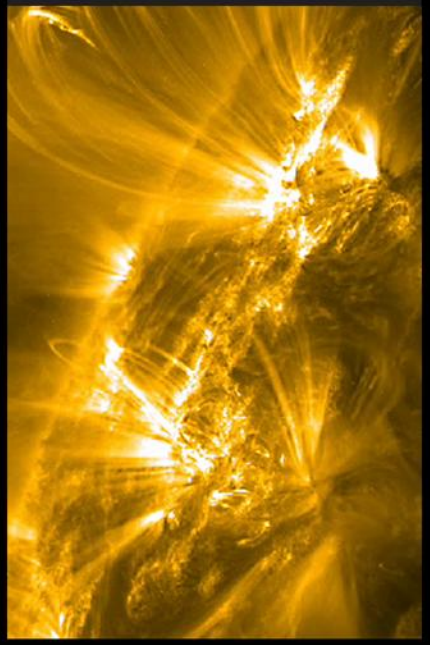
National Aeronautics and Space Administration

EARTH SCIENCE



HELIOPHYSICS

PLANETARY SCIENCE

ASTROPHYSICS

NASA's Science Programs

Presentation to NAC
Dr. Alan Boss
March 8, 2012

www.nasa.gov

Science Committee Members

Wes Huntress, Chair
Alan Boss, Carnegie Institution, Chair of Astrophysics
Noel Hinners, Independent Consultant
Scott Hubbard, Stanford University
Eugenia Kalnay, University of Maryland
Gene Levy, Rice University, Chair of Planetary Protection
Dave McComas, Southwest Research Institute
Byron Tapley, Vice Chair, University of Texas-Austin, Chair of Earth Science
Charlie Kennel, Chair of Space Studies Board (*ex officio* member)

T. Jens Feeley, NASA Executive Secretary

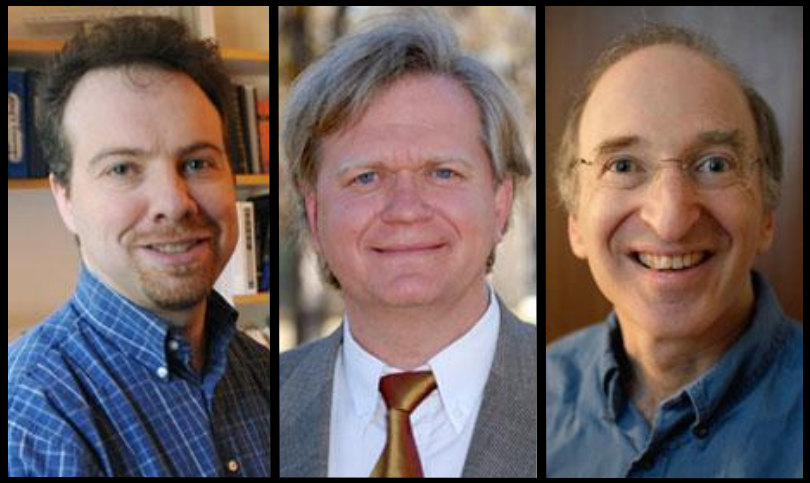
Agenda

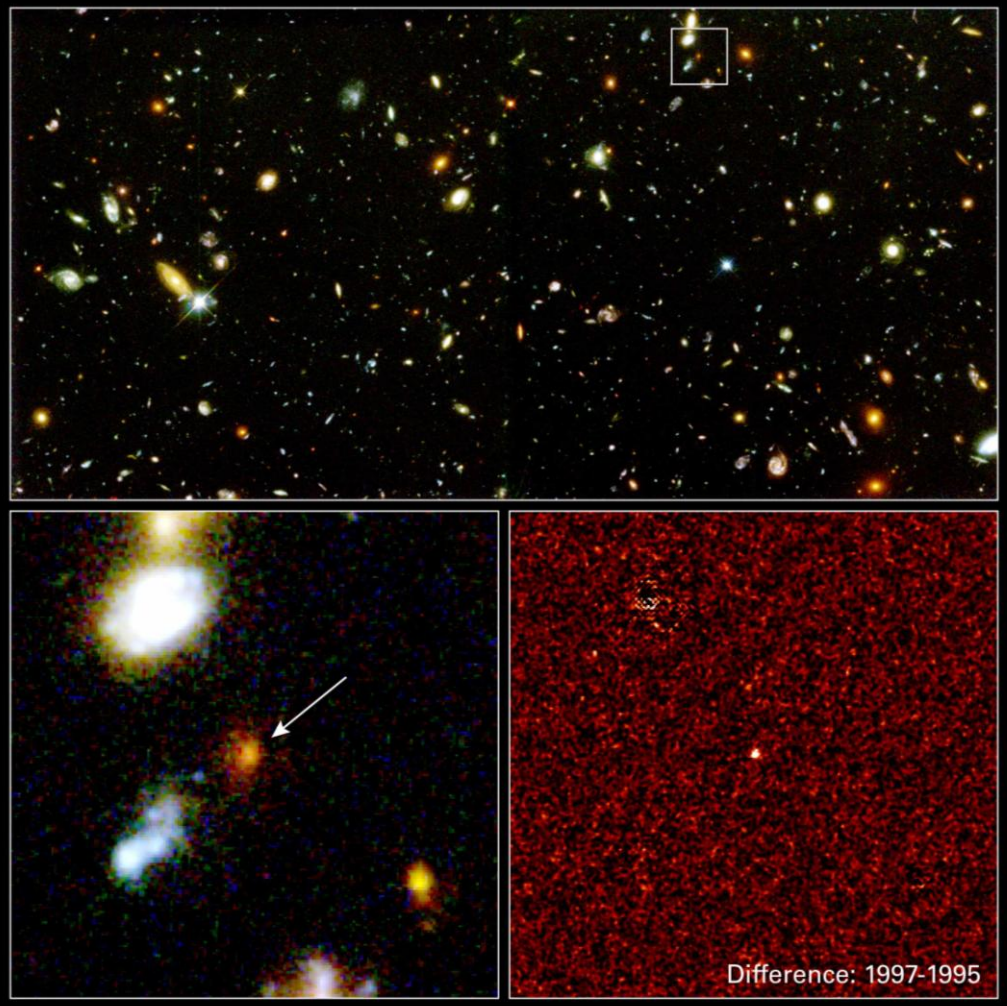
- **Science Results**
- Programmatic Status
- Findings & Recommendations

JWST on track for 2018 launch

2011 Nobel Prize in Physics

The 2011 Nobel Prize in Physics was awarded to **Saul Perlmutter**, **Brian P. Schmidt** and **Adam G. Riess** "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae." These observations were made, in part, by NASA's Hubble Space Telescope.



