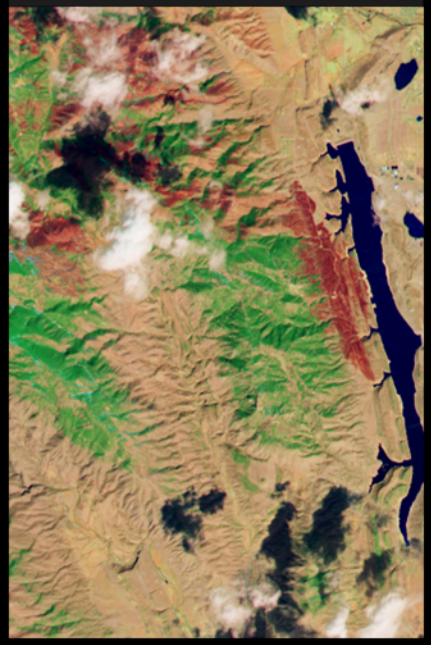
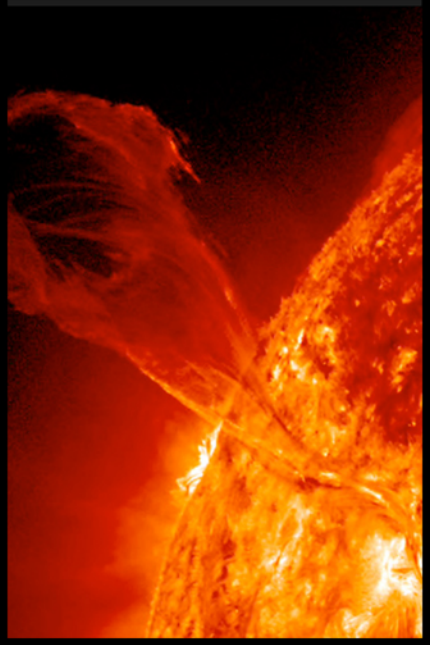
National Aeronautics and Space Administration



EARTH SCIENCE



HELIOPHYSICS

PLANETARY SCIENCE

ASTROPHYSICS

NAC SCIENCE COMMITTEE REPORT

Dave McComas, Chair

31 July 2013

Science Committee Members

Dave McComas, Southwest Research Institute, Chair

Byron Tapley, (Vice Chair) University Texas-Austin, Chair of Earth Science
Maura Hagan, NCAR, Chair of Heliophysics
Gene Levy, Rice University, Chair of Planetary Protection
Janet Luhmann, UC Berkeley, Chair of Planetary Science
Brad Peterson, Ohio State, Chair of Astrophysics

Noel Hinners, Independent Consultant
Eugenia Kalnay, University of Maryland
Carle Pieters, Brown University
Mark Robinson, Arizona State University (new member)
Meg Urry, Yale University

Charlie Kennel, Chair of Space Studies Board (*ex officio* member)

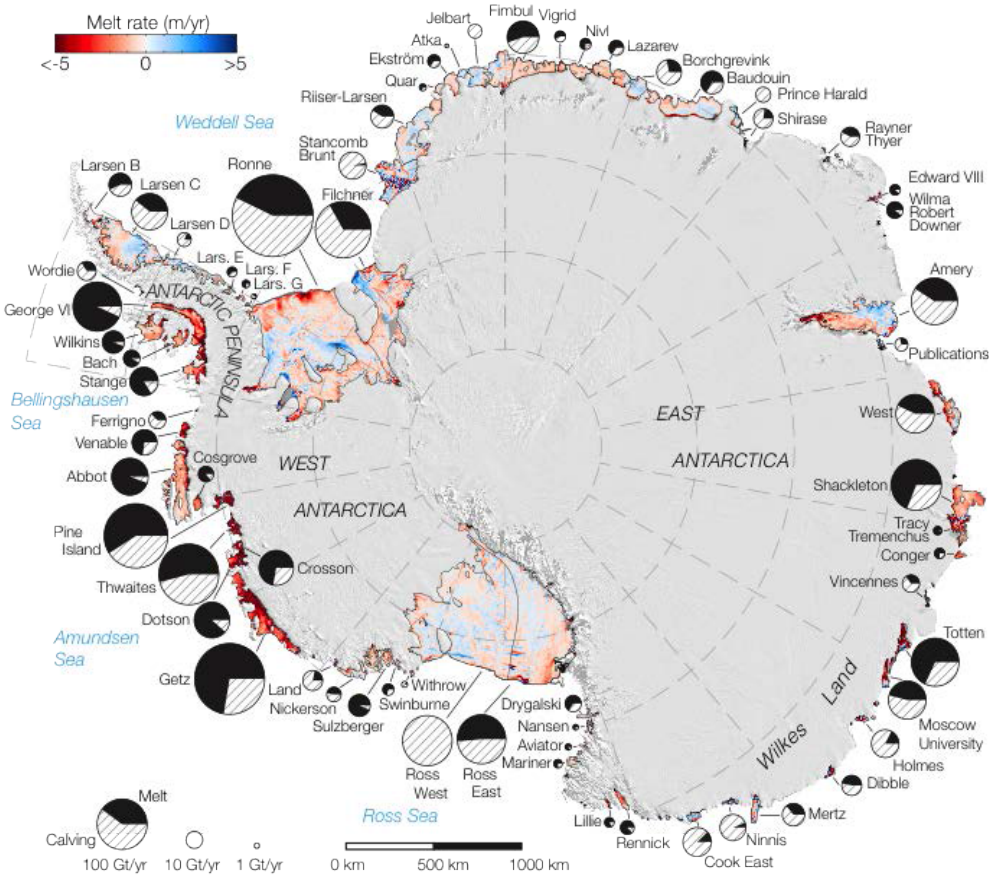
Outline

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

Ice Shelf Melting Around Antarctica

Rignot et al. (2013), Science, doi: 10.1126/science.1235798

- As dynamic features that control the flow of ice from the interior, understanding changes in ice shelves is critical to determining Antarctica's contribution to current and future sea level rise.
- NASA-funded scientists used ice thickness and altimetry data—from **Operation IceBridge**, ground-based radar echo sounding, and interferometric SAR (inSAR) satellite data—along with reconstructions of surface accumulation to complete a comprehensive survey of Antarctic ice shelves.
- They discovered that ***ice shelves lose the most mass to melting as opposed to calving***, which had traditionally been thought to be the far-dominant mechanism for ice removal. Overall, they estimated the basal melt rate to be 1325 +/- 235 Gt/yr, compared to an iceberg calving flux of 1089 +/- 139 Gt/yr.

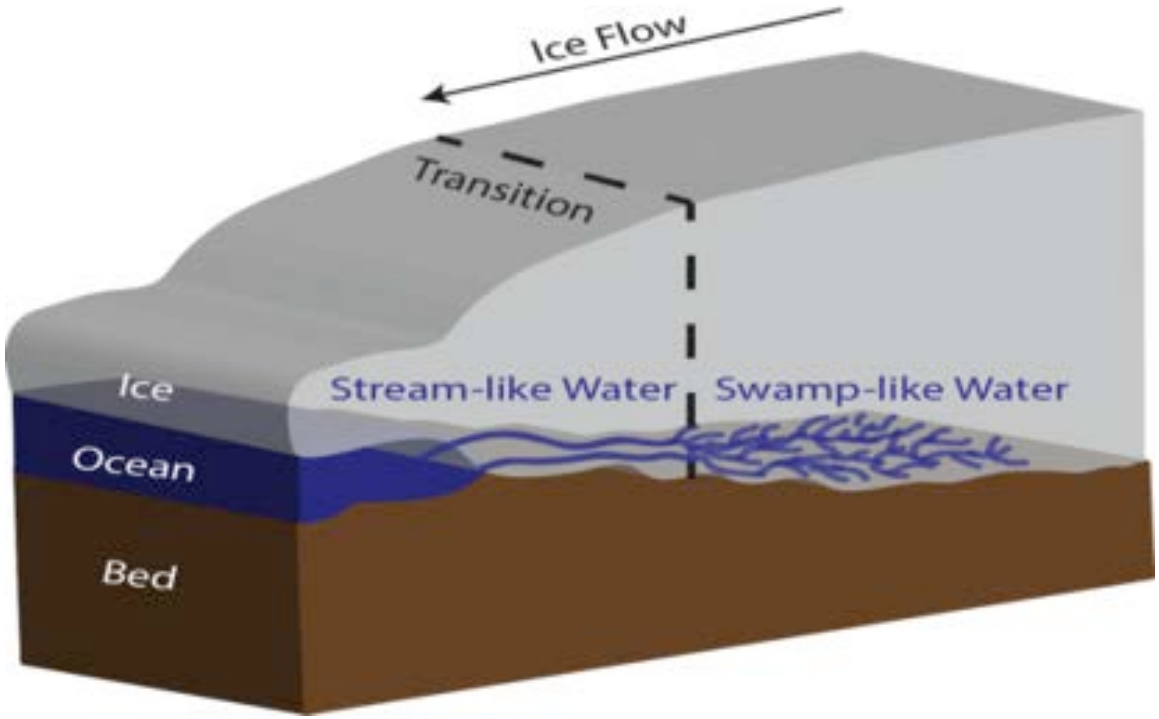


Basal melt rates of Antarctic ice shelves color coded from < –5 m/year (freezing) to > +5 m/year (melting) and overlaid on a 2009 MODIS mosaic of Antarctica. Ice-shelf perimeters in 2007–2008, excluding ice rises and ice islands, are thin black lines. Each circle graph is proportional in area to the mass loss from each shelf, in gigatons (1 Gt = 1012 kg) per yr, partitioned between iceberg calving (hatch fill) and basal melting (black fill).

