

# Planetary Science

Jim Green & Ron Greeley

April 22, 2011

# Outline

- Current PSD status - Green
- PSD plan to respond to the Decadal – Green
- PSS Response & Recommendations - Greeley
- Science Nuggets - Green

# Status of Missions in Formulation

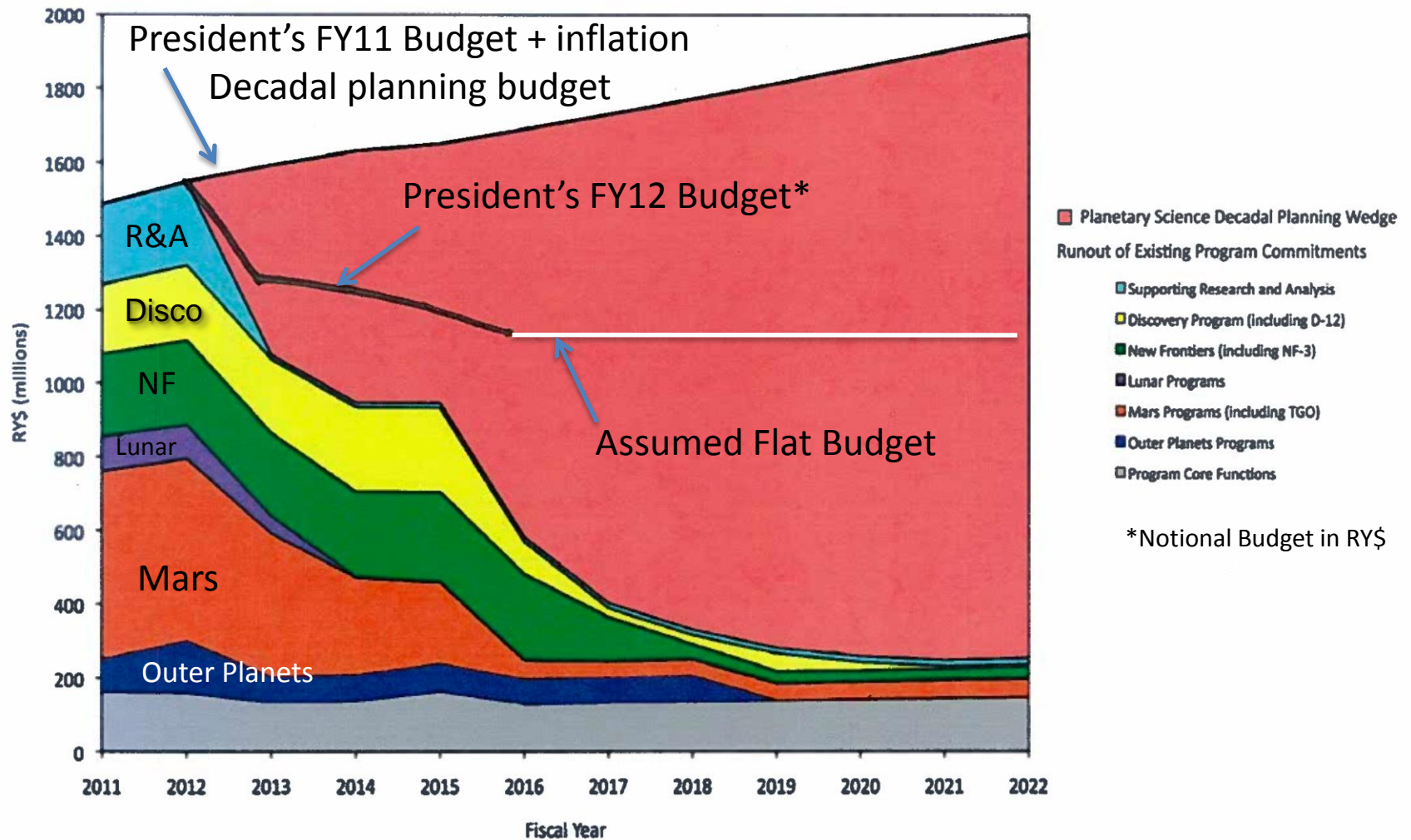
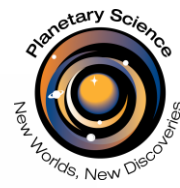
- Discovery-12 AO Status:
  - 28 proposals received, wide diversity of science targets, goals and approaches.
  - Proposers chose to use many of the incentivized, NASA-developed technologies
  - Evaluation in progress and *on schedule* – April/May
  
