National Aeronautics and
Space Administration

Science Committee Report

Dave McComas

Chair, Science Committee

Science Committee Members

Dave McComas, Southwest Research Institute, Chair
Carle Pieters, (Vice Chair), Brown University

Maura Hagan, NCAR, Chair of Heliophysics Subc
Janet Luhmann, UC Berkeley, Chair of Planetary Science Subc
Steve Running, University of Montana, Chair of Earth Science Subc
Scott Gaudi, The Ohio State University, Chair of Astrophysics Subc (NEW)
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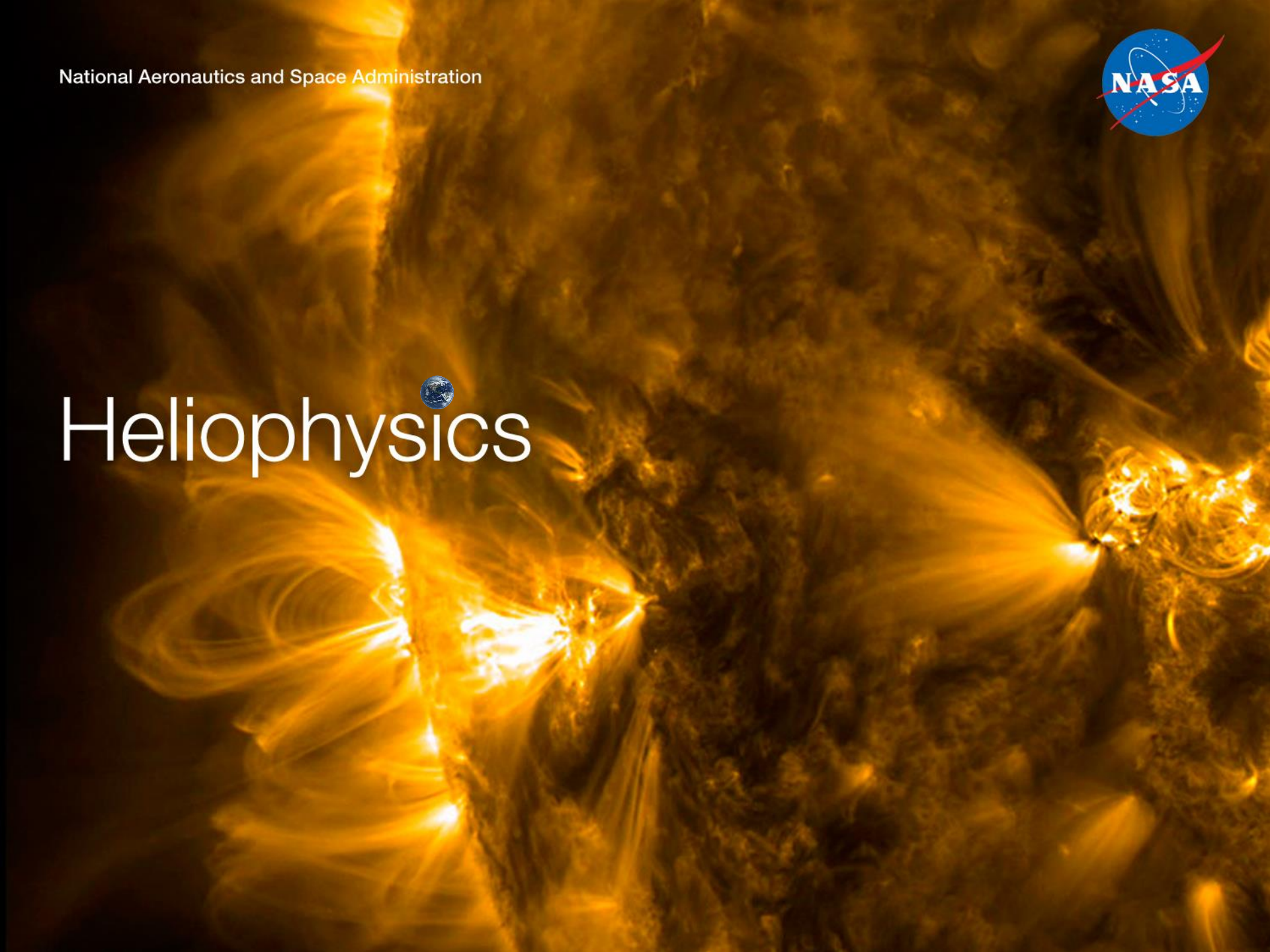
Doug Duncan, University of Colorado
Mark Robinson, Arizona State University
Harlan Spence, University of New Hampshire
James Green, University of Colorado at Boulder
Robert Kirshner, Harvard University (NEW)

David Spergel, Chair of Space Studies Board (*ex officio* member)

Outline

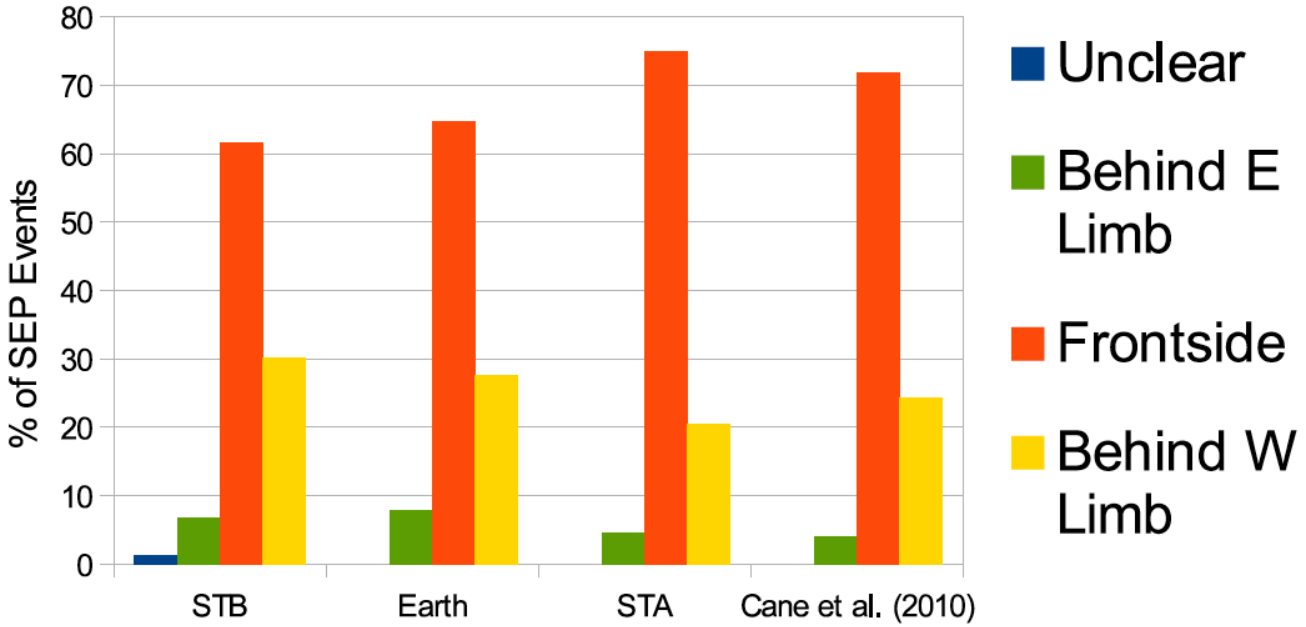
- **Science Results**
- Programmatic Status
- Findings

National Aeronautics and Space Administration



Heliophysics

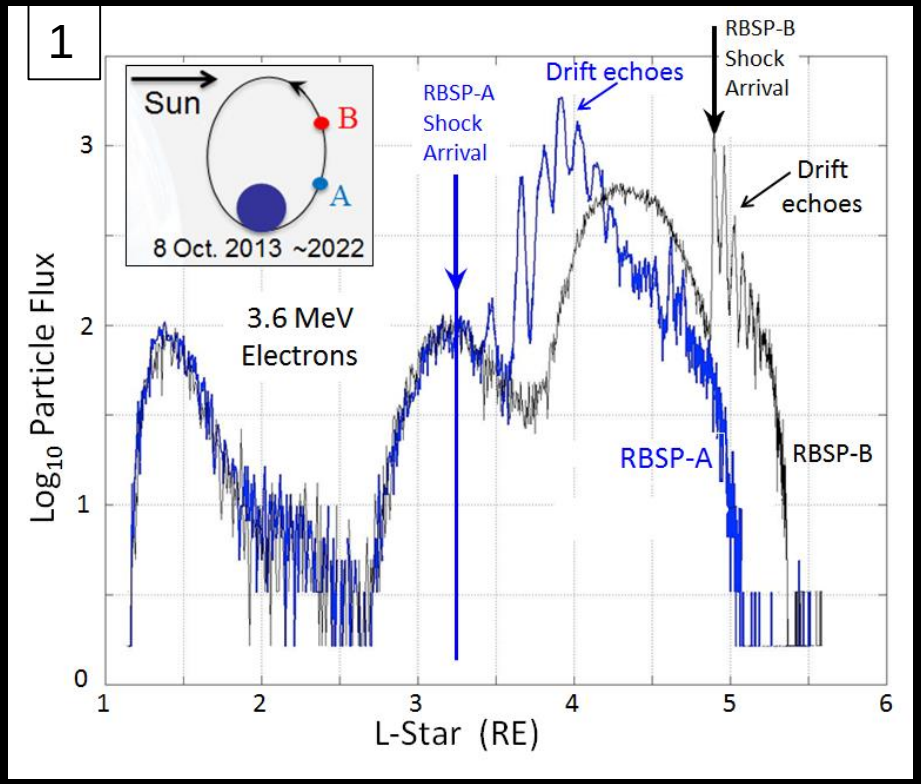
What fraction of solar energetic particle events originate on the far-side of the Sun ?

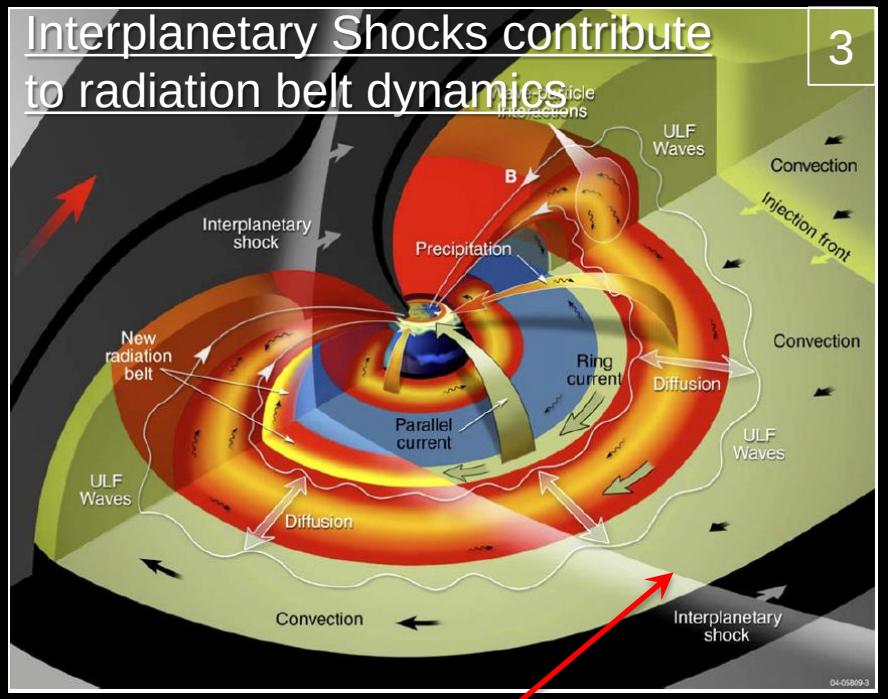


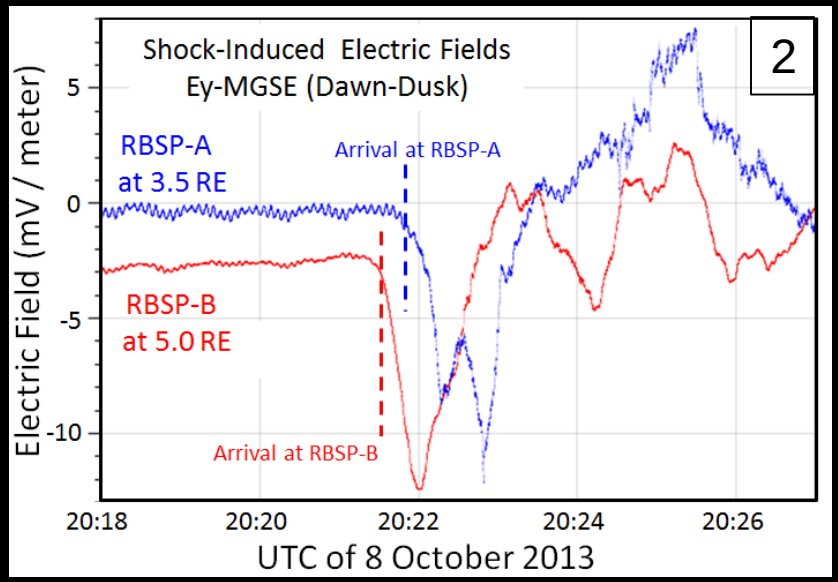
- A study of >25 MeV proton events using STEREO-A, STEREO-B, and near-Earth spacecraft data shows that ~1/3 of the solar energetic particles observed at each of the 3 locations originate on the opposite side of Sun
- About 26% of the events originate beyond the East limb and 7% beyond the West limb
- Events that originate behind the limb (as viewed from Earth) provide no flare warning, although the coronal mass ejection (CME) may be observed

Interplanetary Shock Wreaks Havoc on Earth's Electron Radiation Belt

- Van Allen Probes track an interplanetary shock through the inner magnetosphere (1).
- Induced electric fields (2) cause drift echoes and acceleration of MeV-class electrons throughout the outer radiation belt (1)
- Local shock effects and wave drift-resonance diffusion contribute to the acceleration (3)





