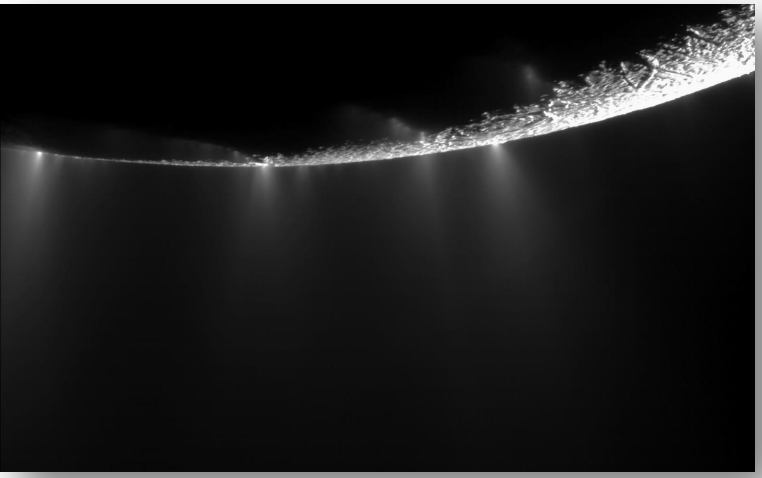
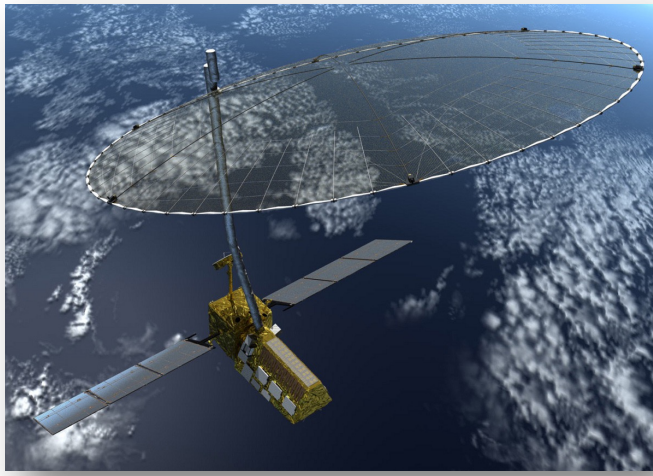
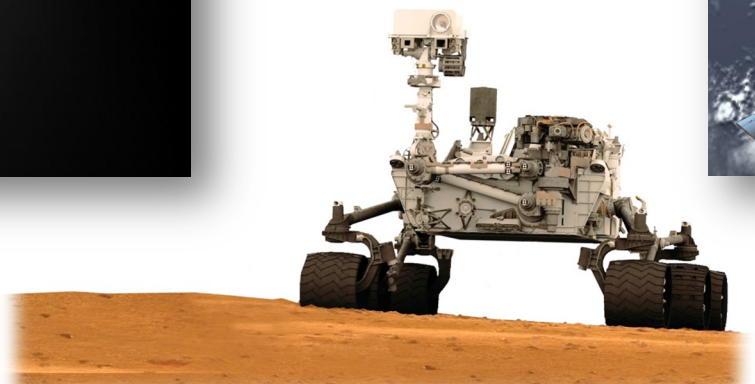
Robotic Exploration of Earth and Space at NASA's Jet Propulsion Laboratory (JPL)