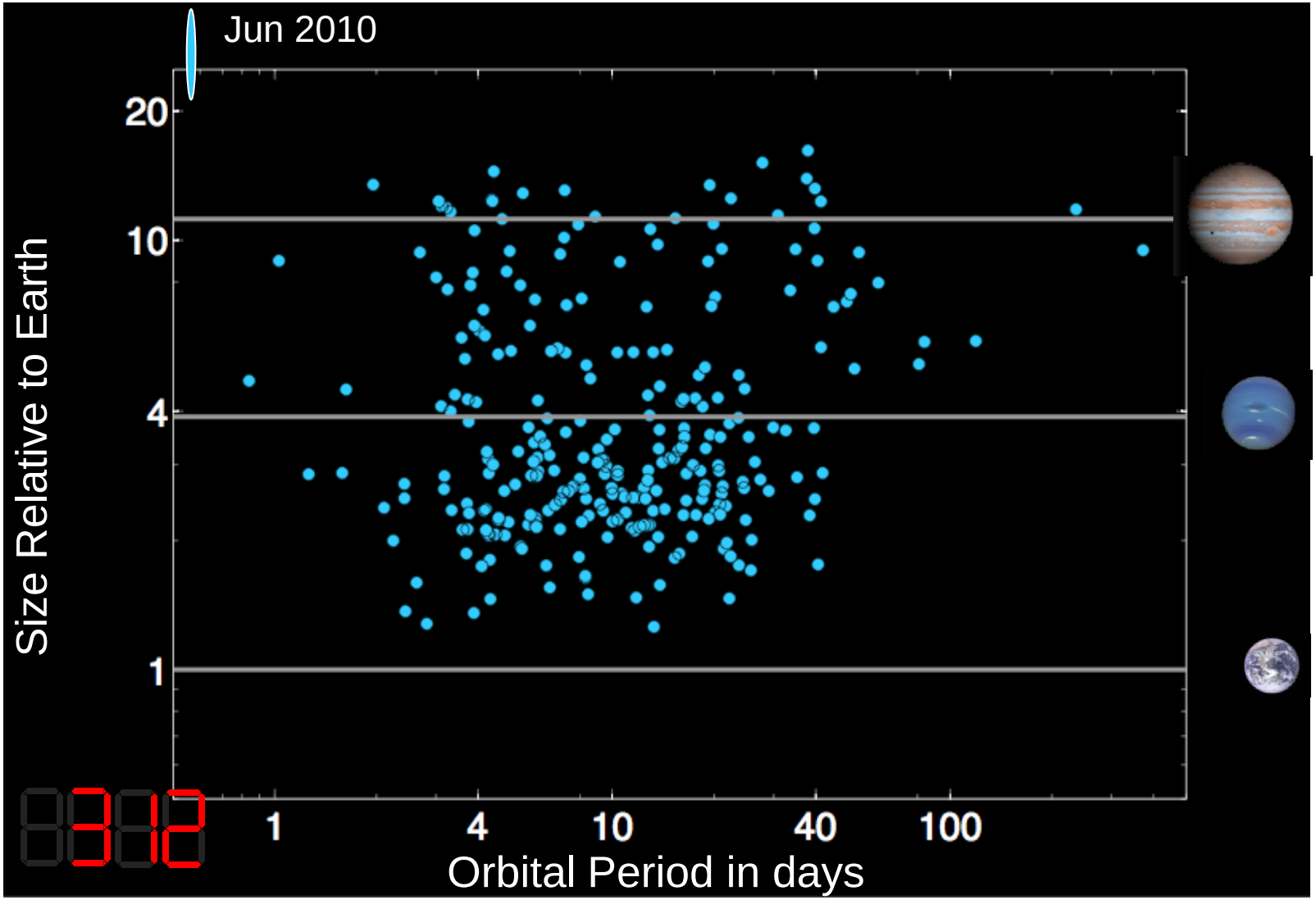


Distant Supernova in the Hubble Deep Field
Hubble Space Telescope • WFPC2

NASA and A. Riess (STScI) • STScI-PRC01-09

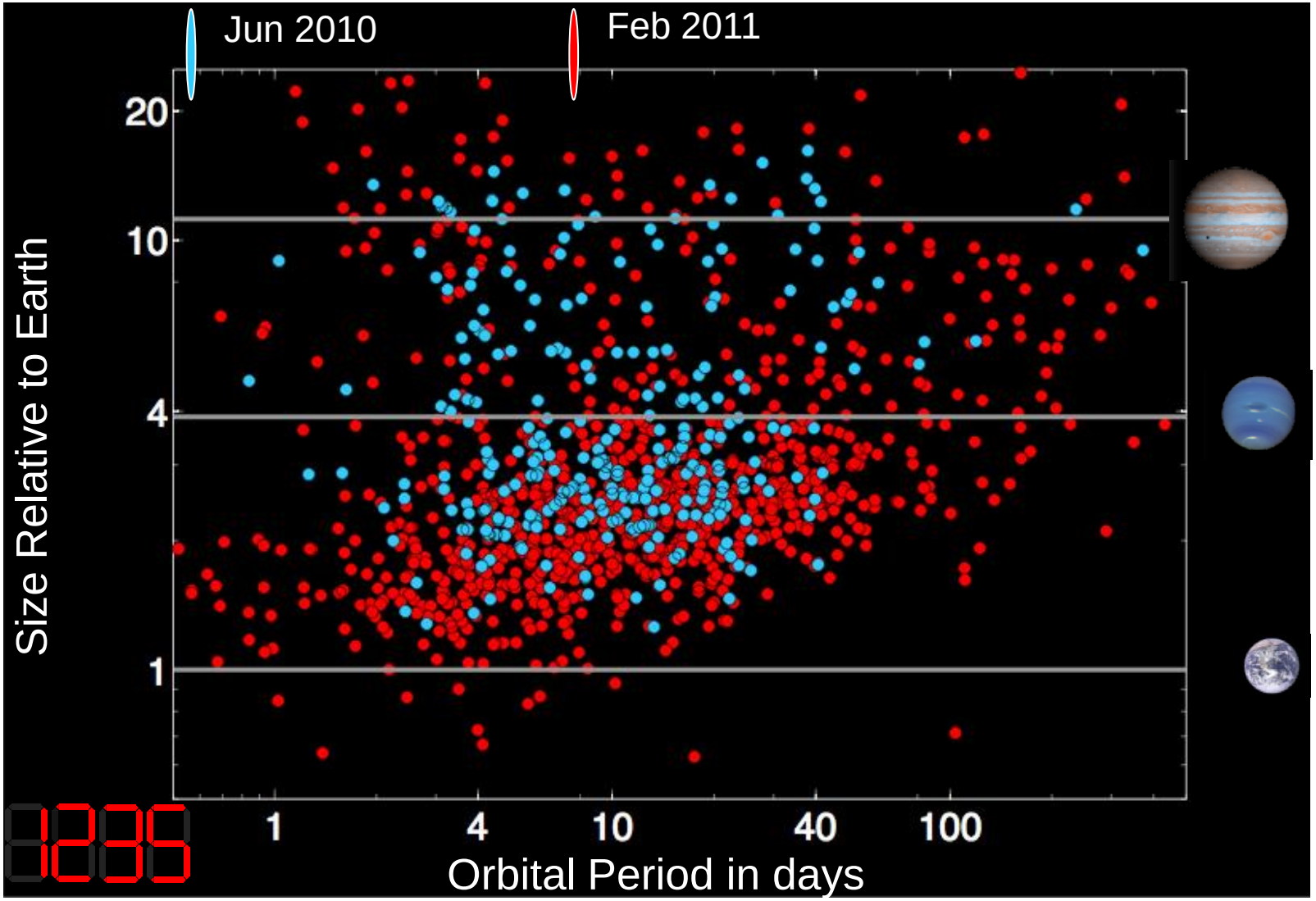
Kepler Candidates as of June 2010

Q0-Q1: May-June 2009



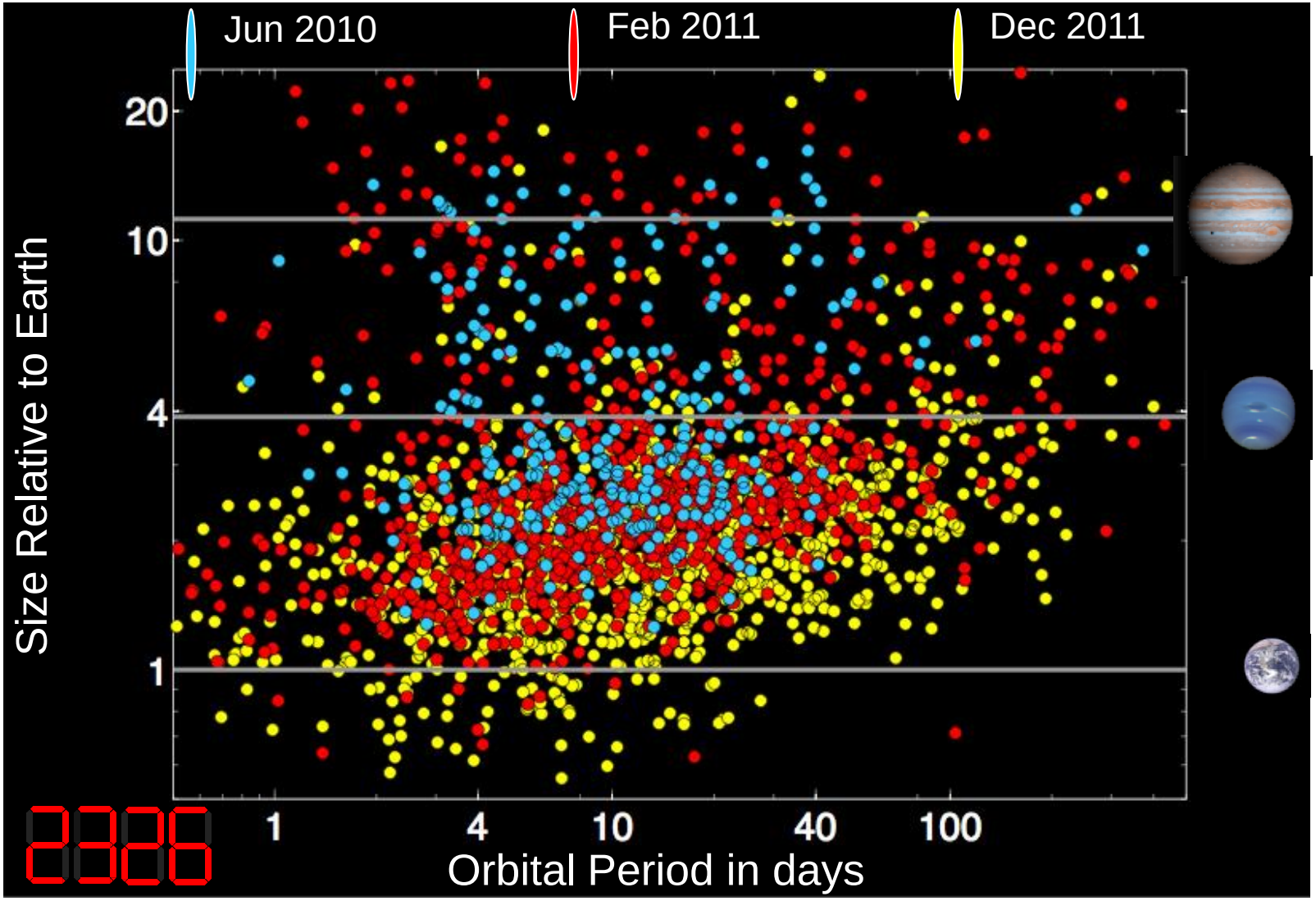
Kepler Candidates as of Feb 2011

Q0-Q5: May 2009 - Jun 2010