- New Frontier Step-2 proposals on January 28, 2011
  - MoonRise: SPA Basin Sample Return (Brad Joliff, PI)
  - OSIRIS-Rex: Asteroid sample return (Mike Drake, PI)
  - SAGE: Venus lander (Larry Esposito, PI)
  - Evaluation in progress and *on schedule* – May/June

# Schedule Of Events

- Decadal released March 7<sup>th</sup> at LPSC
- Decadal Town Hall meetings (March 15 – April 17)
  - See: <http://solarsystem.nasa.gov/2013decadal>
- Discussions with OMB and OSTP (ongoing)
- FY11 budget passed late last week (CR through Oct 1)
  - PSD funding allocation will occur this week
- FY12 budget under discussion in Congress
- Development of FY13 budget has begun
- President's FY13 budget request to Congress Feb. 2012
  - Will reflect Decadal recommendations within budget realities

# Planetary Funding Profiles

## FY11 and FY12 Requests



# Planetary Program Architecture

## Recommended by the Planetary Decadal Survey

### Large Missions (“Flagship”-scale)

*“Recommended Program”*  
*(budget increase for JEO new start)*

- 1) Mars Astrobiology Explorer-Cacher – descoped
- 2) Jupiter Europa Orbiter (JEO) – descoped
- 3) Uranus Orbiter & Probe (UOP)
- 4/5) Enceladus Orbiter & Venus Climate Mission

*“Cost Constrained Program”*  
*(based on FY11 Request)*

- 1) Mars Astrobiology Explorer-Cacher – descoped
- 2) Uranus Orbiter & Probe (UOP)

*“Less favorable” budget picture than assumed*  
*(e.g., outyears in FY12 request)*

**Descope or delay  
Flagship mission**

### Discovery

\$500M (FY15) cap per mission (exclusive of launch vehicle) and 24 month cadence for selection

### New Frontiers

\$1B (FY15) cap per mission (exclusive of launch vehicle) with two selections during 2013-22

**Research & Analysis (5% above final FY11 amount then ~1.5%/yr)**

**Technology Development (6-8%)**

**Current Commitments (ie: Operating Missions)**

# PSD Decadal Budget Planning

- Lay In Current Commitments
  - All Operating Missions Through Expected End of Life
  - Current R&A Awards
  - All missions in development or competition
    - Juno, GRAIL, MSL, LADEE, MAVEN, EMTGO
    - New Frontiers-3, and Discovery 12
  - In-Space Propulsion Technology
  - Radioisotope Power System Program
  - Pu-238 Production
- Accommodate Decadal Recommendations
  - Maintain a healthy R&A program
  - Discovery AO's on 2 year Cadence
  - New Frontiers AO's on 5 year Cadence
  - Mars 2018 Cache Rover Directly Tied to MSR
    - Includes initiation of MSR high-priority technologies wedge
- Per OMB \$10M/year set aside for cooperative activities with Human Exploration
- Full decadal recommendations greatly exceed President's FY12 Budget
  - Must use decision rules from decadal to develop a balanced budget

# Decadal Decision Rules

- Page 9-6: NASA's suite of planetary missions ... should consist of a balanced mix of Discovery, New Frontiers, and Flagship missions, enabling both a steady stream of new discoveries and challenges ...
- Page 9-21: It is also possible that the budget picture could turn out to be less favorable ... If cuts to the program are necessary, the committee recommends that the first approach should be descope or delaying Flagship missions. Changes to the New Frontiers or Discovery programs should be considered only if adjustments to Flagship missions cannot solve the problem.
- Actions based on Decadal Guidance:
  - Maintain a balanced program – small, medium, large missions
  - Maintain a partnership with ESA
  - Descope flagship missions as a first resort due to tight budgets
  - If flagship descopes are *not sufficient* then stretch out New Frontiers and Discovery A/Os



# NASA-ESA Bi-Lateral Meeting (1/2)

- 2016 ExoMars/TGO progressing well:
  - Passed KDP-A March 29, 2011
  - Outstanding issues:
    - Acceleration of NASA instrument schedules & relax some AIV requirements
    - Elevation to Category-1/APMC due to international *program-level* commitment
- 2018 Dual Rover Mission:
  - ESA cost proposal and NASA's FY12 President's Budget required a new approach
  - Concurrently the mission's technical complexity created unacceptable cost and technical risk
- Agencies agreed to descope to a single-rover architecture:
  - Merge rover design - leverage both partner's goals, capabilities & assets
    - NASA focused on Decadal Science/sample caching
    - Use MSL *build-to-print* decent stage for landing
    - ESA focused on mobility and drilling
  - Joint Executive Board provided guidelines and defined roles and responsibilities
  - Joint Engineering WG began April 6<sup>th</sup> to create best technical solution
  - Forming joint science team to set joint science objectives and Level-1 requirements