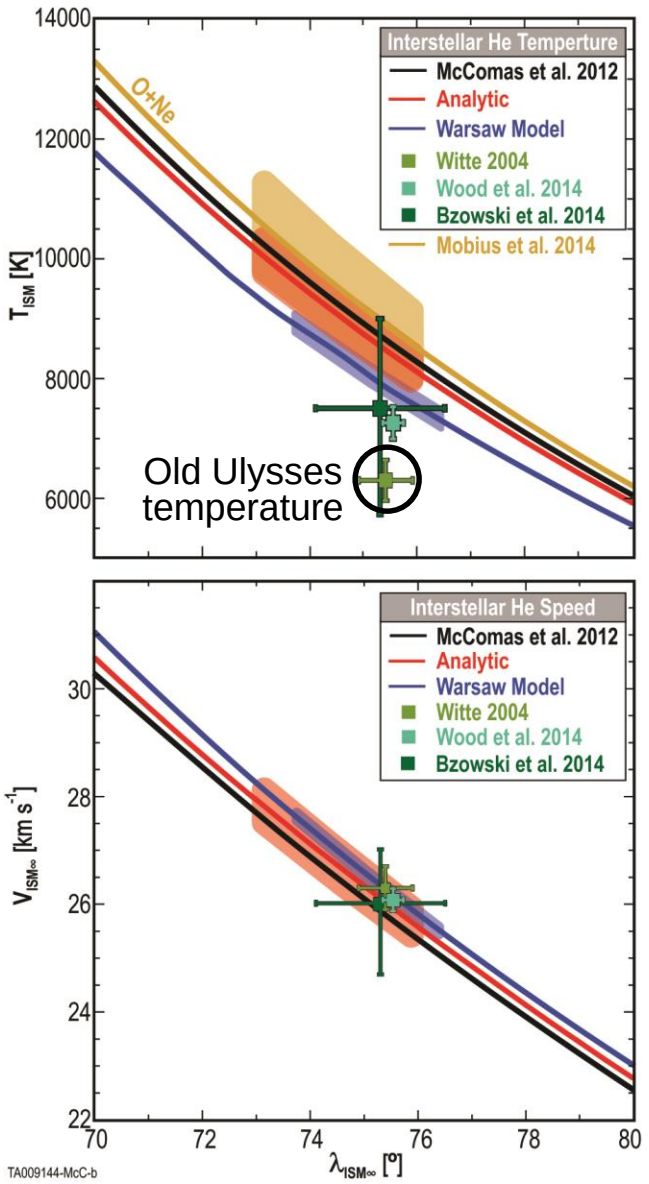


Foster et al., 2014, in press

Possible Resolution of Ulysses-IBEX Enigma

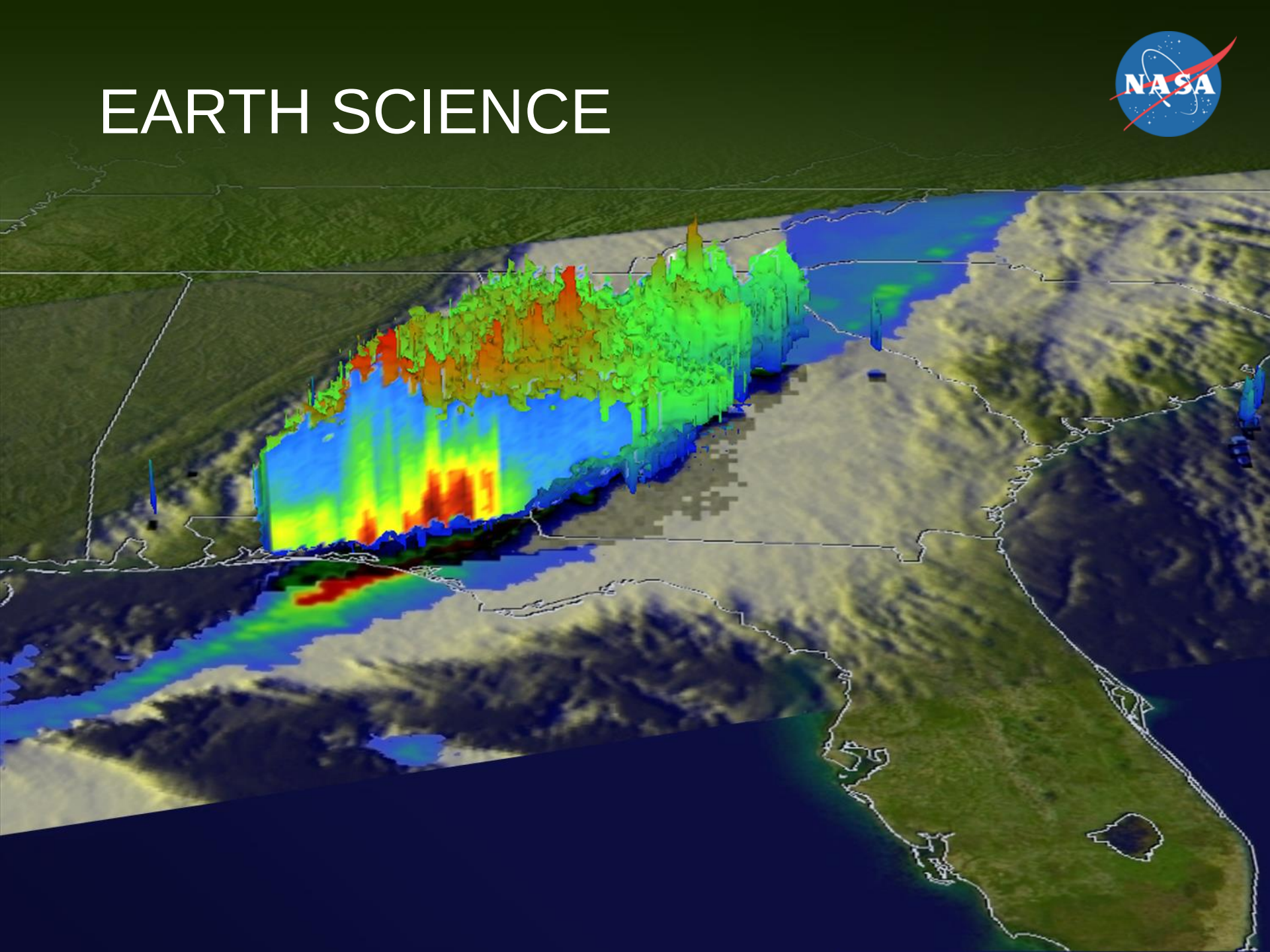
- Interstellar He gas flows freely into heliosphere at 10's of km/s from Local Interstellar Medium (LISM)
- **Ulysses-IBEX Enigma:**
  - Ulysses data provided inflow vector and quite cold LISM temperature of **~6300 K, flow speed ~26 km/s, inflow longitude ~75°**
  - IBEX data provide tightly coupled relation between flow vector and temperature with much higher temperatures (**>7500 K**) for ~26 km/s
  - 2009-2010 IBEX data suggested somewhat slower flow (**~24 km/s**), Ulysses temperature (**~6300 K**) and a somewhat different inflow longitude **~78°**
- **Possible Resolution:**
  - Newer 2012–2014 IBEX data indicate faster (**~26 km/s**) flow and inflow longitude similar to Ulysses (**~75** °) more likely but require higher temperatures
  - Reanalysis of old Ulysses data (*Bzowski et al*. 2014; *Wood et al*, 2014) find higher temperatures (**~7500 K**)
  - Heliosphere in much warmer region of LISM (**~7000–9500 K**) - may be isothermal
  - IBEX measures ~100 deeper into distributions than Ulysses (also first H, D, O, Ne observations)

    → IBEX discovering non-thermal distribution shapes and far more complicated interstellar interaction



McComas et al., ApJ, 2015

EARTH SCIENCE



GPM Observes Super Typhoon Hagupit on Dec. 5th

December 4th, 5th:

Super Typhoon Hagupit threatens the Philippines a year after deadly Super Typhoon Haiyan devastated the island nation. GPM's Microwave Imager (GMI) observed extreme rates of almost 100.9 mm (almost 4 inches) per hour on the southern side of Hagupit's eye.

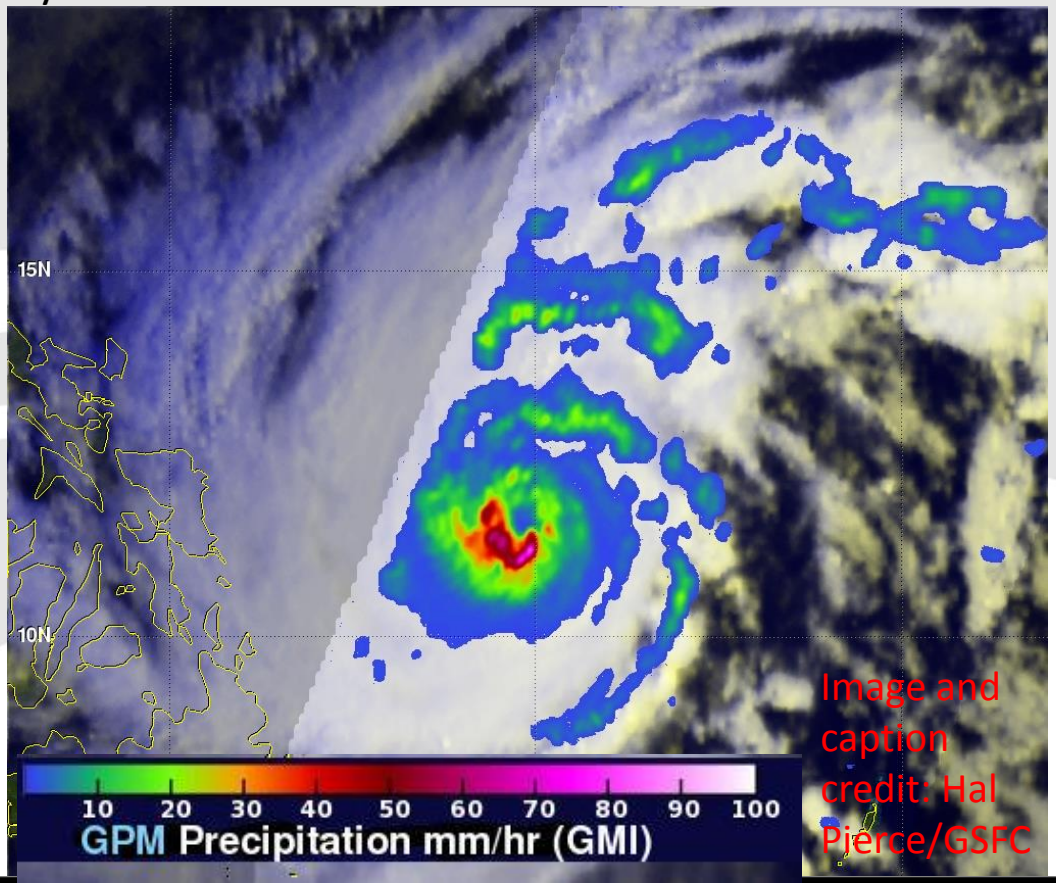
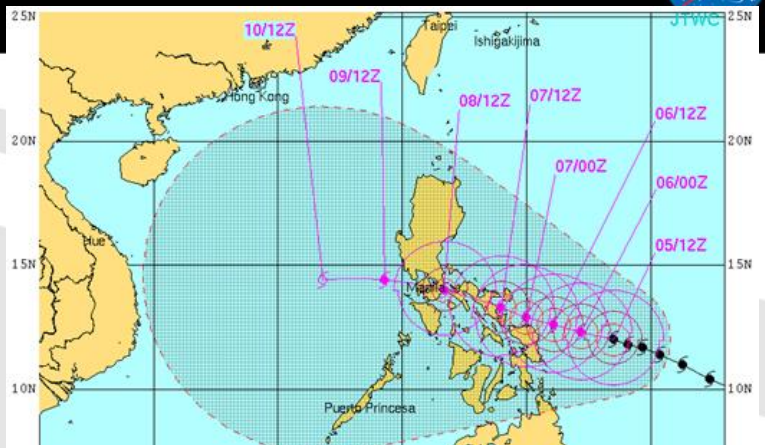
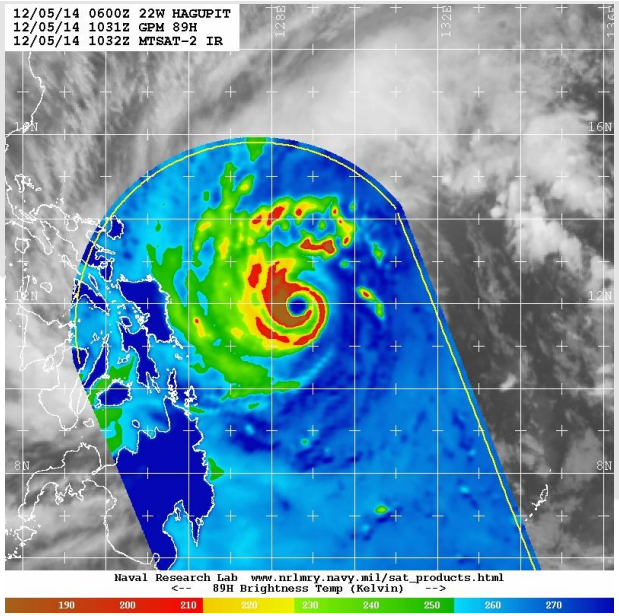


Image and caption credit: Hal Pierce/GSFC



The Naval Research Lab (NRL) is using GMI and other sensors in their Automated Tropical Cyclone Forecasting System (ATCF) for improved track prediction.

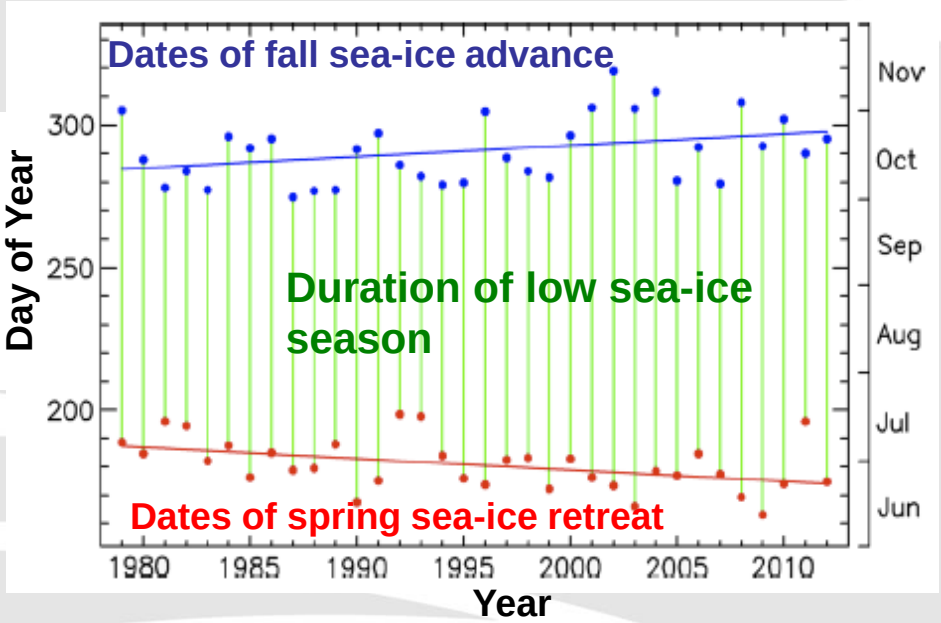


http://www.nrlmry.navy.mil/tc_pages/tc_home.html

New indicators of climate change leveraging NASA remote sensing resources

Timing of Arctic Sea Ice Advance and Retreat as an Indicator of Ice-Dependent Marine Mammal Habitat

PI: Harry Stern, University of Washington, Seattle

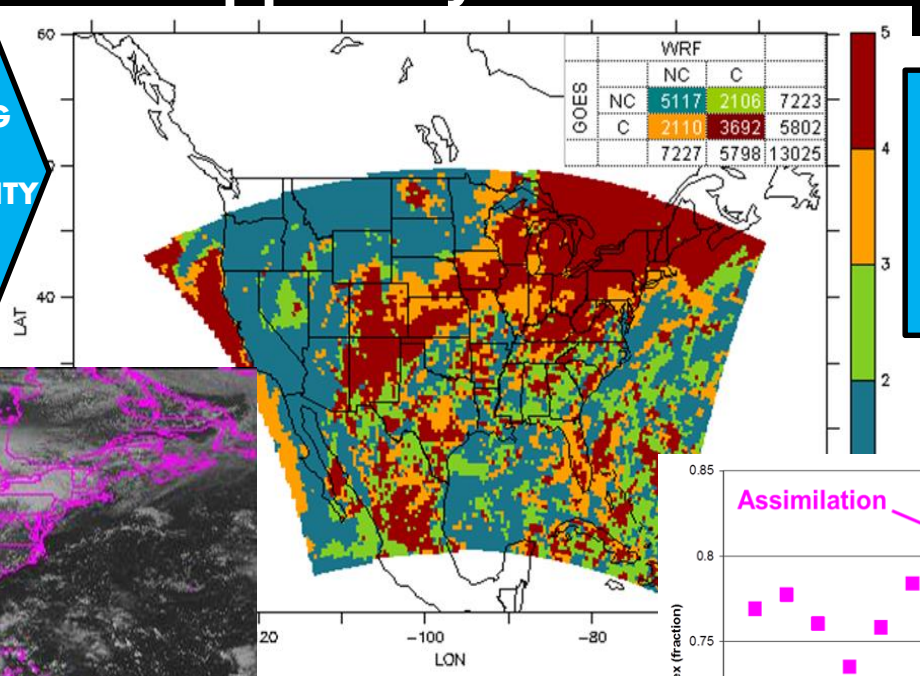


Habitat change indicator for ice dependent marine mammals

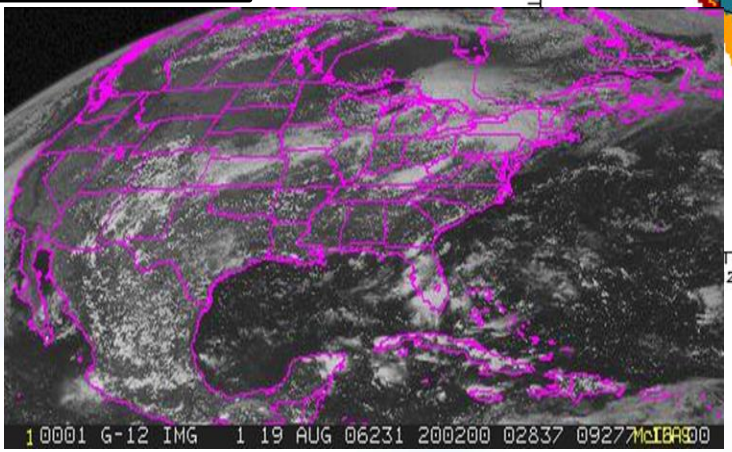
- Utilizes data from NSIDC
- Polar bear results are being used by Canada, Nunavut, Greenland, and the International Union for Conservation of Nature Red List and Polar Bear Specialist Group