Cinzia Zuffada
JPL Associate Chief Scientist

Jet Propulsion Laboratory
California Institute of Technology





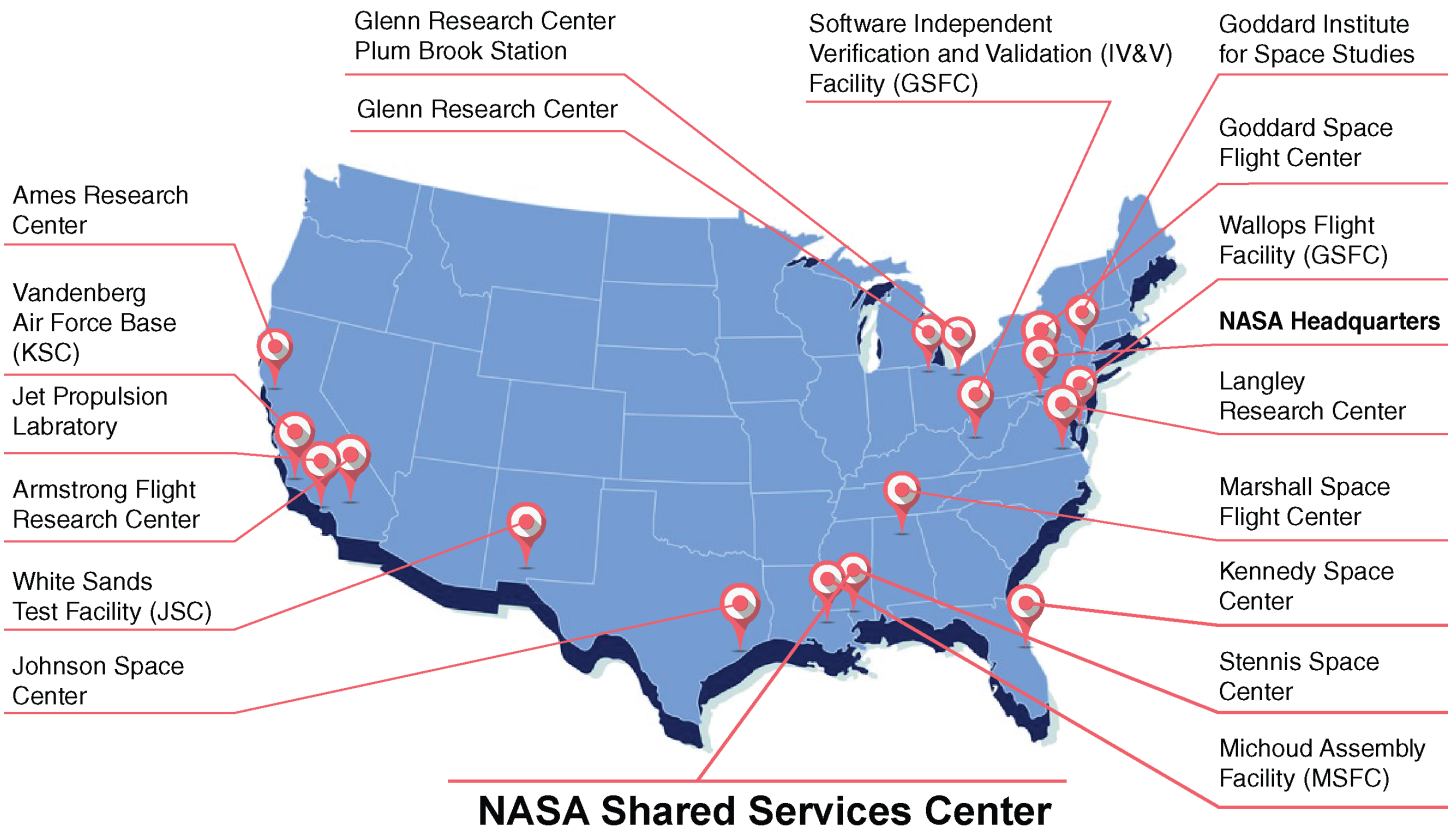


JPL is part of NASA and Caltech

- Federally-funded (NASA-owned) Research and Development Center (FFRDC)
- University Operated (Caltech)
- $2.3B Business Base
- 6,000 Employees

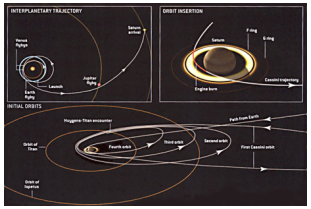
- 167 Acres (includes 12 acres leased for parking)
- 139 Buildings; 36 Trailers
- 673,000 Net Square Feet of Office Space
- 906,000 Net Square Feet of Non-Office Space (e.g., Labs)

NASA Centers & Facilities



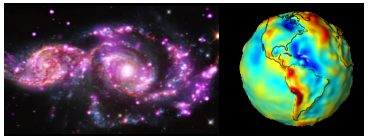
End-to-End JPL Capabilities Needed to Implement Missions

Project Formulation - Team X

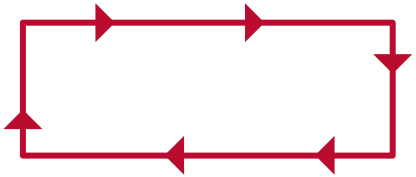


Mission Design

Mars Rovers

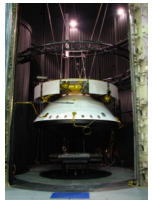


Scientific Research



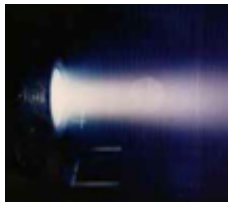
Large Structures-SRTM

Real Time Operations



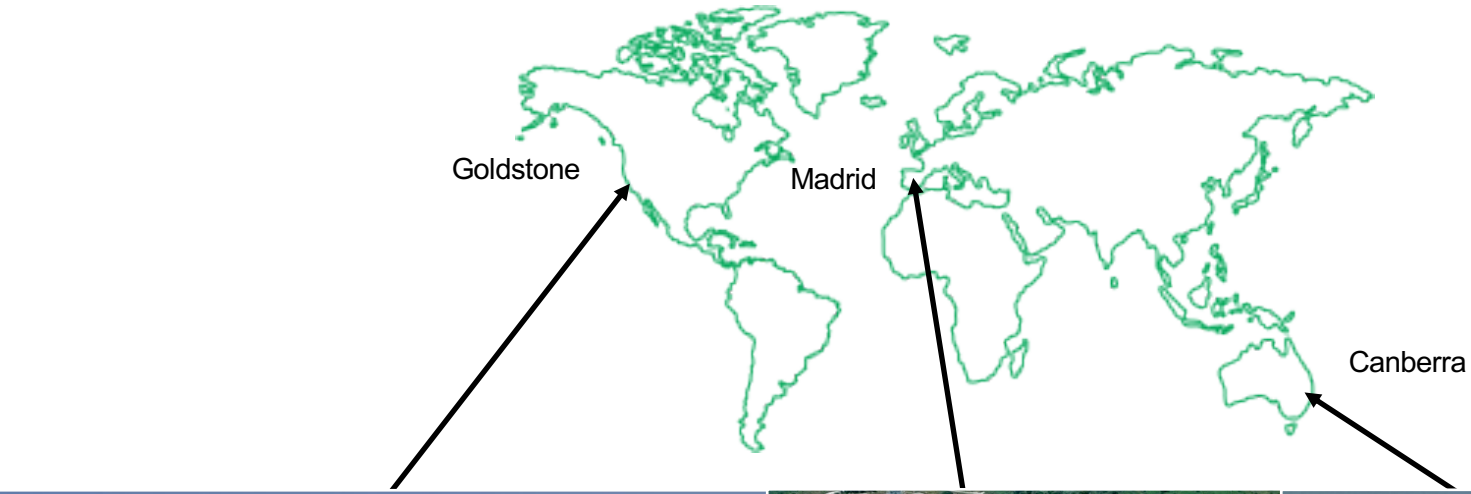
Environmental Test

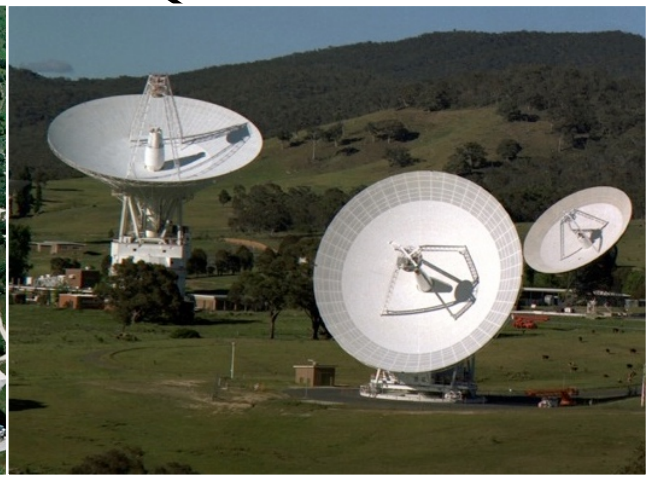
Integration and Test



Spacecraft Development

Deep Space Network (DSN)



