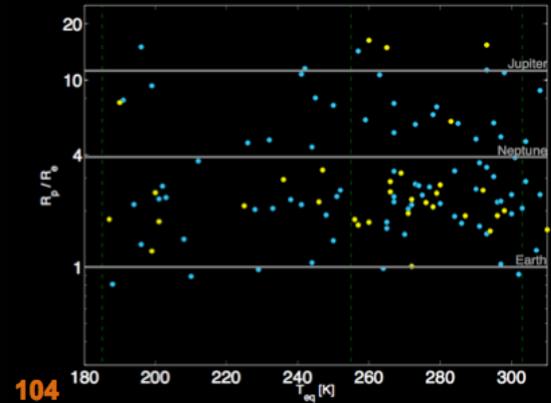
Planet Candidates

As of November 4, 2013



Candidates in Habitable Zone

As of November 4, 2013

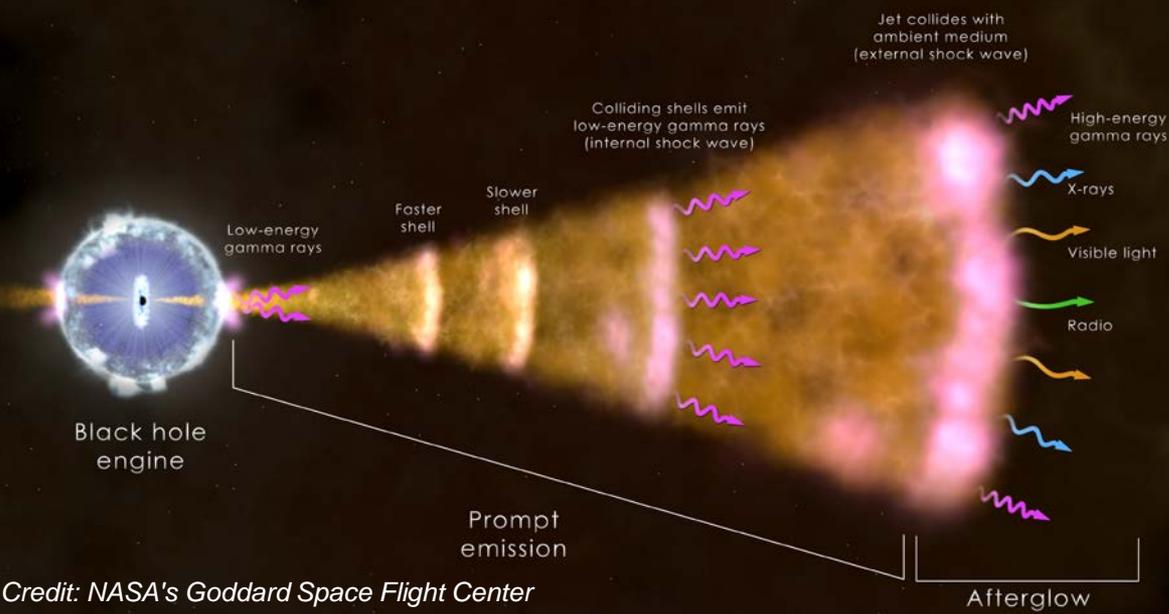
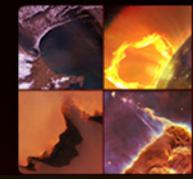


Yellow dots indicate new candidates as of Nov. 2013 while blue dots indicate candidates as of Jan. 2013.

- The recently-completed analysis of data from the first three years of Kepler operations (Quarters 1-12) has revealed an additional 833 exoplanet candidates.
- The total number of exoplanet candidates identified by the mission is now up to 3538.
- The greatest increase in candidates is in the Earth-sized category ($R < 1.25 R_{\text{earth}}$), which increased from 351 to 674, a 78% increase.
- More than 2 dozen of the new exoplanet candidates lie in the habitable zone of their stars, and 10 of those planets are Earth-sized and potentially rocky.

- The total number of habitable zone exoplanet candidates discovered by Kepler is now 104.
- A research team from the University of California at Berkeley reported the results of a study to estimate the occurrence rate of habitable zone planets in the size range from 1 to 2 Earth radii about Sun-like stars.
- By extrapolation of the data currently available from the Kepler mission, the group estimates that 22% \pm 8% of Sun-like stars may possess a planet in this size range orbiting within its habitable zone.

NASA Sees 'Watershed' Cosmic Blast in Unique Detail



In the most common type of gamma-ray burst, illustrated here, a dying massive star forms a black hole (left), which drives a particle jet into space. Light across the spectrum arises from hot gas near the black hole, collisions within the jet, and from the jet's interaction with its surroundings.

On April 27, 2013 a blast of light from a dying star in a distant galaxy became the focus of astronomers around the world. The explosion, known as a gamma-ray burst and designated GRB 130427A, tops the charts as one of the brightest ever seen.

GRB 130427A is the subject of five papers published online Nov. 21. Four of these, published by Science Express, highlight contributions by Fermi, Swift and RAPTOR. The NuSTAR study is published in The Astrophysical Journal Letters.

- NASA's Fermi Gamma-ray Space Telescope, Swift Gamma-ray Burst mission, and Nuclear Spectroscopic Telescope Array (NuSTAR), working in concert with ground-based robotic telescopes, captured never-before-seen details that challenge current theoretical understandings of how gamma-ray bursts work.
- The Gamma-ray Burst Monitor (GBM) aboard Fermi captured the initial wave of gamma rays from GRB 130427A shortly after 3:47 a.m. EDT April 27. In its first three seconds alone, the "monster burst" proved brighter than almost any burst previously observed. Swift detected the burst almost simultaneously and quickly relayed its position to ground-based observatories. Telescopes operated by Los Alamos National Laboratory in New Mexico, as part of the Rapid Telescopes for Optical Response (RAPTOR) Project, quickly turned to the spot. They detected an optical flash that peaked at magnitude 7 on the astronomical brightness scale, easily visible through binoculars. It is the second-brightest flash ever seen from a gamma-ray burst. Just as the optical flash peaked, Fermi's Large Area Telescope (LAT) detected a spike in GeV gamma-rays reaching 95 GeV, the most energetic light ever seen from a burst. This relationship between a burst's optical light and its high-energy gamma-rays defied expectations.
- The LAT detected GRB 130427A for about 20 hours, far longer than any previous burst. This extraordinary event enabled NASA's newest X-ray observatory, NuSTAR, to make a first-time detection of a burst afterglow in high-energy, or "hard," X-rays after more than a day. Taken together with Fermi LAT data, these observations challenge long-standing predictions.

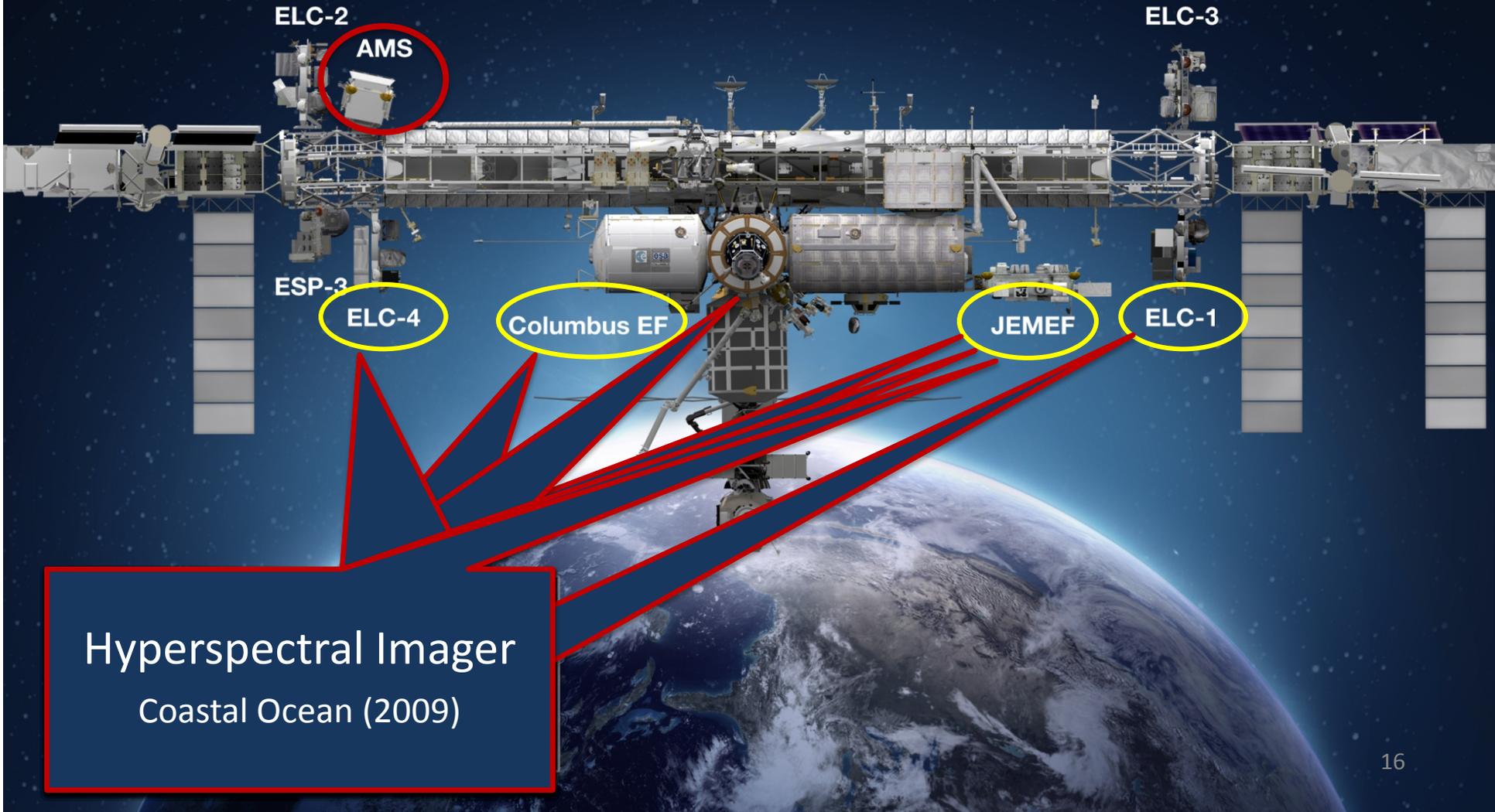
The header features a horizontal strip of four square images: a blue and white nebula, a bright yellow star, a dark space scene with a bright light source, and a colorful nebula. The word "Outline" is centered in a bold, black, sans-serif font.