Evidence for a Water System Transition Beneath Thwaites Glacier, West Antarctica

Schroeder et al. (2013), Proc. National Academy of Science, doi: 10.1073/pnas.1302828110

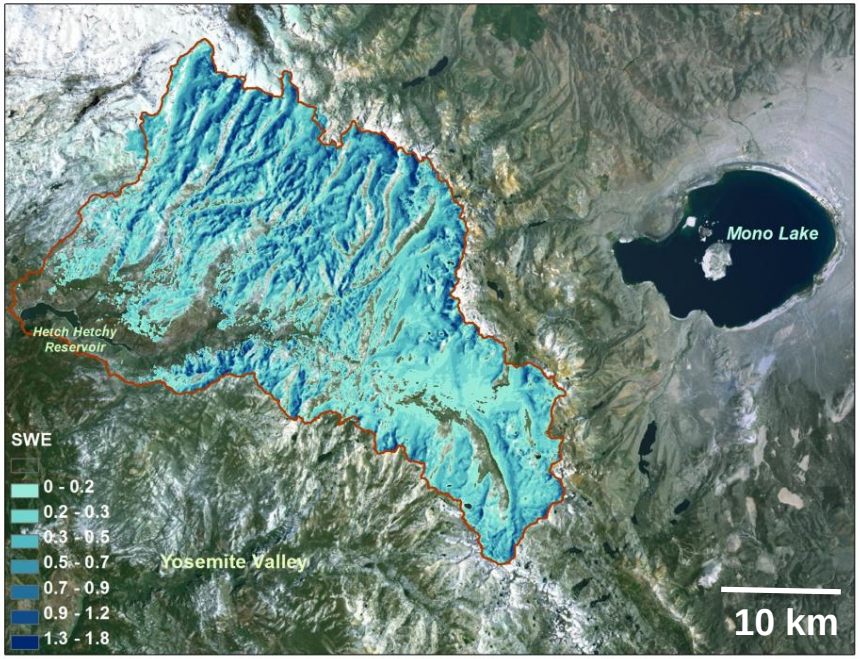
- Thwaites Glacier is one of the largest, most rapidly changing glaciers on Earth. It is a critical gateway to W. Antarctica's ice with great potential to raise sea level.
- Previous studies used the amplitude of ice-penetrating radar reflections to characterize subglacial water, but ice temperature complicates this approach. This new method overcomes that problem using the angular distribution of the reflections (specularity).
- They discovered that water is held in a swampy canal system—several times the size of Florida Everglades—beneath the deep interior of the ice sheet, transitioning downstream to channels.
- **The channel zone offers greater friction to flowing ice, slowing it down, and causing it to thicken. If this area is undermined by warming ocean waters or other hydrologic changes, it could lead to ice sheet collapse and rapid sea level rise.**

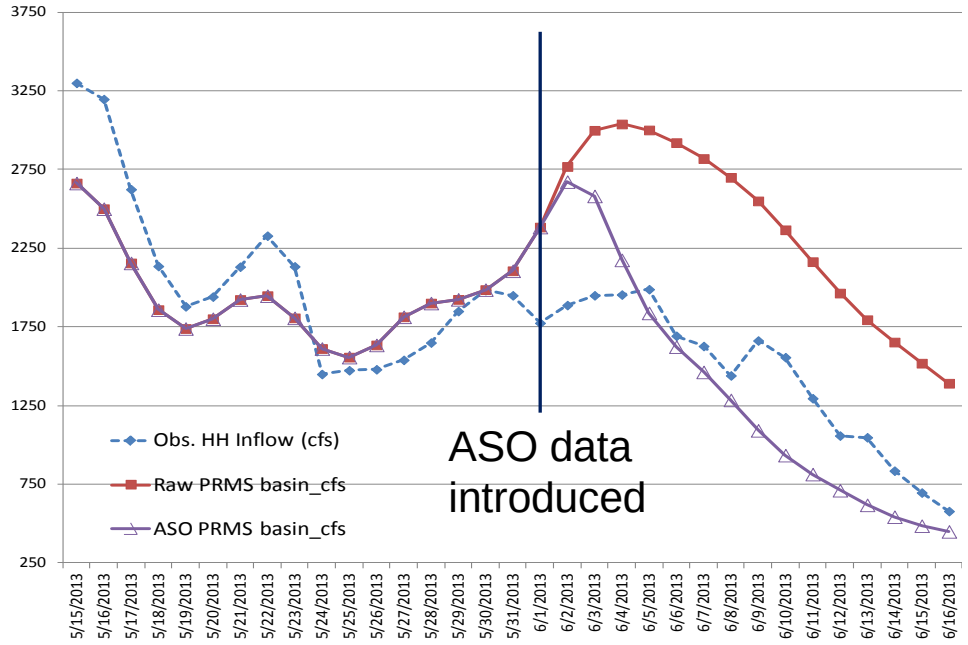


Schematic representation of the Thwaites Glacier system, showing the subglacial transition from swamp-like, distributed canals to more concentrated stream-like channels, as the ice flows from the ice sheet interior to the ocean

NASA co-funded this study with NSF

Improved Estimates for Water Management in California

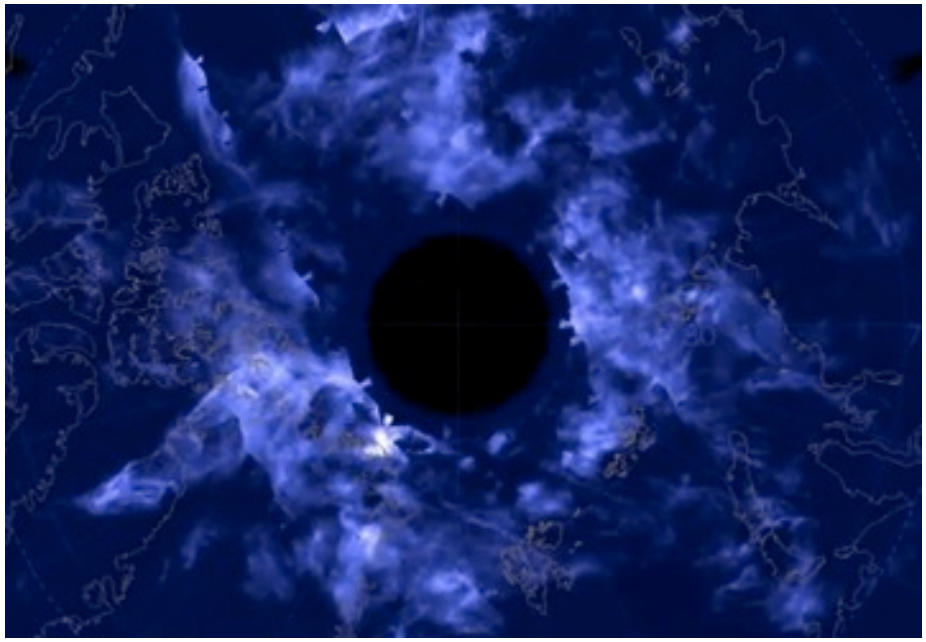




The California Dept. of Water Resources (DWR) prediction of water inflow into the Hetch Hetchy Reservoir in thousand acre feet (shown in red) was modified on June 1, 2013 based on snow water equivalent (SWE) data from the NASA/JPL Airborne Snow Observatory. The new forecast (shown in purple) provided a factor of 2 better estimate of the actual inflow (shown in blue) and enabled water managers to optimize reservoir operations.

Tom Painter, JPL

Noctilucent Clouds (NLC)



- The NH 2013 NLC season started on May 13, a week earlier than any other season observed by the AIM satellite.
- The early start is puzzling…
  - NLC occurrence is anti-correlated with the solar cycle.
  - strong SH stratospheric winds are altering global circulation.

- Two CHAMPS (Charge and Mass of Meteoric Smoke Particles) sounding rockets launched on Oct. 13, 2011 from the Andoya measured the number density and size of meteoric dust particles, which are the seeds for NLCs – the clouds that shine brightly over the summer poles at night.

Heliophysics IBEX Spacecraft Provides First View of Solar System's Tail

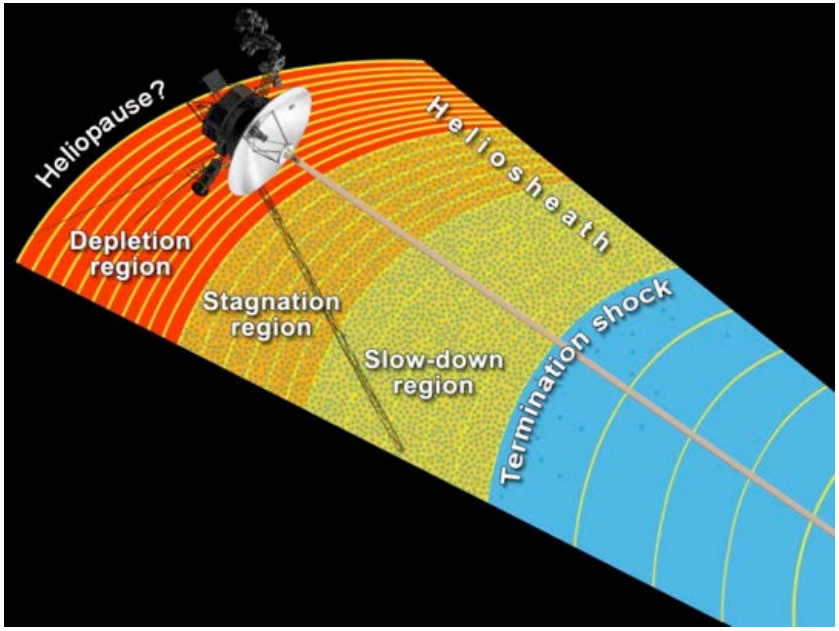
Above: Artist concept of the heliosphere's tail recently detected by the IBEX spacecraft. By combining observations from the first three years of IBEX data, scientists have mapped out a tail that shows a combination of fast and slow moving particles. Credit: NASA.

- Like a comet, the solar system has a tail. NASA's Heliophysics Interstellar Boundary Explorer (IBEX) has for the first time mapped out the structure of this tail, which is shaped like a four-leaf clover.