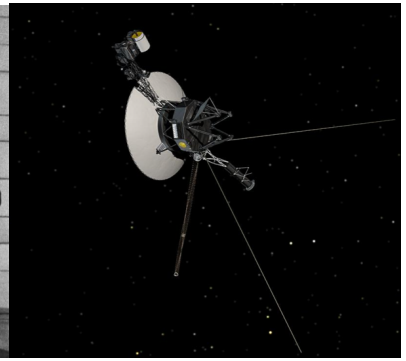


From Caltech students testing rockets to exploring the planets in our lifetime

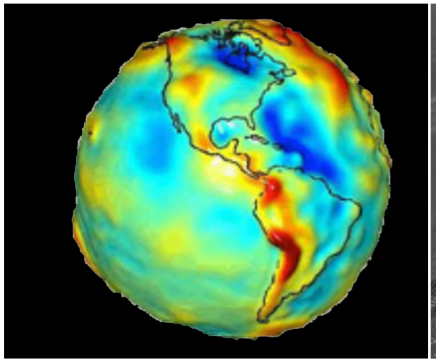
Caltech students (1936)

Missiles (1940s)

Explorer 1 (1958)



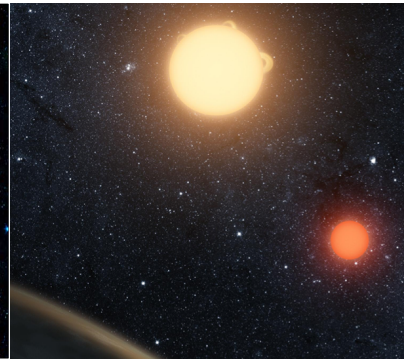
Voyager 1 & 2 (1977 – present)



Earth Science
(1978 – now)

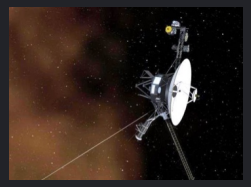
Mars Exploration Rovers
(2004 – present)

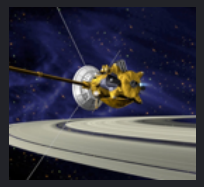
Spitzer Space Telescope
(2004 – present)

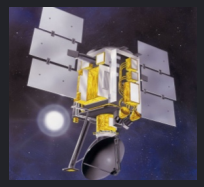


Exoplanet Exploration
(2009 – present)

19 Spacecraft and 11 Instruments Across the Solar System and Beyond

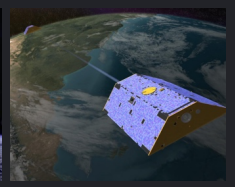

Two Voyagers (1977)


Cassini (1997)

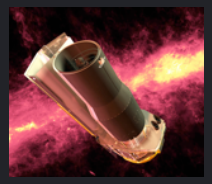

QuikSCAT (1999)

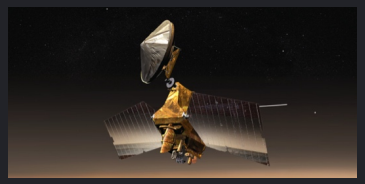

Mars Odyssey (2001)

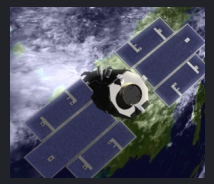

Jason 2 (2008)


GRACE (2002)


Opportunity (2003)


Spitzer (2003)

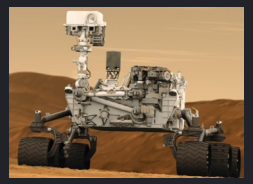

Mars Reconnaissance Orbiter (2005)

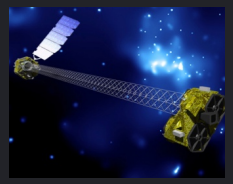

CloudSat (2006)


Dawn (2007)

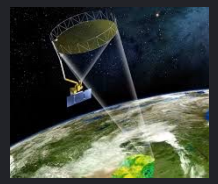

NEOWISE (2009)


Juno (2011)


Curiosity (2011)


NuSTAR (2012)


OCO-2 (2014)


SMAP (2015)


Jason 3 (2016)

Instruments

Earth Science

- MISR (1999)
- AIRS (2002)
- TES (2004)
- MLS (2004)
- ASTER (2009)
- OPALS (2014)
- RapidScat (2014)

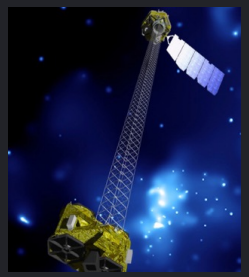
Planetary and AstroPhysics

- MARSIS (2003)
- MIRO (2004)
- Diviner (2004)
- Cold Atom Laboratory (2017)