Outline

- Science Results
- **Programmatic Status**
 - Earth Science
 - Heliospheric Physics
 - Astrophysics
 - Planetary Protection
- Findings & Recommendations

International Space Station

Earth Science Instruments



ELC-2

AMS

ELC-3

ESP-3

ELC-4

Columbus EF

JEMEF

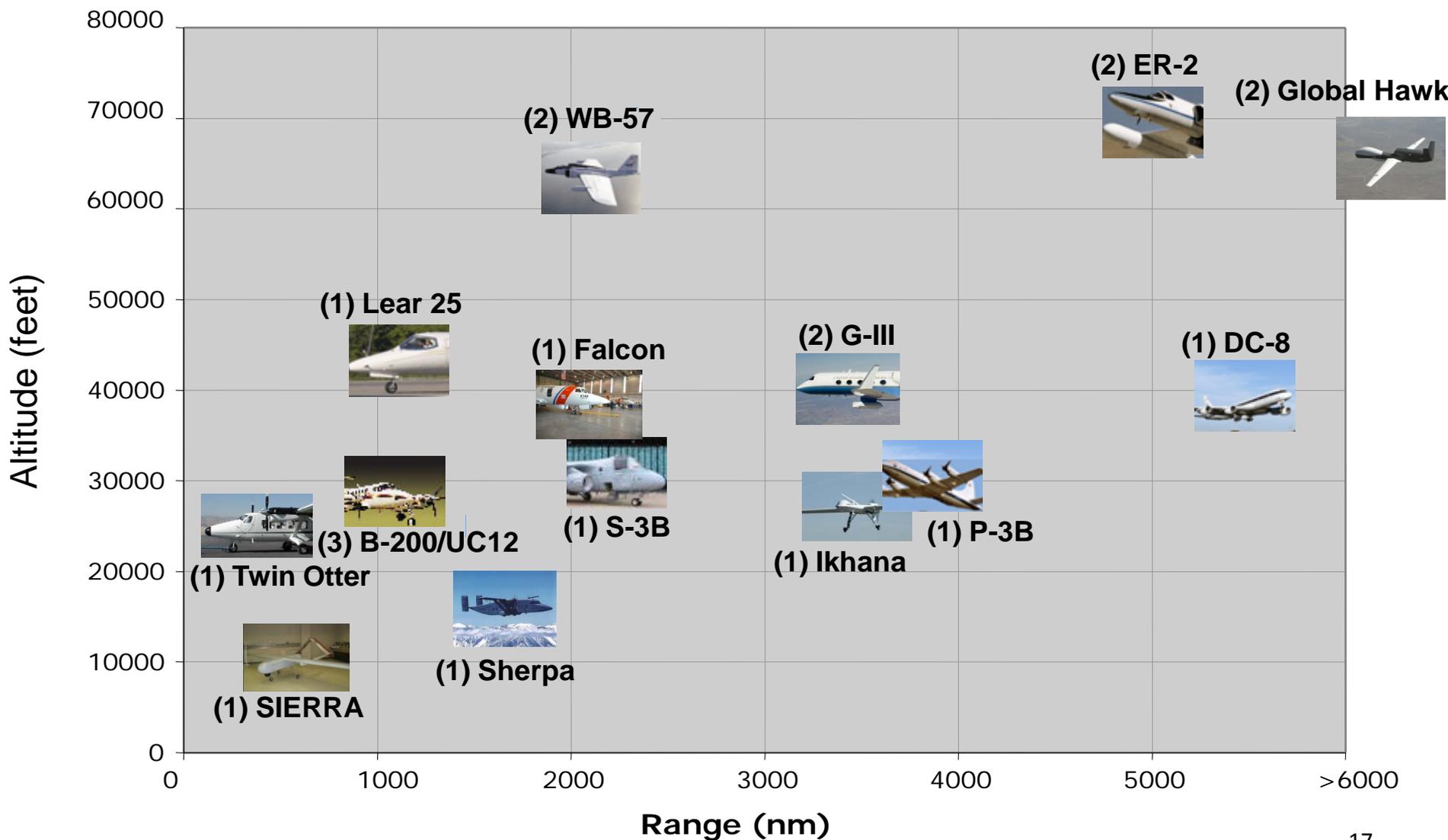
ELC-1

Hyperspectral Imager

Coastal Ocean (2009)