# NASA-ESA Bi-Lateral Meeting (2/2)

- Key decision gate for ESA is May 26-27 PB-HME
  - Go/No-Go decision for 2018 basic architecture concept(s) and ESA/NASA responsibilities
- Joint Mars Sample Return Working Group continues activities will ramp up as 2018 Joint Rover Mission take shape

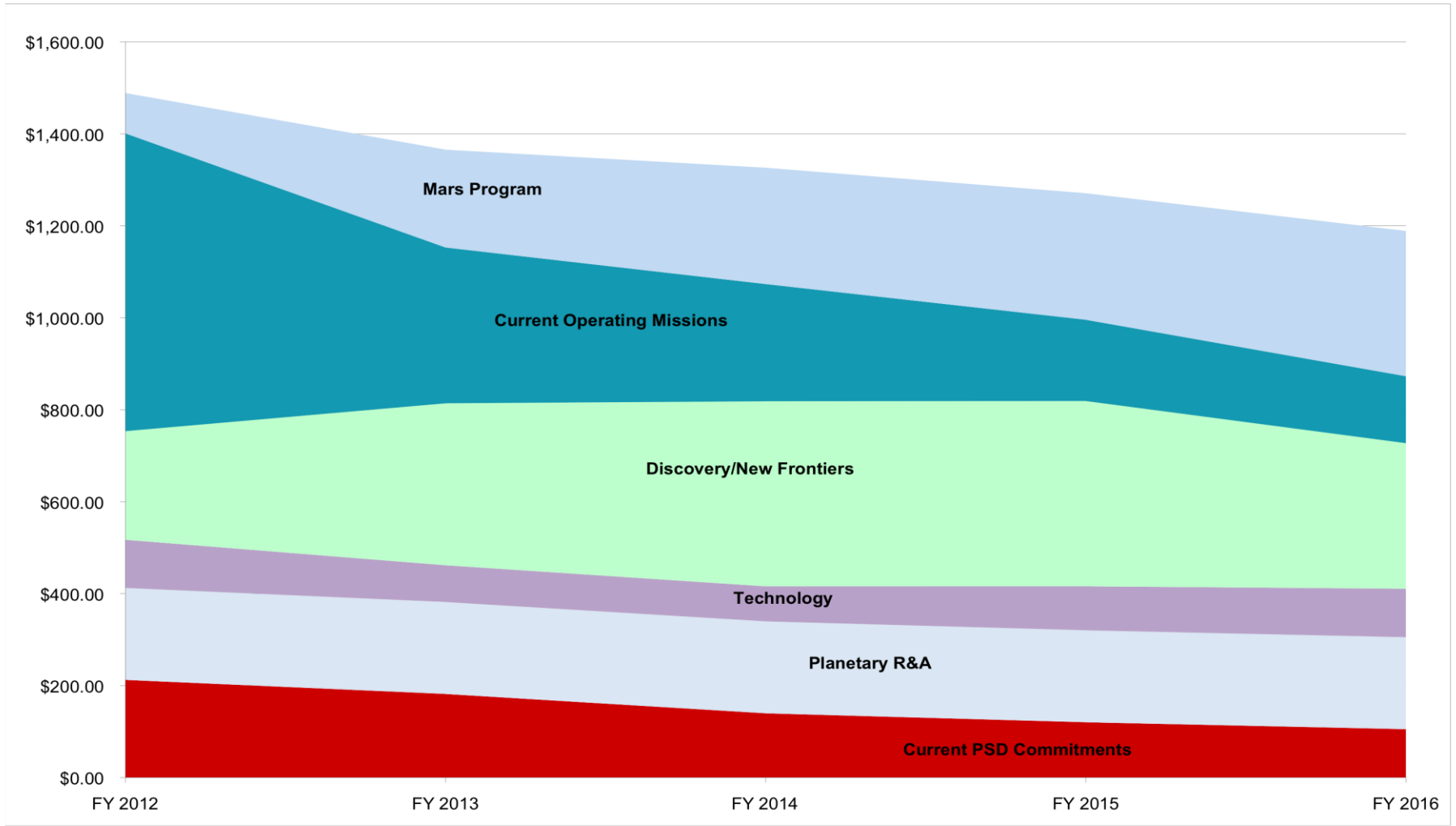
## Cosmic Visions:

- ESA directs its 3 CV-L class missions to reformulate studies
  - NASA invited to have observer during their deliberations/study
- NASA directs JPL to work descoped Europa mission study
  - ESA invited to have observer during our deliberations/study
- Reaffirm NASA's commitment to support ESA's *Laplace* mission if it is chosen as the CV-Large class mission as a Mission of Opportunity

# Approach to Develop new “Notional” Budget

- Capped R&A at \$200M/year
- Next Discovery AO on current >36 month cadence
  - All subsequent AO’s accelerated to 24 Month Cycle
- Select NF-3 planned for NF-4 and NF-5 within decade
  - Will maintain New Frontiers schedule
- Extended Mission budget for ALL operating missions
  - Senior Review used for determining which missions to be extended
- Dedicated Lunar R&A wedge transferred to PSD R&A
- Residual Lunar Quest Program moved to Discovery
- JEO Descoped to Studies Funded FY11/12
  - No JEO Instrument AO
  - Budget for some radiation technology efforts

# A PSD "Notional" Decadal Budget



# Planetary Science Subcommittee

Ron Greeley

# *Planetary Science Subcommittee Initial Assessment*

## **VISION AND VOYAGERS FOR PLANETARY SCIENCE IN THE DECADE 2013-2022**

- **Decadal survey was executed well and the recommendations are reasonable within the scope of the study**
  - **Gives priorities**
  - **Anticipates various funding scenarios**
- **PSS is encouraging the planetary community to support the Survey**
- **Planetary Science is extremely diverse in scientific disciplines**
  - **The community should speak with a uniform consensus voice**
  - **The Survey was essentially completed before the President's proposed budget was released and without full considerations of the increased NLS-2 costs**
- **PSS role**
  - **NOT to revise the Decadal Survey**
  - **Rather, to consider and recommend approaches for implementation**

# PLANETARY SCIENCE SUBCOMMITTEE PROCESS

- **March 7: Decadal Survey "rollout" by Steve Squyres and Jim Green's response (many PSS members were present); Venus and Lunar science groups met to discuss results, which were incorporated in PSS analysis**
- **March 17-18 *Outer Planet Analysis Group* meeting: discussion with Squyres and formation of initial "findings"**
- **Other Planetary Analysis Group input**
- **April 18-19 PSS meeting at NASA HQ for in-put and initial reactions (presented to Science Committee April 22)**
- **NEXT STEPS**
  - **PSD draft response to Decadal Survey in progress now**
  - **Draft to be sent to PSS for review in May**
  - **PSS telecon with Jim Green in June after PSS review**

# PSS ANALYSIS AND OBSERVATIONS

## *PSS overview of initial PS Division response*

- **“Notional” budget to fit the President’s budget profile is commendable in the current climate**
- **A strategic goal is to try to keep a balance of mission sets**
- **Decadal Survey includes many recommendations beyond missions; these, too, must be costed and prioritized**
- **PSS is particularly grateful for maintenance of the R&A line, consistent with Decadal Survey priorities**



# **LARGE FLIGHT PROJECTS**

## **(i.e., “Strategic” or “Flagship” Class)**

*PSS recognizes:*

- 1. Flagship(s) do not fit the current budget profile**
  - Decadal Survey recommended “scrub” for Mars '18 to \$2.5B**
  - But still would not fit budget**
- 2. Jupiter-Europa Orbiter**
  - Decadal Survey costed at \$4.7B**
  - Requires substantial change with Survey providing potential descope options for study**
- 3. International (ESA) joint Flagship mission(s) being explored**
- 4. Need to keep options open (e.g., study of de-scoped options following Decadal Survey priorities and methodologies)**

# **PLANETARY SCIENCE SUBCOMMITTEE**

## ***Large Mission “De-scope” Considerations***

### **Establish appropriate science working groups**

- **Center scientists and planetary community scientists**
- **Work directly with the engineers and technologists throughout the de-scope process**
- **Continue to assess impacts on science by the de-scope option(s)**
- **Determine the *minimum acceptable science***