JPL

2017 Anniversaries

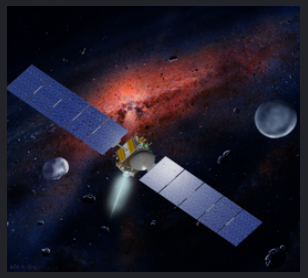
5 Years



NuSTAR

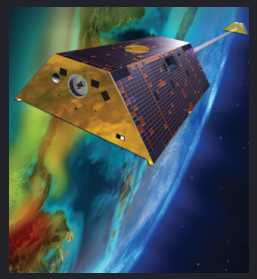
Curiosity

10 Years



DAWN

15 Years



GRACE

20 Years

Mars Pathfinder

Cassini

25 Years

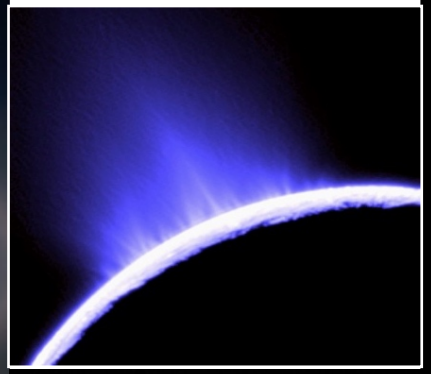
Topex/Poseidon

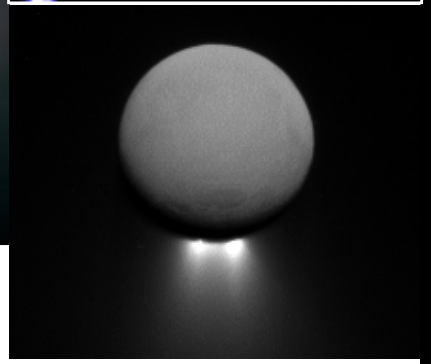
40 Years

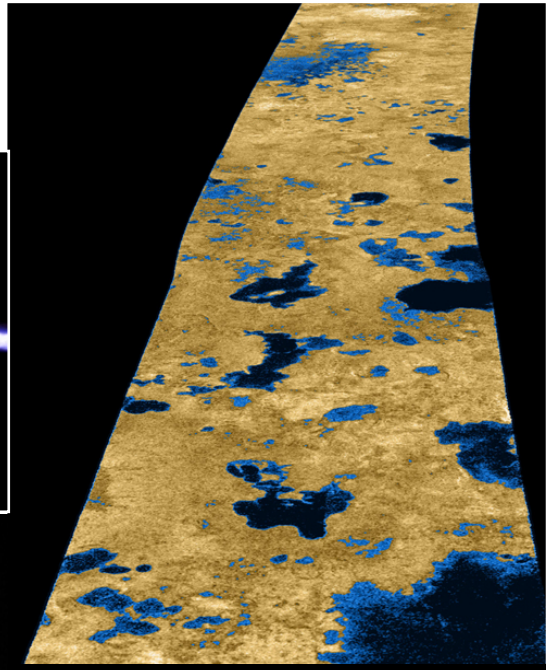
Voyager

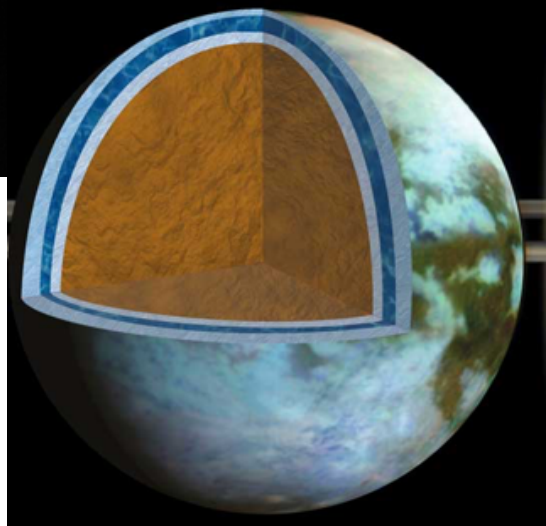
JPL

Cassini/Huygens elucidates Saturn rings, Enceladus' geysers, and Titan's lakes and ocean