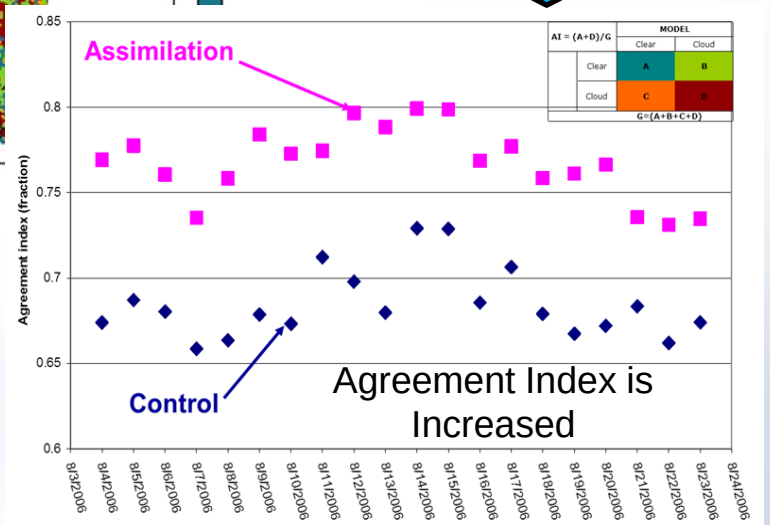
Incorporating Space-borne Measurements to Improve Air Quality Decision Support Systems for Texas

CLOUD LOCATIONS & TIMING FROM SATELLITE INGESTED INTO THE AIR QUALITY MODEL USED TO PLAN ACCEPTABLE EMISSIONS

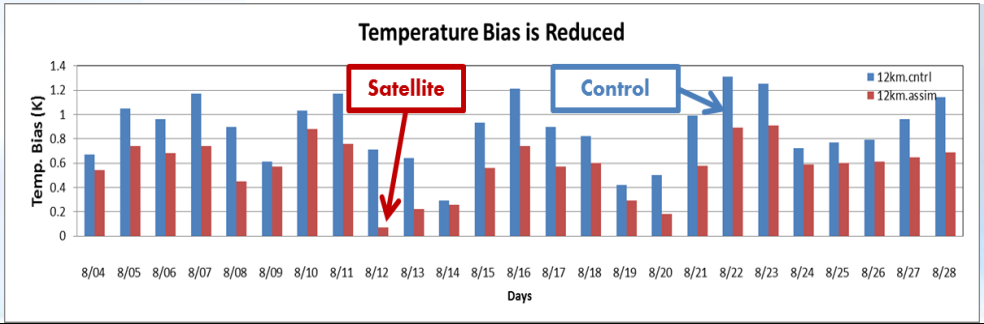


IMPROVED AIR QUALITY PLANNING AND REGULATORY DECISIONS

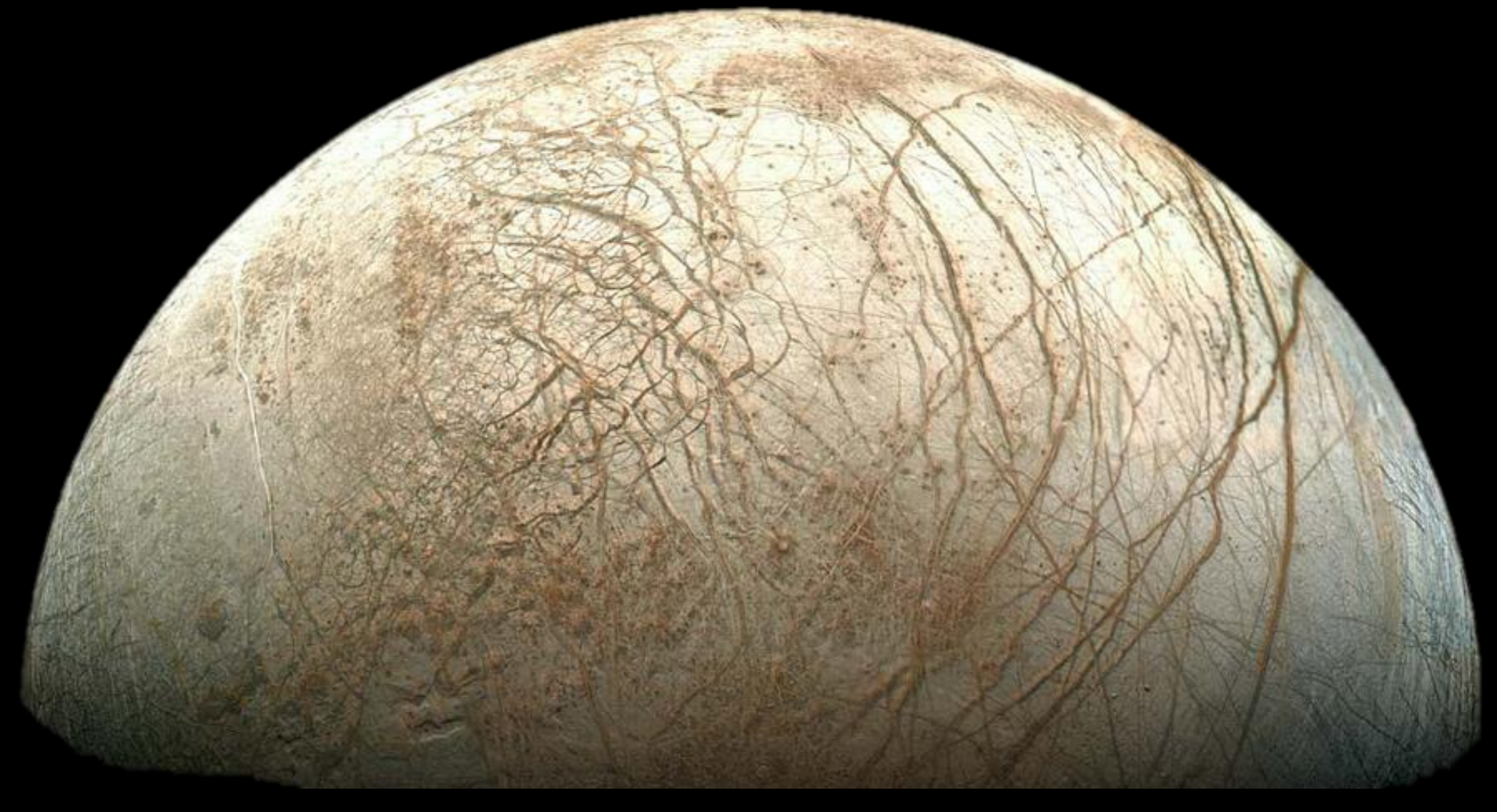




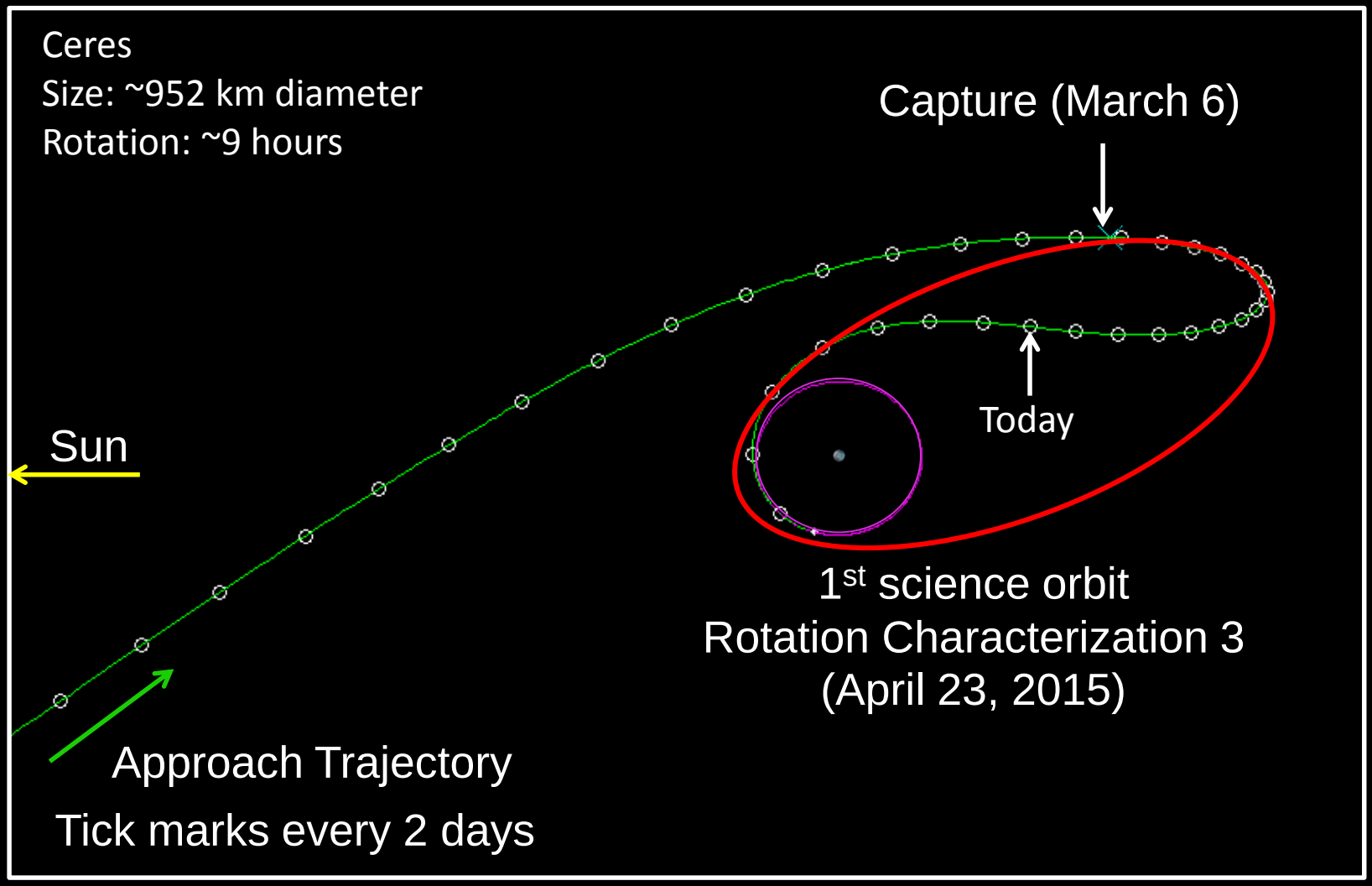
- The temporal and spatial location of clouds have a large impact on the projected air quality given a set of emissions. This tool is designed to provide accurate cloud information.
- Texas Commission for Environmental Quality (TCEQ) used this tool in their latest State Implementation Plans (SIPs)
- The State of Texas joined NASA Applied Sciences in funding 30% of the Project (~$310K)