- Scientists described the tail, called the heliotail, based on the first three years of IBEX observations in a paper published in the July 10 edition of the Astrophysical Journal.

Voyager 1 Explores the Final Frontier of Our Heliosphere

Voyager 1, now more than 11 billion miles from the sun, is closer to becoming the first human-made object to reach interstellar space.



Transitional Regions at the Heliosphere's Outer Limits: This artist's concept shows NASA's Voyager 1 spacecraft exploring a region called the "depletion region" or "magnetic highway" at the outer limits of our heliosphere, the bubble the sun blows around itself. Credit: NASA/JPL

- Research using Voyager 1 data and published in the journal Science on June 27, 2013 provides new details on the last region the spacecraft will cross before it leaves the heliosphere, or the bubble around our sun, and enters interstellar space.
  - Three papers describe how Voyager 1's entry into a region called the magnetic highway resulted in simultaneous observations of the highest rate so far of charged particles from outside heliosphere and the disappearance of charged particles from inside the heliosphere.

- Scientists have seen two of the three signs of interstellar arrival they expected to see: charged particles disappearing as they zoom out along the solar magnetic field, and cosmic rays from far outside zooming in.

- Scientists have not yet seen the third sign, an abrupt change in the direction of the magnetic field, which would indicate the presence of the interstellar magnetic field.

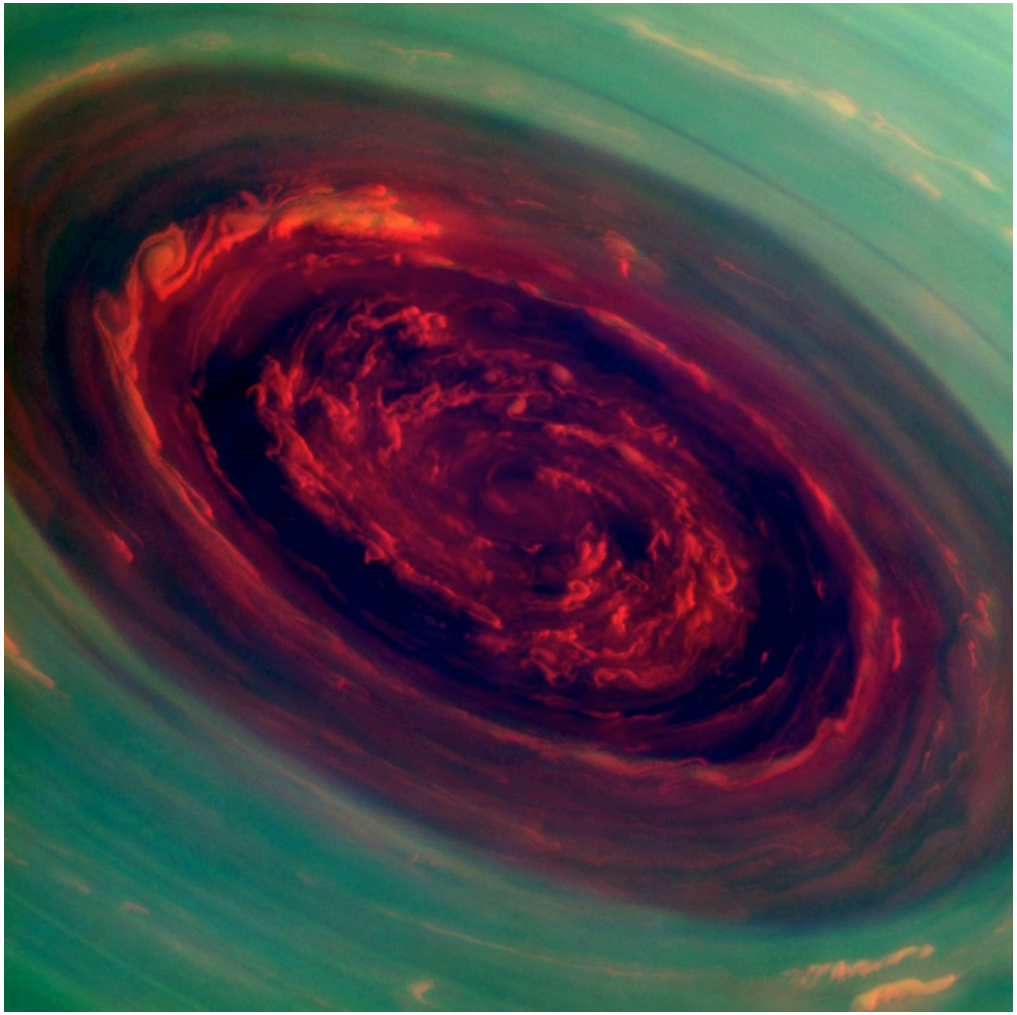
Eye Spied: Saturn's Behemoth Polar Hurricane

Stunning new views from NASA's *Cassini* spacecraft reveal the eye of the enormous hurricane locked in place at Saturn's north pole.

•The new views of Saturn's polar areas, the first in visible light, are possible due to recent changes made in Cassini's orbital path when Saturn's north pole is illuminated by sunlight.

•The eye of the storm, about 1,250 miles wide, would stretch the distance between Washington DC and Tulsa Okla. The wind in the storm's eyewall blows more than four times the 73 mph of a hurricane force wind on Earth.

• Learning how these Saturnian storms use the water vapor that is available to them could tell scientists more about how all hurricanes are generated and sustained.

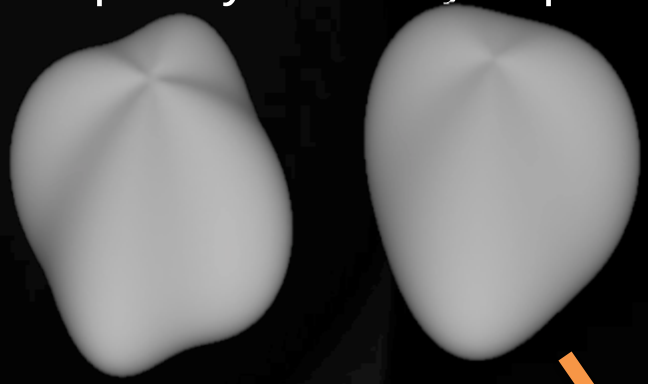


In this false color image, the red indicates deep clouds, while green shows clouds that are higher in altitudes. The Sun is to the right in this image.

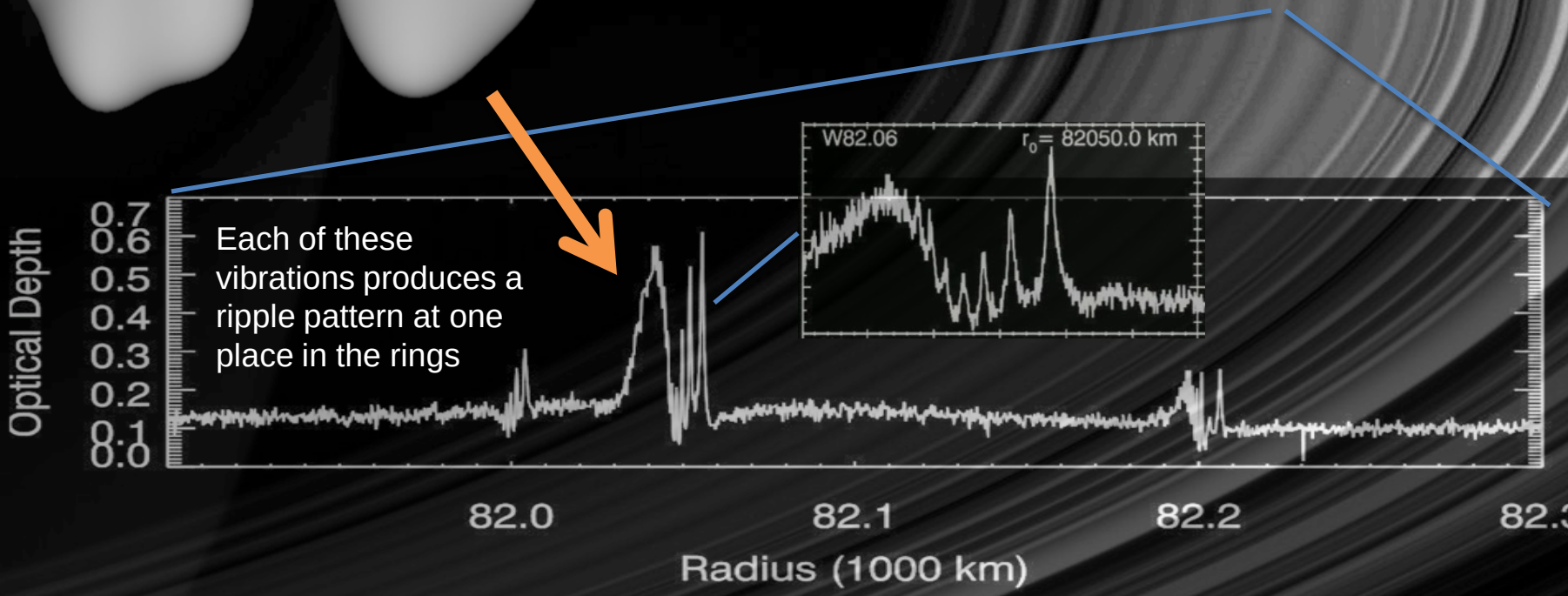
A. Ingersoll et al.

A Seismograph as Big as Saturn's Rings

Cassini scientists have discovered that Saturn's rings act as a seismograph that records large-scale oscillations, probably emanating from deep within the planet, that "ring" Saturn like a bell. In the same way that helioseismology tells us about activity inside the sun, "Kronoseismology" provides a completely new way to probe structure and activity in Saturn's interior.