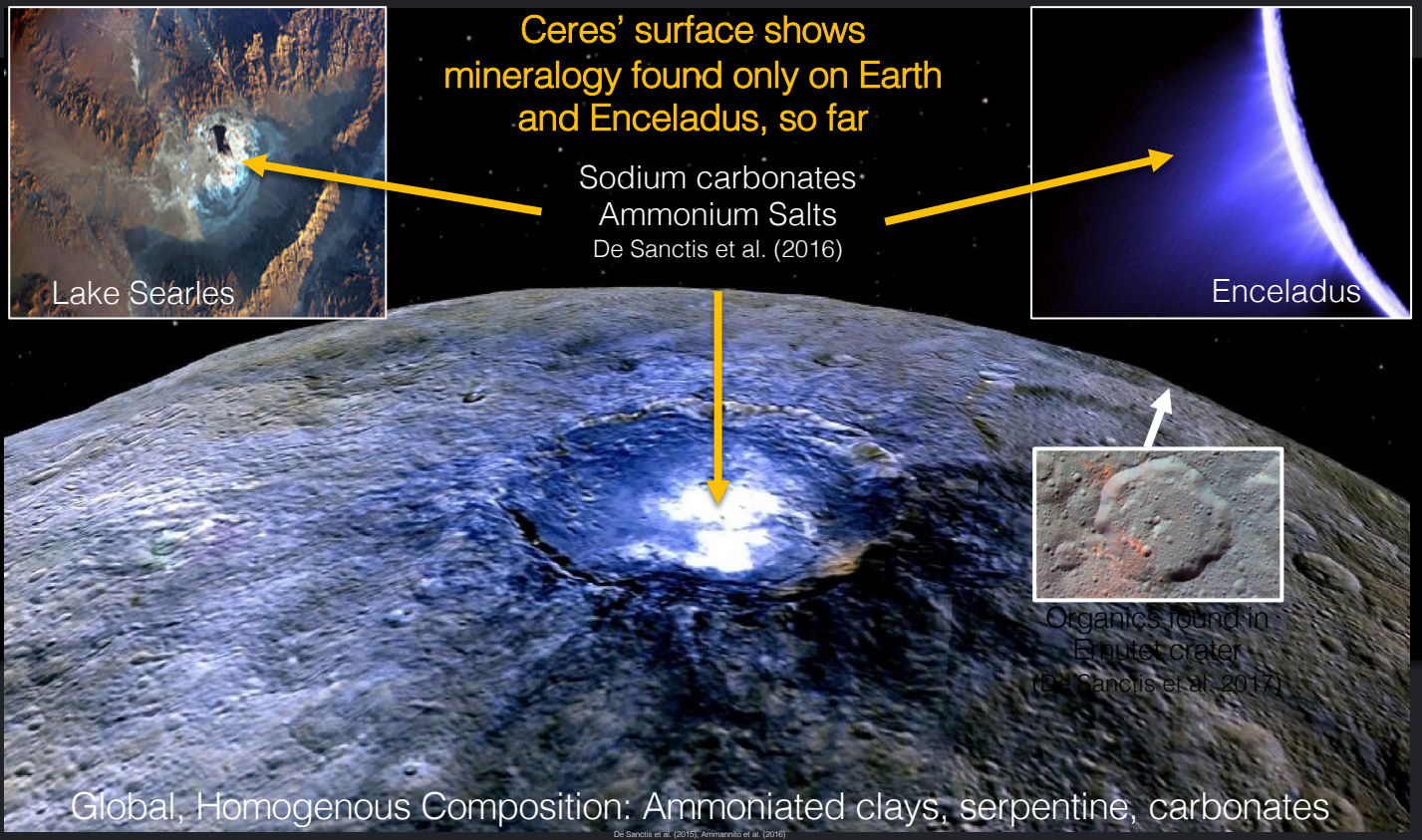
Strata at Base of Mt. Sharp

Indicates the flow of water before the mountain formed

JPL

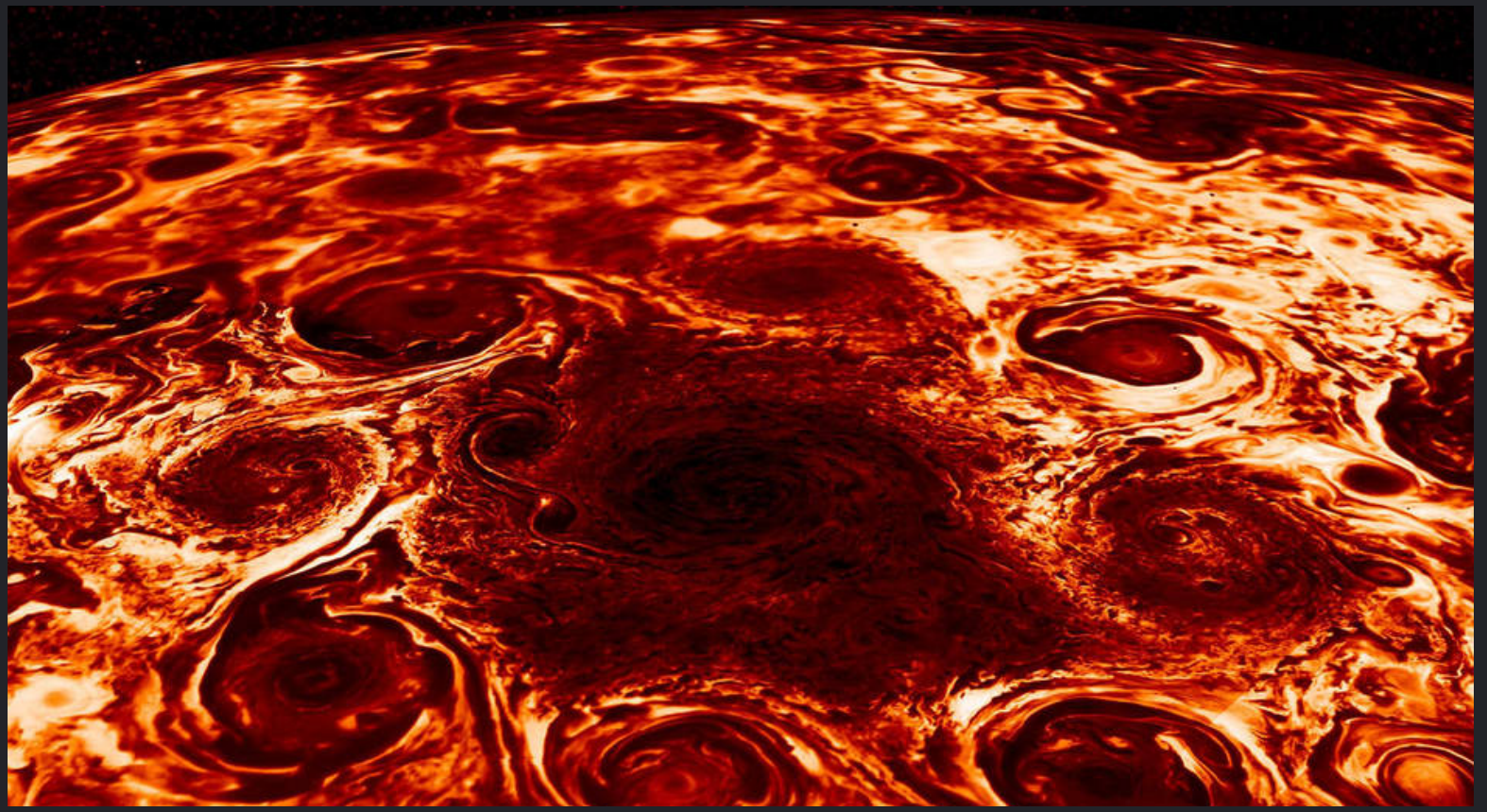
Dawn revealed Ceres to be a chemically active world