Planetary Science



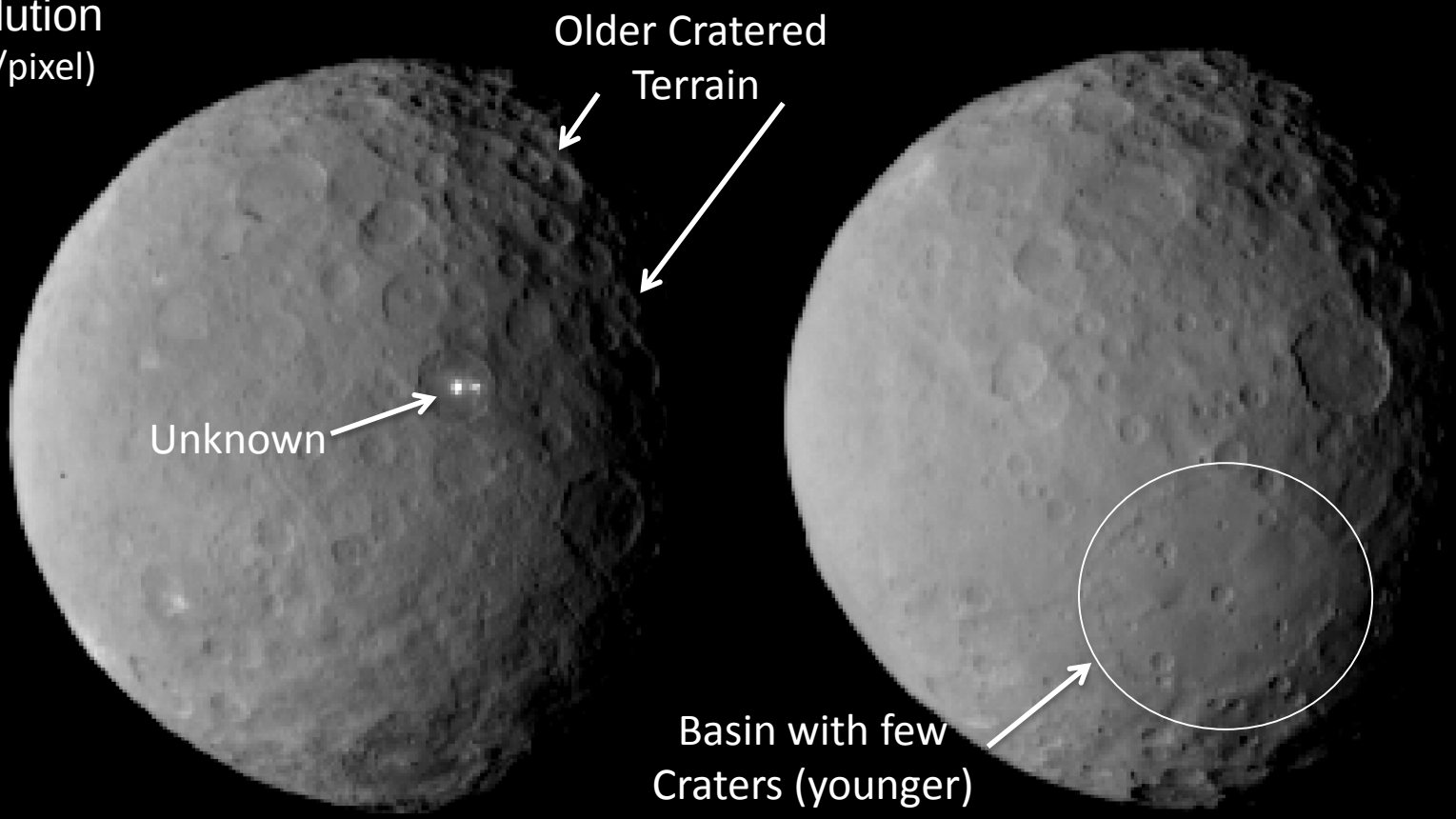
Dawn's Approach



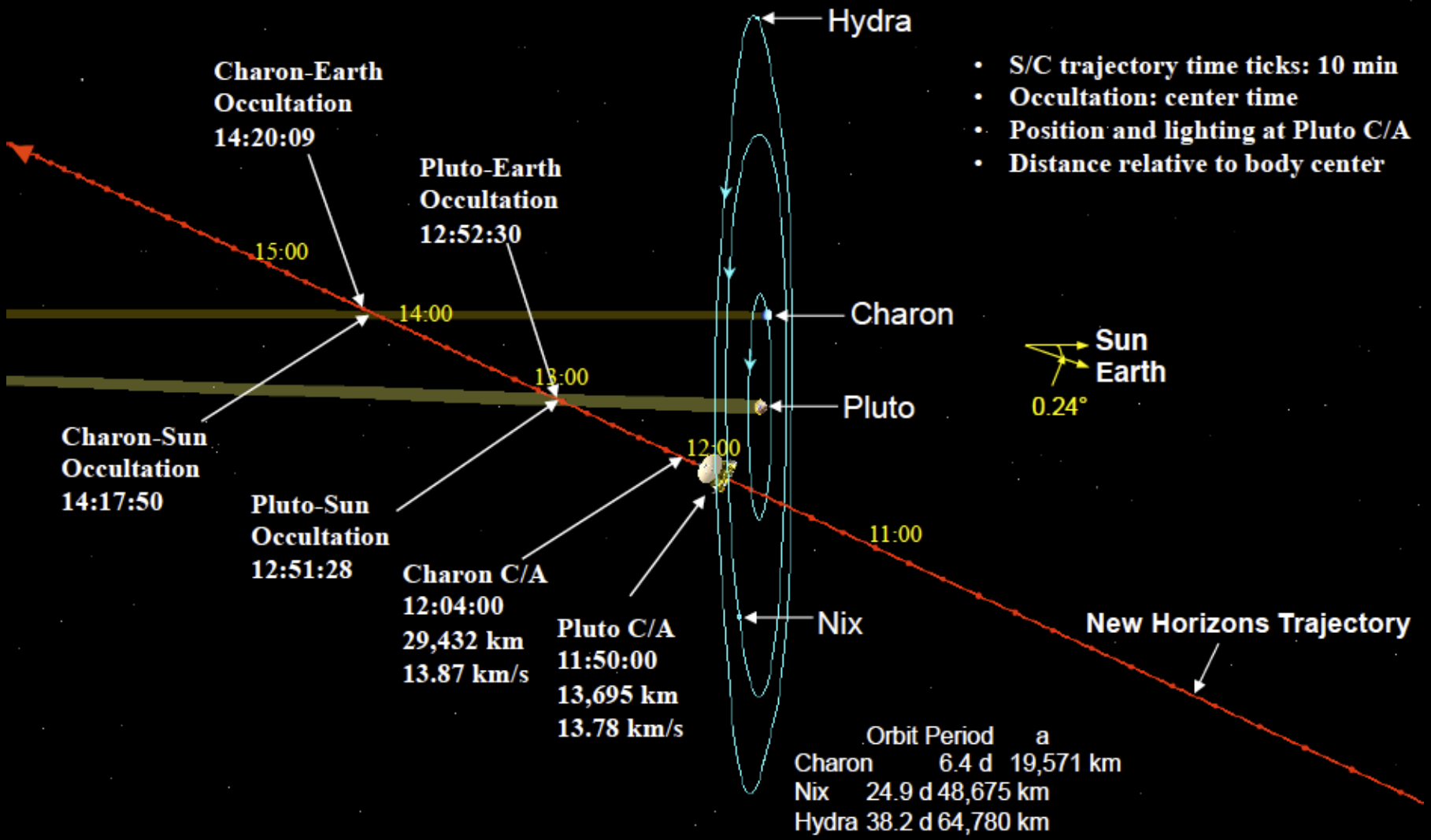
The Types of Terrain

RC 2 - Feb 19

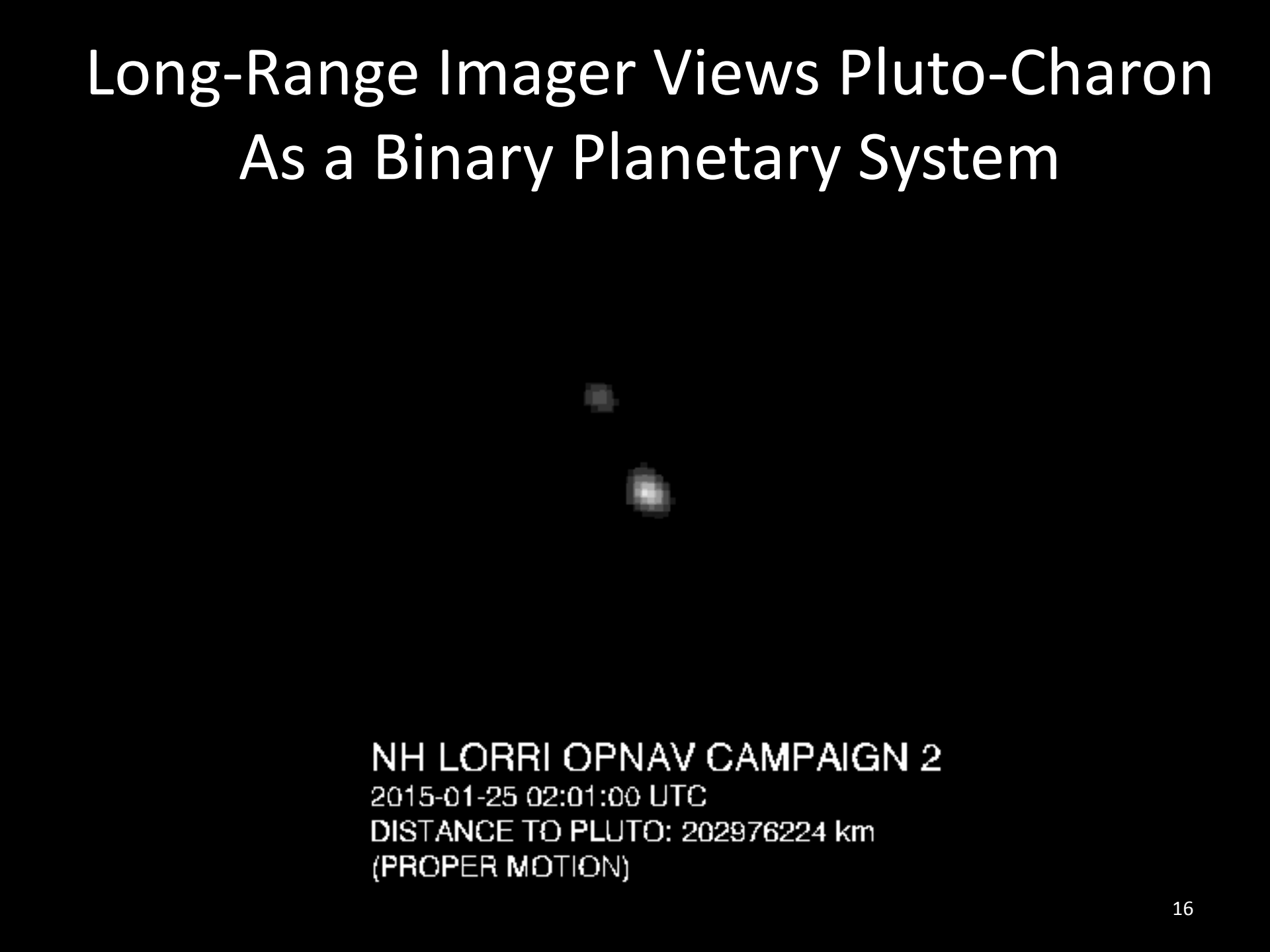
7 x Hubble Resolution (4 km/pixel)



Closest Approach On July 14, 2015



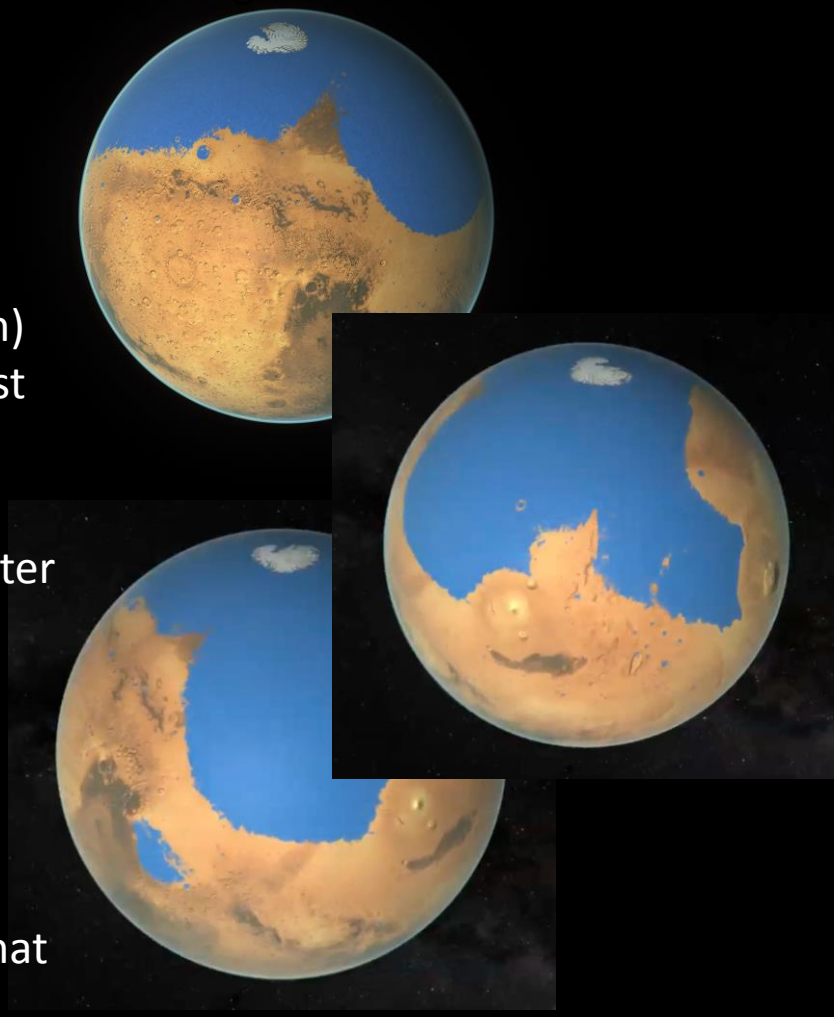
Long-Range Imager Views Pluto-Charon As a Binary Planetary System



Mars Has Lost an Ocean's Worth of Water

We know Mars has water but the question is *how much* and for *how long*?

- NASA researchers used 3 ground-based infrared telescopes on Earth to study the remaining water molecules in the Martian atmosphere
- The results showed that a very large amount of heavy water (having the deuterium or D hydrogen) remains on Mars today meaning that Mars has lost a significant amount of normal water (having just hydrogen or H) over time
- This allows an estimate of the total amount of water on Mars to be determined based on the accepted value of D/H
- Result: Today Mars has only 13% of the water it once had losing 87%
- Mars must have kept that water for >1.5 BY
- MAVEN is there now looking into the processes that tell us *how* Mars lost its water



20% of the planet would be covered with water to a maximum depth of 1 mile

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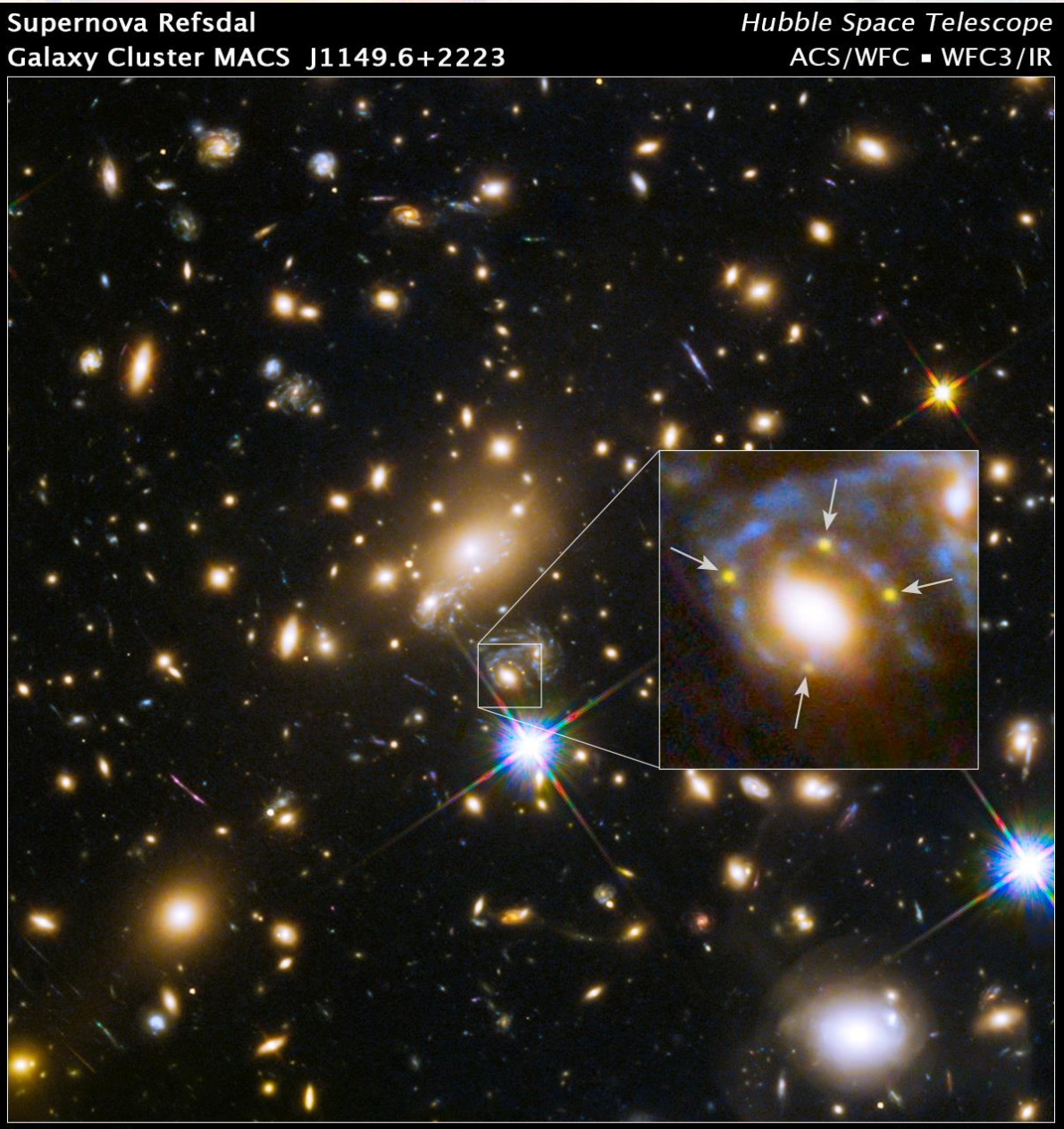
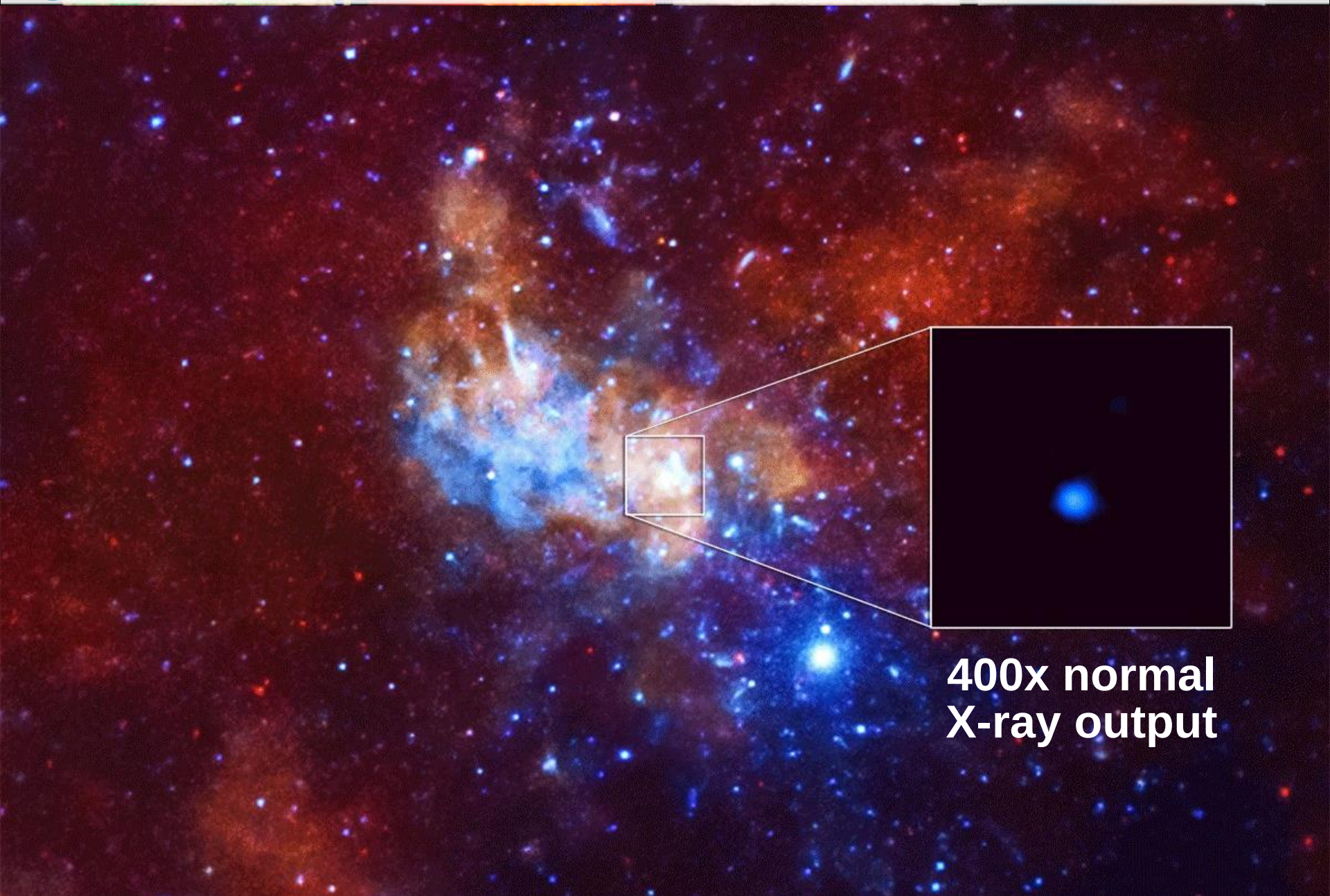
Astrophysics