### **PSS considerations for the de-scope process**

- **Develop a schedule with critical decision milestones (i.e., PSS recognizes iterative nature of process, but it should not be completely "open-ended")**
- **Independent costing to be done by the same entity for all candidate Flagship(s) options**
- **Apply the same criteria, assumptions, and levels of uncertainties for all projects to the extent possible**
- **Ensure that relevant science groups (e.g., MEPAG) are “in the loop”**

# PSS CONSIDERATIONS FOR FLAGSHIPS

## Mars '18

- **Sample Return is the next MAJOR step for Mars science**
- **Sample return is NOT the culmination of Mars Science**
- **Mars community must articulate the potential gain from sample return and communicated to the broader community**
- **As a joint mission, a joint AO should be released for the negotiated competed payload, following the example used for the NASA-ESA Mars '16 mission**

## Outer Planet ESA Jupiter Ganymede Orbiter

- **Being assessed**
- **If selected, NASA and ESA should consider the opportunity for US instruments/participation**

*Before the end of the 2013-2022 decade, an Outer Planet Flagship should be vigorously pursued, consistent with the Decadal Survey recommendations*

# **PLANETARY SCIENCE SUBCOMMITTEE ANALYSIS OF OTHER DECADAL SURVEY RECOMMENDATIONS**

- **The need for plutonium continues as high priority**
- **Support for technology development**
  - **Regardless of Flagship “outcomes,” technologies for sample acquisition/return should continue; Titan-related technologies, Venus/extreme environments, and other critical aspects for ALL classes of missions should be undertaken especially for small missions**
  - **Establish a PS Division technology group to manage activities**
  - **Ensure that appropriate Planetary Analysis Groups are involved**
- **“Stream-line” R&A programs (consistent with PSS draft report on SRT / R&A study; e.g., consider program consolidation to eliminate overlap)**
  - **Time is right for “comparative planetology” program**
  - **Consider periodic “senior review” of R&A program balance**

# **ADDITIONAL PSS CONSIDERATIONS**

- **Make use of existing relevant science groups**
  - **CAPTEM for sample handling / curation, laboratory instrument development, etc. issues recommended in Decadal Survey**
  - **Analysis Groups supporting SMD-HEO**
  - **MEPAG (Mars) for Mars'18 issues**

# Conclusion

- **The PSS is in agreement with the approach taken by the PSD for the implementation of a balanced program faithful to the new NRC Planetary Decadal Survey**
  - **It is essential that planetary Flagship mission(s) be preserved for science program balance**



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# MESSENGER

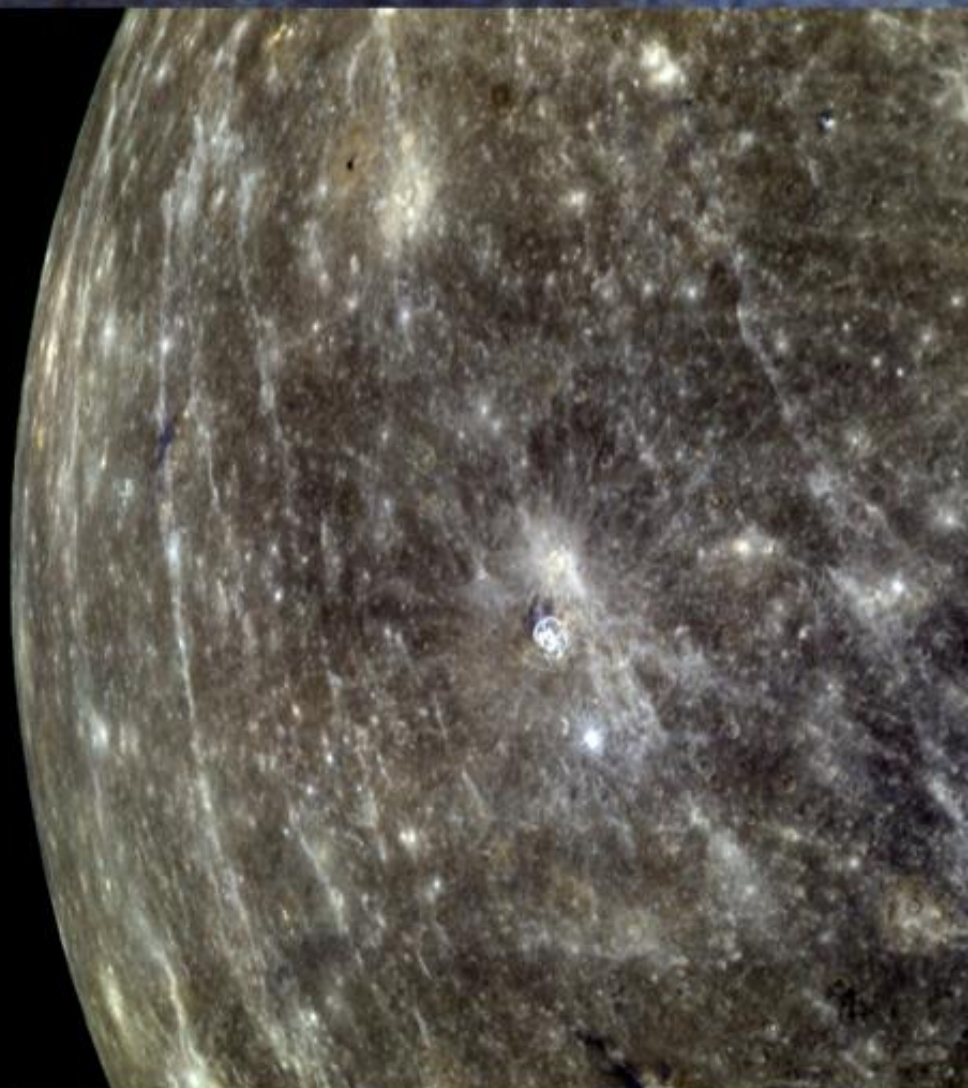
MErcury Surface, Space ENvironment, GEochemistry, and Ranging