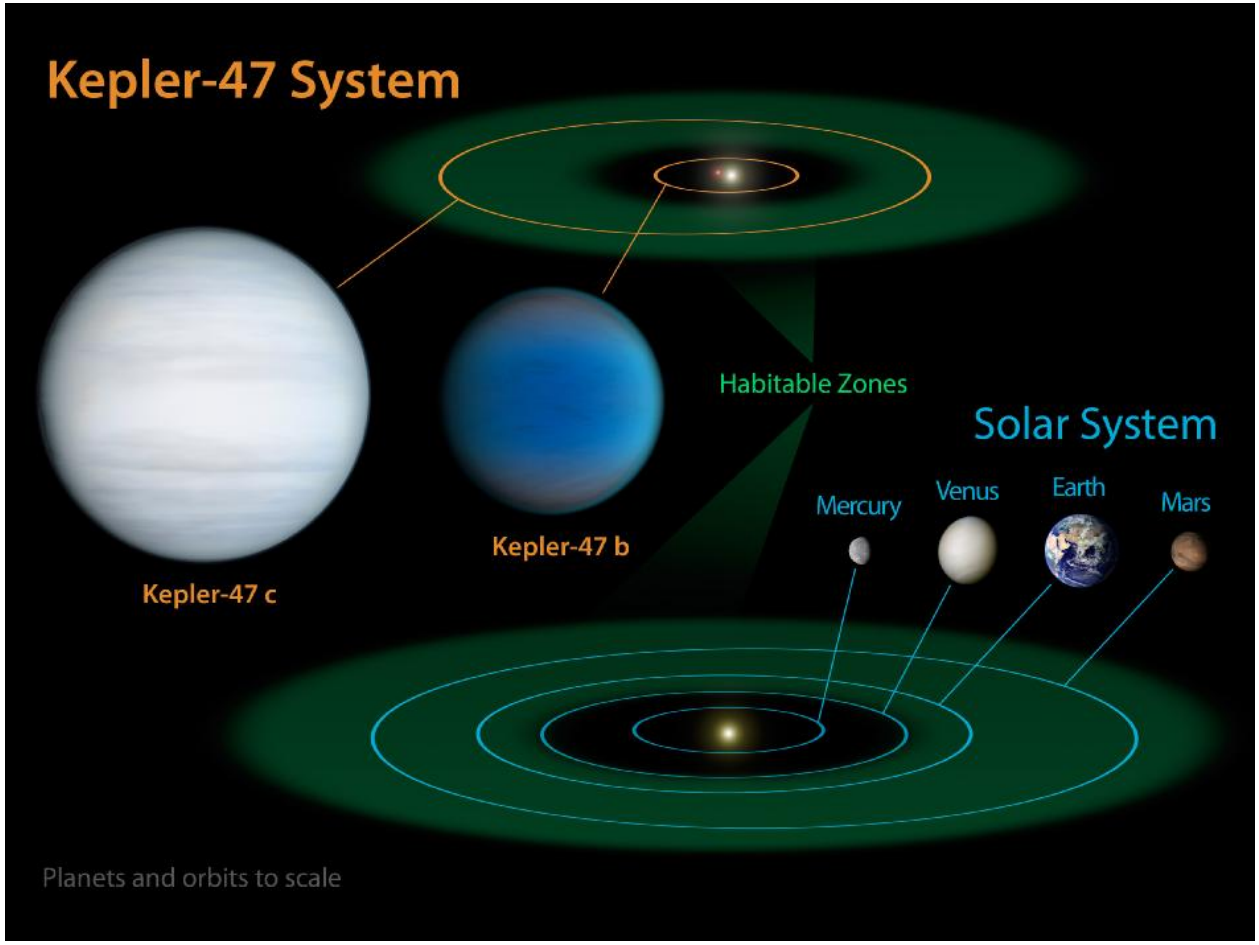


These oscillations distort Saturn's shape in distinctive ways (highly exaggerated here)



* Kronoseismology: Using Density Waves in Saturn's C Ring to Probe the Planet's Interior, M.M. Hedman and P.D. Nicholson, CRSR, Cornell University *Astrophysical Journal*

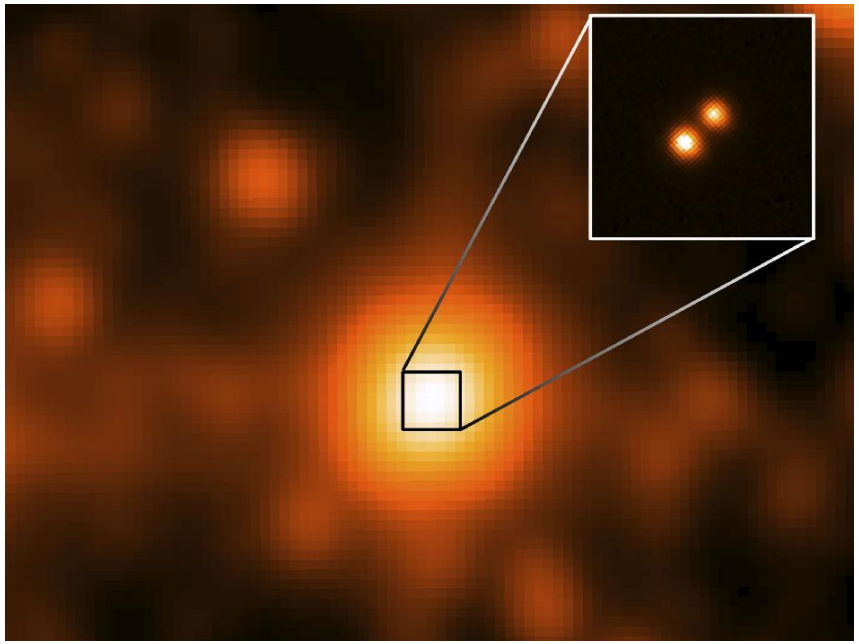
Kepler Identifies Exoplanets



- Kepler-47 is an interesting case of multiple planets orbiting a binary star system. A Neptune-size planet is in the "habitable zone" (where water can exist in liquid form).

Wide-field Infrared Survey Explorer Discovers Nearest Planetary System in a Century

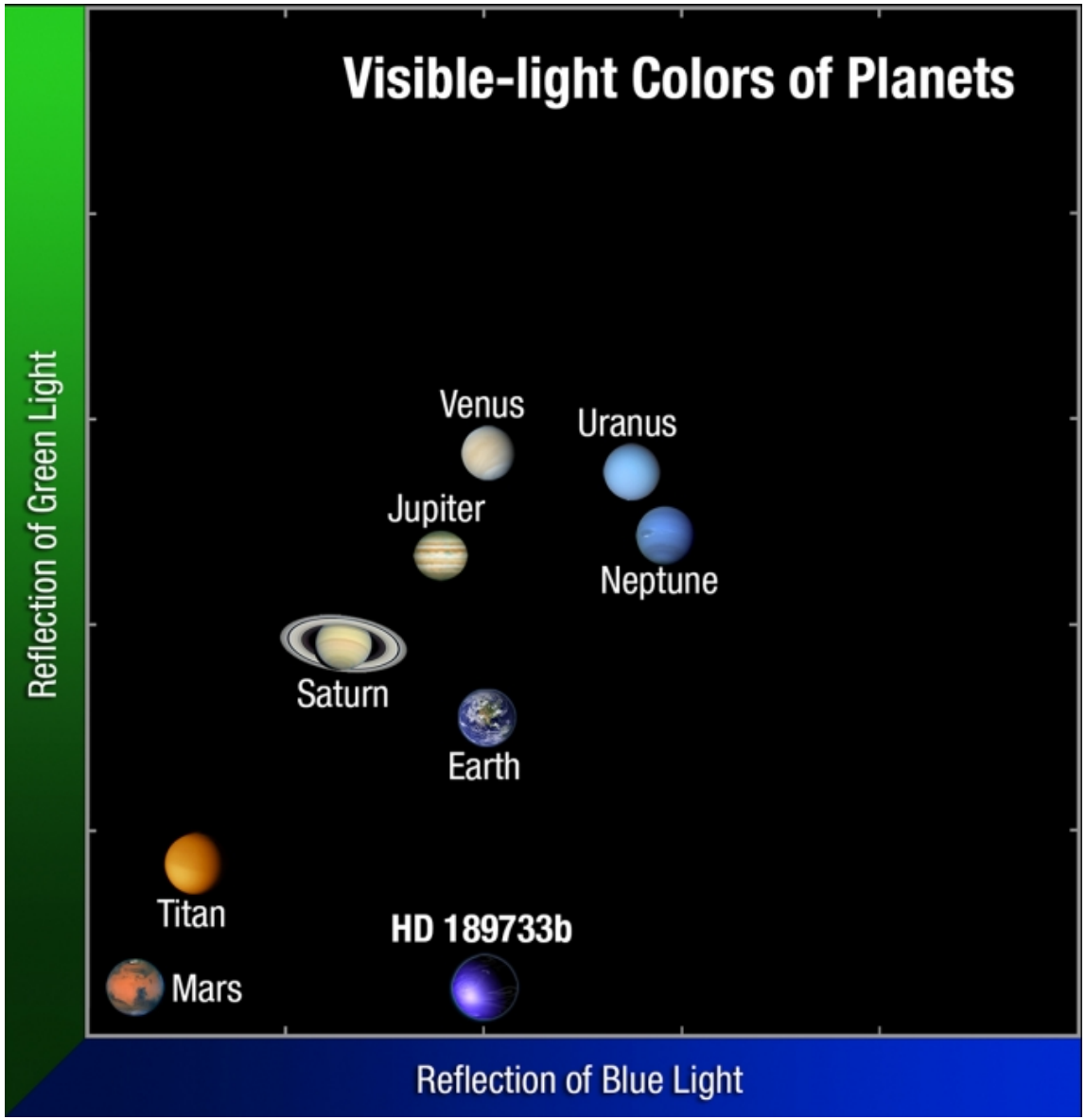
- Pair of brown dwarf stars missed even though they are the third closest system to the Sun
- Second closest system was discovered in 1916, a century ago
- Both so cold that they emit almost no radiation at visible and near IR wavelengths.
- WISE, with follow-up with ground-based Gemini (inset), found a system of “brown dwarfs” (substellar mass objects) that is the third closest system to the Earth.