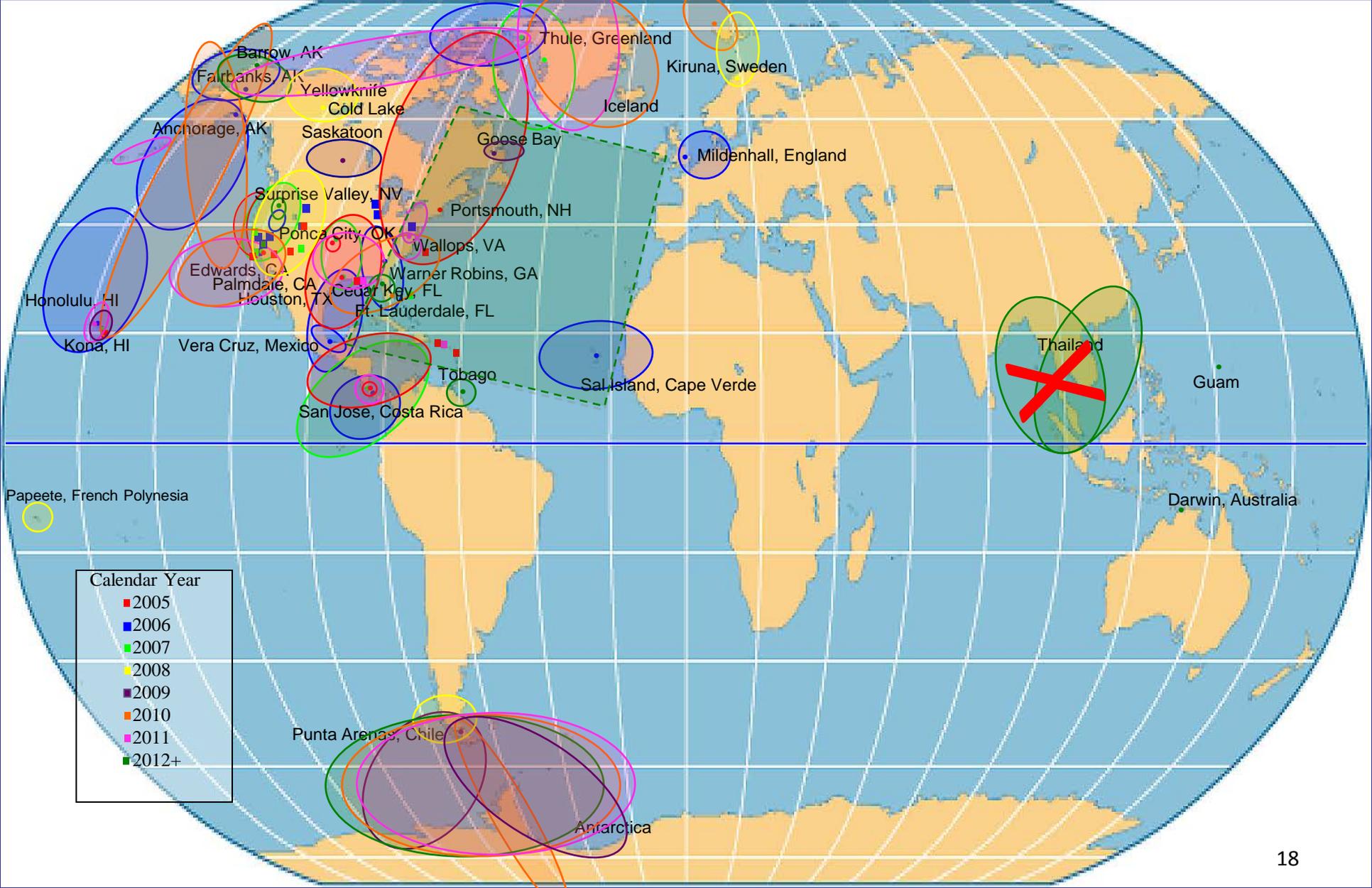


NASA Airborne Science Aircraft





2005-2013 Airborne Campaigns



Calendar Year

- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012+

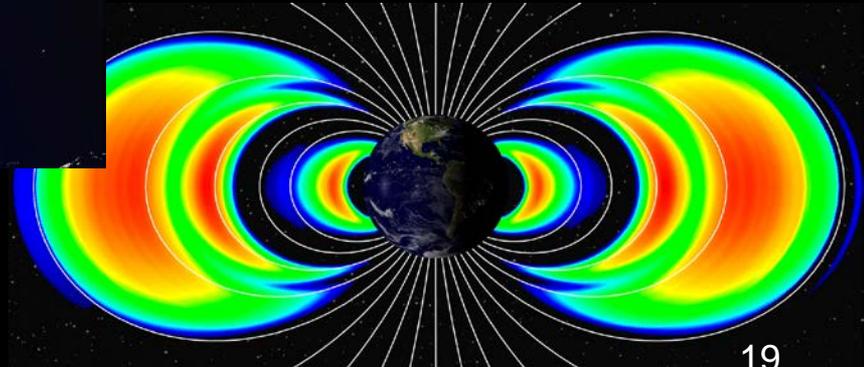
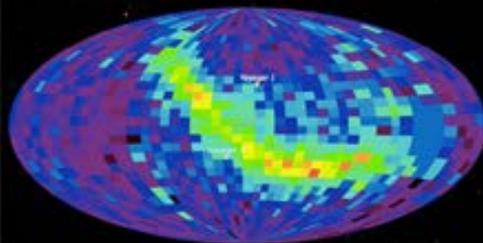
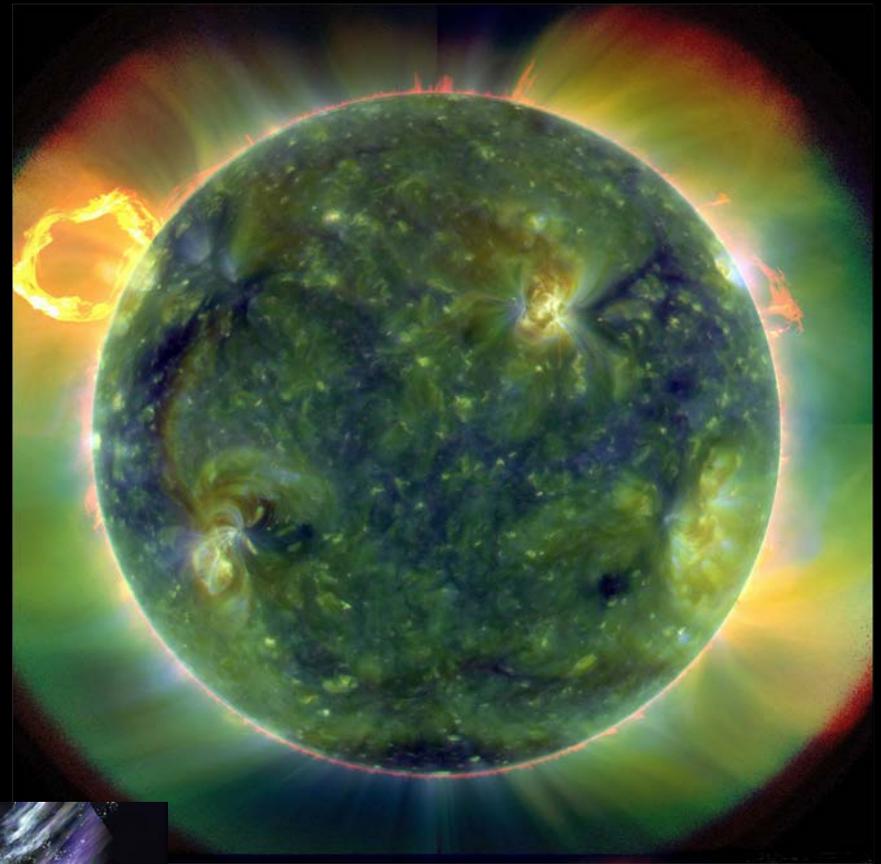
NASA Heliophysics Science Objective

Understand the Sun and its interactions with the Earth, the Solar System, and the Galaxy.

*Solve the Fundamental
Mysteries of Heliophysics*

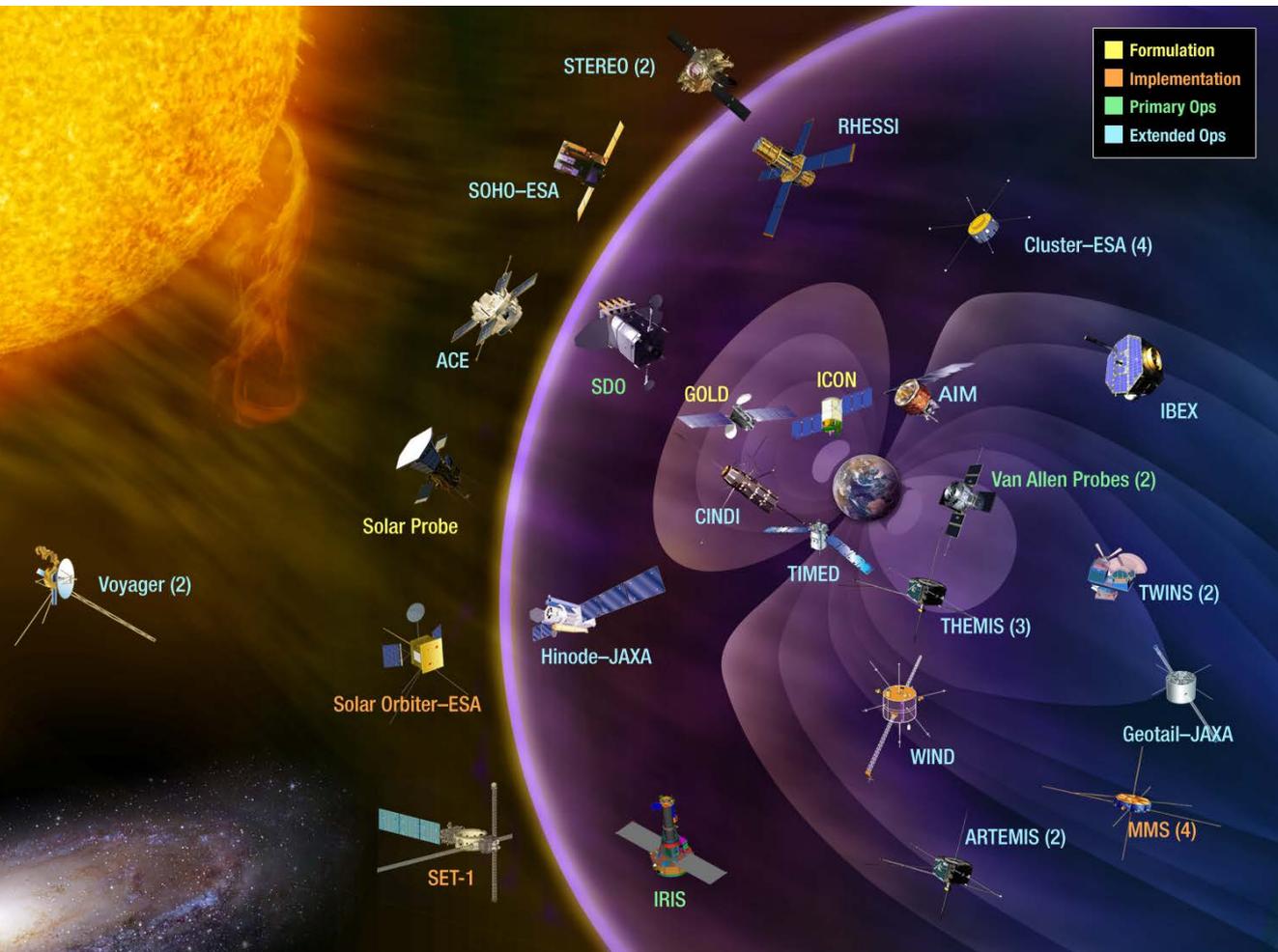
*Understand the Nature of
our Home in Space*