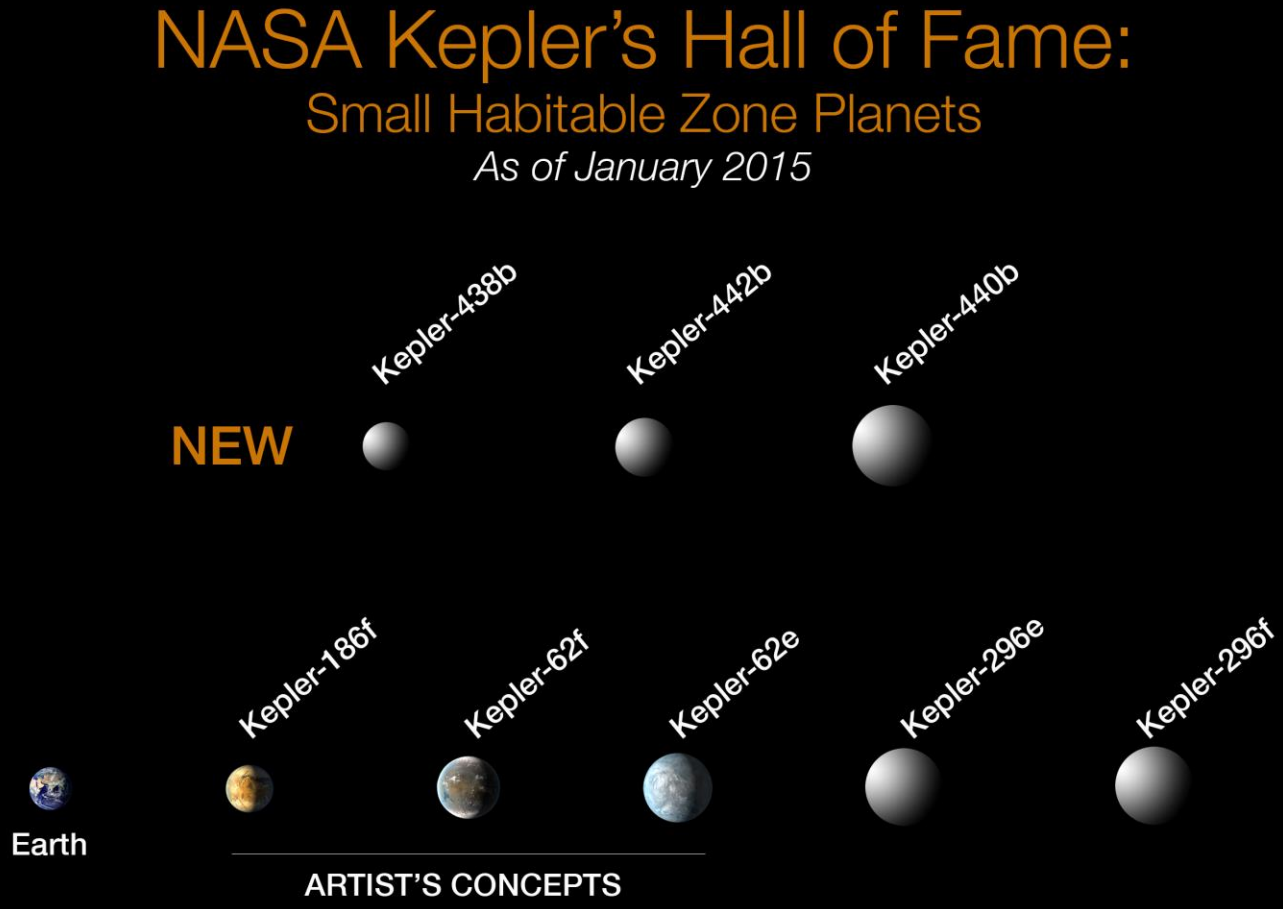
Hubble Sees Supernova Split into Four Images by Cosmic Lens



NASA's Chandra Detects Record-Breaking Outburst from Milky Way's Black Hole



NASA's Kepler Marks 1,000th Exoplanet Discovery, Uncovers More Small Worlds in Habitable Zones



Outline

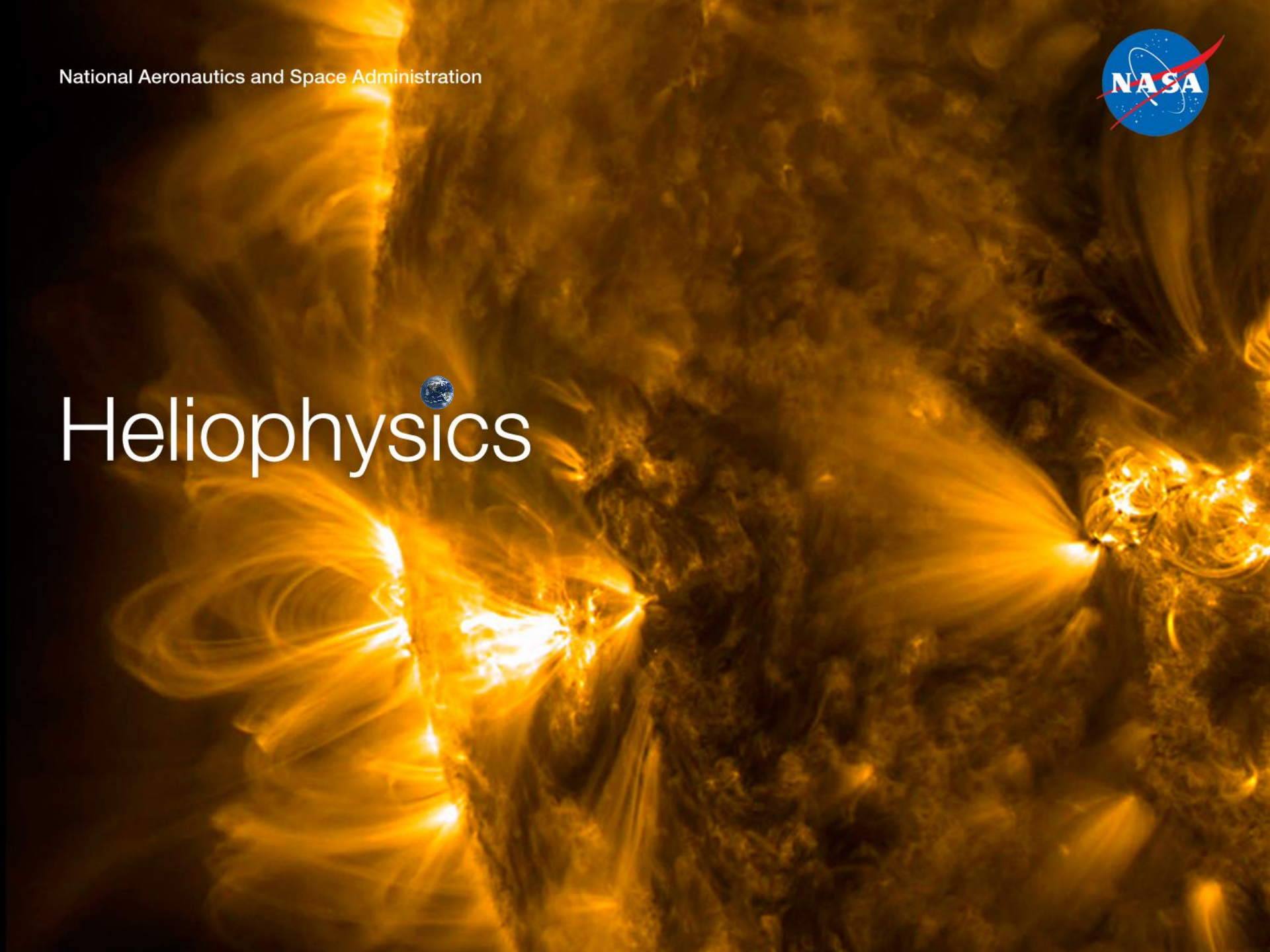
- Science Results
- **Programmatic Status**
  - Heliophysics
  - Earth Science
  - Planetary Science
  - Astrophysics/JWST/WFIRST
  - Other Reports
- Findings & Recommendations

Conversations with Grunsfeld & Tupper On Missions, Programs and Budget and SMD FY 16 Budget Briefing

- Provides for a sustained land imaging capability beyond Landsat 8
- Includes budget for TSIS-1, and altimetry missions after Jason-3 (formerly NOAA responsibilities)
- Supports Mars 2020 mission and formulation of a potential Europa mission
- Increases efforts to detect and study NEOs
- Enables release of a New Frontiers AO in FY16
- Restores SOFIA budget; to enter Senior Review in 2016
- Supports Pre-formulation of WFIRST/AFTA
- Increases collaboration with NASA's Space Technology Mission Directorate
- Implements the revised and competed STEM education program to ensure that the most meritorious activities within SMD are supported

John also took the opertunity to reiterated his full support for Heliophysics as a critical independent Directorate and the need to get an excellent DD

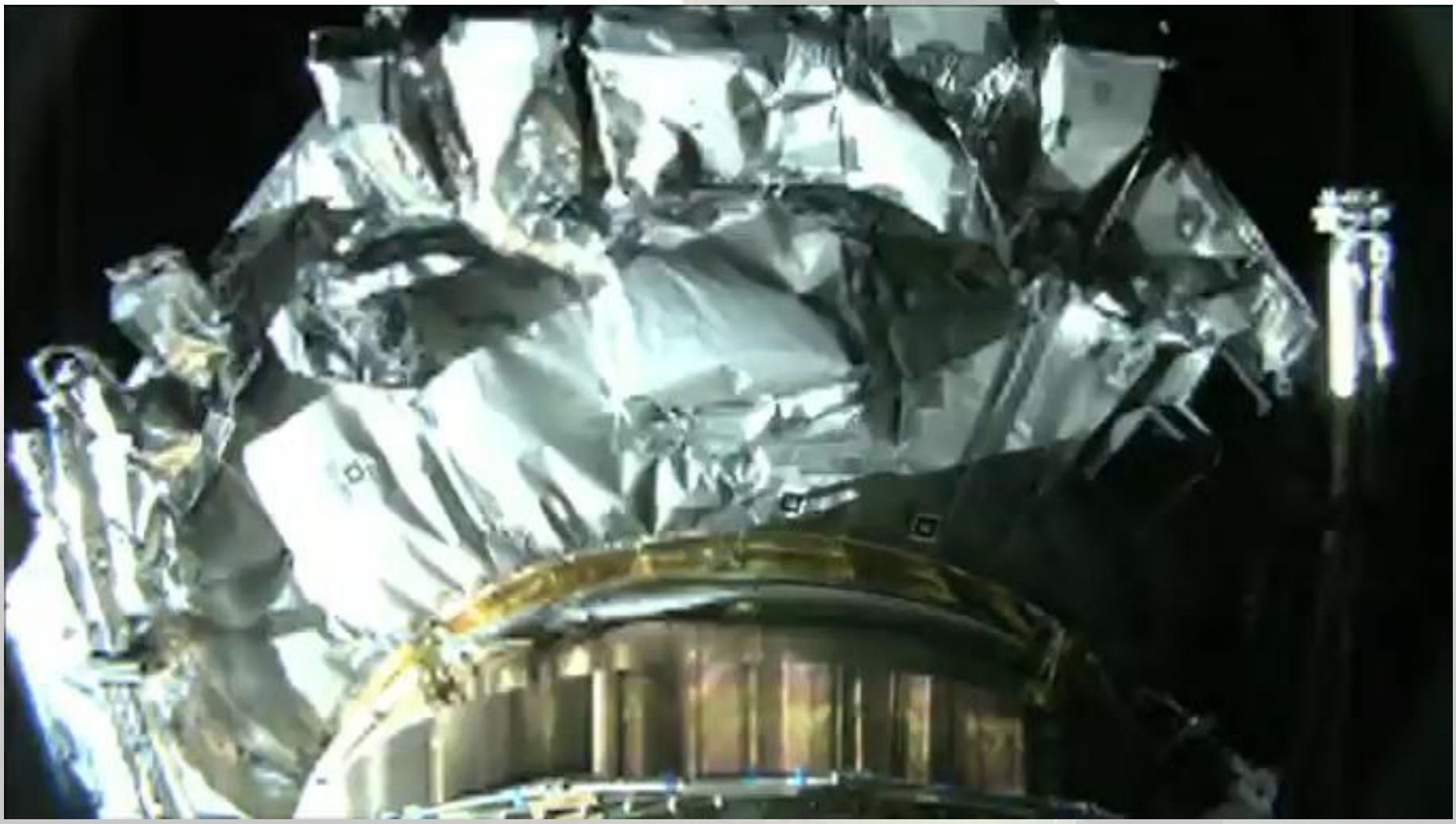
National Aeronautics and Space Administration