Hubble Obtains Deepest Image Ever

- The Hubble eXtreme Deep Field (XDF), a million-second series of images, is the deepest ever, detecting galaxies that were formed when the universe was less than 4% its current age.

Hubble Finds a True Blue Planet



This plot compares the colors of planets in our solar system to exoplanet HD 189733b. The exo-planet's deep blue color may be produced by silicate droplets, which scatter blue light in its atmosphere.

Outline

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

Technology Highlight:
First Flight for GEO-TASO Trace Gas and Aerosol Instrument

The airborne Geostationary Trace gas and Aerosol Sensor Optimization (GEO-TASO) instrument conducted the first of several test flights on July 16, on board the NASA HU-25C Falcon.

GEO-TASO, a nadir-viewing UV-Vis spectrometer, measures aerosols and trace gases like ozone and formaldehyde.

Originally conceived to demonstrate the air quality measurements called for by the GEO-CAPE decadal survey mission concept, GEO-TASO is now also a precursor test-bed for the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument, the first Earth Venture Instrument (EV-I) mission awarded by NASA.

Additional GEO-TASO flights are taking place through July. Data collection flights planned for September in conjunction with DISCOVER-AQ

Tom Delker (left) and Jeremy Craner (right) from Ball Aerospace with NASA Langley's Les Kagey (center), installing the GEO-TASO instrument on the NASA Falcon. (Image Credit: NASA/David C. Bowman)

'Quick look' data with an RGB image of the visible spectrometer channel on the left and the context camera image on the right, with a full 45 degree field of view.

SARP 2013 Science flights on the DC-8 (June 17-19)

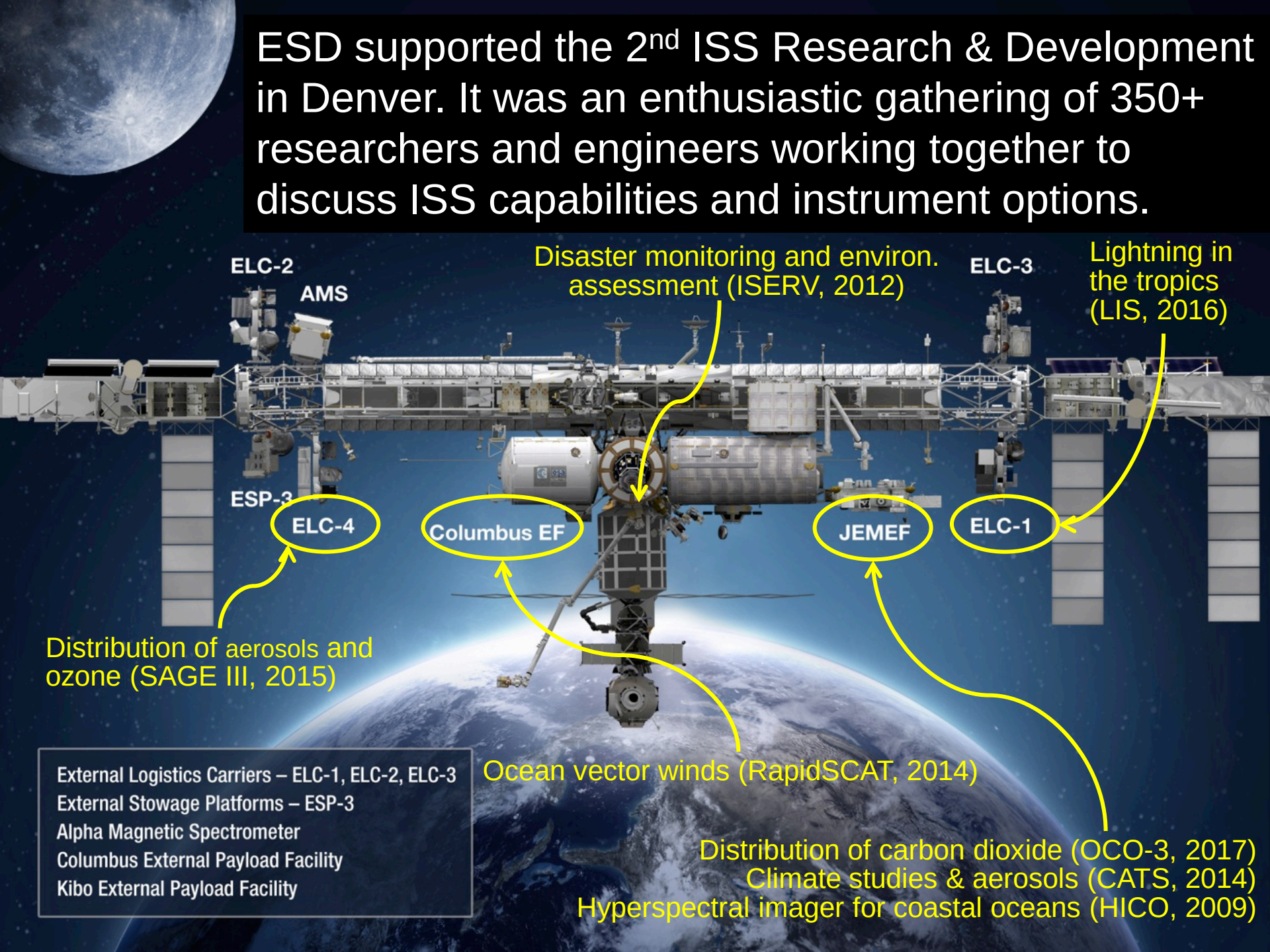
SARP students receiving briefing on DC-8 airborne science operations

Tyra Brown (Millersville University of Pennsylvania meteorology major) & Sean Freeman (Florida State meteorology major) at the University of Houston Air Quality instrument reviewing data

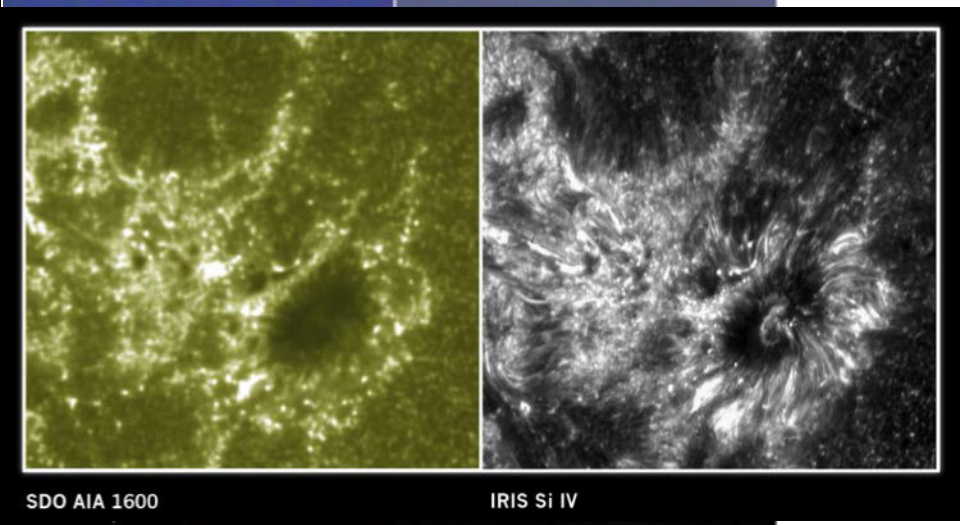
Samuel Whiteley (UCSD physics major) & Jennifer Mouthino (Worcester Polytechnic Institute chemical eng. major) collect air samples with Whole Air Sampler while mentor Josette Marrero (UCI) looks on

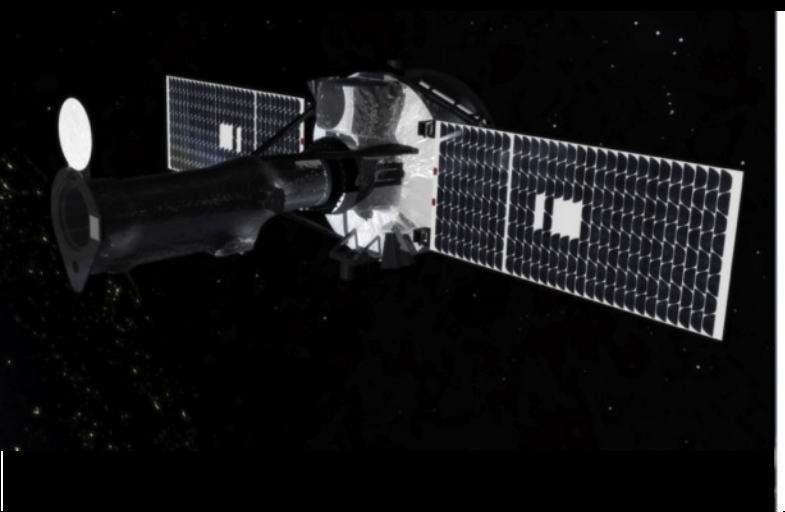
For more SARP pictures please visit http://facebook.com/nasasarp

ESD supported the 2nd ISS Research & Development in Denver. It was an enthusiastic gathering of 350+ researchers and engineers working together to discuss ISS capabilities and instrument options.