*Build the Knowledge
to Forecast Space
Weather Throughout
the Heliosphere*



Heliophysics System Observatory

A fleet of spacecraft to understand the sun and its interactions with Earth and the solar system

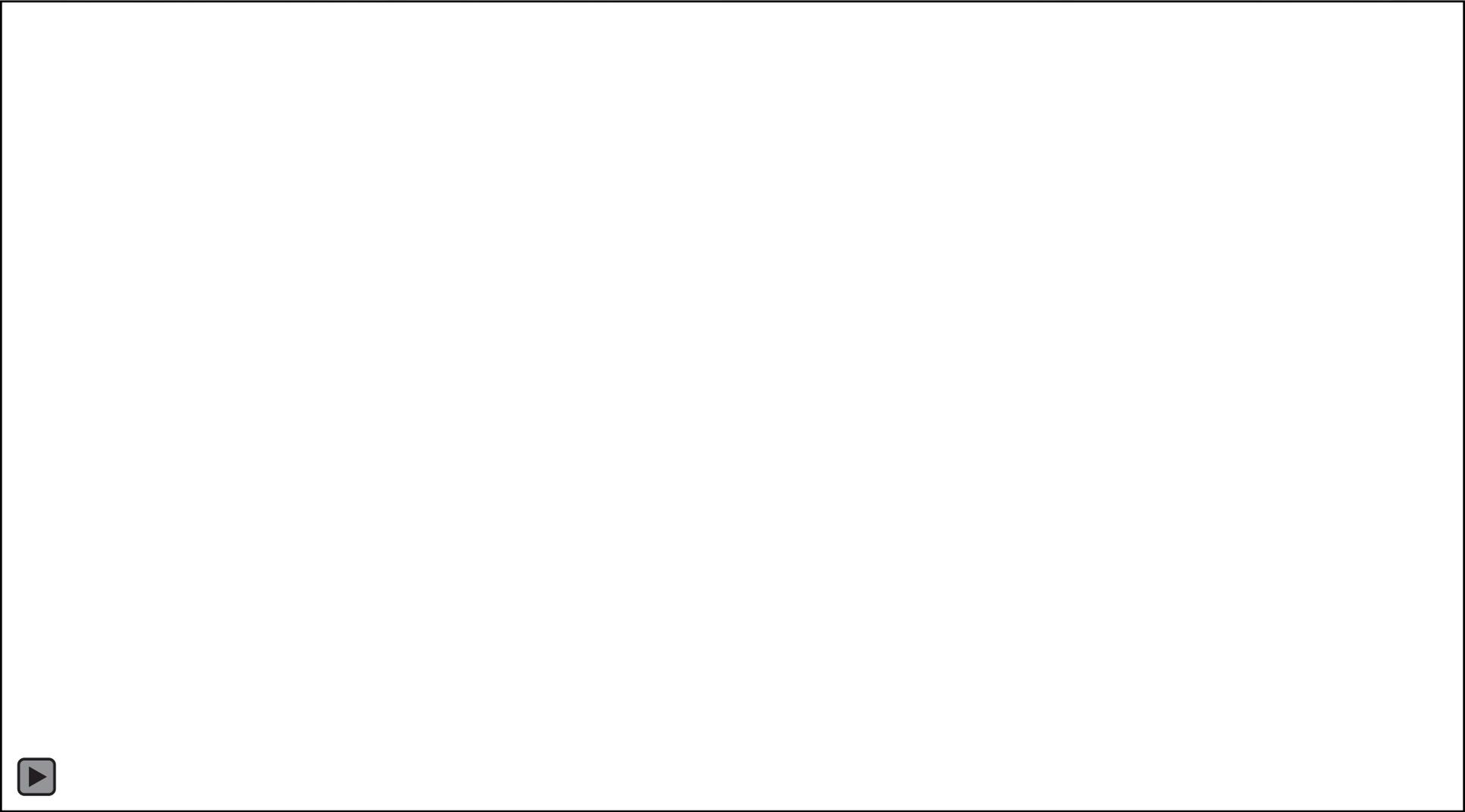


- Heliophysics has 18 operating missions (on 29 spacecraft): Voyager, Geotail, Wind, **SOHO**, **ACE**, Cluster, TIMED, RHESSI, TWINS, Hinode, **STEREO**, THEMIS/ARTEMIS, AIM, CINDI, IBEX, **SDO**, **Van Allen Probes**, IRIS

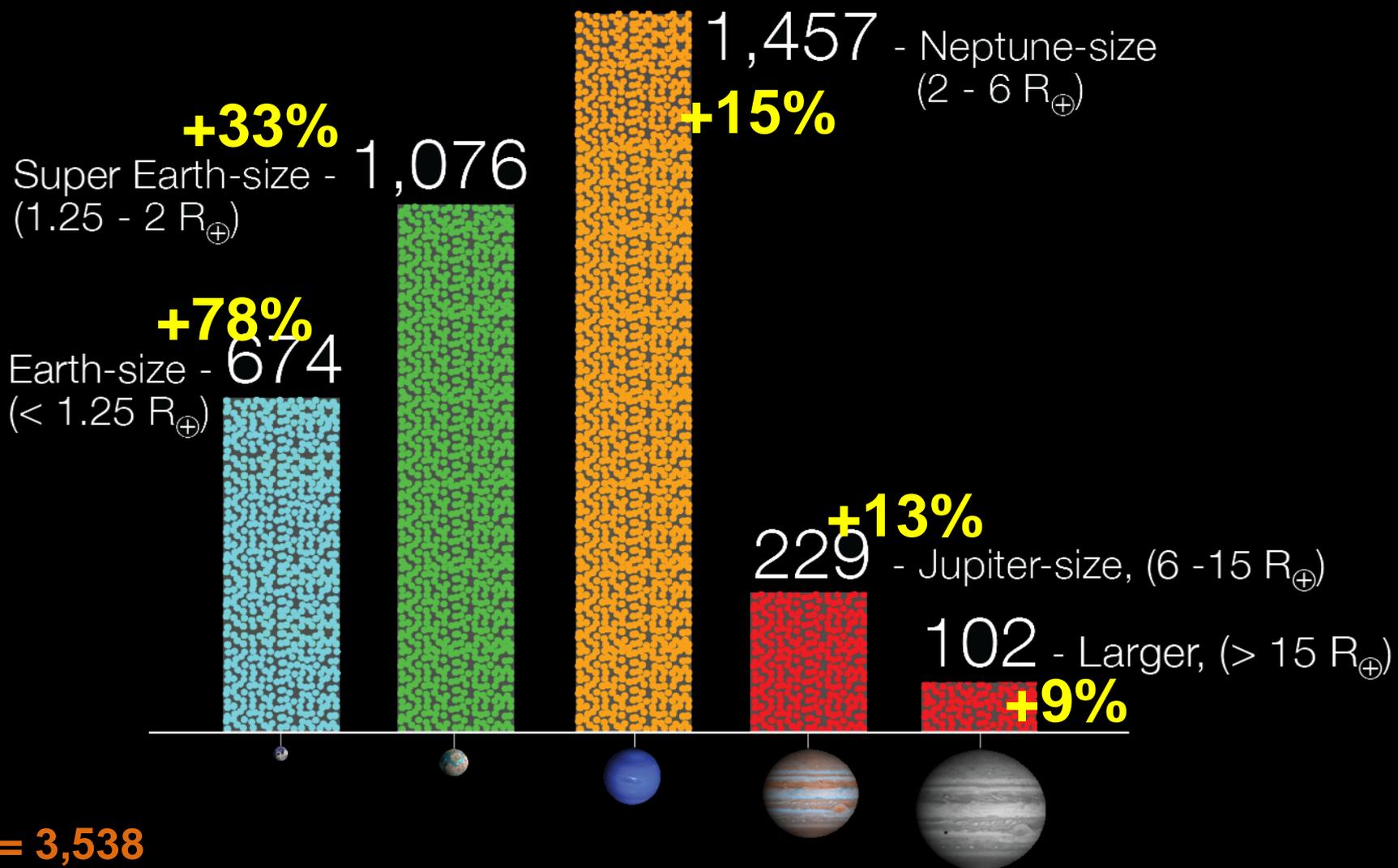
(Missions in **red** contribute to operational Space Weather.)