## Global Imaging Campaign of Mercury Has Begun

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- As the first spacecraft to orbit Mercury, MESSENGER will map Mercury's surface globally with an broad imaging campaign.
- Global images will be obtained for morphology and stereo at 250 m/pixel and in 8 colors at 1 km/pixel.
- In the 1-year mission, MESSENGER will acquire >75,000 images.
- As of 20 April, >11,000 images have already been sent back to Earth.



MESSENGER color image, with the central wavelengths of 1000 nm, 750 nm, and 430 nm displayed in red, green, and blue, respectively, highlights compositional and optical maturity variations.

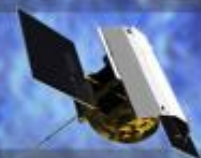




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# MESSENGER

MErcury Surface, Space ENvironment, GEochemistry, and Ranging

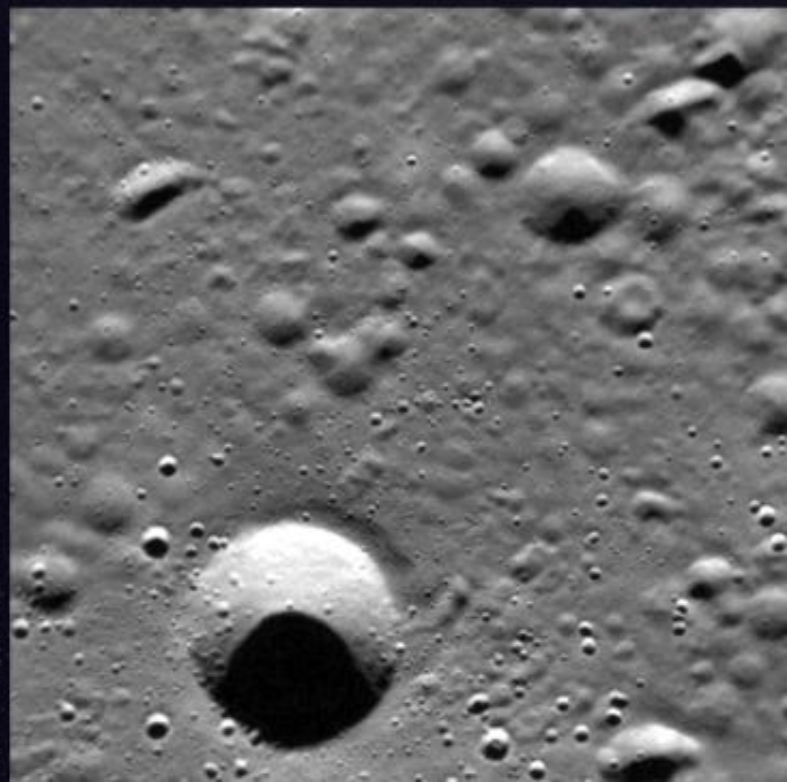


## Mercury's Surface Revealed in the Highest Resolution Ever Obtained

- MESSENGER has captured images of Mercury's surface down to 16 m/pixel.
- Areas of high scientific interest are targeted for high-resolution images.
- Prior to MESSENGER's orbital data, the highest resolution was ~90 m/pixel.
- The highest resolution planned from orbit will be ~10 m/pixel.