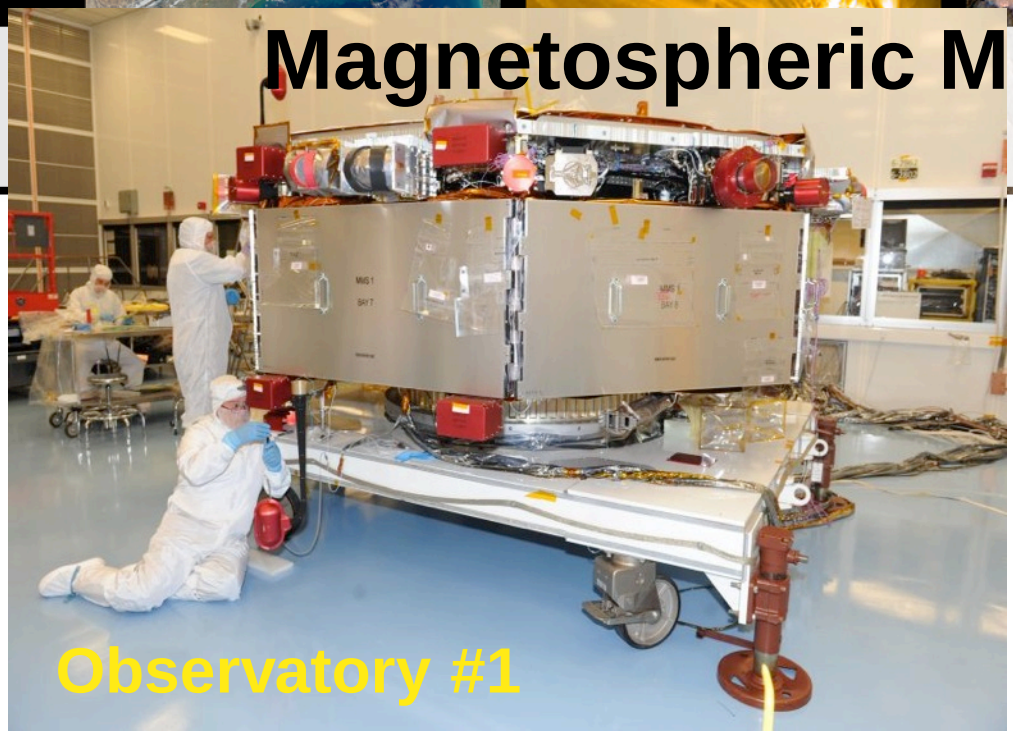
NASA Launches Its Newest Solar Observatory
The Interface Region Imaging Spectrograph (IRIS)

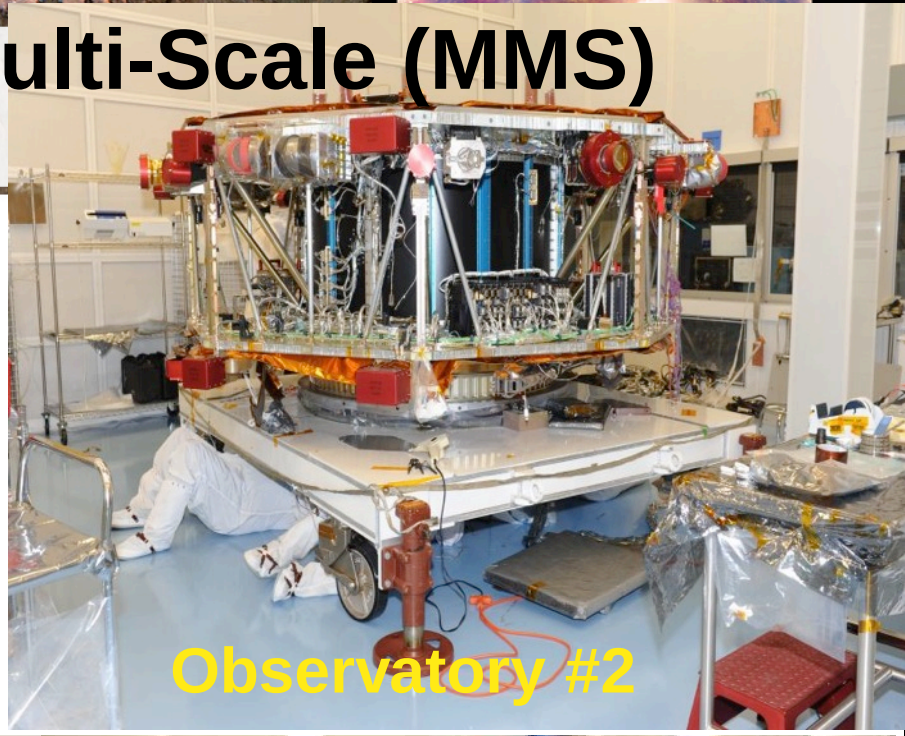


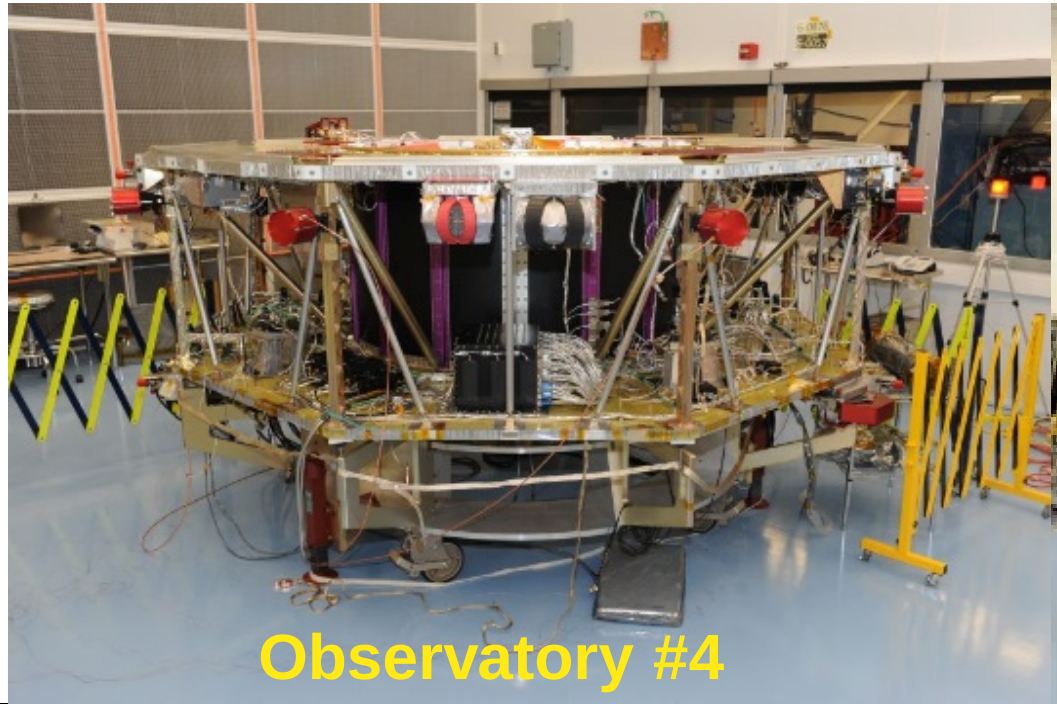


- Observes how solar material moves, gathers energy and heats up as it travels through interface region between the photosphere and million-degree corona
- IRIS successfully launched on June 27, 2013 from Vandenberg AFB on Pegasus XL rocket
- Spacecraft health is excellent
- First light media event July 25

Magnetospheric Multi-Scale (MMS)







2013 Heliophysics Senior Review

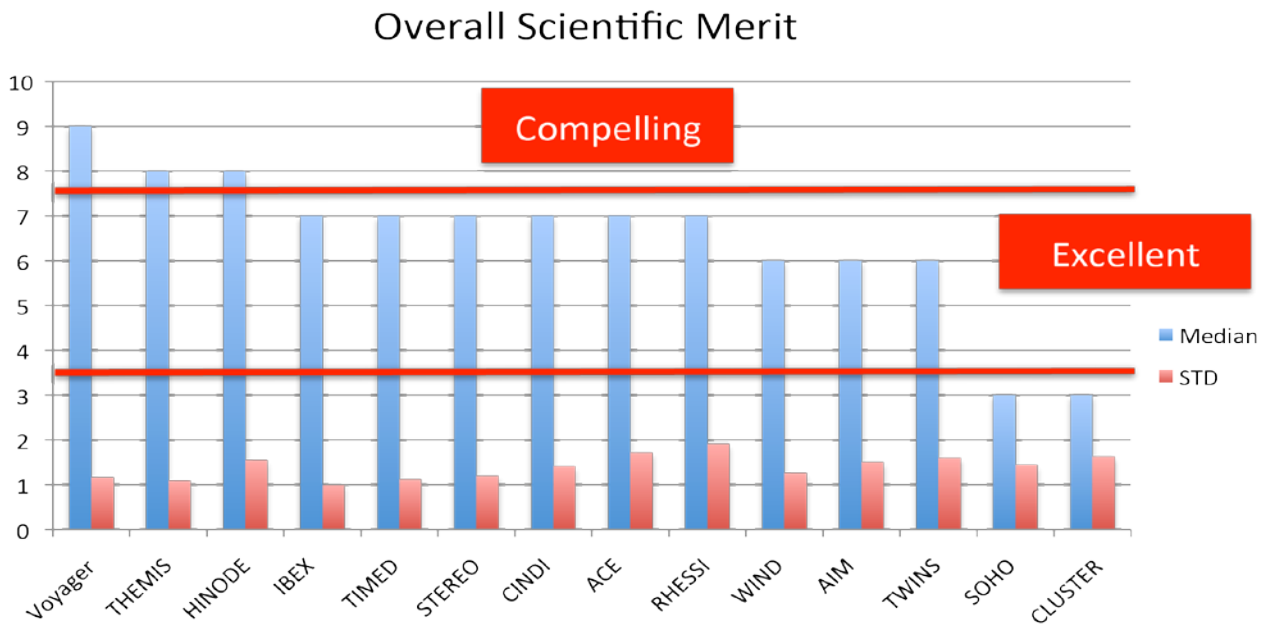
- Biannual Senior Review examines value of continuing observations and science for extended missions

- Extended mission monies largely support data collection, calibration, and validation → most science supported by research grant programs

- Extended missions represent only ~1/12 of Heliophysics budget

-14% decrease for FY14 in funding of 14 operating missions

-Invaluable resource with SMD's biggest science "bang for the buck"