Heliophysics

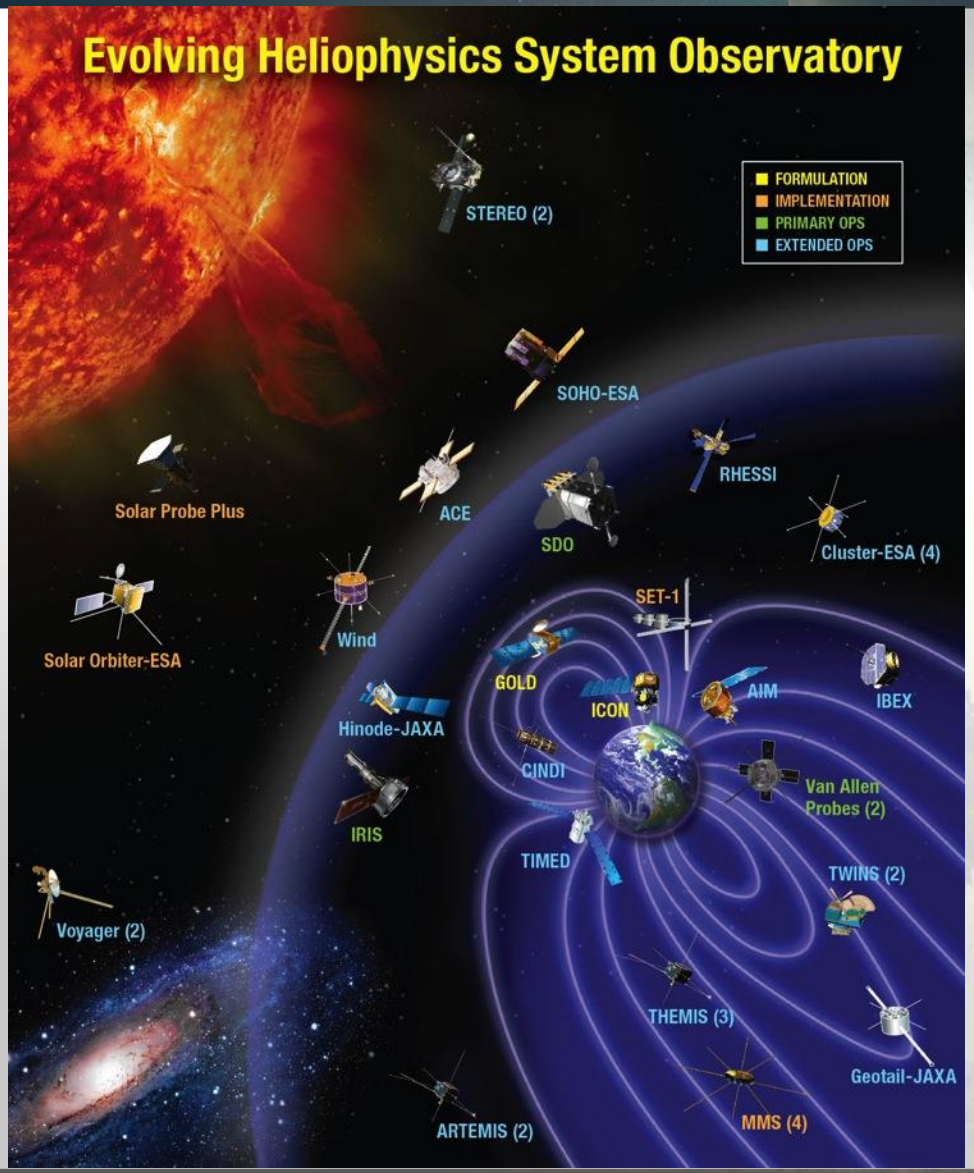
MMS Launch March 12, 2015 at KSC

MMS Deployment



Heliophysics System Observatory

A coordinated and complementary fleet of spacecraft to understand
the Sun and its interactions with Earth and the solar system, including space weatherweather



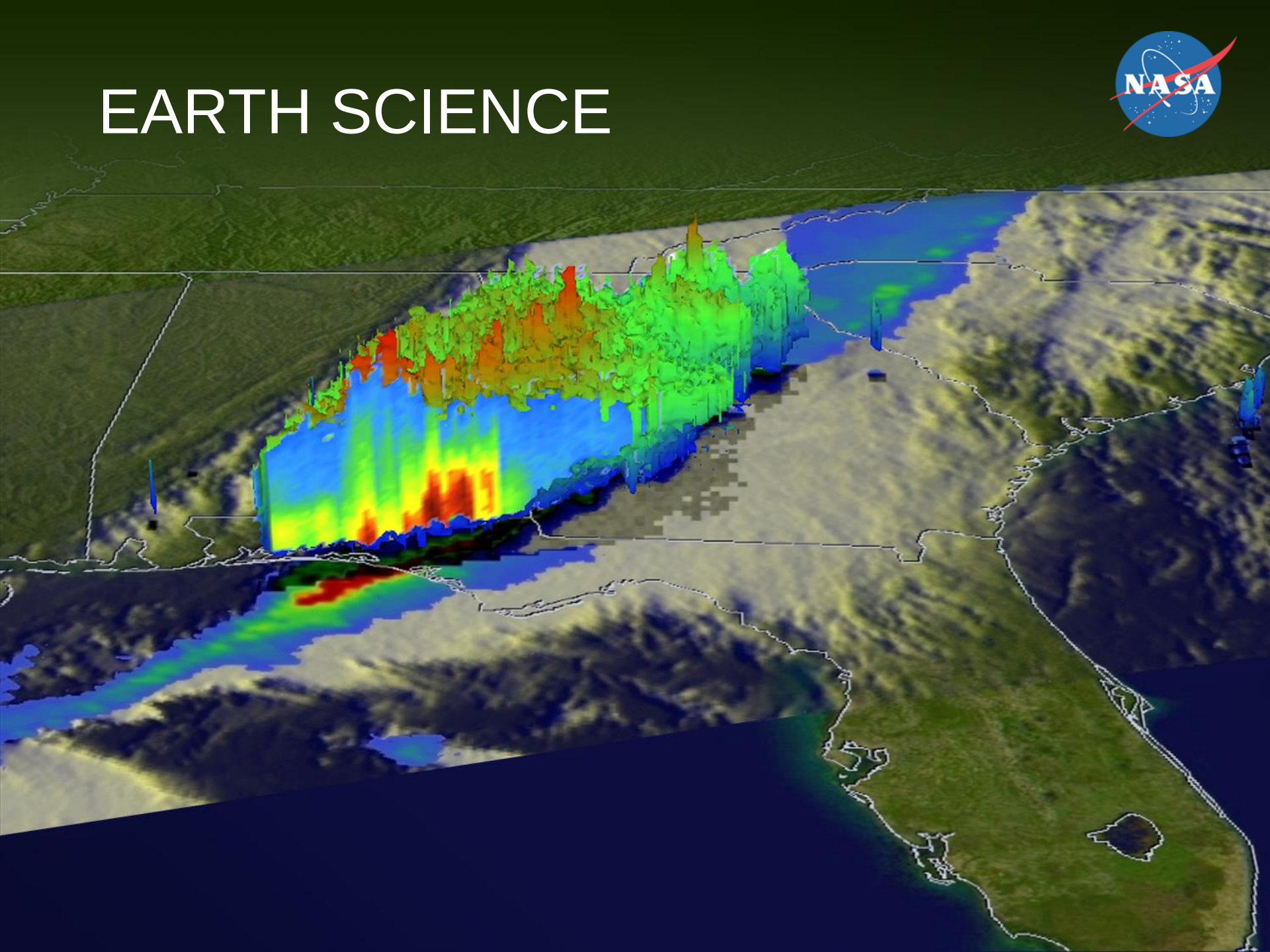
- **Heliophysics has 18 operating missions (on 29 spacecraft): Voyager, Geotail, Wind, SOHO, ACE, Cluster, TIMED, RHESSI, TWINS, Hinode, STEREO, THEMIS/ARTEMIS, AIM, CINDI, IBEX, SDO, Van Allen Probes, IRIS, MMS**
- **(Missions in red contribute to operational Space Weather.)**
- **5 missions are in development: SET, SOC, SPP, ICON, and GOLD**

Heliophysics FY16 Budget Top Level

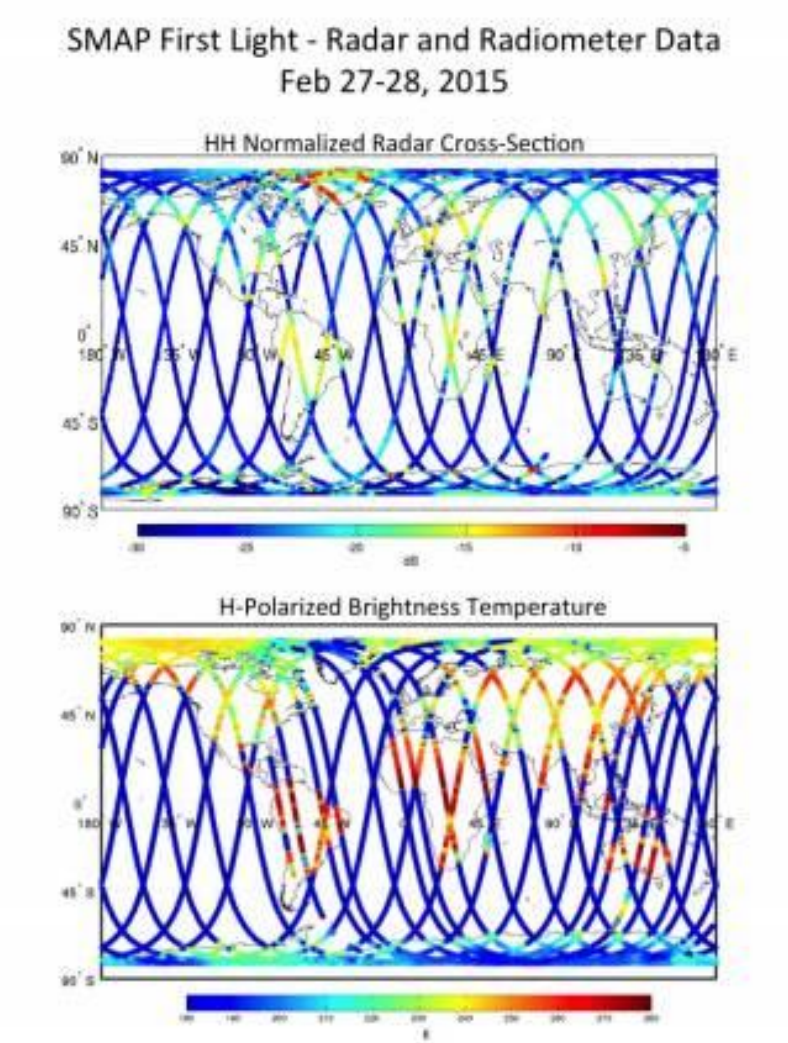
($M)	2016	2017	2018	2019	2020
Heliophysics	$651	$685	$698	$708	$722

- Funds currently operating missions per upcoming April 2015 Senior Review
- Fund Missions in development (~$3.5B investment):
  - Proceed with MMS for an LRD of Mar 2015 ✓
  - Proceed with SOC for LRD Oct 2018
  - Proceed with SPP development for LRD Jul 2018
  - Proceed with ICON development for LRD Oct 2017
  - Proceed with GOLD development for LRD Sep 2017 (still in formulation)
- Fund missions entering extended ops (Van Allen, IRIS, SDO)
- Competed PI research award program, current (~$63M) + DRIVE augmentation (~$40M) + program growth
- Maintain viable sounding rocket/Wallops research range program for the benefit of SMD
- Utilize mission wedge for future missions

EARTH SCIENCE



SMAP First Light Image



First image from a test of the radar instrument on NASA's Soil Moisture Active Passive (SMAP) satellite Feb. 27-28. The test was performed with SMAP's antenna in a non-spinning mode, which limits measurement swath widths to 40 kilometers (25 miles).

Image: NASA/JPL-Caltech/Goddard Space Flight Center

UPDATE: ***SMAP Antenna now spinning in science mode***

http://newsoffice.mit.edu/2015/first-light-images-nasa-smap-revealed-0310

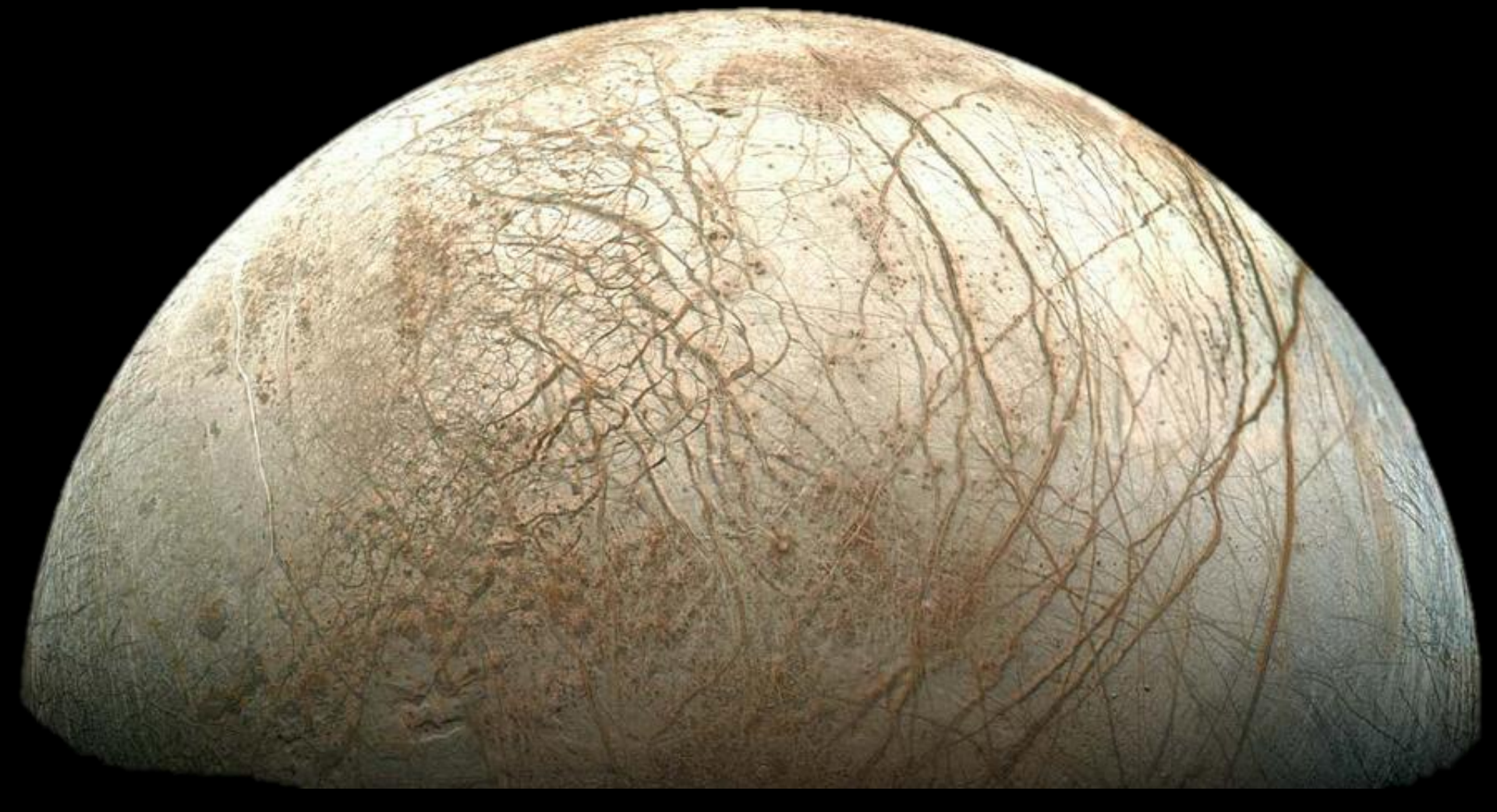
OVERALL SUMMARY (1 of 3)