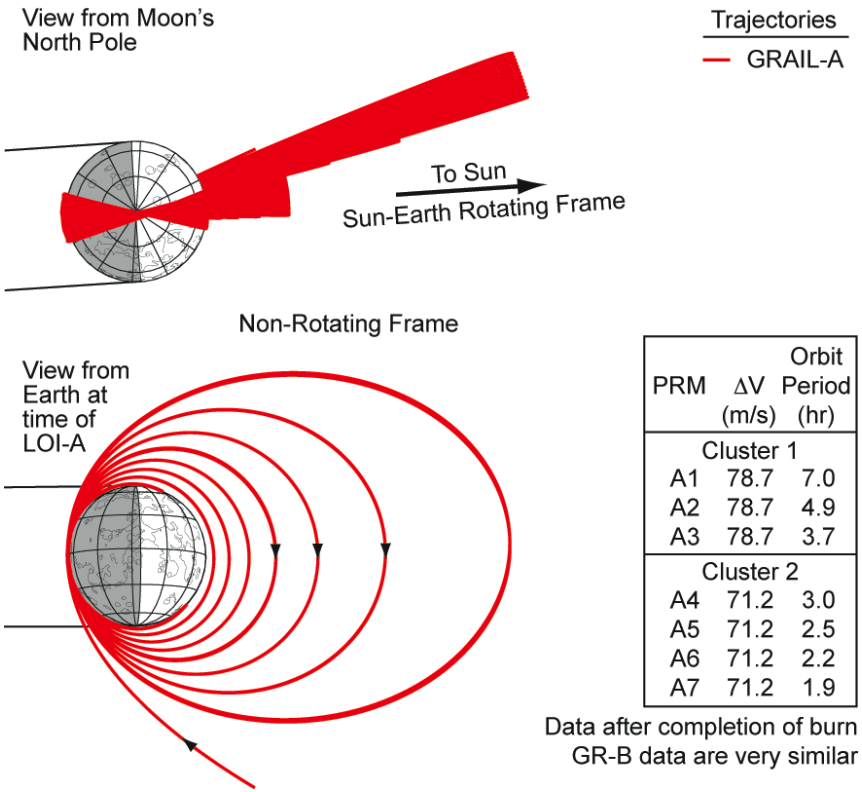


Kepler Candidates as of Dec 2011

Q0-Q6: May 2009 - Sep 2010



GRAIL A & B Becomes Ebb and Flow

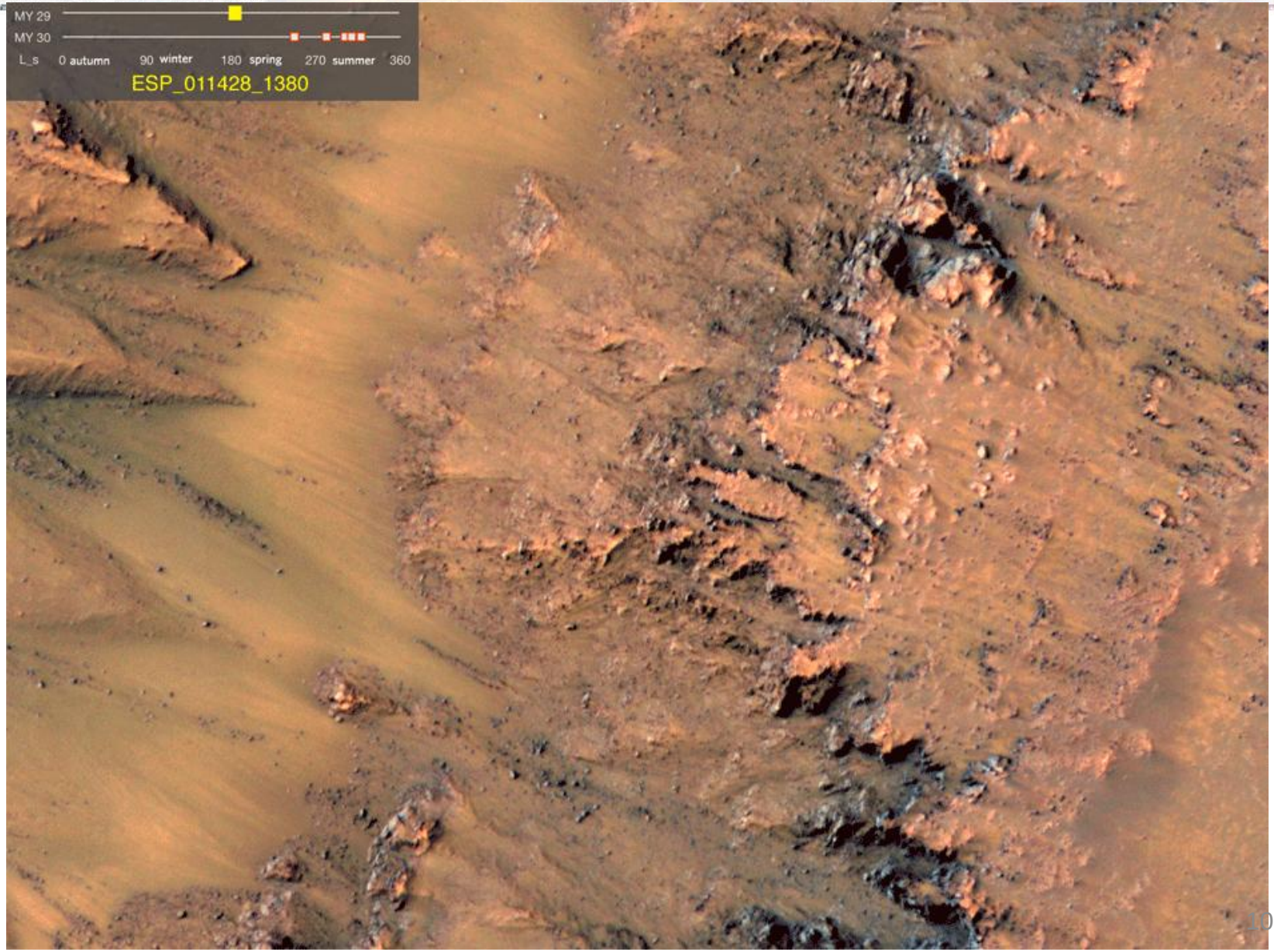


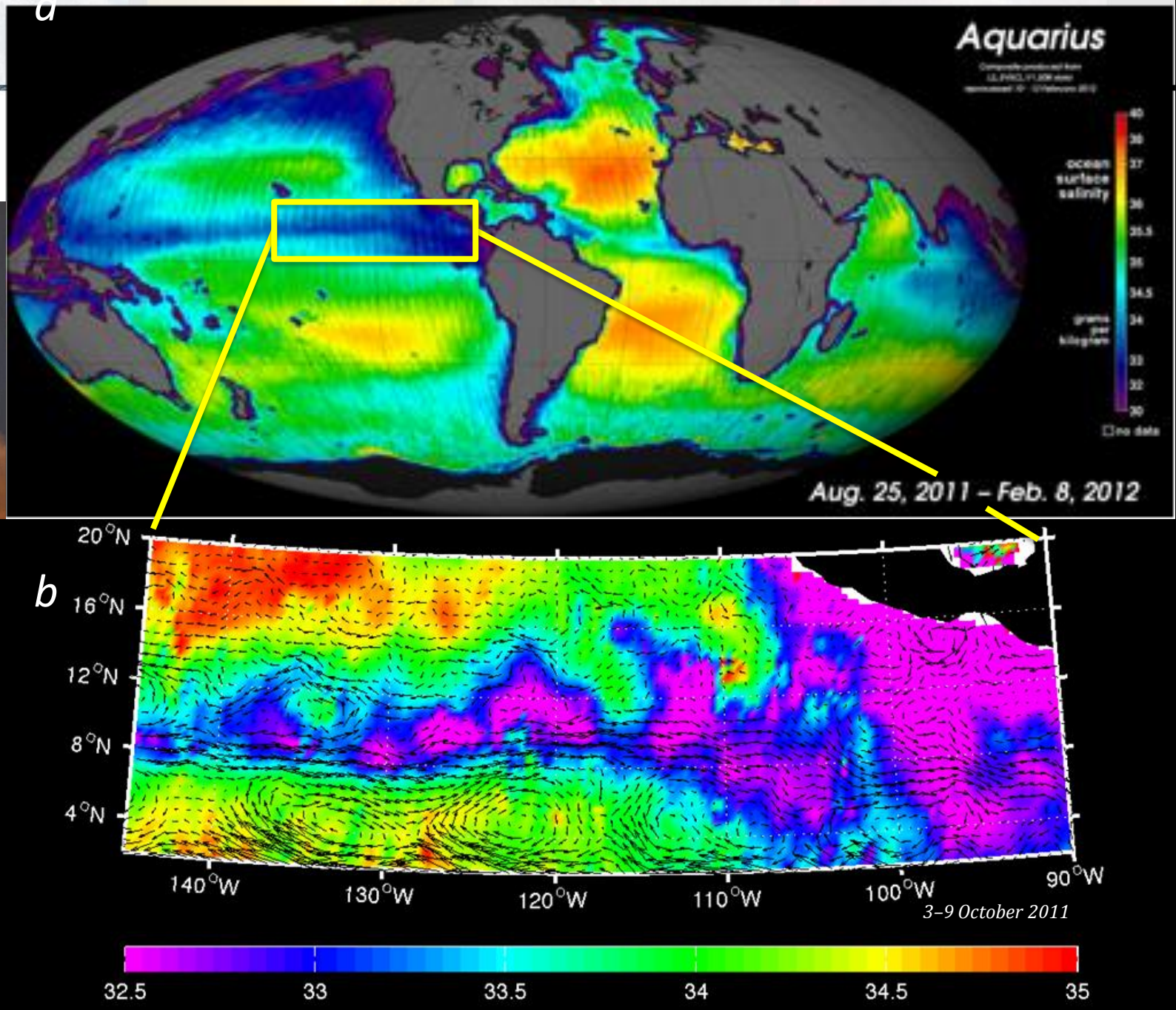
PRM	ΔV (m/s)	Orbit Period (hr)
Cluster 1		
A1	78.7	7.0
A2	78.7	4.9
A3	78.7	3.7
Cluster 2		
A4	71.2	3.0
A5	71.2	2.5
A6	71.2	2.2
A7	71.2	1.9