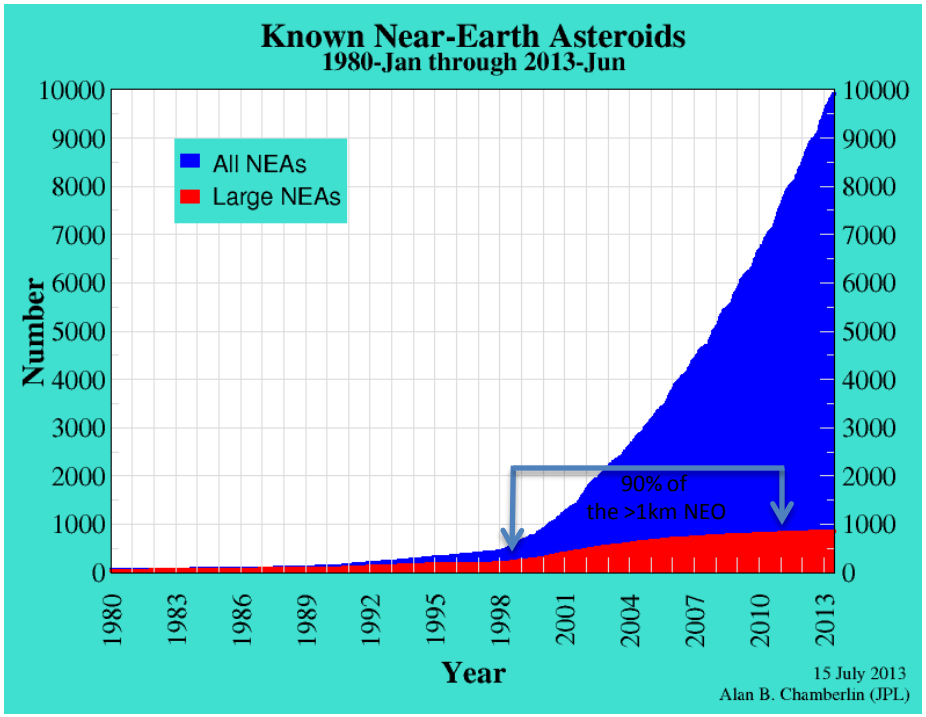


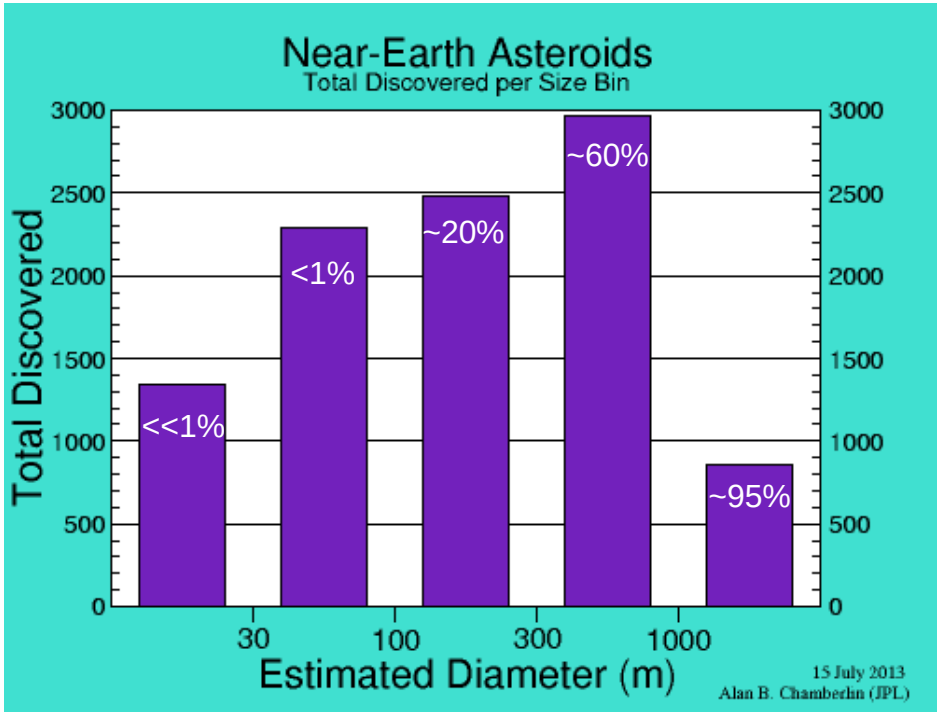
Wave at Saturn (and Mercury)

Cassini site on the NASA portal had 236,000 unique page views;
Cassini's Saturn page (saturn.jpl.nasa.gov) had 265,000 unique visitors.
Over 20 countries participated in the Campaign


NBC NIGHTLY NEWS
msn
LOOK UP!

Quick Status of the NEO Survey Program





- Congressional Bill 1998 – Find 90% of the >1km NEO within 10 yrs
- Congressional Bill 2005 – Find 90% of the >140m NEO within 15 yrs

Comet ISON - Campaign Science

This is an Oort Cloud Comet – the first in the modern space age!

It is a pristine comet having never visited the Sun

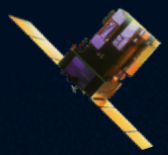
A unique opportunity to make multi-wavelength observations

Key Dates
21 Sep 2012: Discovered
1 Oct 2013: Closest Approach to Mars
28 Nov 2013: Closest Approach to the sun
26 Dec 2013: Closest Approach to Earth? (Only if it survives solar encounter)

How NASA Space Assets Will Observe Comet ISON

Deep Impact imaged ISON for the first time on January 17 and 18 from 493 million miles away

MESSENGER will be observing ISON as it passes by Mercury on November 19th on its way to the Sun



SOHO will be observing ISON as it passes by the Sun in late November

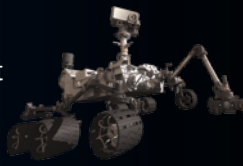
Hubble observed ISON in April-May and will see it again in October and December (if ISON survives)

STEREO will be observing ISON as it passes by on its way to Sun in late November

In January and March, Swift observed ISON when it was 460 million miles away from the Sun

Opportunity will be observing ISON as it passes by Mars on its way to the Sun on October 1st

Astronauts aboard the International Space Station will be able to observe Comet ISON as it passes by Earth in late November



Curiosity will be observing ISON as it passes by Mars. Close approach is October 1st

In November, Chandra will observe ISON with its X-ray instruments

Lunar Reconnaissance Orbiter will be observing ISON as it passes by the Moon in late November

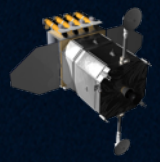
Mars Reconnaissance Orbiter will be observing ISON as it passes by Mars . Close approach is October 1st

For more information, visit:
http://solarsystem.nasa.gov/ison

BRRISON, a sub-orbital balloon, will be launched mid September to study ISON from above nearly all of the Earth's atmosphere

Spitzer observed ISON on June 13. The comet was 310 miles away from the Sun

FORTIS, a sounding rocket, will be launched in mid-to-late November to obtain ultra-violet spectra from ISON



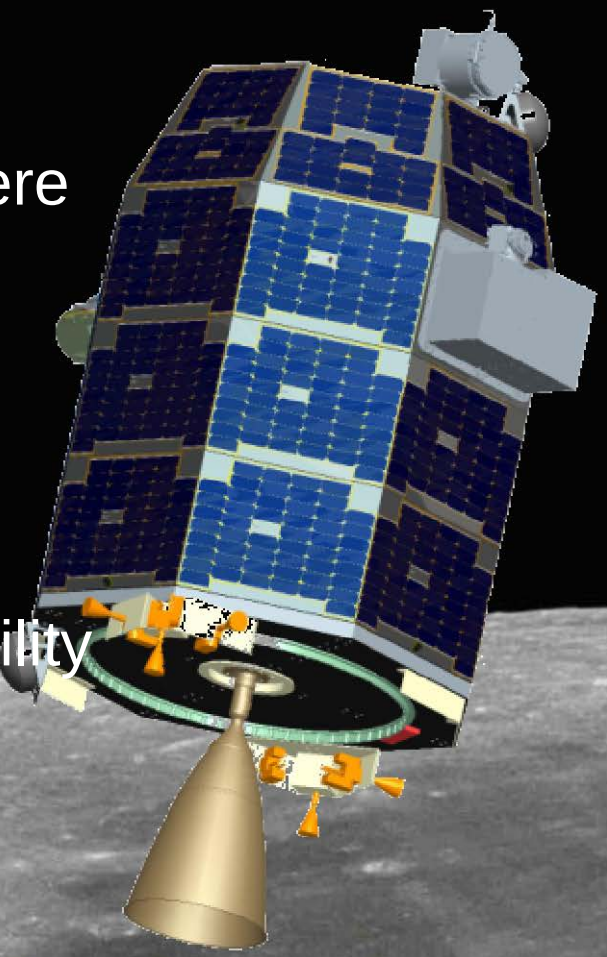
SDO will have the ability to observe ISON under extreme-ultraviolet light when the comet is closet to the Sun

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

Launch: Sept. 6, 2013 Wallops Flight Facility



Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

Launch November, 2013 Cape Canaveral

- Mars orbit insertion in Sept. 2014

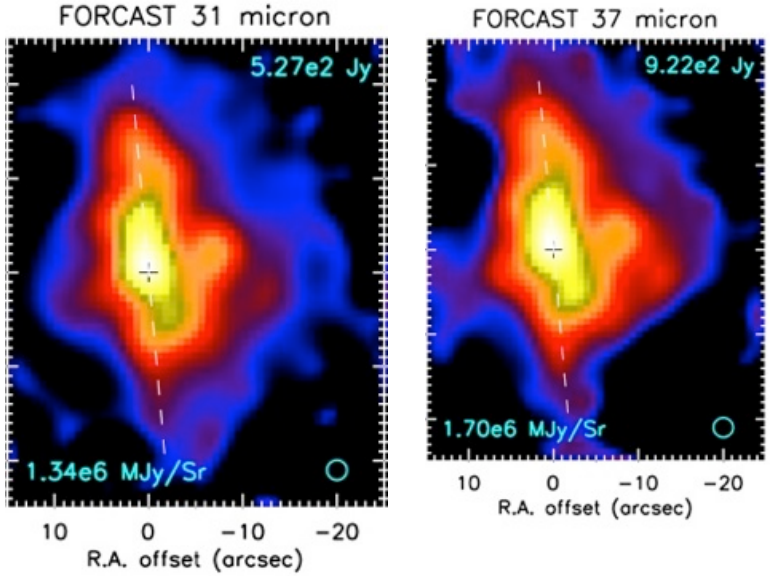
Science:

- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

Program Update – SOFIA

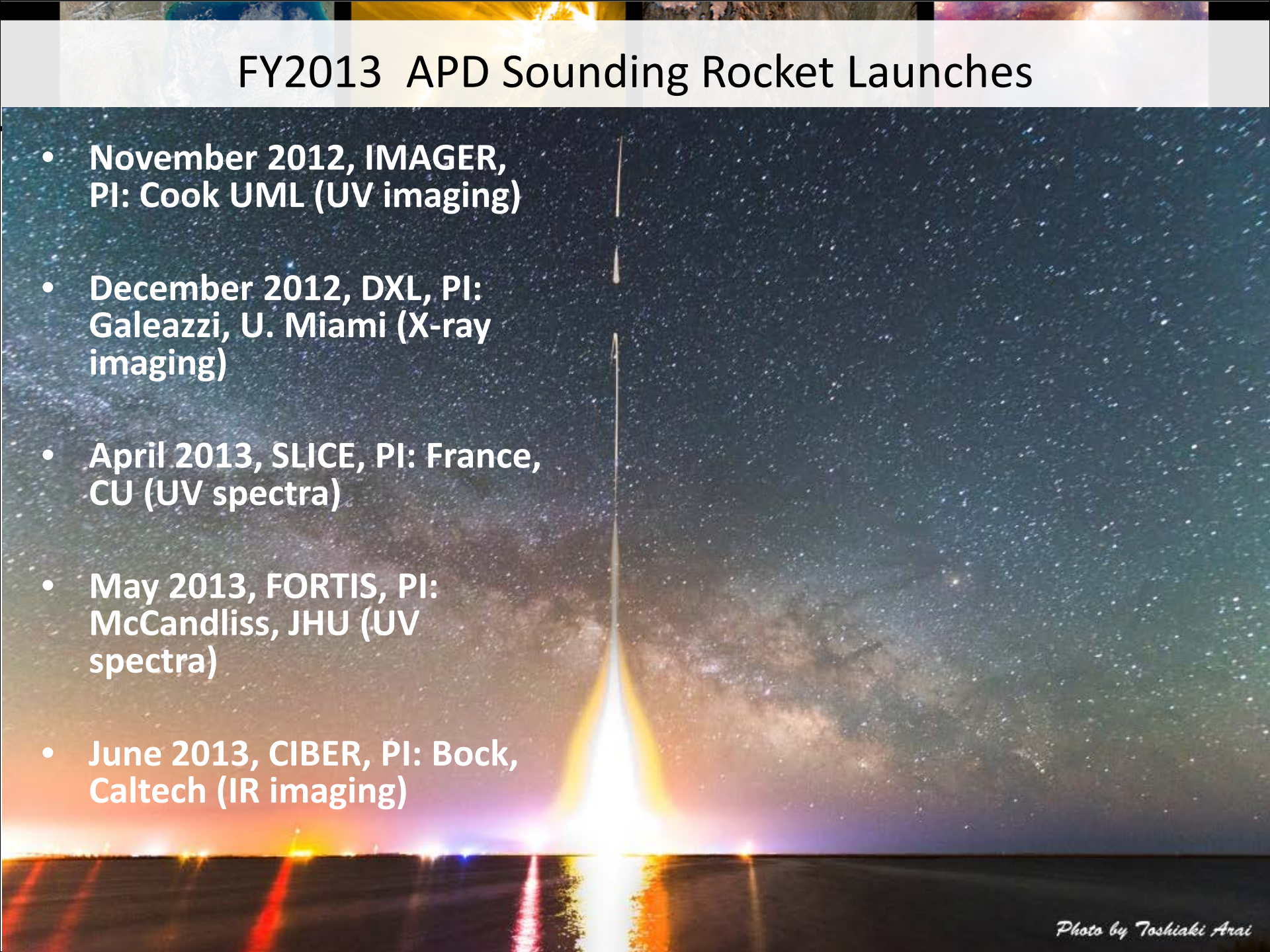
- Conducting Cycle 1 GO observations.
  - Completed three science flights using FORCAST, June 20 – July 1.
- SOFIA departed on first Southern Hemisphere deployment on July 12 (Christchurch, NZ).
  - Completing nine science flights using GREAT, July 17 – August 1.
- Received over 111 proposals in response to US & German Cycle 2 observing calls.
  - 3:1 oversubscription rate.
- HAWC+ instrument is at JPL for upgrades.
- Baseline plan established for 3rd-generation instrument call.
  - Release AO July 2014; select instrument by April 2015.


SOFIA in Christchurch NZ on Sunday July 14.



NASA SOFIA Science press release on FORCAST April 17 - images of structure of massive protostar G35

FY2013 APD Sounding Rocket Launches



- November 2012, IMAGER, PI: Cook UML (UV imaging)
- December 2012, DXL, PI: Galeazzi, U. Miami (X-ray imaging)
- April 2013, SLICE, PI: France, CU (UV spectra)
- May 2013, FORTIS, PI: McCandliss, JHU (UV spectra)
- June 2013, CIBER, PI: Bock, Caltech (IR imaging)

Photo by Toshiaki Arai

Outline

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

Finding

NASA 2014 Strategic Plan Development

The Government Performance and Results Act Modernization Act (GPRAMA) of 2010 introduced new requirements that are driving the 2014 planning process. Based on a highly informative briefing from J. Pollitt, the NAC Science Committee finds that the planned reporting strategy is problematic. Each of the four SMD science objectives span multiple Agency goals, and should not have to be attributed to a single goal.

If an objective must be attributed to a single goal, it should be attributed to the goal that best represents the majority of the work in that area. A troubling example is the developing plan to attribute the Heliophysics science objective to the Agency “of Earth” goal while the bulk of the Heliospheric strategic elements is aligned with the Agency “of Science” goal, just as it is for Astrophysics and Planetary Science.

Finding

High Value of Extended Missions

In a constrained budget environment, one option discussed is to terminate operating missions. The Science Committee finds that many of the missions currently in extended phase provide some of the best science per cost in SMD.

While the successful planning, building, launching and commissioning of spacecraft constitutes a remarkable technical feat, the motivation for and end goal of these eyes, ears and hands in space is the science that results from data collected by these missions. Level 1 science requirements are developed during the period of formulation and implementation consistent with goals of Decadal Surveys and SMD Mission Roadmaps. Level 1 Science Requirements are the set that a mission must satisfy in order to achieve its pre-launch objectives. By nature, as proposed missions are conservative in their science goals and engineering limits, the history of NASA SMD missions shows over and over that extended mission data collection leads to science advances equaling or exceeding that of the primary mission.

It is imperative that active spacecraft returning high quality data be funded into extended missions consistent with evaluations of NASA senior reviews. This strategy capitalizes on investments in mission hardware at affordable costs that result in new science, workforce development, and engaging and inspiring the next generation of explorers.

Recommendation

Short Title: Evaluate Best Practices for Science Education and Public Outreach

Recommendation:
The Council recommends that NASA analyze the relative effectiveness of past science education and outreach efforts at NASA, measuring against agency goals and objectives and correlating with key variables (e.g., cost, expertise, science input, and target audience). Where there are clear successes, identify a set of best practices, and use less successful efforts to indicate lessons learned; disseminate these results for the benefit of any federal organization engaged in EPO activities.

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Recommendation (Cont'd)

Major Reasons for the Recommendation:
The Administration has proposed consolidating EPO programs across federal agencies and departments. To inform this process, it would be extremely valuable for NASA to mine data collected from decades of education and public outreach efforts, looking at metrics that reflect impact on the students and the public or that reflect other agency goals and objectives. In particular, the direct involvement of scientists in SMD EPO activities has been extremely effective. The NASA EPO data are a valuable archive that could be exploited to the benefit of the nation, maximizing the value from limited federal EPO dollars.

Consequences of No Action on the Recommendation:
Government planning for a new EPO structure would proceed without the valuable information derived from past activities and archives of NASA and other STEM-active agencies, and the lessons learned from their previous EPO activities. This could potentially lead to waste and mismanagement of the nation's precious EPO resources.

Recommendation

Short Title: Participation of Planetary Protection Officer in Mission Planning & Design

Recommendation:
Planning and design of missions requiring implementation of planetary protection measures should be informed at the outset, and through all mission stages, by active participation of the Planetary Protection Officer.

Major Reasons for the Recommendation:
Meeting planetary protection standards can impose significant design, technical, and cost requirements on missions that engage extraterrestrial environments with biological potential. It is a principle of NASA planning that the earliest possible identification and incorporation of requirements into mission planning, design and implementation is the approach that minimizes mission risk and best controls project costs. Thus planetary protection requirements should be an integral part of mission planning and implementation from the outset.

Recommendation (Cont'd)

Major Reasons for the Recommendation (Cont'd):
As noted in NPR 8020.12D, projects can benefit from communication with the PPO during pre-project activities, including to obtain preliminary mission categorization. PPO participation during pre-project phases can also inform the evaluation of preliminary mission design alternatives to comply with planetary protection requirements.

Consequences of No Action on the Recommendation:
Later overlay of planetary protection measures and requirements can increase mission risk by requiring alterations at later mission stages, which are needlessly disruptive and costly.