- ESD budget increases significantly

	FY15	FY16	FY17	FY18	FY19	FY20
FY16	**1.730**	**1.894**	**1.913**	**1.932**	**1.952**	**1.971**
FY15		1.762	1.784	1.805	1.829	---

- NASA now has mandate for additional long-term measurements for the nation:
  - Altimetry after Jason-3
  - Solar Irradiance, Ozone Profile, Earth Radiation Budget all starting in FY16
- Sustainable Land Imaging Program (w/USGS; NASA funds flight hardware):
  - TIR-FFD (2019)
  - Upgraded Landsat-9 (2023)
  - Focused technology development to inform designs of Landsat-10+
- Continued development and launch of: SAGE-III/ISS, ECOSTRESS/ISS, GEDI/ISS, CYGNSS, TEMPO, GRACE-FO, ICESat-2, SWOT, NISAR, PACE
- Continue Venture Class on schedule with full funding
- OCO-3 completion and flight to ISS in late 2017
- CLARREO Technology Demonstration instruments on ISS - development and flight in late 2019 (2 instruments, Reflected Solar/HySICS and IR Pathfinder)

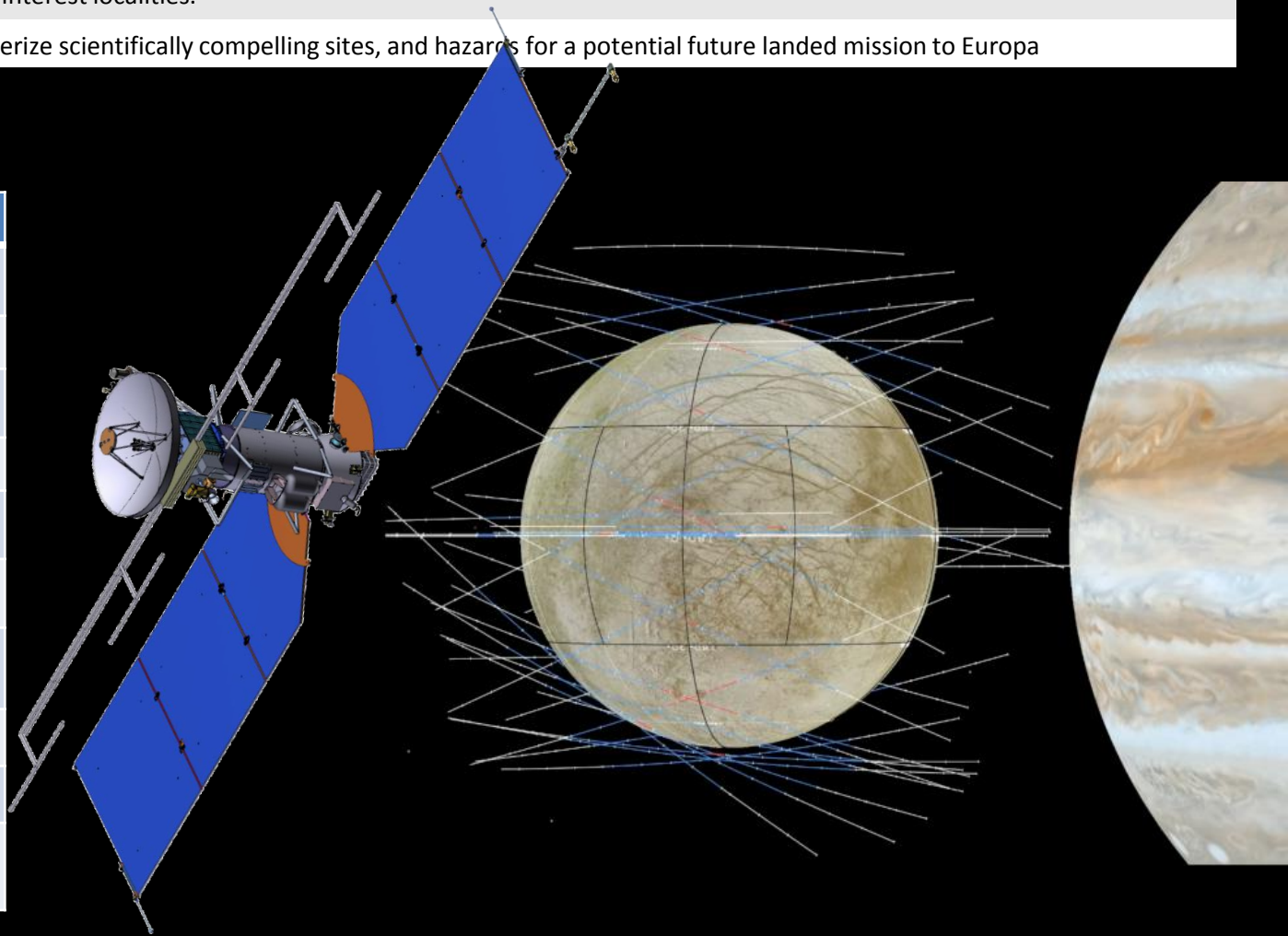
Planetary Science



Europa Flyby Concept Overview

Science Objectives	
Ice Shell & Ocean	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange
Composition	Understand the habitability of Europa's ocean through composition and chemistry.
Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.
Recon	Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

Model Payload	
	Instrument Type
1	Ice Penetrating Radar
2	Shortwave Infrared Spectrometer
3	Topographical Imager
4	Neutral Mass Spectrometer
5	Reconnaissance Camera
6	Thermal Imager
7	Magnetometer
8	Langmuir Probe
9	Gravity Science



President's FY16 Budget Request ($M)

[----------Notional----------]

	FY15	FY16	FY17	FY18	FY19	FY20
Planetary Science	$1,437.8	$1,361.2	$1,420.1	$1,458.0	$1,502.4	$1,527.8
Science Research		276.3	282.0	292.0	291.7	285.7
Discovery		156.1	201.6	277.2	337.4	344.9
New Frontiers		259.0	124.0	81.5	85.7	137.8
Mars Exploration		411.9	539.3	561.3	531.5	464.2
Outer Planets		116.2	117.7	81.6	87.6	110.5
Technology		141.7	155.5	164.4	168.5	184.7

Planetary Budget Features: What's Changed

- Initiates formulation for a mission to Jupiter's moon Europa, to explore the most likely host of current life beyond Earth
- Releases the next New Frontiers AO in 2016
- Maintains Stirling technology development to support future radioisotope power systems
- Establishes the Planetary Missions Program Office at MSFC to manage Discovery, New Frontiers, **JUICE** and **Europa** flight projects
- **Lunar Reconnaissance Orbiter** and **Opportunity** rover not funded in 2016 budget
  - Will reassess condition/cost of maintaining LRO & Opportunity this summer
- Increase in funding for Near Earth Object Observation Program to accelerate hazardous asteroid detection and characterization

→ $40M to $50M – SMD can't support a mission by itself, but strongly recommend that HEOC/SC discuss collaboration indeatil at next meeting!

National Aeronautics and Space Administration

Astrophysics

Astrophysics - Big Picture

- **The FY15 appropriation and FY16 budget request provide funding for NASA astrophysics to continue its programs, missions, and projects as planned**
  - The total funding (Astrophysics including JWST) is flat at ~$1.3B through FY20
  - Fully fund JWST to remain on plan for an October 2018 launch
  - Fund continued pre-formulation and technology work leading toward WFIRST
  - Restore SOFIA to the budget with a reduction in FY15 and full funding beyond
  - Provide funding for SMD's education programs
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future**
  - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Suzaku, Swift, XMM-Newton continued following the 2014 Senior Review
  - SOFIA is in prime operations as of May 2014
  - Missions on track for launch include LISA Pathfinder (2015), ASTRO-H (2015), NICER (2016), TESS (2017), JWST (2018), Euclid (2020)
  - New Explorers being selected (SMEX in 2015, MIDEX in 2017), WFIRST being studied, NASA joining ESA's Athena and ESA's L3 gravitational wave observatory
- **Progress being made against recommendations of the 2010 Decadal Survey**
  - Update to the Astrophysics Implementation Plan has been released
  - NRC Mid Decade Review (with NSF, DOE) to begin in early 2015
  - NASA initiating large mission concept studies for 2020 Decadal Survey

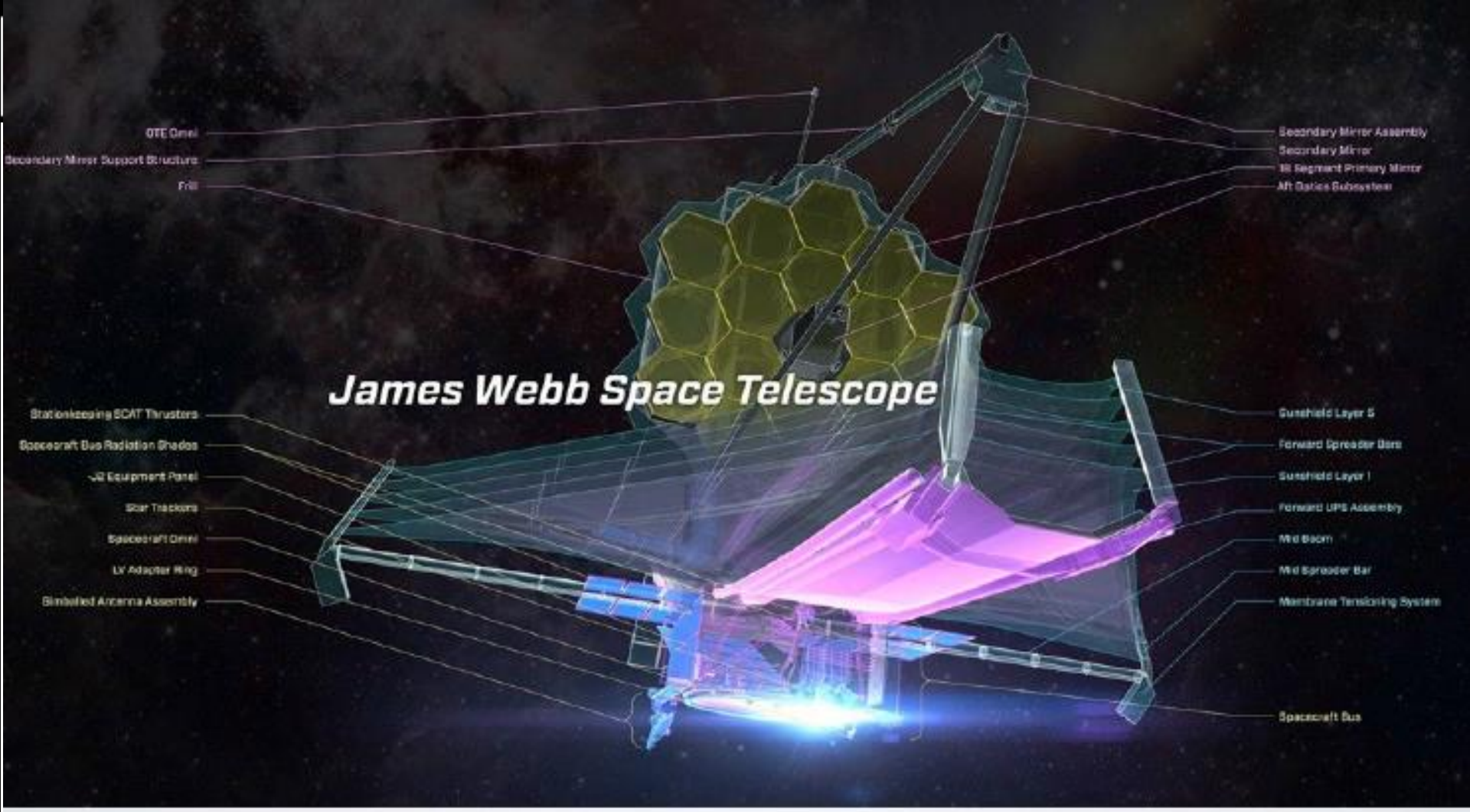
FY16 President's Budget Request

Outyears are notional planning from FY16 President's budget request

($M)	2014	2015	2016	2017	2018	2019	2020
Astrophysics*	$678	$685	$689	$707	$750	$986	$1,118
JWST	$658	$645	$620	$569	$535	$305	$198

- Supports operating missions: Chandra, Fermi, Hubble, Kepler, NuSTAR, SOFIA, Spitzer, and Swift.
- Funds development of Explorer missions TESS and NICER. TESS will continue the search for exoplanets, scanning all of the sky for Exoplanets closer to Earth than those found by Kepler.
- Supports pre-formulation studies for WFIRST/AFTA.
- Maintains a competed astrophysics research program and support of the balloon program.
- Supports the commitment of an October 2018 launch date for JWST.
  - Will deliver the Integrated Science Instrument Module for integration;
  - Completes integration of flight primary mirror subassemblies onto the flight primary mirror backplane;
  - Completes acceptance testing of the cryocooler compressor assembly;
  - Completes spacecraft bus structure; and
  - Completes the sunshield structure manufacture and test.

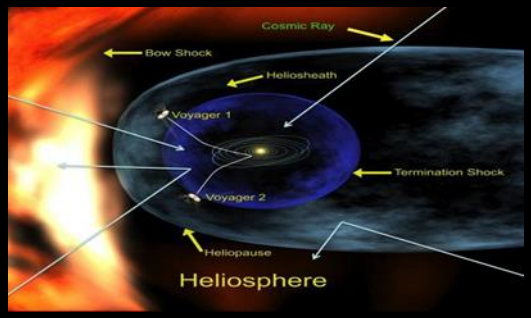
* Excludes "SMD STEM Activities" in all years.