Data after completion of burn
GR-B data are very similar

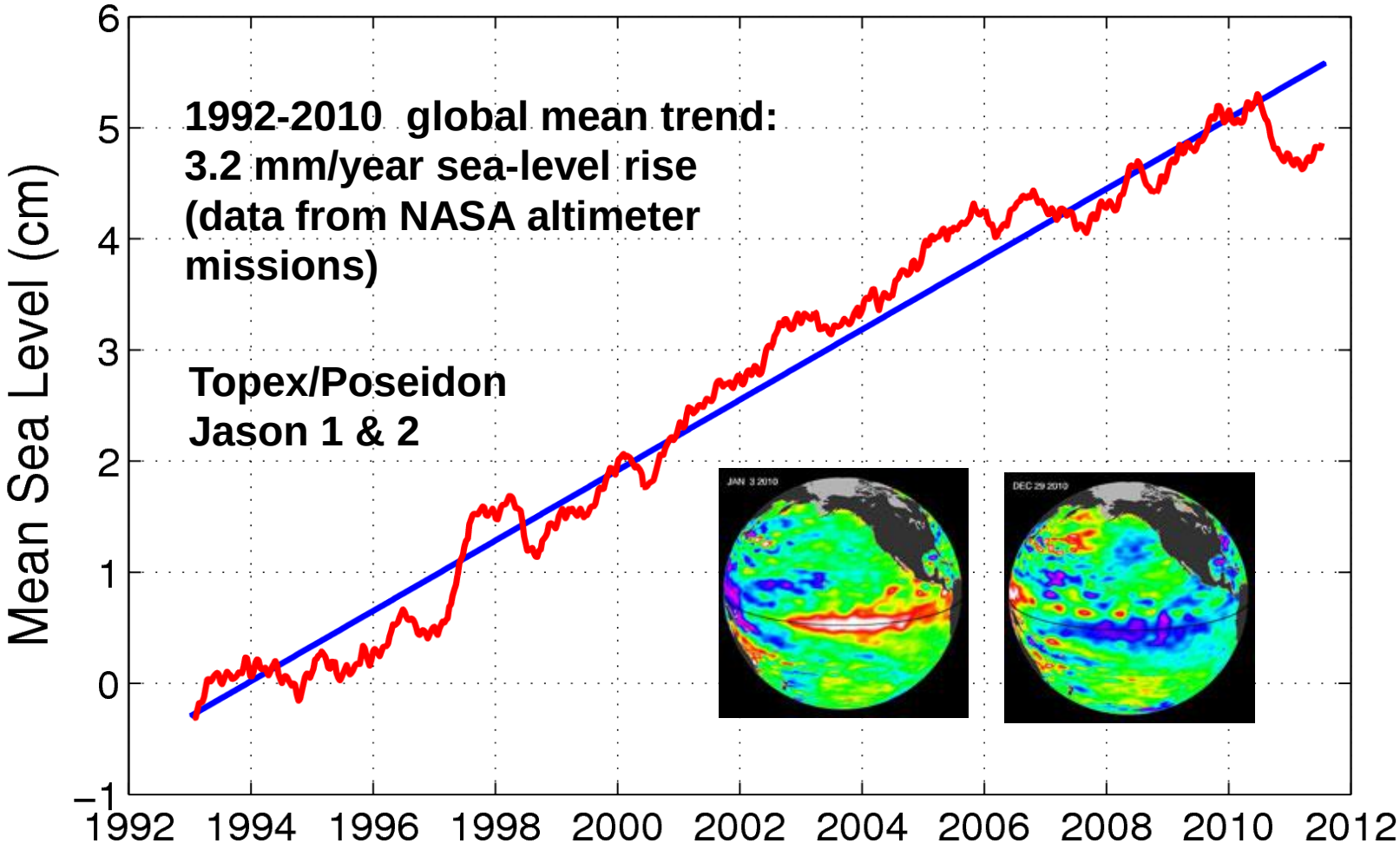
- 4th Grade Class from Bozeman, MT submits the winning names
- Science phase has just begun

Liquid Water on Mars

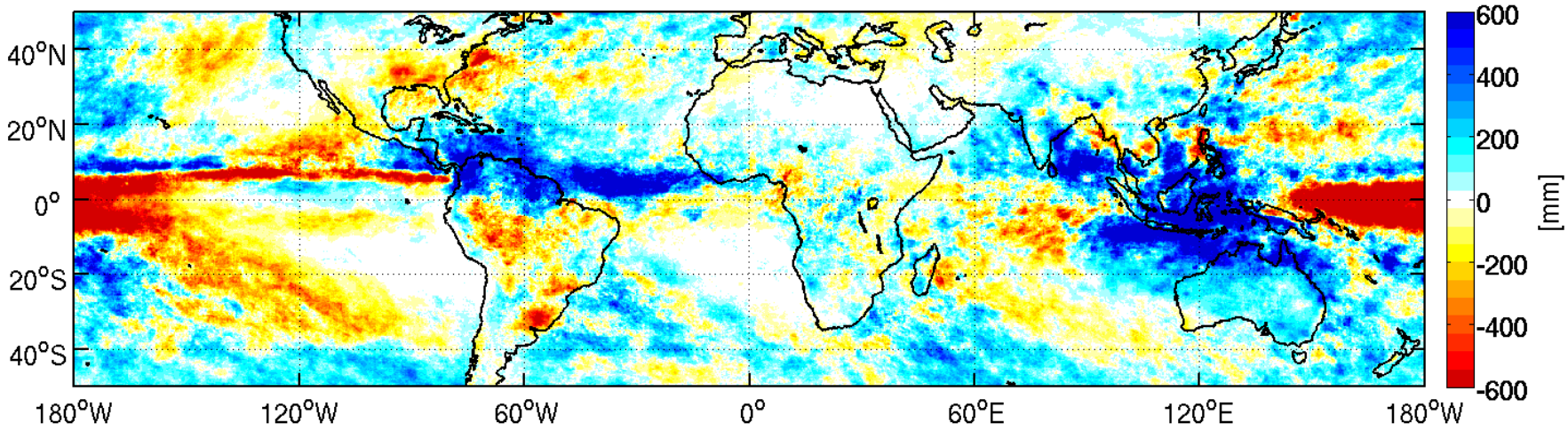



a
Aquarius
ocean surface salinity
grams per kilogram
no data
Aug. 25, 2011 – Feb. 8, 2012
b
20°N
16°N
12°N
8°N
4°N
140°W
130°W
120°W
110°W
100°W
90°W
3–9 October 2011
32.5
33
33.5
34
34.5
35