Left:  
April 10, 2011  
18 m/pixel  
Image is 18 km across  
Detail of crater's  
central peaks



Right:  
April 05, 2011  
16 m/pixel  
Image is 16 km across  
Close-up of northern  
plains





APL

# MESSENGER

MErcury Surface, Space ENvironment, GEochemistry, and Ranging




## Seeing the Previously Unseen at Mercury's North Pole

- MESSENGER's polar orbit has enabled terrain near the north and south poles to be viewed at close range for the first time.
- Images to date reveal a large expanse of volcanic plains in Mercury's north.
- MESSENGER will investigate the suggestion from radar observations that ice may be present in permanently shadowed crater floors.



Images are near 80.1°N, 62.1°E  
Each image is ~85 km across



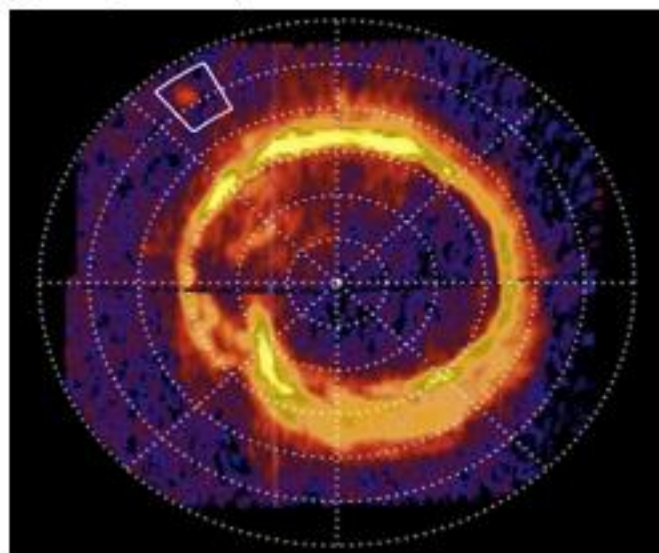


## Saturn's Moon Enceladus Leaves a Footprint

It has been suggested that cryovolcanic activity at Enceladus could lead to electrodynamic coupling between Enceladus and Saturn, similar to that which occurs with Jupiter and Io and with Europa and Ganymede.

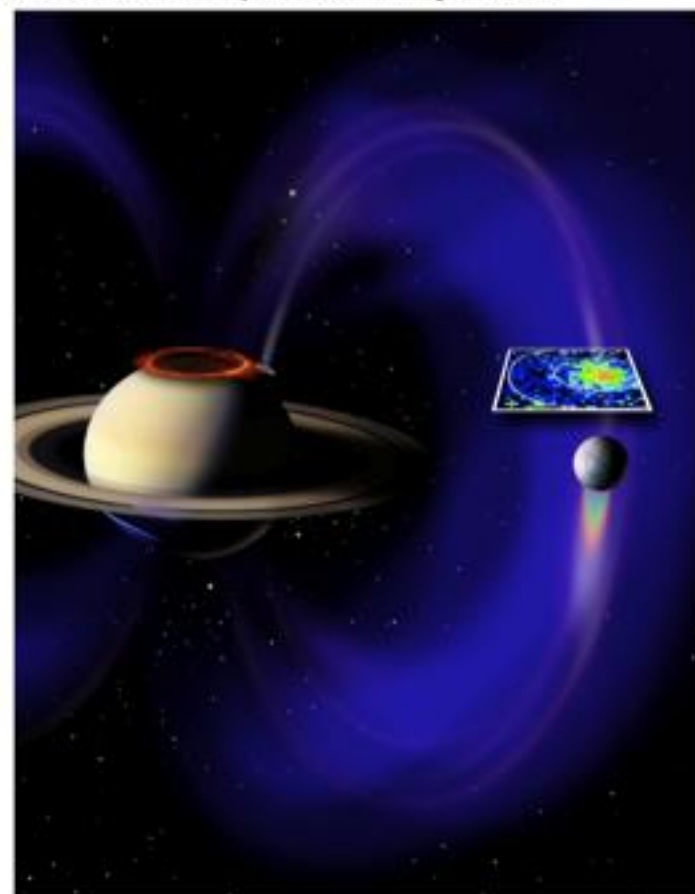
Pryor and others have recently published in *Nature*<sup>1</sup> analysis of data collected during a Cassini fly-by within 55 kilometers of Enceladus in August 2008 revealing magnetic field-aligned ion and electron beam emissions from Enceladus with sufficient power to stimulate detectable aurora. Subsequent observations with the Cassini ultraviolet imaging spectrometer system detected the expected Enceladus auroral footprint in Saturn's atmosphere.