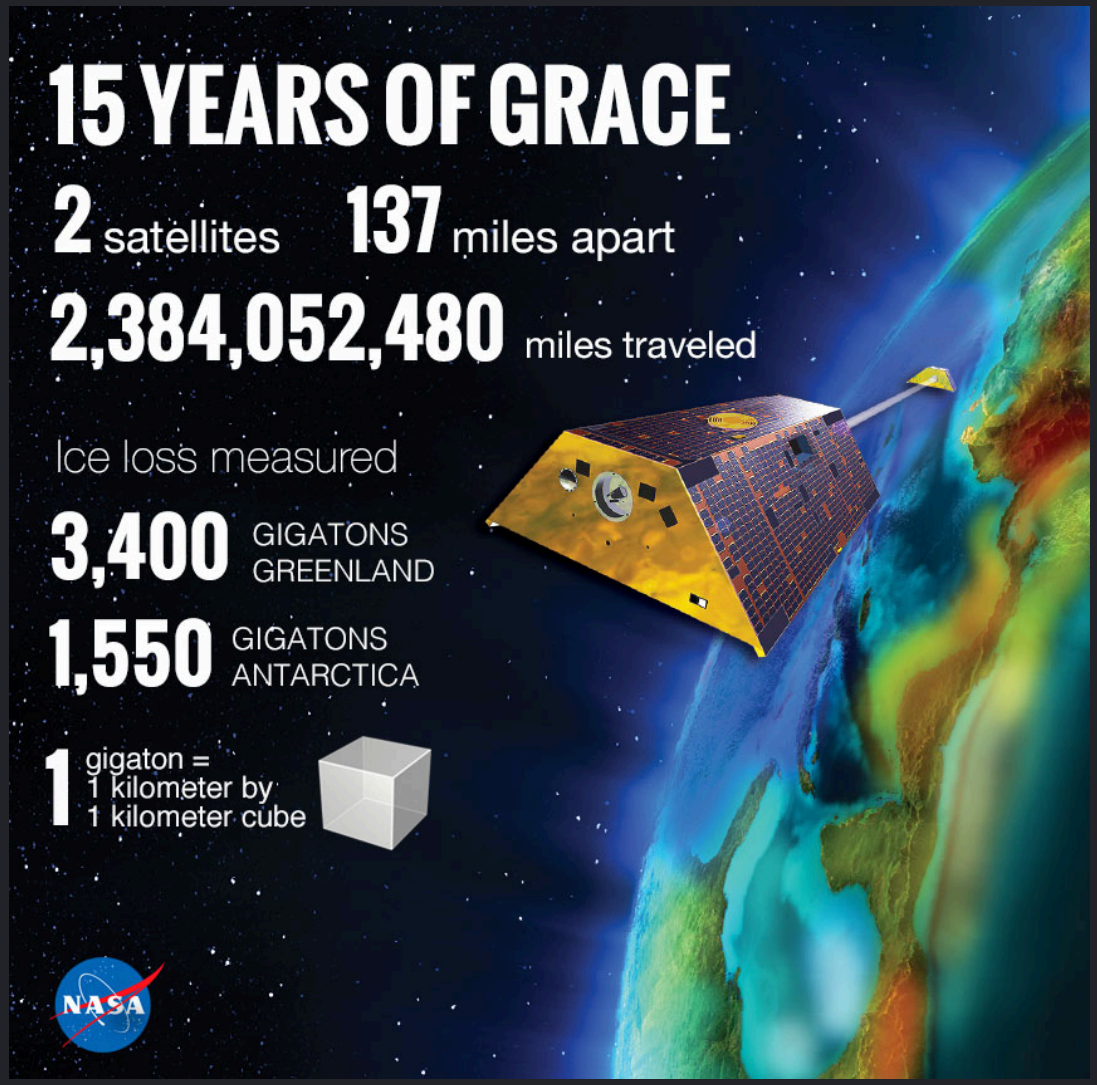
10 Years Since Launch

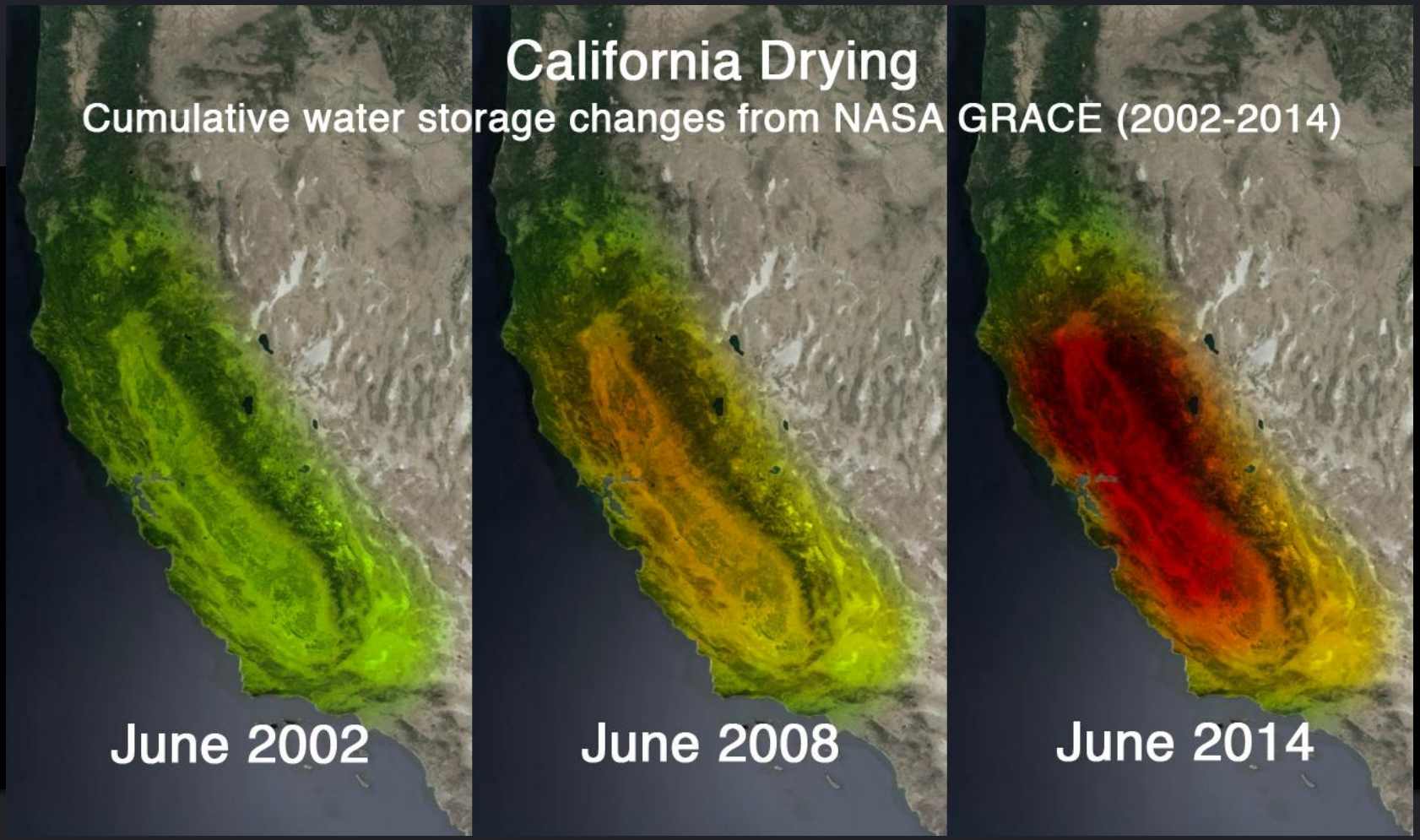


JUNO Reveals Cyclones at Jupiter North Pole

Less than 2 years since Orbit Insertion

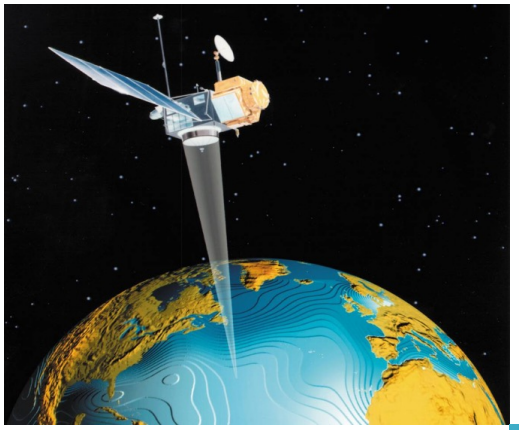


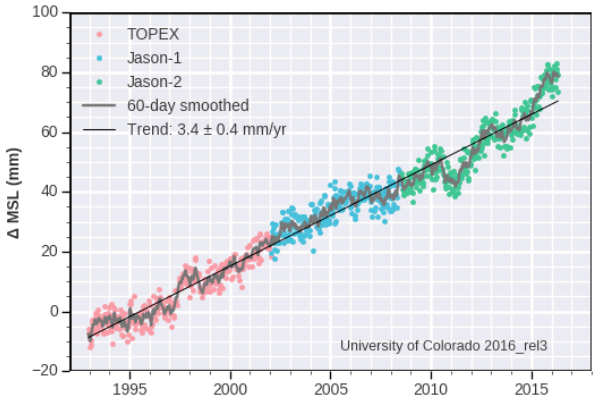

15 YEARS OF GRACE
2 satellites
137 miles apart
2,384,052,480 miles traveled
Ice loss measured
3,400 GIGATONS GREENLAND
1,550 GIGATONS ANTARCTICA
1 gigaton = 1 kilometer by 1 kilometer cube
NASA