Satellite Measurements Detect and Diagnose 5 mm Sea-Level Drop in 2011

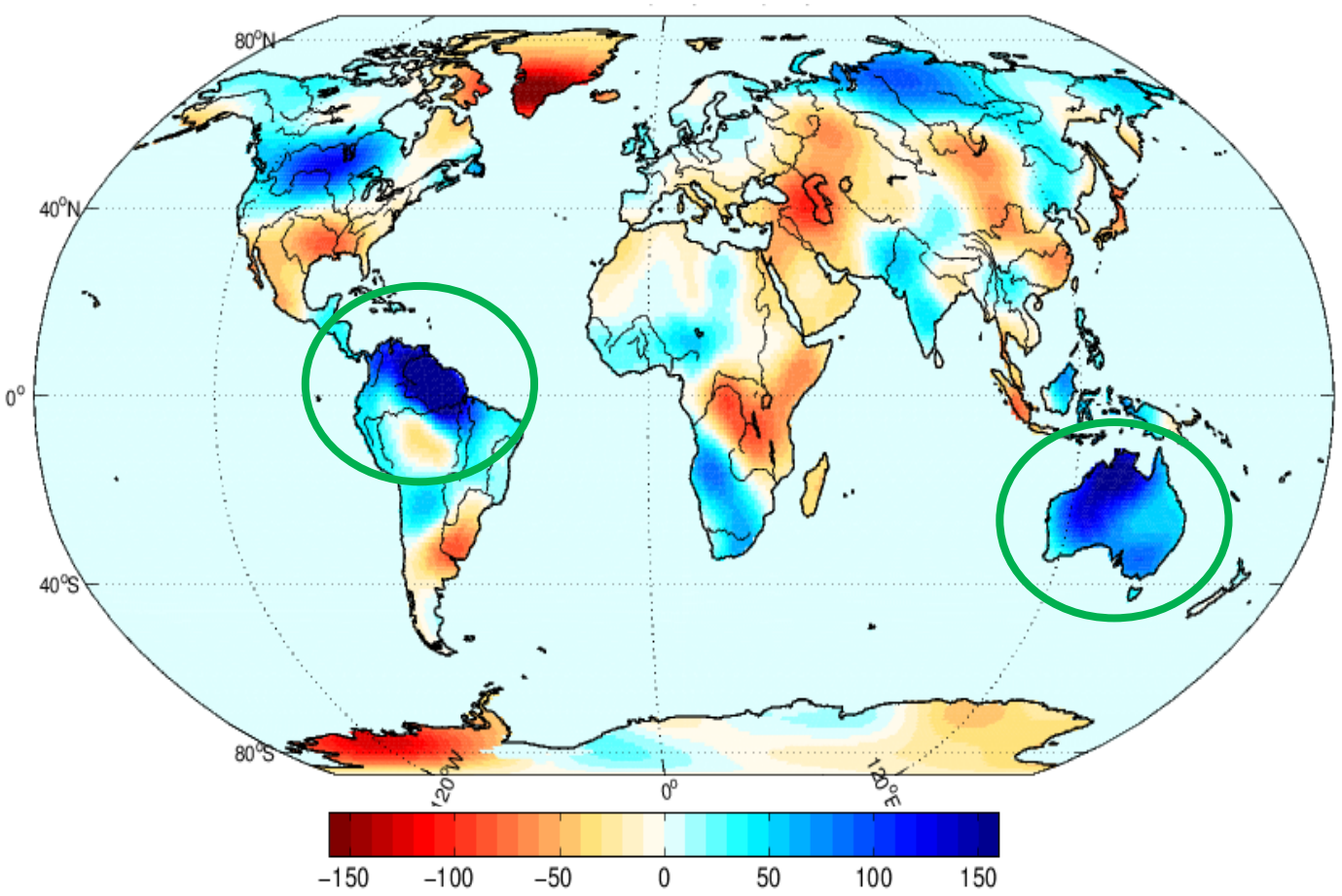


Satellite Measurements Detect and Diagnose 5 mm Sea-Level Drop in 2011



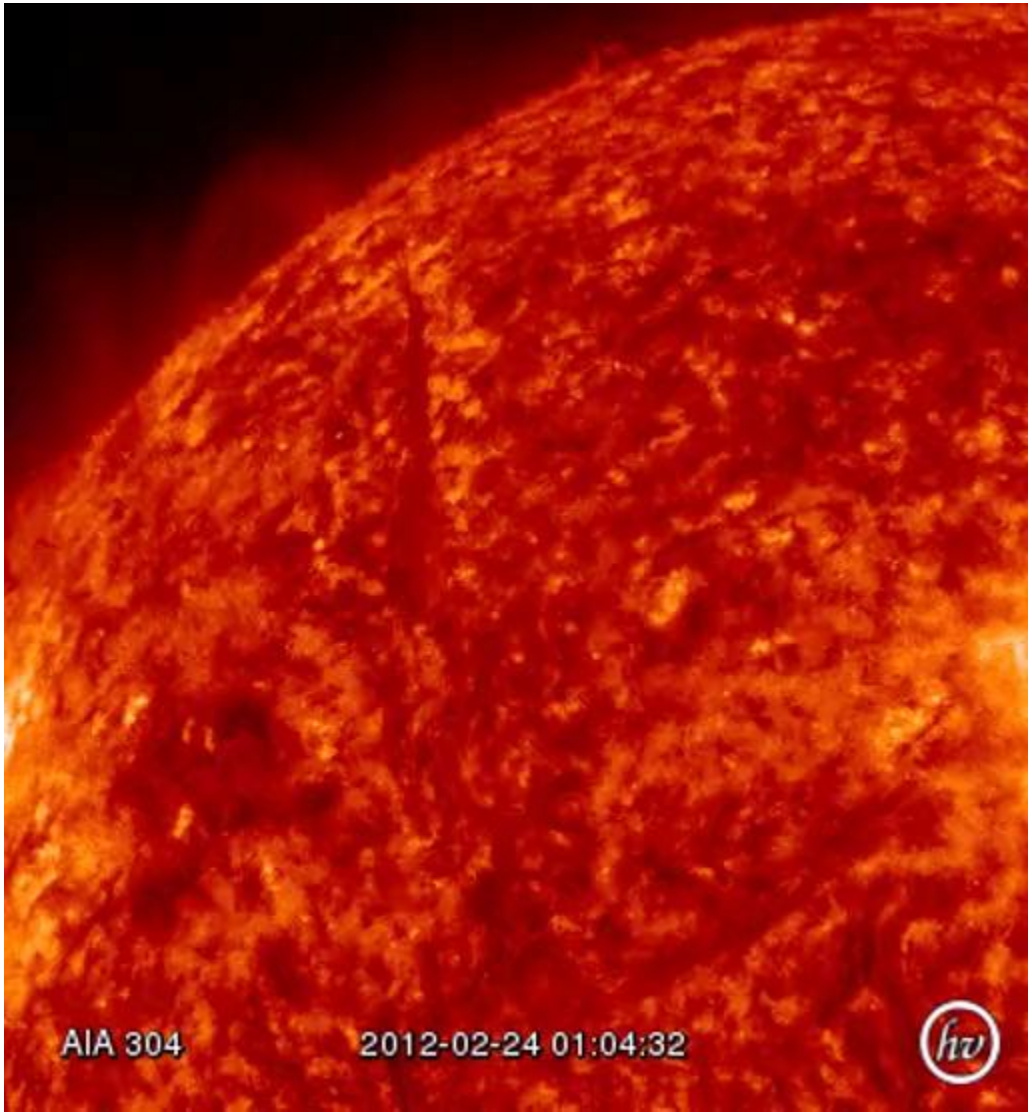
TRMM measurements of
Precipitation change, 2010-2011

Satellite Measurements Detect and Diagnose 5 mm Sea-Level Drop in 2011



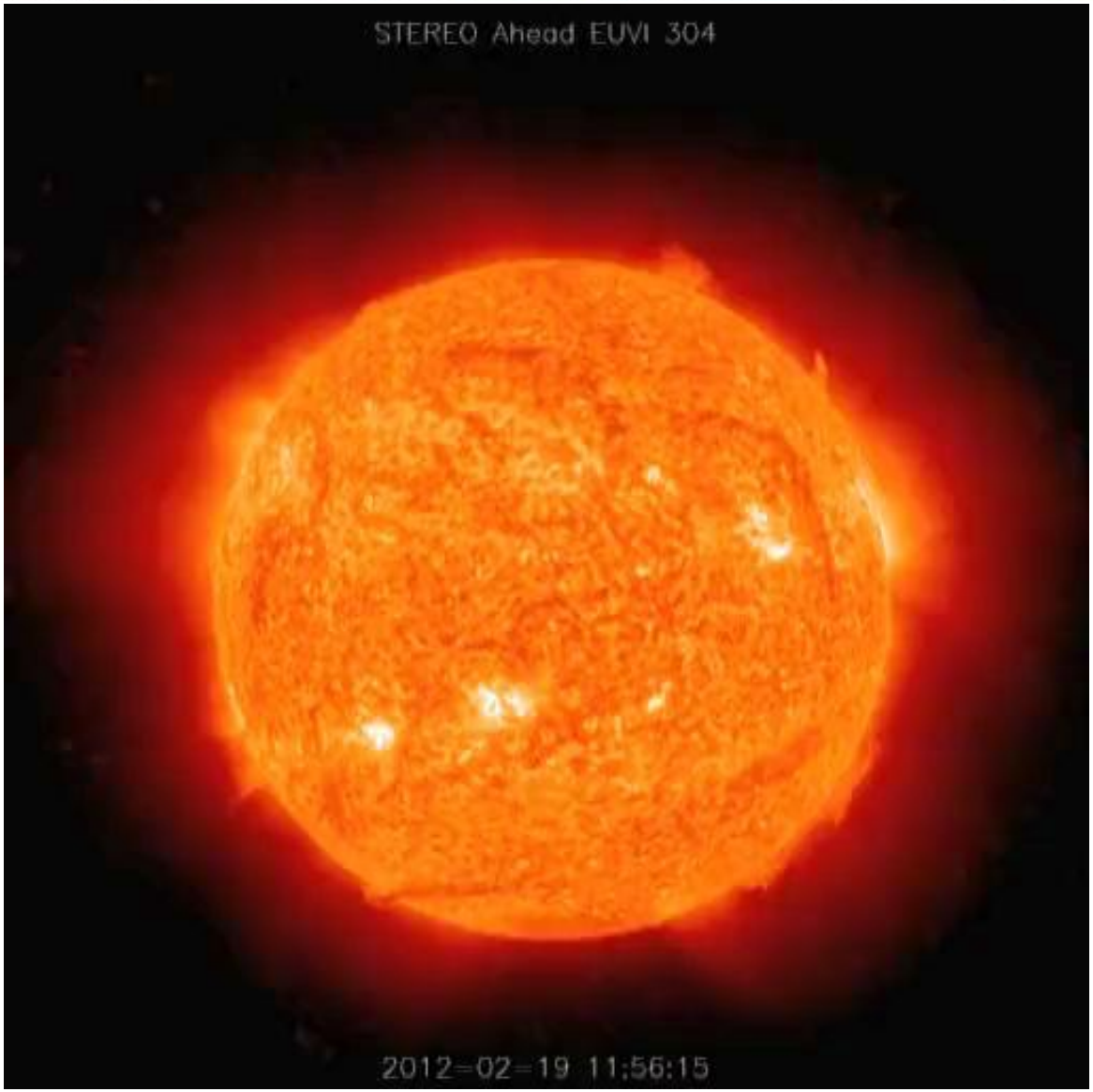
GRACE measurements of
Ground Water change, 2010-2011

SDO: **Solar Filament Eruption, Solar Tsunami - Close-up**



Close-up of magnetic solar filament erupting during the early hours of February 24, 2012. Notice closer to the surface the solar atmosphere splits and waves of solar material fan out in opposite directions from the split (almost 248,500 miles long), like tsunami waves. This eruption hurled a coronal mass ejection in the direction of Earth. This video ranges from Feb 23 22:32:44 to Feb 24 04:31:32 UT.