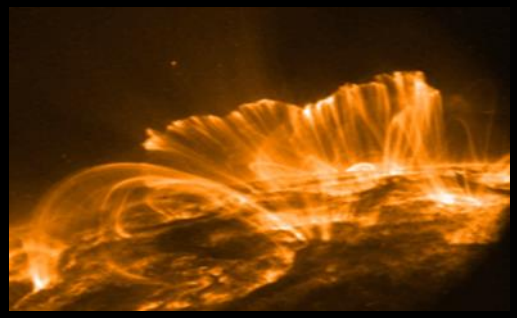


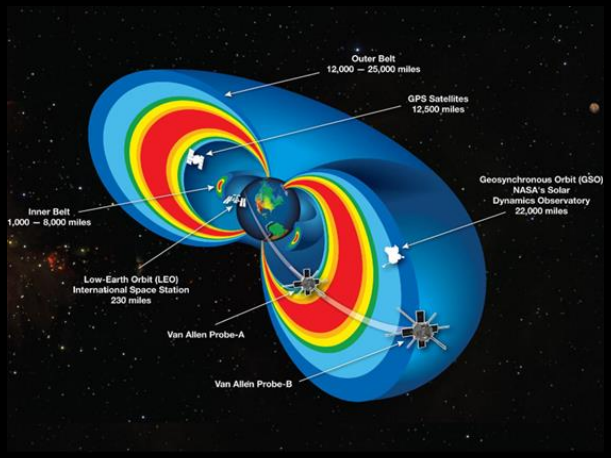
April 6, 2015

Eric P. Smith
JWST Program Director

NASA Advisory Council Science Committee Presentation





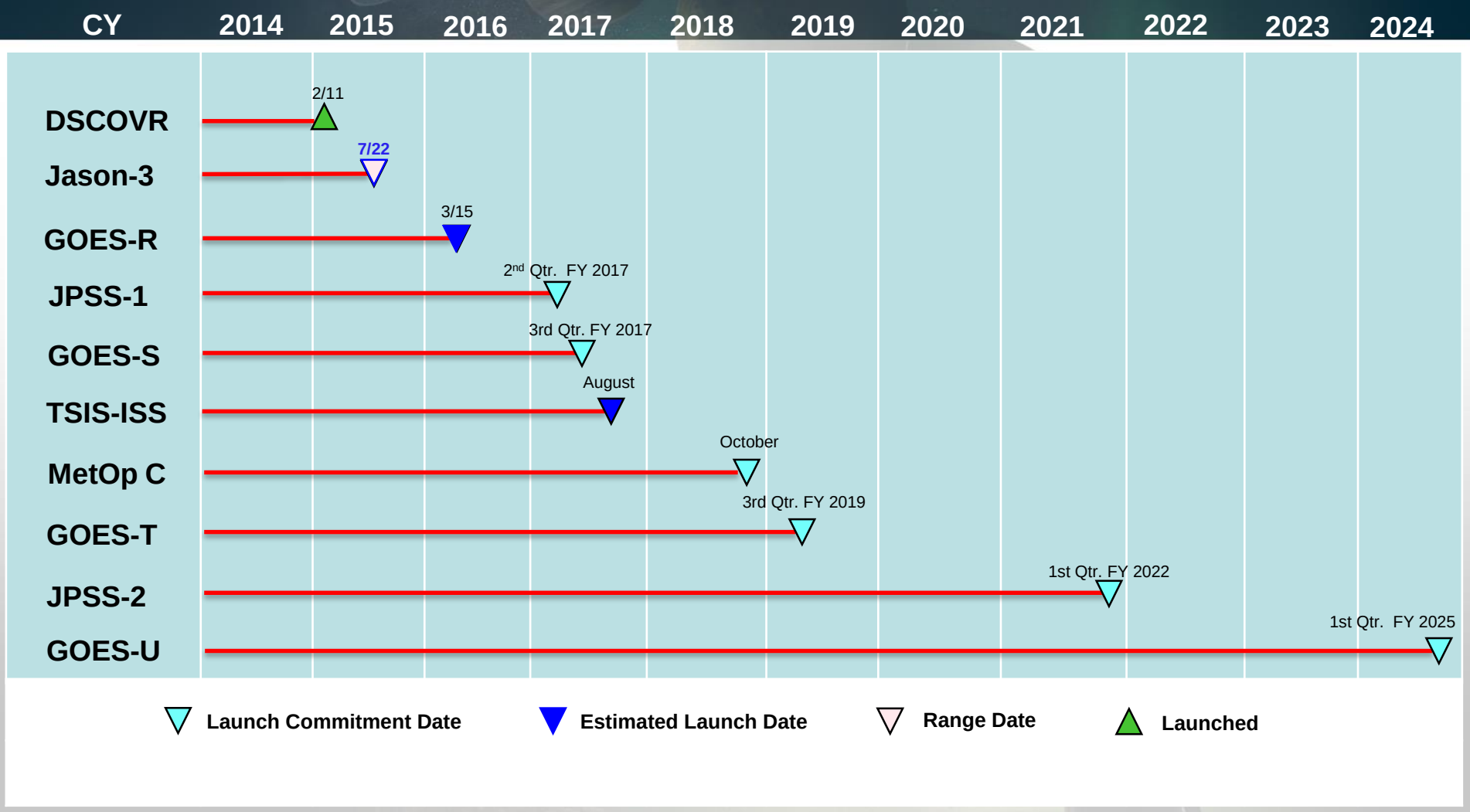


Mercury in "enhanced" color – RGB: PC2, PC1, 430/1000

Selected Other Reports

DSCOVR is L1 Bound!

Reimbursable Launch Commitment Dates



Planetary Protection Report to SC

January 2015 - Recommendation to NAC/Science Committee
Improve MSL Project Office – Planetary Protection Officer Communications
Recommendation
The Planetary Protection Subcommittee notes that Planetary Protection concerns continue for the life of a mission, and final resolution of Planetary Protection concerns does not end with compliance checks and launch. Ongoing surface operations for MSL must continue to comply with Planetary Protection requirements that were articulated in the PP Letter of 2011. PPS recommends that NASA ensure closer and more timely communications of the MSL Project with the PPO, consistent with the Project's obligations under the MSL planetary protection categorization letter.

April 2015 update to NAC/Science Committee

At the January SC Meeting, the consensus was for PPS to address this issue with a letter directly to the Science Directorate. Since then, the MSL Science Team has provided advanced notice to the PPO of a pending publication related to planetary protection. PPS will reconsider the need for a letter at our June 8-10 meeting, and will continue to support the PPO in seeking timely notification of relevant scientific findings.

Moving in the Right Direction

Outline

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

SC Recommendation: Sample Retention Requirement

Recommendation:

That NASA establish a requirement for retention of a large fraction (e.g. 75% has been used historically) of the samples obtained by all sample return missions, robotic and human, for future scientific studies.

Major Reasons for the Recommendation

This recommendation preserves precious extraterrestrial samples for future analysis by a broad spectrum of investigators using-as-to-be developed technologies. A requirement to retain 75% of samples already applies to Discovery and New Frontiers mission AOs and has proved to be critical in maximizing science return. Exceptions from the policy should be justified (e.g. renewable sampling, planetary protection requirements that cannot otherwise be met, etc.).

Consequences of No Action on the Recommendation:

Missed opportunities to apply new analytical technologies and preserve samples as baseline for future reference.

SC Recommendation: Approval of Contractor Participation in Conferences

Recommendation:

That the approval of contractor participation in conferences system be modified to improve scientific efficiency while meeting the legislatively mandated requirements on NASA travel as follows or if absolutely necessary with very minor changes:

1: At least 3 months before the close domestic scientific conference's early registration, the contractor program manager or principal investigator submits to NASA an estimate of the number of people planning to attend on that contract, an estimate of the total travel cost, and the early registration deadline. This will allow NASA to estimate the total costs associated with that conference and appropriate approval processes required.

2: NASA approves or disapproves conference attendance and notifies contractors no later than one month prior to the end of the early registration period of the conference.

3: Assuming NASA approval is granted, the program manager/principal investigator approves individual travel to the conference up to their estimated number of participants.

Major Reasons for the Recommendation

This change will result in significant savings in effort on both the requesting and approval side of the process, and subsequent improvements in scientific productivity and cost savings.

Consequences of No Action on the Recommendation:

Continued highly inefficient approval process and significant harm to NASA science.

Joint SC / HEOC Finding: SMD/HEOMD Collaboration

Through the series of joint meetings that the NAC HEO and Science committees have had, we have seen productive collaboration between science, engineering and operations within NASA, and also between NASA and academia. We find that this collaboration leads to broader understanding and better outcomes for both Human Exploration and Science. We see opportunity for more synergy, and encourage enhanced and more formal and informal collaboration between these organizations.

Joint Science / Human Exploration and Operations Commiittee Meeting: Space Radiation Presentations

Overview

- Mars Mission and Space Radiation Risks — *Steve Davison, NASA-HQ, 30 min*
- Health Standards Decision Framework — *David Liskowsky, NASA-HQ, 10 min*

Space Radiation Environment

- Introduction — *Chris St. Cyr, NASA-GSFC, 5 min*
- Solar Energetic Particles — *Allan Tylka, NASA-GSFC, 30 min*
- Comparison and Validation of GCR Models — *Tony Slaba, NASA-LaRC, 30 min*
- GCR Radiation Environment Predictions — *Nathan Schwadron, Univ. of NH, 30 min*
- Emerging GCR Data from AMS-2 — *Veronica Bindi, Univ. of Hawaii, 30 min*

Radiation Health Risk Projections — *Eddie Semones, NASA-JSC, 45 min*

- NCRP Recommendations, Permissible Exposure Limits, Space Radiation Cancer Risk Model, Operations and In-Flight Solar Particle Event Mitigations

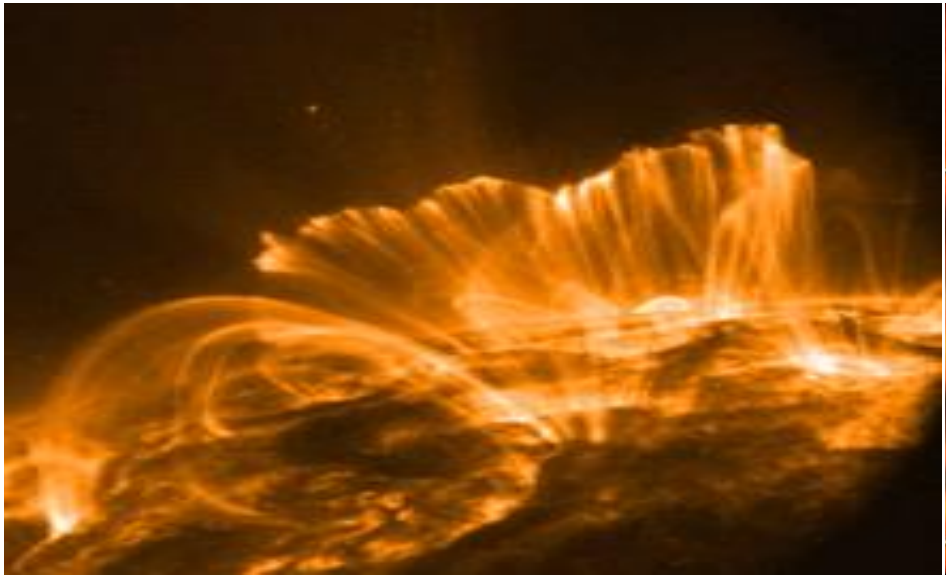
Space Radiation R&T for Risk Mitigation — *Lisa Simonsen, NASA-LaRC, 45 min*

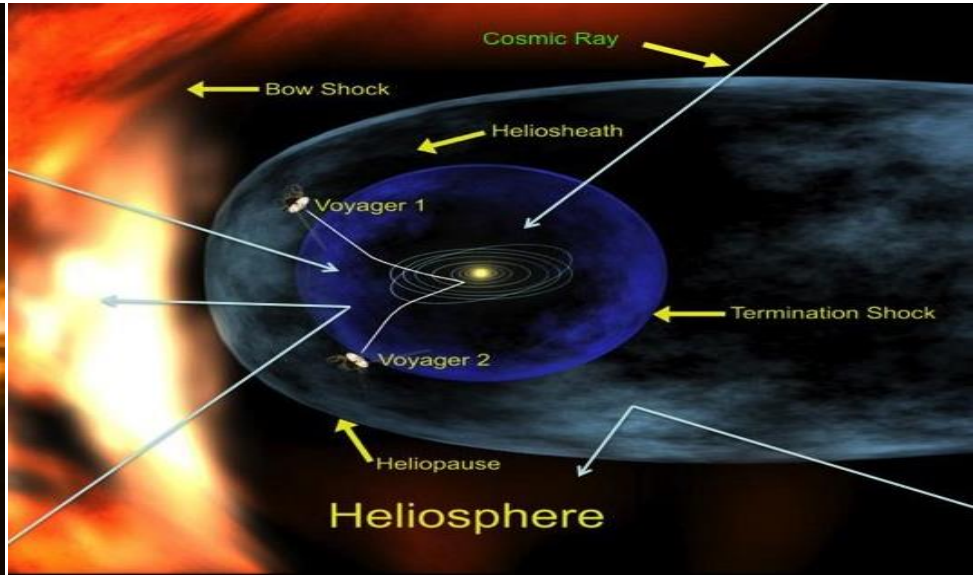
- Radiobiology Research Portfolio (Cancer, CNS, Cardio) and Spacecraft Shielding Design, Analysis, and Optimization

Space Radiation Challenge

Solar Particle Events (SPE) – low to medium energy protons

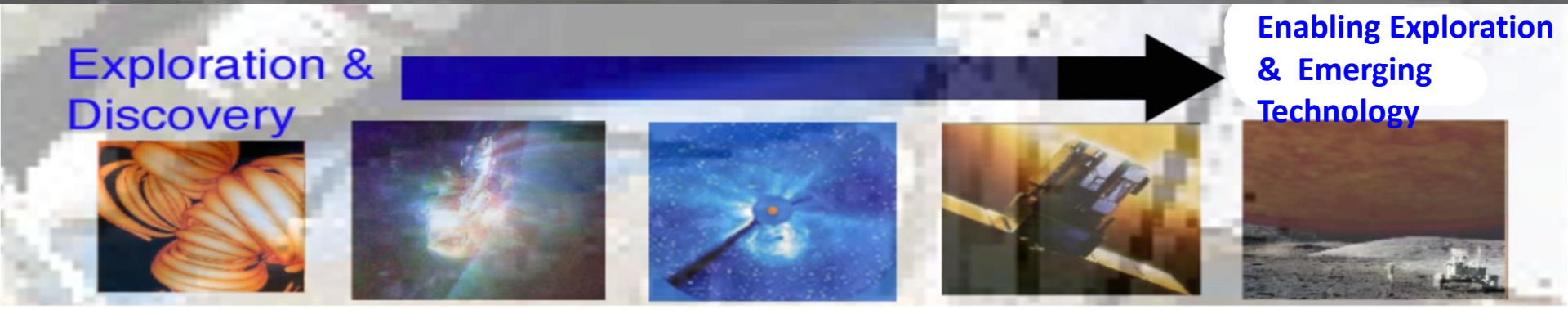
Galactic cosmic rays (GCR) – penetrating protons and heavy nuclei





Implications of the Worsening GCR Radiation Environment

- Deepest Solar Minimum and Weakest Maximum more than 80 years
  - Increased GCR radiation intensity, particularly in solar minima
  - Reduced allowable time in deep space for astronauts
  - Lower probability of SEP events
- Need Improved Understanding/Predictability of SEPs
  - Probability of Extreme Events
  - Resolve physics and predictability of extreme events



SC/HEOC Recommendation on Enhanced Radiation Risk Assessment (1/2)

Background:

The committees were impressed by the breadth and depth of the radiation research presentations and progress being made for understanding the nature of the deep space radiation environment, its implications for human space flight and the ethical issues that arise. The overarching message was that radiation for deep space flight is indeed a serious issue to be addressed as technology and understanding evolve. It was also clear that it is not likely we can mitigate all radiation risks to fully meet current radiation health standards. Thus, some level of risk must be accepted (mission risk and long term astronaut health risk) within the broader context of all risks associated with a mission to Mars.

Because knowledge of key components continues to move forward, it is difficult to quantify the overall risk. For example, it is not clear how accurately we can define mission risk and long term astronaut health risk based on our current understanding of heliophysics and human biology.

SC/HEOC Recommendation on Enhanced Radiation Risk Assessment (2/2)

We recommend NASA openly communicate the radiation risks while they continually work to mitigate them through improved knowledge and technology. In particular, there may be additional means of investigating the full extent of the radiation problem (for example, stellar observations, geologic record, further understanding of the heliospheric environment). Synthesizing expertise from both human exploration and science is essential to achieving this goal.

Furthermore, we encourage *implement a universal long-term astronaut health monitoring and medical care program* to mitigate long duration exposure health consequences to astronauts, and build a baseline for future long term health and engineering decisions.

Major Reasons for the Recommendation:

To ensure that NASA understands the radiation environment, biological response, and associated risks to the maximum extent possible while simultaneously acknowledging that the real radiation risks are probably not fully quantifiable.

Consequences of No Action on the Recommendation:

Increased potential that space radiation risks to astronauts will be mitigated in an inefficient or less than optimal manner and astronaut safety may be compromised.

Finding: Astronaut Insurance and Health Care

The NASA Advisory Council finds it disgraceful that the NASA is not able to provide free life insurance for astronauts while they are in space nor lifetime health care after their service. Human spaceflight is an intrinsically risky endeavor both while in space and potentially from space-related effects long after returning to Earth. The Council feels that the nation has a responsibility to our men and women that we send into space and that the present arrangement were astronauts are responsible for buying their own life insurance for space missions and health care after they retire from the Corps is simply unacceptable and not befitting our space agency or great nation.