- 6 missions are in development: SET, MMS, SOC, SPP, ICON, and GOLD

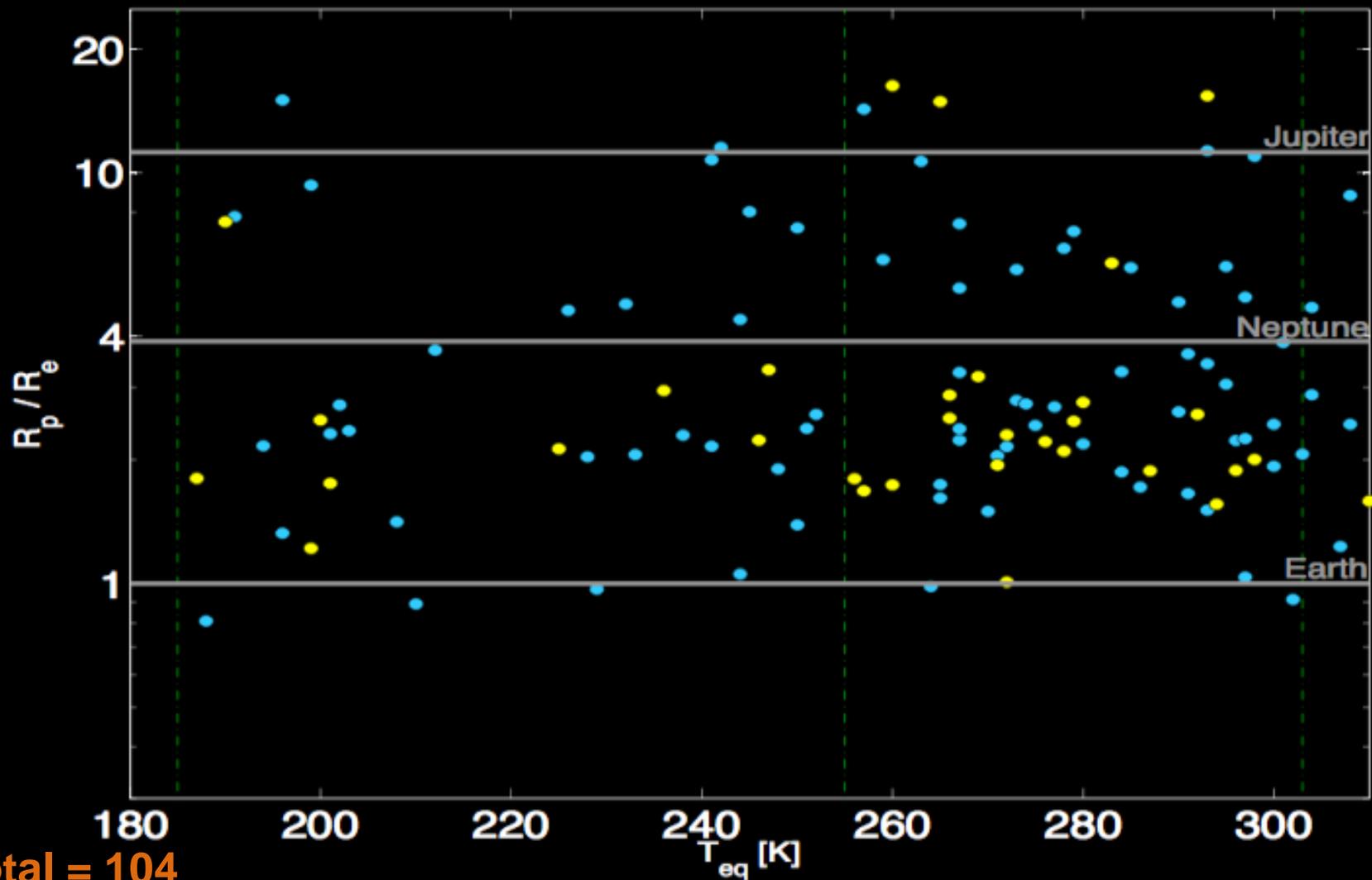
\$5.5B total investment in Heliophysics space assets (excluding launch costs)
\$68M annual operating budget (1.2% per year)



Sizes of Kepler Planet Candidates



Kepler Candidates in Habitable Zone



Total = 104

A night sky over a body of water. A bright meteor streaks across the sky from the upper left towards the center. The sky is filled with stars and a soft glow from a sunset or sunrise on the horizon. The water reflects the colors of the sky and the meteor. In the foreground, there is a small patch of land with some vegetation.

LADEE Launch

WFF Sept. 6, 2013

Lunar Atmosphere and Dust Environment Explorer

Objective:

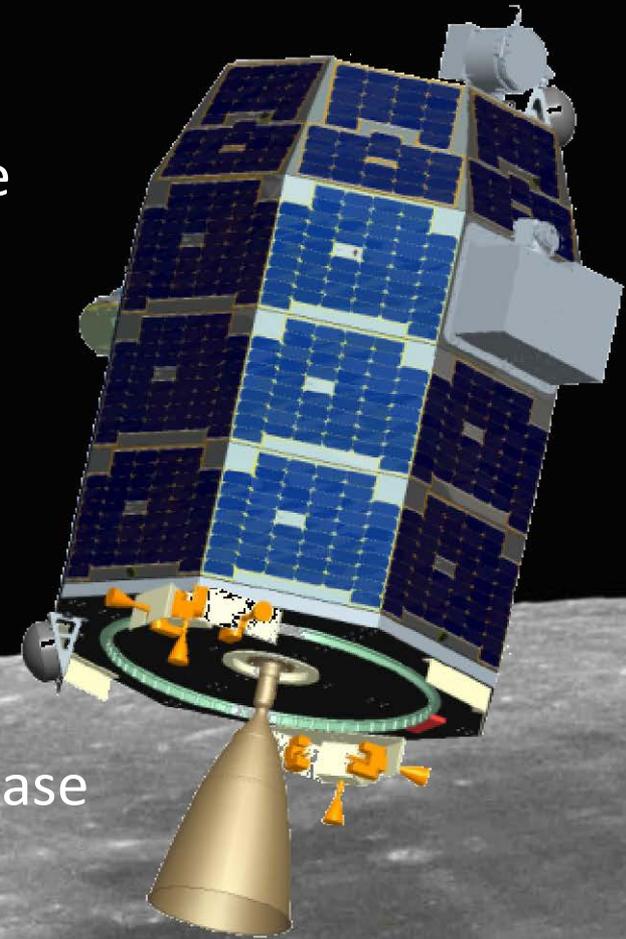
- Measure the lofted Lunar dust
- Composition of the thin Lunar atmosphere

Instruments:

- Science: NMS, UVS, and LDEX
- Technology: Laser Communications

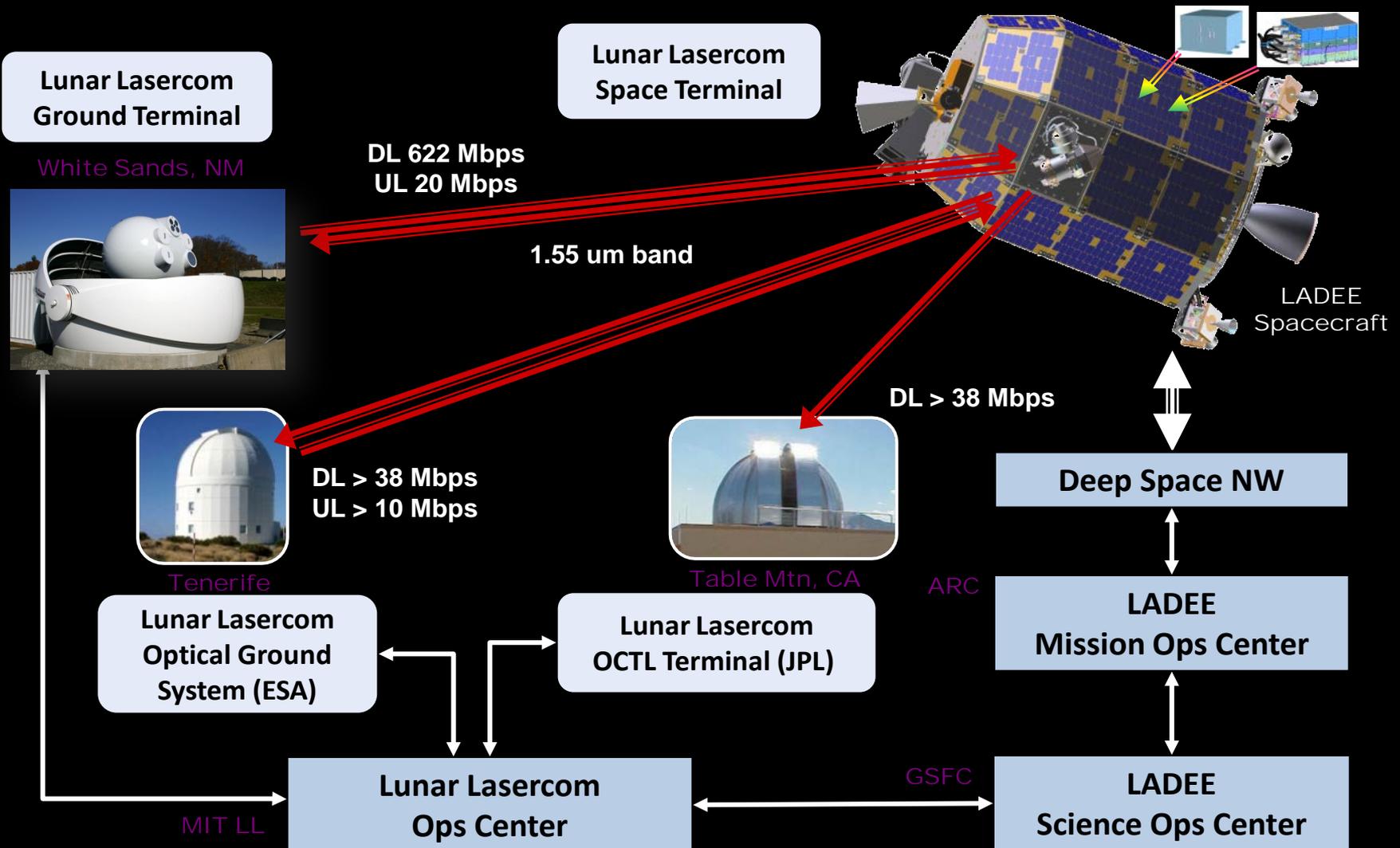
Status:

- Several LLCD “block” tests complete
- Instrument covers off - Commissioning phase has begun





Lunar Laser Communication Demonstration



Seeking Signs of Past Life

CONDUCT RIGOROUS IN-SITU SCIENCE

GEOLOGICALLY DIVERSE SITE

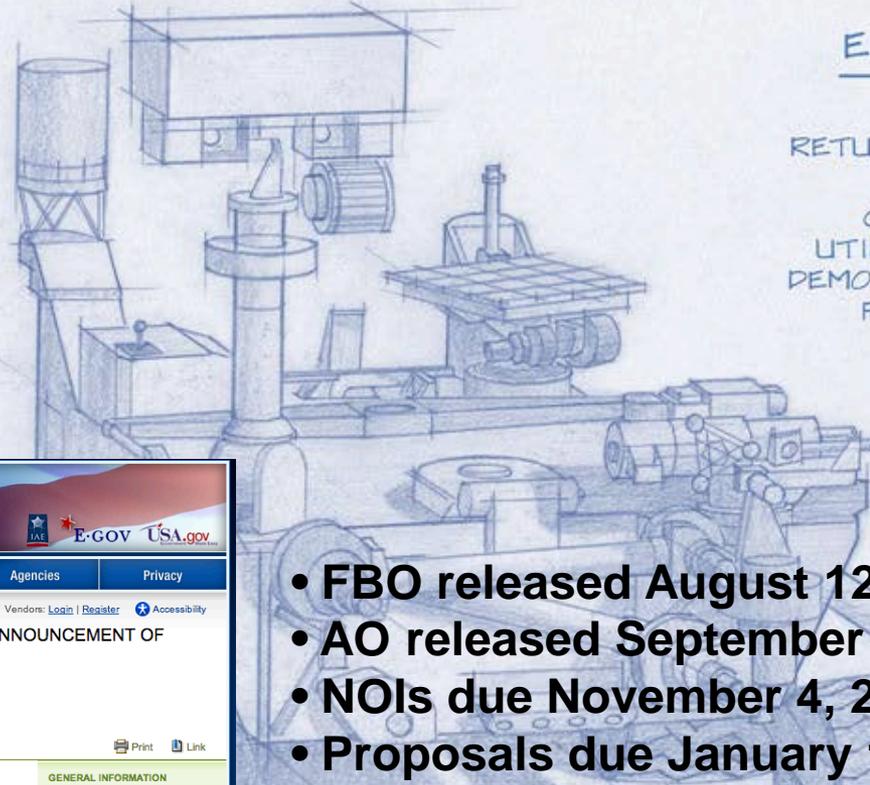
COORDINATED, NESTED
CONTEXT AND FINE-SCALE
MEASUREMENTS

ASTROBIOLOGY

ENABLE THE FUTURE

RETURNABLE CACHE OF SAMPLES

CRITICAL IN-SITU RESOURCE
UTILIZATION AND TECHNOLOGY
DEMONSTRATIONS REQUIRED FOR
FUTURE MARS EXPLORATION



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A--NOTICE OF INTENT TO RELEASE MARS 2020 ANNOUNCEMENT OF OPPORTUNITY
Solicitation Number: NNH13ZDA013J
Agency: National Aeronautics and Space Administration
Office: Headquarters
Location: Office of Procurement (HQ)

Notice Details Packages Interested Vendors List [Print](#) [Link](#)

Original Synopsis
Aug 12, 2013
10:33 am

[Return To Opportunities List](#) [Watch This Opportunity](#)
[Add Me To Interested Vendors](#)

Solicitation Number: NNH13ZDA013J Notice Type: Sources Sought

Synopsis:
Added: Aug 12, 2013 10:33 am
The National Aeronautics and Space Administration (NASA) Science Mission Directorate (SMD) intends to release an Announcement of Opportunity (AO) entitled Mars 2020 Investigations to solicit proposals for investigations for a space flight mission to Mars, to be launched in July/August 2020. The target date for release of the AO is no earlier than (NET) September 16, 2013. Upon release, the full text of the AO and any

GENERAL INFORMATION
Notice Type:
Sources Sought
Posted Date:
August 12, 2013
Response Date:
August 26, 2013
Archiving Policy:
Automatic, on specified date
Archive Date:
August 12, 2014
Original Set Aside:
N/A
Set Aside:
N/A

- FBO released August 12, 2013
- AO released September 24, 2013
- NOIs due November 4, 2013
- Proposals due January 15, 2014

**Mars 2020 will require implementation
of planetary protection controls**

MARS SCIENCE LABORATORY HERITAGE
ROVER AND MODERATE INSTRUMENT SUITE
STAYS WITHIN THE RESOURCE CONSTRAINT

MSL LL Takeaway

From MSL-LL Presentation

- NASA needs to understand scope, complexity and risk of directed/strategic/Flagship missions, preferably by MCR but no later than PDR
 - Incorporate independent non-advocate CATE-like (Cost and Technical Evaluation) review at MCR for directed missions; ensure scope and resources are matched
 - Improve independent review (IR) to enable greater depth of penetration and improved analysis and reporting

Note: SMD treats competed missions with more rigor in early formulation than directed missions.
- Formulation must be adequately funded if Implementation performance is to be improved
- Programs/projects must follow Agency's policies and meet LCR criteria before being allowed to progress to next phase
- Centers/mission directorates need to better oversee their projects. Independent Review is only a check - not a substitute for oversight
- PP needs to be improved to ensure future missions can meet PP req'ts
- Mars 2020 and NASA need to ensure scope and resources match. Heritage is key.
- NASA needs to improve its implementation of lessons learned through following its processes and conducting training and workshops

Mars 2020 and Mars Exploration Program (MEP)

From MSL-LL Presentation

Given NASA's severely constrained budget and increased scrutiny by OMB, GAO and Congressional committees, the Mars 2020/MEP recommendations are extremely important to sustaining NASA's Mars Program.

Key Recommendation Summary:

- SMD should:
 - Implement recommendations of this study for Mars 2020, including unique Mars 2020/MEP recommendations.
 - Fill MEP Program Director position immediately
 - Ensure Mars 2020 meets cost and performance targets. This requires:
 - Maximizing MSL heritage
 - Selecting minimum payload
 - Constraining non-SMD add-ons to those not impacting MSL heritage
- Mars 2020 must be accomplished recognizing it is potentially the 1st of 3 sample return missions
 - Understanding linkages to the full campaign, including site selection, is essential and requires dedicated engineering staffing

Planetary Protection Policy and Requirements

Control interplanetary transfer of viable bio-organisms or spores from one planet to another. Specifically:

- Back
 - Prevent transfer of possibly infectious biological agents to Earth from another planet.
 - Guard against health hazards to humans
 - Safeguard integrity of terrestrial biota
- Forward
 - Protect the biological integrity of planetary environments to allow determination of the presence or absence of extraterrestrial life.
 - Resulting from independent origin?
 - Result of non-anthropogenic transfer?