SDO: CME towards Earth

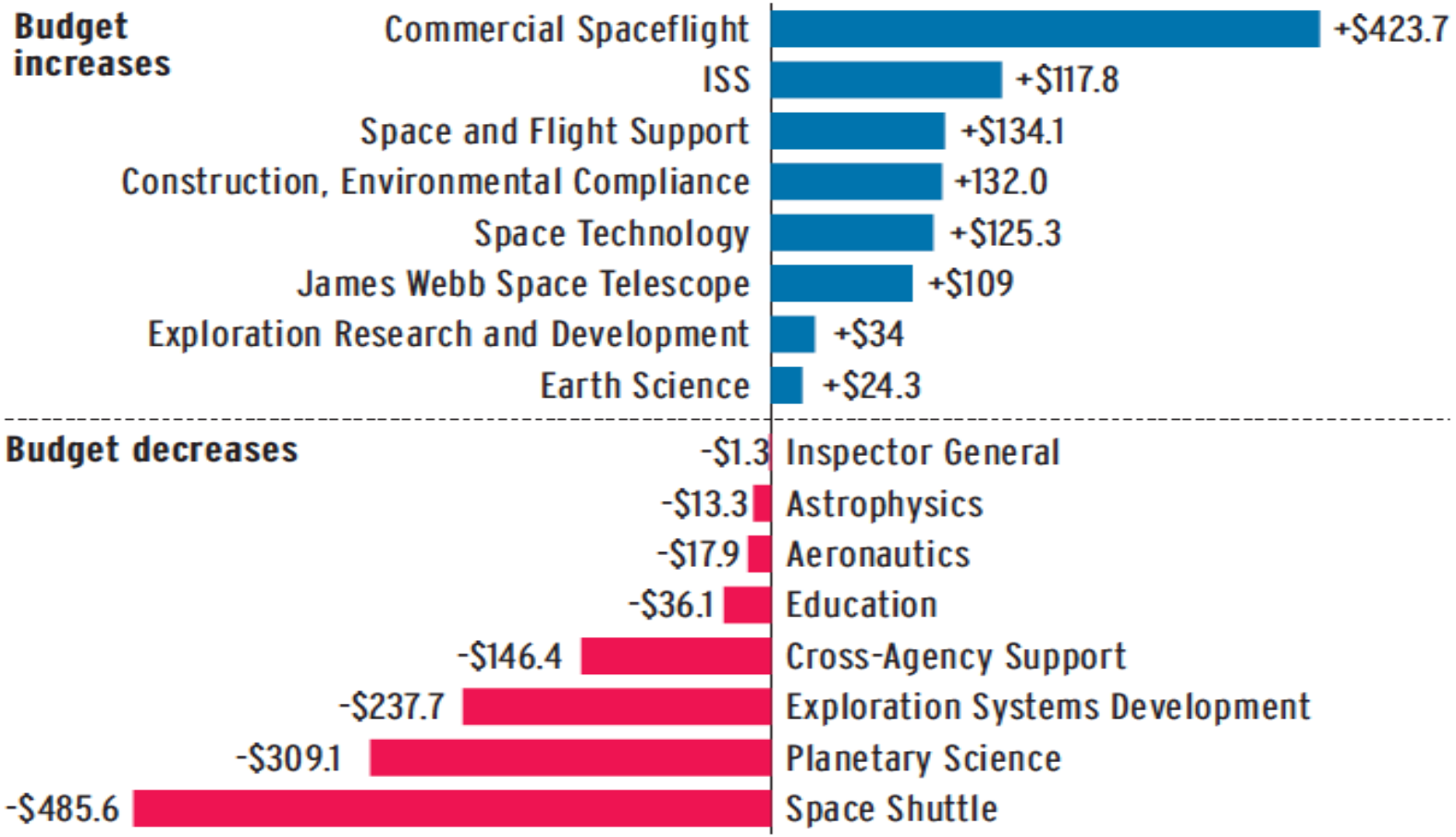


Agenda

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

NASA Budgetary Puts and Takes

NASA's 2013 budget takes a combined $1.2 billion out of programs including the Orion Multi-Purpose Crew Vehicle (part of Exploration Systems Development, below) and Planetary Science, and uses that money to fund a like amount of increases for the Webb telescope, Commercial Crew, Space Technology, etc. Figures shown in millions of dollars and are relative to 2012 spending levels.



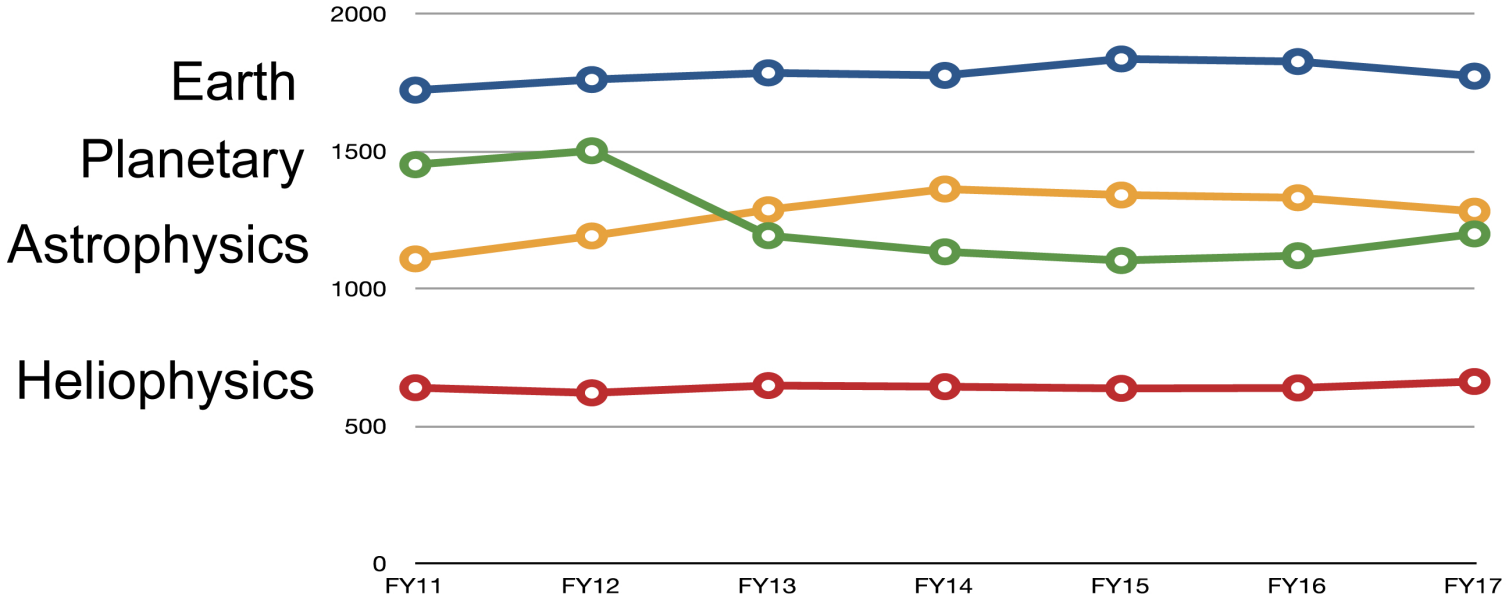
SOURCE: SPACE NEWS RESEARCH

SPACE NEWS GRAPHIC

SMD FY13 Budget

SMD FY13 Budget							
	FY11	**FY12**	**FY13**	**FY14**	**FY15**	**FY16**	**FY17**
Earth	1721.9	1760.5	1784.8	1775.6	1835.5	1826.2	1772.8
Planetary	1450.8	1501.4	1192.3	1133.7	1102.0	1119.4	1198.8
Astrophysics	1107.9	1191.3	1287.0	1362.1	1340.3	1330.5	1281.3
Helophysics	639.2	620.5	647.0	643.0	636.7	638.3	661.6
SMD TOTAL	**4919.8**	**5073.7**	**4911.1**	**4914.4**	**4914.5**	**4914.4**	**4914.5**
Change from FY12							
Earth			24.3				
Planetary			-309.1 (Mars -226.2)				
Astrophysics			95.7				
Helophysics			26.5				

(Astrophysics contains JWST)



Earth Science Budget Features

What changed:

- Budgeted for increased-cost, lower-risk launch vehicles for OCO-2, SMAP
- GPM LRD delayed owing to development issues (both U.S. and JAXA) – on track for 6/2014 LRD
- OCO-2, OCO-3 LRD changes owing to LV issues for OCO-2
- Multi-Mission Ops line accommodates Sr. Review, continuation of ACRIMSAT, and planned new missions

What's the same:

- Tier-1 Decadal missions SMAP and ICESat-2 are progressing toward launch in 2014 and 2016, respectively
- EV-2 (Small-sat) and EV-Instrument AOs released for selections in FY2012
- Continues focused pre-formulation activities for GRACE-FO for launch in 2017
- DESDynI Radar continues in pre-formulation study, launch NET 2021
- Maintains support for foundational and decadal missions in formulation and development
- Maintains support for operating missions
- Maintains support for USGCRP activities

Heliophysics Budget Features

What Changed:

- Covers increased launch vehicle costs
- Modest investment in Sounding Rocket Sustainer Motor design activity.