The footprint varies in emission magnitude more than can be explained by changes in magnetospheric parameters — and as such is probably indicative of variable plume activity.



*At right is an ultraviolet image from the Cassini spacecraft in orbit at Saturn.*

*The Saturn aurorae ("northern lights") glow in an oval shape around the north pole, as shown in yellow-orange. Enceladus' footprint is the orange-red spot in the white box at the upper left.*



*Enceladus, a moon of Saturn, is magnetically "connected" to the polar region of Saturn and leaves a footprint, as shown in this artist's conception.*

<sup>1</sup> Pryor, W.R. et al, "The auroral footprint of Enceladus on Saturn", *Nature* Vol 472, pp 331–333, 21 April 2011

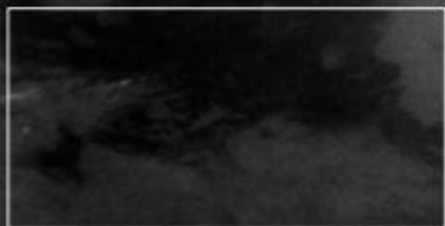
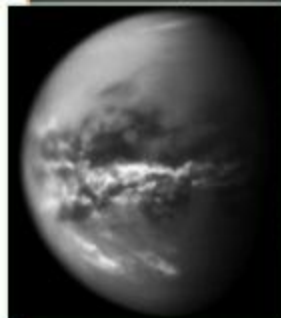


# Seasonal Methane Rains Transform Titan's Surface

*First observational evidence of substantial rainfall in the equatorial region of Saturn's moon Titan*

27 Sept. 2010

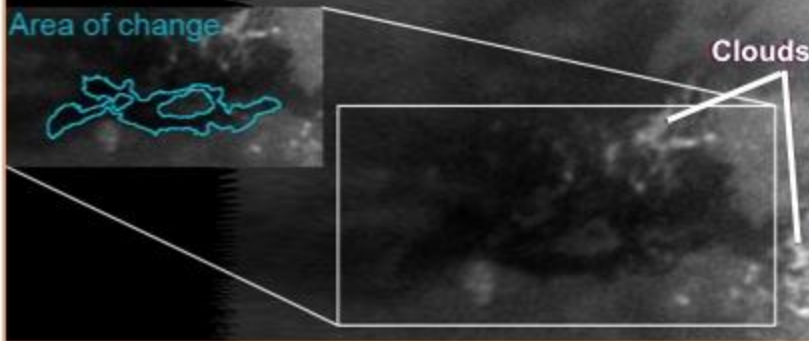
1000 km



29 Oct. 2010

Area of change

Clouds



*Methane clouds in the troposphere, the lowest part of the atmosphere, appear white and are mostly near Titan's equator. The darkest areas are surface features; the inset boxes indicate the area of change. Cassini observations of clouds like these provide evidence of a seasonal shift of Titan's weather systems to low latitudes following the August 2009 equinox in the Saturnian system.*

- Dramatic new findings reported in *Science*<sup>1</sup> suggest that Titan's weather is changing with the seasons, now early northern spring (~April on Earth), and storms have become more common at low latitudes.
- A huge cloud observed on Titan in Sept. 2010 was quickly followed by extensive changes on the surface:
  - ~500,000 km<sup>2</sup>, roughly the combined area of Arizona and Utah.
- The best explanation for the changes is widespread methane rainfall from the storm making the surface wet, perhaps even flooding it in some places.
- The observation of recent rain suggests that the climate is similar to the southwestern U.S., where infrequent rain carves washes and riverbeds.
- The new data also provides good reason to believe that the river channels carved in Titan's arid desert regions, such as those sighted in the images returned by the Huygens probe during its descent near the equator in January 2005, are in fact carved by seasonal rains.

*Huygens probe landing site from ~16 km altitude.*



<sup>1</sup> Rapid and Extensive Surface Changes Near Titan's Equator: Evidence of April Showers, E. P. Turtle, et al, *Science* 18 March 2011: 1414-1417.