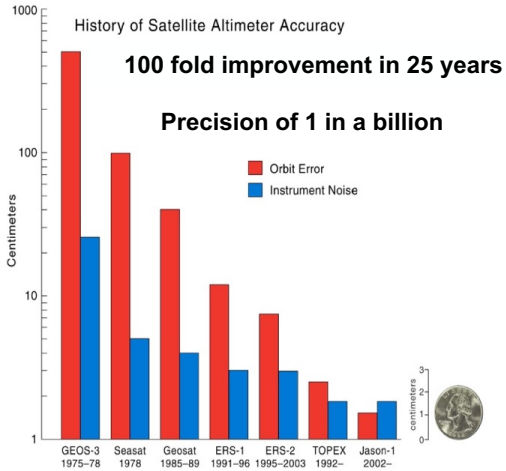

California Drying
Cumulative water storage changes from NASA GRACE (2002-2014)
June 2002
June 2008
June 2014

JPL

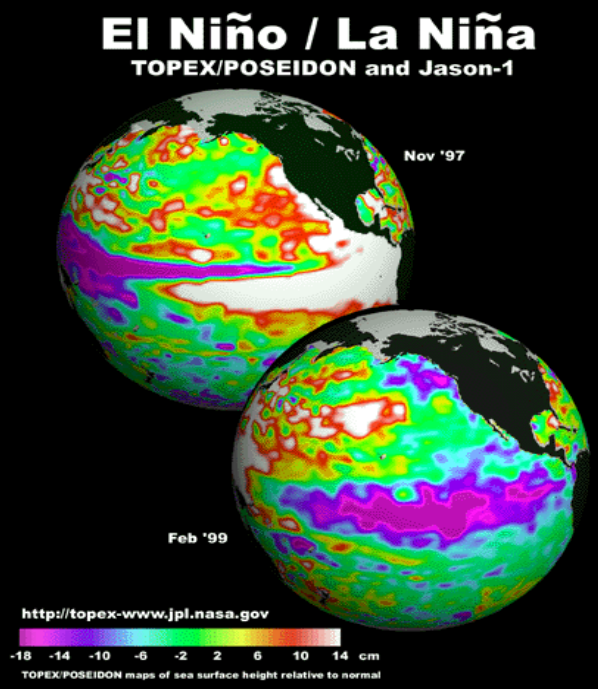
TOPEX-Poseidon 25th Anniversary







Observations of the Largest El Nino/La Nina of the 20th Century



These landmark observations made in 1997-99 provides the first global view of the formation and decay cycles of El Niño and La Niña. The data were assimilated into ocean models for improved understanding and prediction of El Niño and La Niña which affect the global weather patterns.

JPL

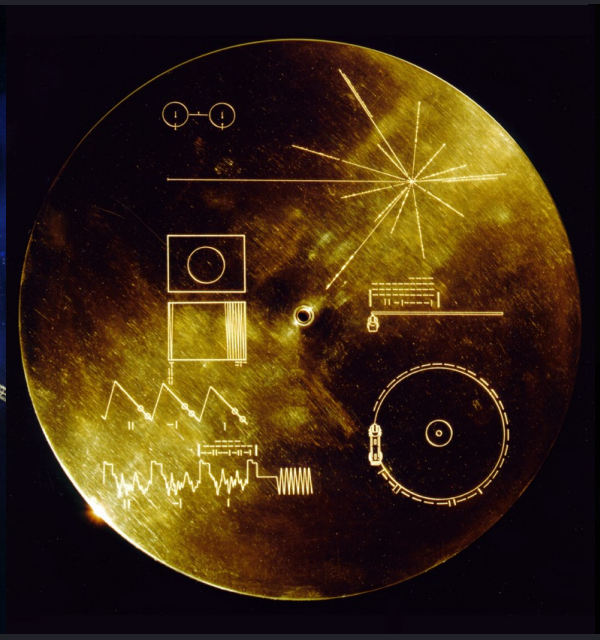
NuSTAR Discoveries in the First Five Years

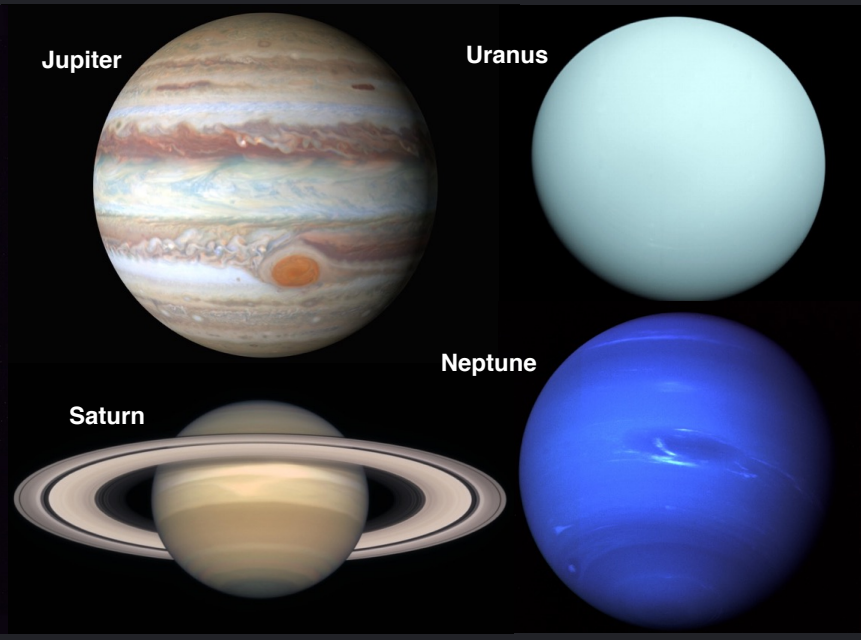
NASA's Black Hole Hunter

A star that exploded as a supernova 350 years ago. First ever map of emission from radioactivity in the remnant of an exploded star imaged by NuSTAR's specialized detectors.