What's the Same:

- Fully funds missions in formulation/development: RBSP/BARREL, IRIS, MMS, SOC, SPP.
- Continues support for 16 operating missions (Voyager, Wind, ACE, TIMED, RHESSI, STEREO, THEMIS/ARTEMIS, AIM, IBEX, SDO; *Partnerships*: Geotail, SOHO, Cluster, Hinode; *MO*: TWINS, CINDI).
- Maintains Supporting Research and Suborbital Program

Astrophysics: WFIRST

- Astro2010 recommended WFIRST as the highest priority large mission; WFIRST remains NASA's first priority for a large astrophysics mission following JWST.
  - The President's FY13 NASA budget request includes no new large missions; Astrophysics expects none before we successfully complete JWST.
- The FY13 budget request does not fund a start on WFIRST; it would be unrealistic to expect such funding before JWST is launched.
  - WFIRST will not launch in this decade (2018 + 7 yrs = 2025).
  - Astrophysics does not anticipate budget growth in the foreseeable future.
  - FY13 budget request does not support WFIRST technology development as originally planned.
- In the meantime, NASA is proceeding in parallel as follows:
  - Through the Science Definition Team and Design Reference Missions, establish a basis for WFIRST planning.
  - Partner on ESA's Euclid to advance the science of Astro2010 and WFIRST. NASA's contribution to Euclid does not slow WFIRST development: reduced budget flexibility in FY13-FY17 would not allow significant progress on WFIRST.
  - Advance the technology required for WFIRST as the budget allows.

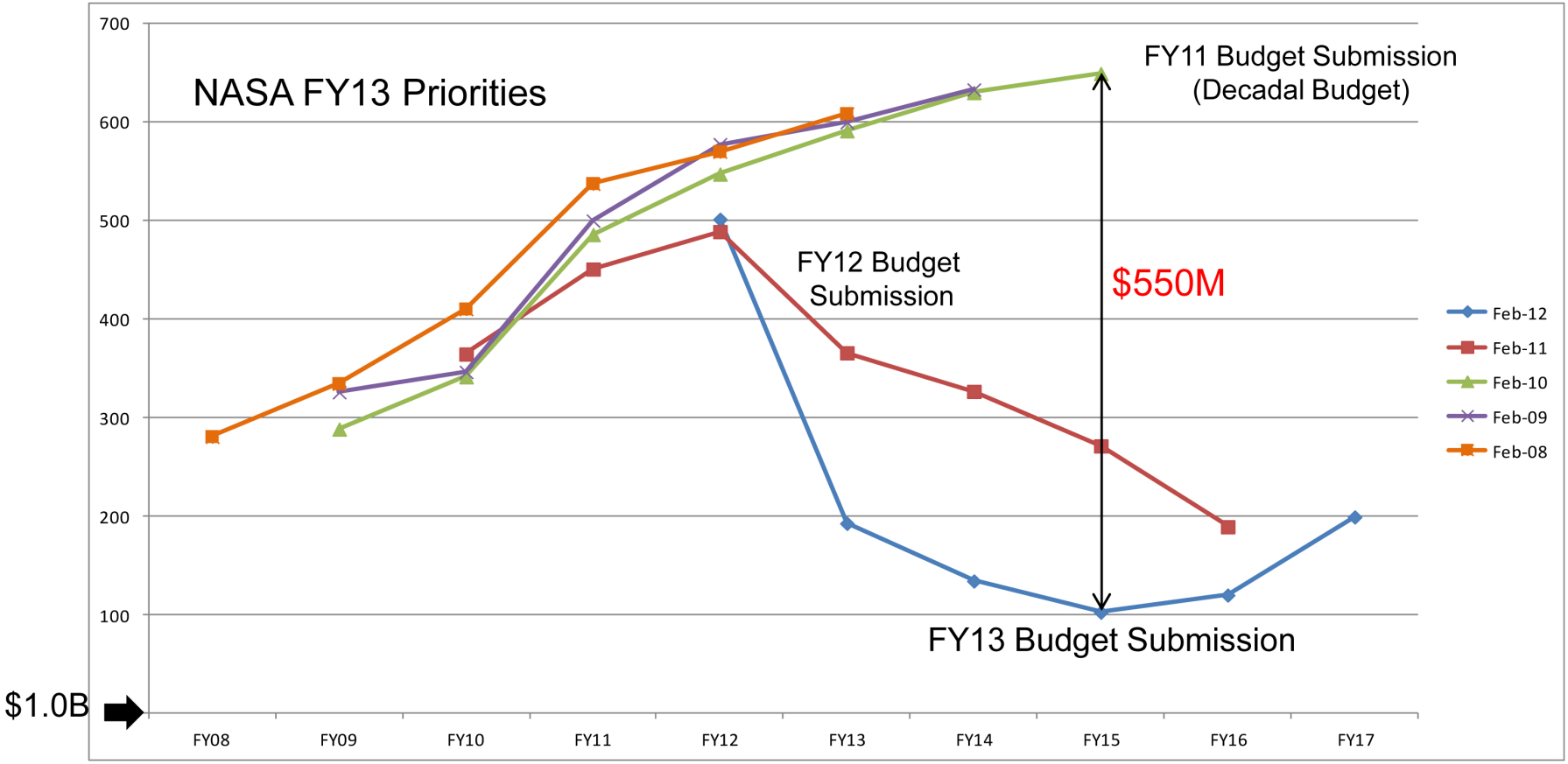
APS Letter Report: Report Card

N = will not be achieved **P**= partially achieved **Y** = likely achieved **TBD** = to be decided

Status	***Large-scale Space Activities:***
N	Wide-Field Infrared Survey Telescope (WFIRST) with DOE
Y	Explorer Program Augmentation
N	Laser Interferometer Space Antenna (LISA) with ESA
N	International X-ray Observatory (IXO) with ESA
Status	***Medium-scale Space Activities:***
Y	New Worlds Technology Development Program (deferred in ROSES11)
N	Inflation Probe Technology Development Program
Status	***Small-scale Space Activities:***
N	Astrophysics Theory Program Augmentation (10% of requested increase)
Y	Definition of Future UV/Optical Space Capability
TBD	Intermediate Technology Development Augmentation (competitive selection)
P	Laboratory Astrophysics Program Augmentation (25% of requested increase)
TBD	JAXA-led SPICA Mission (future MOO announcement)
N	Suborbital Program Augmentation (4% to 7% of requested increase)
P	Theory and Computation Networks (with NSF, DOE; 30% of requested new start)

President's Budget for NASA's Planetary Programs

As Submitted in Five Consecutive Years for FY09 thru FY13



Planetary Science Budget Features

- **What Changed:**

  Initiate a new Mars exploration strategy as an integrated approach by partnering with Human Exploration and the Office of the Chief Technologist:
  - Ending work on 2016 ExoMars Trace Gas Orbiter and Mars 2018 ExoMars rover
  - Looking at a robotic exploration mission
- Reduced Discovery flight rate with Discovery 13 AO release moved to FY15
- Lunar Quest Program phased out after LADEE with remaining activities absorbed into Research Programs and Discovery
- NEO program expanded to improve and increase its detection efforts

- **What's the Same:**
- Continuing 14 operating science missions:
  - MESSENGER, GRAIL, LRO, Deep Impact, MRO, Odyssey, Opportunity, Dawn, Juno, Cassini, New Horizons
  - ESA partnered missions: Venus Express, Mars Express, Rosetta
- LADEE and MAVEN launches in 2013
- Technology and Data Programs: Develop Radioisotope Power Systems (RPS); Planetary instruments; continue to support Planetary missions with navigation and sample curation
- Continue with Research & Analysis awards selections and awards

Programmatic Impacts

- Discovery
  - Discovery 13 delayed to FY15 (~54 months)
- New Frontiers
  - NF-4 delayed one year to FY16
- Outer Planets
  - Contains: Cassini, OP-R&A, and strategic mission studies
  - No future missions have been budgeted (no Europa nor participation with ESA on JUICE)
- Mars 2016/2018 missions with ESA eliminated
- Operating Missions
  - Mars extended mission budget not sufficient to support all current missions AND Curiosity

Agenda

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

Finding: The President's FY13 Budget Proposal

- NASA's top line in the Administration's FY13 budget proposal is nearly the same as in FY12 (down $58.6M or **-0.3%**). The FY13 budget establishes JWST as an agency priority and provides in full the resources identified in last year's re-plan to complete JWST and launch it in 2018. Earth science is also increased in FY13 and the out-years.

- The overall SMD budget has taken a decrease of $162.5M **(-3.3%)** in FY13 and is flat-lined over the 5-year run-out. This funding situation results in a proportionally larger (11-fold) decrease for SMD compared to the entire Agency. Many recommendations in the recent NRC Decadal surveys will not be accomplished, particularly Flagship-class missions in Planetary (Mars, Outer Planets) and Astrophysics (WFIRST), and this situation may adversely impact the Heliophysics Decadal Survey which will be released shortly.

- The Planetary program has been singled out for a massive reduction, by 21% in FY13 with further reductions in the out-years. The flight rates of the highest priority programs, Discovery and New Frontiers, will be drastically reduced and there are insufficient funds in the out-years to operate the expected fleet of flight missions. The Mars Exploration Program will take the brunt of the reductions with the elimination of the 2016/2018 joint Mars missions with ESA. The Outer Planets program is reduced to study concepts.