Optimize Safety

Maximize Science

Planetary Protection Requirements Origins & Implications

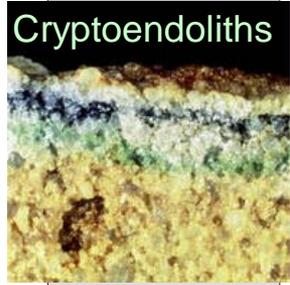
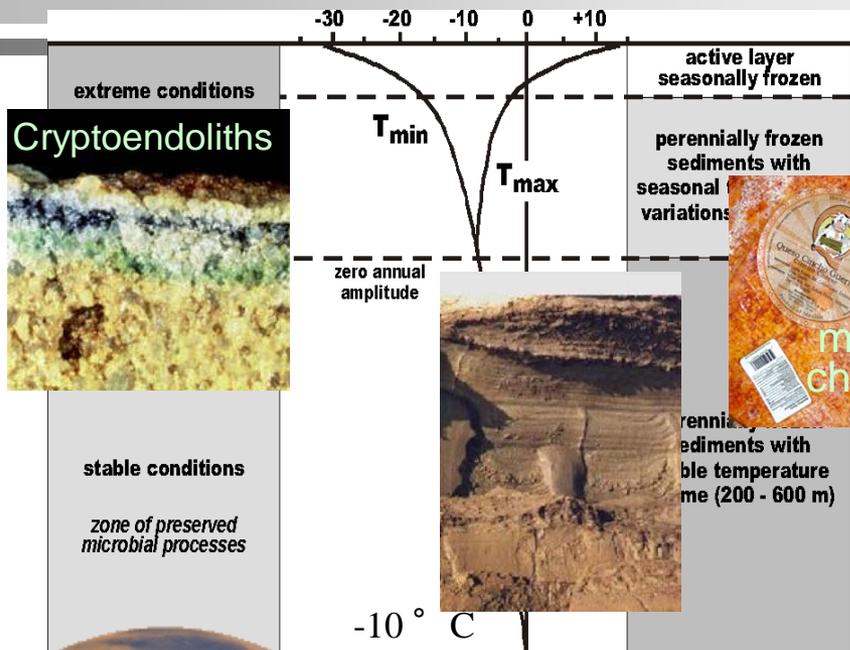
Policies/Requirements are governed by active international agreements

- The PPS does not make up the requirements
 - PPS assesses program adherence to established policy requirements
 - PPS recommends measures needed for adherence to the policy

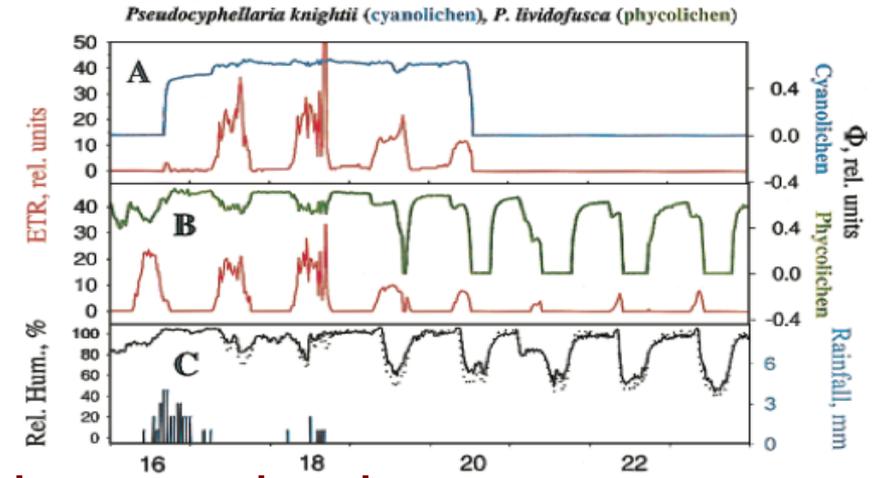
Two broad areas of implication...

- Substantive...
 - Aims at achieving the substantive ends of the policy & agreements
 - Forward contamination risks
 - Back contamination risks
- Public Perception...
 - Public perception of back contamination risks could present existential threat to any interplanetary-return missions ... whether acquiring rocks or returning people

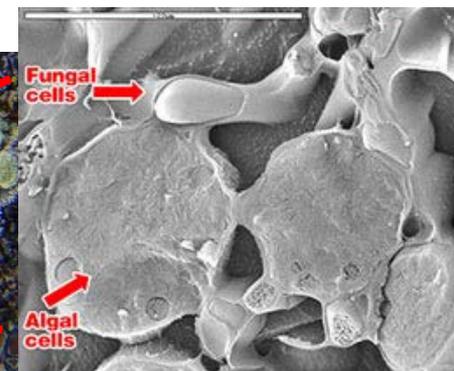
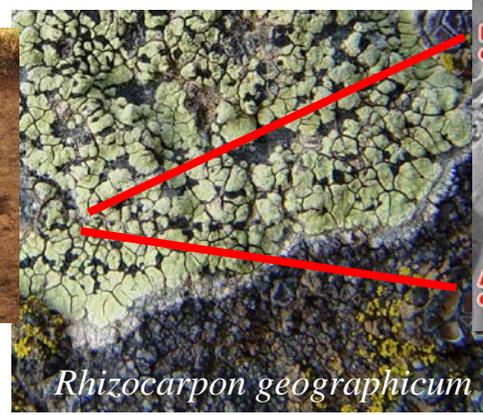
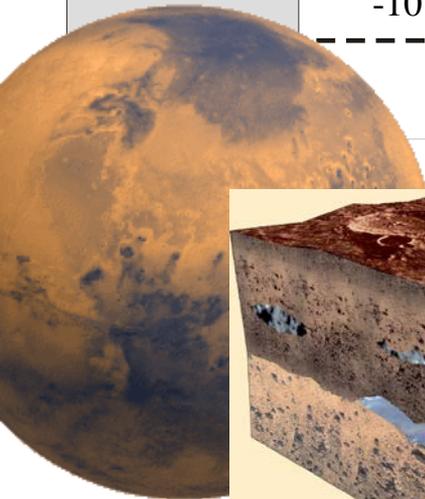
Earth Microbes Surviving Elsewhere?



Lichens absorb 2.5-40 times dry weight of water at 96%RH



photosynthesize



and survive in space

Some pertinent facts...

...uncovered and elaborated in recent decades:

- Life seems to have arisen on Earth very early in terrestrial history
 - Suggests possibility that life (at least microbial life) might not have to climb a very long, very steep hill to eke its way into existence.
- Terrestrial life seems to occur in a much broader range of varieties than once believed
 - Thrives in a much wider range of environments than once thought
 - Increasingly evident that the extent of that range is not yet fully appreciated

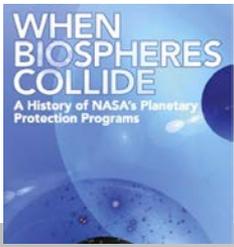
All of this suggests that...

- Life may be more common than . . .
 - Life may exist in more places than . . .
- } **Add impetus to both forward and back planetary protection**

Mars is of special current interest and focus...

...the more we learn, the more arguably confusing things get

- The Martian surface appears not conducive to the presence of life as we think we know it
 - In some respects, the surface seems a self-sterilizing environment
- Situation with the Martian subsurface seems less clear
 - Water may be more widespread than previously believed
 - The distribution of subsurface water and temperatures is largely unknown
 - Weight of what we don't know exceeds weight of what we do know



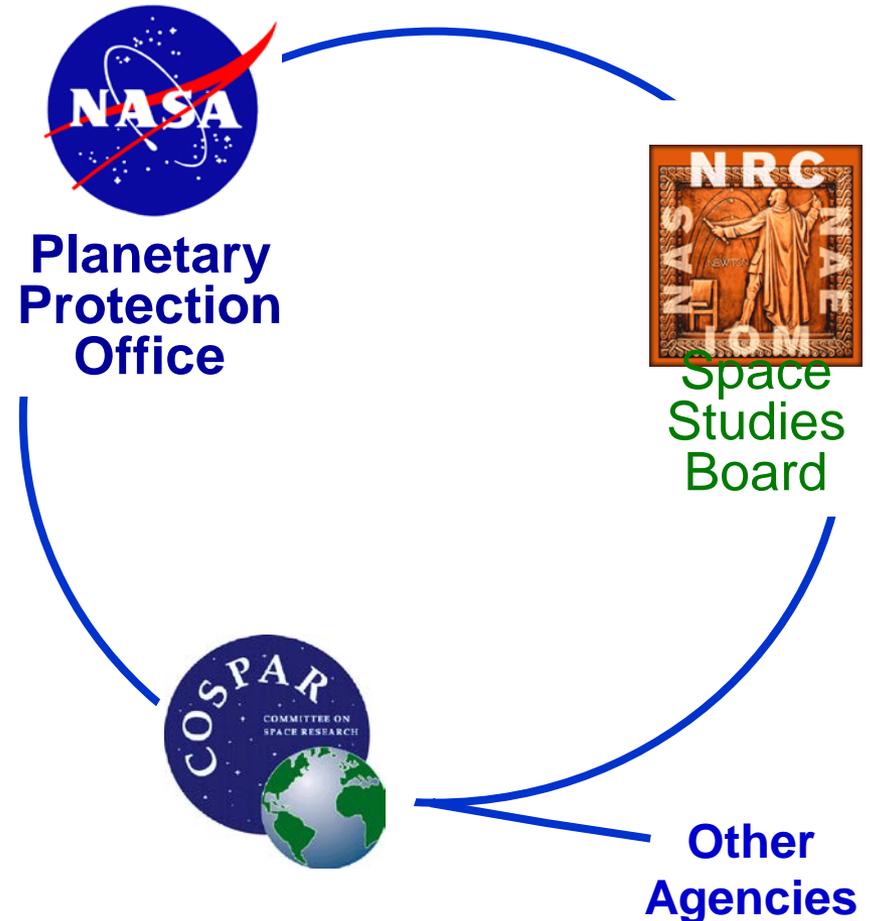
Planetary Protection Framework



NASA follows COSPAR planetary protection policy in accordance with agreement among the parties as to implementation of the Outer Space Treaty