Recommendation

Short Title: Recovering the Planetary Exploration Program

Recommendation:
The Science Committee recommends that NASA seek restoration of funds in its FY14 budget proposal to repair the damage done to the Nation's robotic planetary exploration program within the context, but not at the expense of a balanced science program that has already absorbed numerous funding reductions in recent years.

The Committee concurs with SMD's initiative to reformulate the Mars Exploration Program for missions in 2018-2020 in partnership with human space flight, technology development, and potential international partners, pending any Congressional direction and under the condition that the plan must be consistent with Decadal Survey recommendations.

Recommendation (Cont'd)

Major Reasons for the Recommendation:
The FY13 budget proposal contains a precipitous drop in funding for the Planetary Science Division and sets the program on a decline in the out years reducing the flight rate for Discovery and New Frontiers missions, terminating operating missions before their prime, and removing funding for the 2016 and 2018 Mars missions planned in collaboration with ESA. The funds remaining do not allow for a Mars mission in 2016 but may be sufficient for a medium-class mission in 2018 or 2020.

Consequences of No Action on the Recommendation:
The current funding profile for the Nation's robotic planetary exploration program will sacrifice critical capabilities and our leadership to other space-faring nations as they pursue capabilities and goals abandoned by the United States.

Recommendation

Short Title: Restoring Science in NASA

Recommendation:
The Science Committee recommends that NASA advocate and pursue a policy within the Administration that will place NASA science at the same priority level as science in other agencies such as NSF, DOE and NIST, and be included in any future initiatives that seek to increase the science investment for the Nation.

Major Reasons for the Recommendation:
Science in other Federal Agencies have enjoyed much higher priorities and fared much better in the President's budget proposals.

Consequences of No Action on the Recommendation:
US capabilities to explore and understand our Earth, Solar System and Universe will be eroded.

Recommendation

Short Title: Enhanced Cooperation in Planetary Protection

Recommendation:
The Planetary Protection Working Group (PPWG-ESA) and the Planetary Protection Subcommittee (PSS-NASA) recommend that NASA and ESA renew the Letter of Agreement and further explore mechanisms for more closely coordinating their required planetary protection activities, including technology-development, with the goal of achieving high degrees of coordination and cooperative technology development for planetary protection to ensure most efficient use of available resources. Further, they recommend that the PPWG & PPS continue joint activities in planetary protection, including the regular exchange of meeting minutes and holding joint advisory meetings approximately every 2 years.

Recommendation (Cont'd)

Major Reasons for the Recommendation:
The 2007 ESA-NASA Letter of Agreement provides for cooperation on planetary protection and is the basis for effectively coordinating joint development of planetary protection technologies. However, the current Letter of Agreement expires December 31, 2013. Close cooperation on planetary protection is important to the function of both NASA and ESA, particularly in the context of increasing participation in joint/international missions.

Consequences of No Action on the Recommendation:
The legal authority for cooperation in this important area will expire.

Recommendation

Short Title: Mars Science Laboratory (MSL) Planetary Protection Lessons Learned report

Recommendation:
The Committee requests the preparation of an extensive “lessons-learned” report be completed while the MSL Planetary Protection team remains intact and available for preparation of the report.

The report should include:

1. Issues with spacecraft materials and contamination control that may affect measurements made either *in situ* or after return
2. Key elements of a bioburden accounting software package that can be developed jointly for use in the Mars Sample Return (MSR) campaign
3. Publication of the Adenosine Triphosphate (ATP) assay as related to the NASA Standard Assay, to facilitate adoption of this assay for bioburden accounting on MSR elements
4. Research needed to improve the assessment of proposed landing sites in the context of concerns for liberation of fluids from hydrated or frozen ground in the presence of a Radioisotope Power System.

Recommendation (Cont'd)

Major Reasons for the Recommendation:
Planetary protection engages numerous competing needs, including science and engineering considerations, general contamination control, materials compatibility with bioburden/organic reduction, etc. Plans for future Mars Sample Return missions will rely on heritage hardware, held to higher bio-cleanliness standard than any mission since Viking, for both planetary protection and science. Viking planetary protection "lessons-learned" report was a valuable resource for transmitting knowledge & practice to subsequent projects. It is important that the transmission of lessons-learned from ongoing missions, especially MSL, to developers of the MSR campaign be accomplished.

Consequences of No Action on the Recommendation:
NASA's withdrawal from the Mars Sample Return campaign as previously structured and formulated for initiation during the 2018 Mars launch opportunity makes the recording of lessons from the MSL project experience all the more important. The now potentially long hiatus in U.S. Mars surface operations for sample return threatens an especially severe loss of accumulated knowledge and experience.


Questions/comments?
NASA

Mission Decoder by Division

Earth Science mIssions

ACRIMsat	Active Cavity Radiometer Irradiance Monitor satellite
Aqua	Earth Observing Satellite mission for atmospheric dynamics
Aquarius	Ocean surface salinity mission with Argentina
Aura	Earth Observing Satellite for atmospheric chemistry
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
GPM	Global Precipitation Measurement
GRACE	Gravity Recovery and Climate Experiment
GRACE- FO	Gravity Recovery and Climate Experiment – Follow On
ICEsat-II	Ice, Clouds and land Elevation Satellite-II
Jason-1	Ocean surface topography satellite with France
Landsat	Land imaging satellite
LDCM	Landsat Data Continuity Mission
OCO-2	Orbiting Carbon Observatory-2
OSTM/Jason-2	Ocean Surface Topography Mission with France
QuikSCAT	Quick Scatterometer for ocean winds measurement
SAGE III	Stratospheric Aerosols and Gas Experiment III
SORCE	Solar Radiation and Climate Experiment
SMAP	Soil Moisture Active/Passive
Suomi NPP	Suomi National Polar-orbiting Partnership
Terra	Earth Observing System mission for land, ocean, and clouds
TRMM	Tropical Rainfall Measuring Mission

Heliophysics mIssions

ACE	Advanced Composition Explorer
AIM	Aeronomy of Ice in the Mesosphere
CINDI	Coupled Ion-Neutral Dynamics Investigation
Cluster-2	ESA-led four satellite mission to study Earth's magnetosphere
GEOTAIL	Japan/NASA mission to study Earth's magnetotail
Helio EX-1	To be selected Helio Explorer mission
IBEX	Interstellar Boundary Explorer
IRIS	Interface Region Imaging Spectrograph
LWS SET-1	Living With a Star Space Environment Testbed - 1
MMS	Magnetospheric Multiscale
RHESSI	Reuven Ramaty High Energy Solar Spectroscope Imager
RBSP	Radiation Belt Storm Probes
SDO	Solar Dynamics Observatory
SOHO	Solar and Heliospheric Observatory
STEREO	Solar Terrestrial Relations Observatory
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIMED	Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics
TWINS A&B	Two Wide-Angle Imaging Neutral-Atom Spectrometers
Voyager	Missions to the outer planets, now at the heliopause

Astrophysics mIssions

Astro EX-1	To be selected Astro Explorer mission
Astro-H	Japan facility class X-ray mission
Fermi	Fermi Gamma-ray Large Area Space Telescope
GALEX	Galaxy Evolution Explorer
GEMS	Gravity and Extreme Magnetism Small Explorer
Herschel	ESA infrared space telescope
HST	Hubble Space Telescope
Integral	International Gamma-Ray Astrophysics Laboratory
JWST	James Webb Space Telescope
Kepler	Discovery mission to detect extrasolar planets
NuSTAR	Nuclear Spectroscopic Telescope Array
Planck	ESA microwave space telescope
SOFIA	Stratospheric Observatory For Infrared Astronomy
Spitzer	Spitzer infrared space telescope
Suzaku	Japan X-ray telescope
Swift	Gamma ray burst space telescope
WISE	Wide-field Infrared Survey Explorer
WMAP	Wilkinson Microwave Anisotropy Probe
XMM-Newton	ESA mission to observe celestial X-ray sources

Planetary Science mIssions

ARTEMIS –	Acceleration, Reconnection, Turbulence, and Electrodyanamics of the Moon's Interaction with the Sun
Cassini	Flagship mission to Saturn and its moons
Dawn	Discovery mission to visit the asteroids Vesta and Ceres
Deep Impact	Discovery mission to impact comet Tempe I-1
EPOXI	Extrasolar Planet Observation and Deep Impact Extended Investigation
GRAIL	Gravity Recovery and Interior Laboratory
Juno	New Frontiers mission to Jupiter
LADEE	Lunar Atmosphere and Dust Environment Explorer
LRO	Lunar Reconnaissance Orbiter
MAVEN	Mars Atmosphere and Volatile Evolution
MER	Mars Exploration Rovers (Spirit & Opportunity)
MESSENGER	Mercury Surface, Space Environment, Geochemistry and Ranging
MRO	Mars Reconnaissance Orbiter
MSL	Mars Science Laboratory
MSR	Mars Sample Return
New Horizons	New Frontiers mission to fly by Pluto and into the Kuiper Belt
OSIRIS-REx	Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer
Rosetta	ESA mission to return a sample from a comet
Strofio	Mass spectrometer instrument for ESA's Bepi/Colombo mission

NOAA Reimbursable missions

DSCOVR	Deep Space Climate Observatory
GOES-R series	Geostationary Operational Environmental Satellites
Jason-3	Ocean surface topography satellite
JPSS 1&2	Joint Polar-orbiting Satellite System