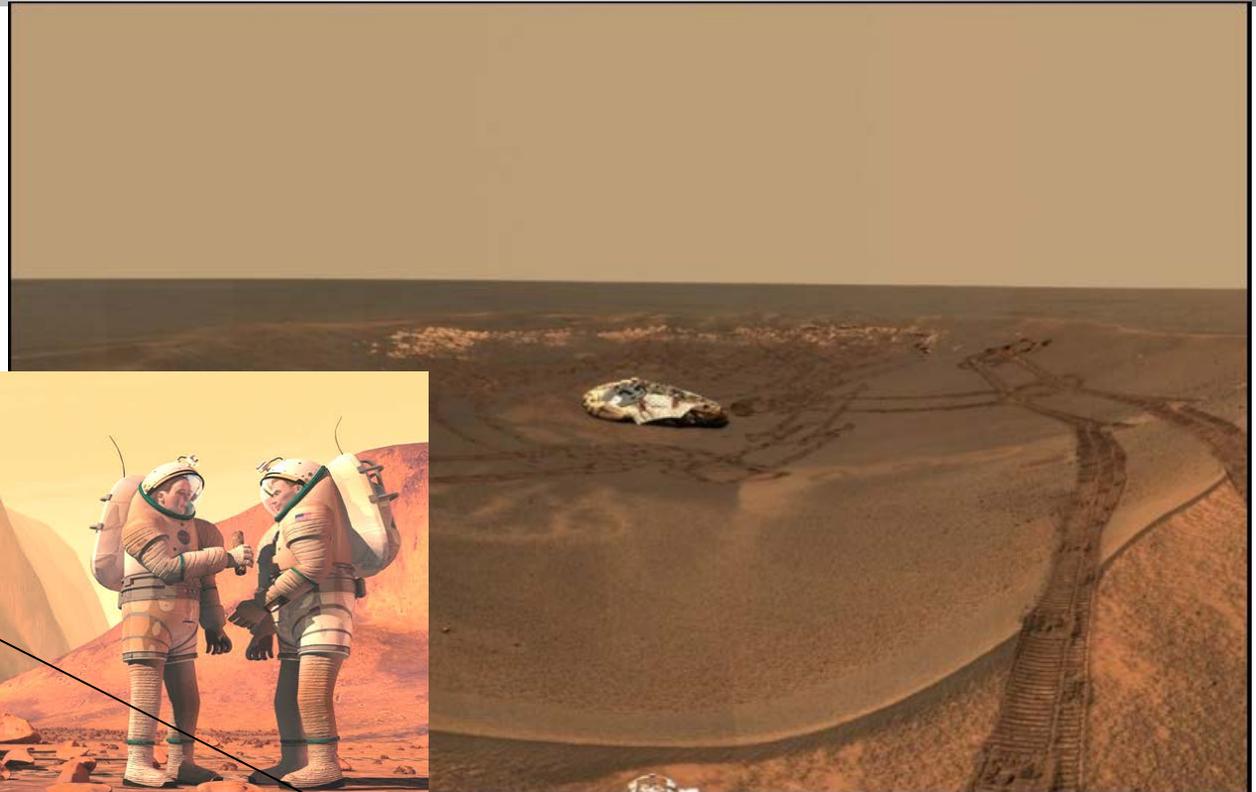
The Planetary Protection Officer, advised by the Planetary Protection Subcommittee, do not make the rules.

They interpret rules set by international agreement, and recommend measures to comply with the international agreement.



Human Missions to Mars

Planetary protection goals remain the same: keep it clean...



But humans will certainly carry microbes to Mars – what do we do when astronauts get sick?

The header features a horizontal strip with several rectangular panels. From left to right, the panels show: a blue and white image of Earth from space, a bright yellow and orange image of a star or nebula, a dark image of a galaxy or nebula, and a colorful image of a nebula or galaxy. The word "Outline" is centered in a large, bold, black font over the middle panels.

Outline

- Science Results
- Programmatic Status
- **Findings & Recommendations**

Recommendation

Short Title: Impact of Travel Restrictions on Science

Recommendation:

The Committee recommends that the NASA interpretation of external guidance on travel restrictions for scientific meetings, conferences and working groups be reconsidered to allow the optimal participation of the scientific community to enhance productivity within the existing highly constrained financial resources.

Recommendation (Cont'd)

Major Reasons for the Recommendation:

Under the current interpretation, travel under NASA contracts, grants, or as NASA employees and contractors has been limited in a way that is highly inefficient and counterproductive for NASA's scientific endeavors. This is compounded by the additional burden of new justification, documentation, tracking and management requirements and their associated costs.

Regular and open communication between scientists is essential for healthy and productive research. Although electronic and virtual means of communication play an increasing role in interacting with colleagues and can accommodate much routine project activity, they cannot replace face-to-face interactions. Specific examples include the much-valued give-and-take of vibrant (sometimes heated) discussions, insight derived from multiple ideas being discussed spontaneously, informal (often unplanned) interactions and brainstorming that occurs before or after a presentation. These person-to-person contacts are extremely cost-effective and are key components in productive scientific interactions.

Consequences of No Action on the Recommendation:

NASA will spend more money on less science by running the program in a way that is inefficient for scientific discovery and progress.

Recommendation

Short Title: Education and Public Outreach funding

Recommendation:

The Committee recommends NASA restore the original Education and Public Outreach funding to all SMD programs.

Major Reasons for the Recommendation:

SMD's Education and Public Outreach (E/PO) efforts have been critical to the national interest and have proved to be effective in communicating science and inspiring and educating the public. The E/PO funding situation remains ambiguous. Budgetary authority was removed from all of the NASA E/PO programs, but because of the continuing resolution, SMD was able to authorize a small fraction of its E/PO programs to continue. Restoration by NASA across all SMD E/PO programs is needed to fulfill NASA's vibrant and highly effective mission of education and public outreach.

Consequences of No Action on the Recommendation:

The nation is already losing a critical and inspirational opportunity for involving our citizens in science. NASA has previously trained a capable E/PO workforce directly involved in NASA's missions that is already being lost. This incredible capability, developed over more than a decade, will disappear in a much shorter amount of time.

Recommendation

Short Title: Reporting Line of the Planetary Protection Office

Recommendation:

The Science Committee recommends that the Planetary Protection Office be moved so as to be out of any mission directorate and located with a reporting line that assures the PPO's independence and freedom from conflict of interest.

Recommendation (Cont'd)

Major Reasons for the Recommendation:

The Mars Science Laboratory (MSL) Lessons-Learned Report specifically recommended reconsideration of *“the current organizational arrangement for the PPO to ensure that Planetary Protection is fully independent of any operational division. In addition the PPO role should be re-examined in light of PPO's expanding role, to include human exploration and cross-mission trades for sample return.”* While Planetary Protection is strongly rooted in science, the PP function entails broader responsibilities, including responsibilities of a regulatory nature and involving compliance with international treaties and agreements to which NASA is a party. Furthermore, the Space Studies Board, long anticipating the MSL Lessons-Learned Report, has repeatedly advised NASA that it must ensure the integrity and independence of the Planetary Protection Office and advisory bodies as separate from the science side of the Agency (NRC 1992, 1997, 2002).

- NRC 1992, Biological Contamination of Mars: Issues and Recommendations, National Academy Press
- NRC 1997, Mars Sample Return: Issues and Recommendations, National Academy Press
- NRC 2002, The Quarantine and Certification of Martian Samples, National Academy Press

Consequences of No Action on the Recommendation:

The conflicts of interest – real and perceived – between Planetary Protection and the science and exploration programs, and the lack of independence, can dilute the force and credibility of NASA's planetary protection implementation, thus reducing the effectiveness and cost effectiveness with which planetary protection is incorporated into missions, and potentially undermining public confidence.