JPL

Voyager Still Reaching for the Stars After 40 Years

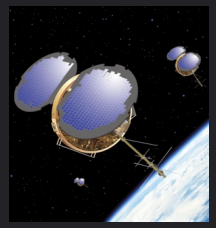




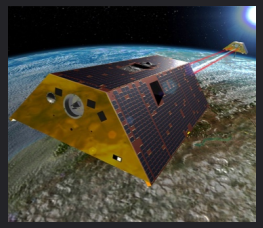
JPL

Near Future

2018

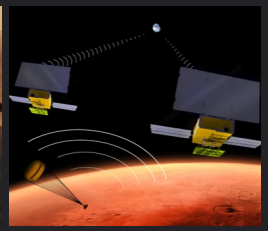


COSMIC-2

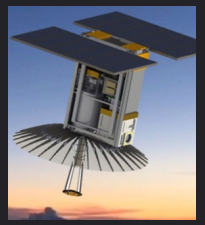


GRACE-FO

InSIGHT

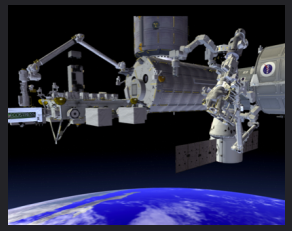


MarCo



RainCube

2019



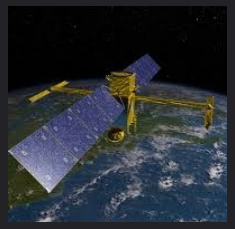
ECOSTRESS

2020

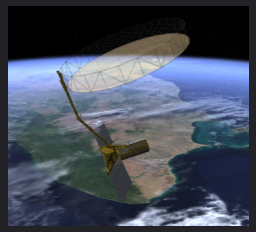
Mars 2020

Mars Helicopter (proposed)

2021

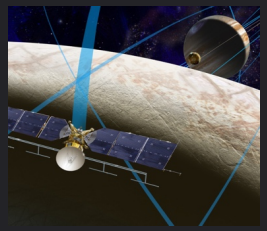


SWOT



NISAR

2022

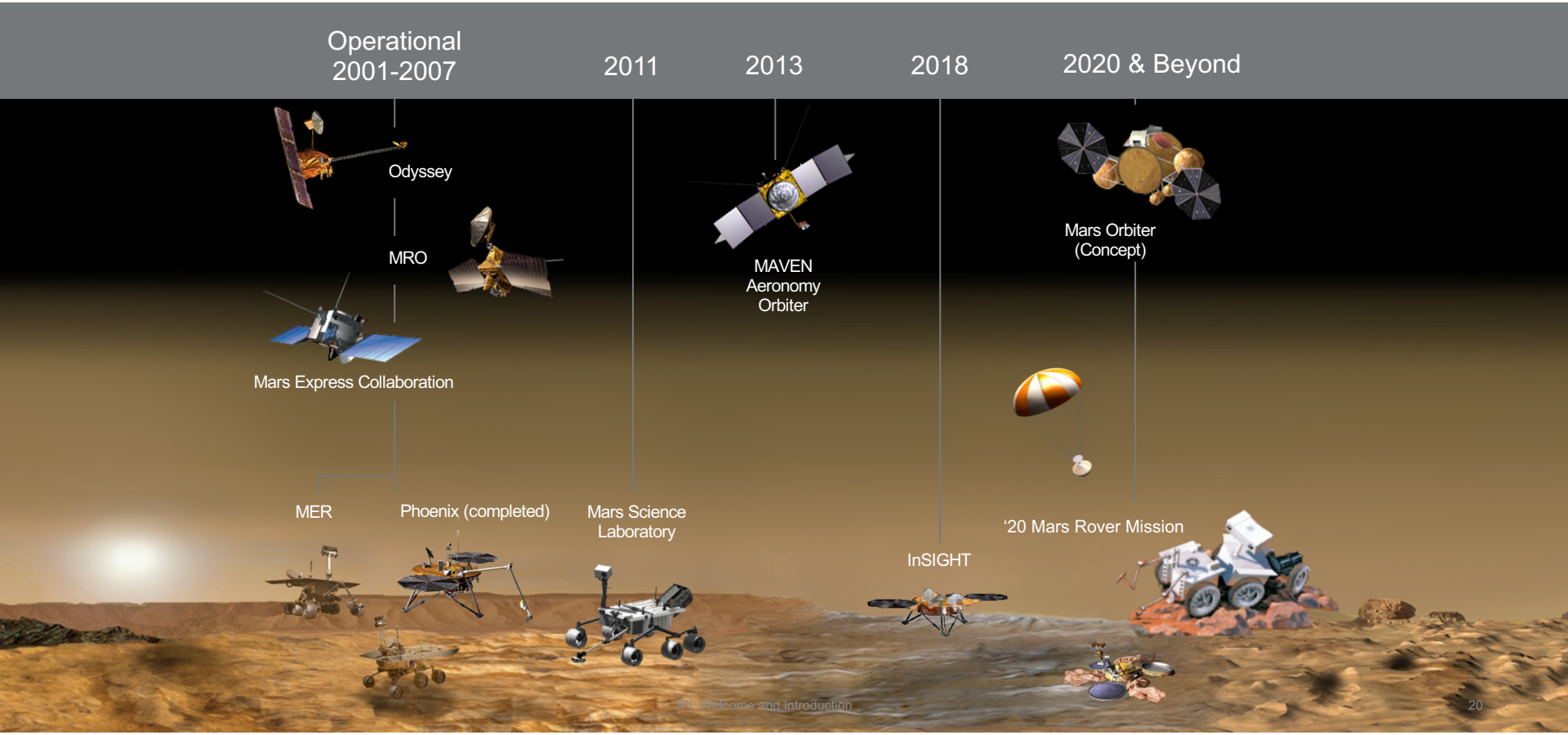


Europa Clipper

PSYCHE (planned)

JPL

Mars Exploration Program

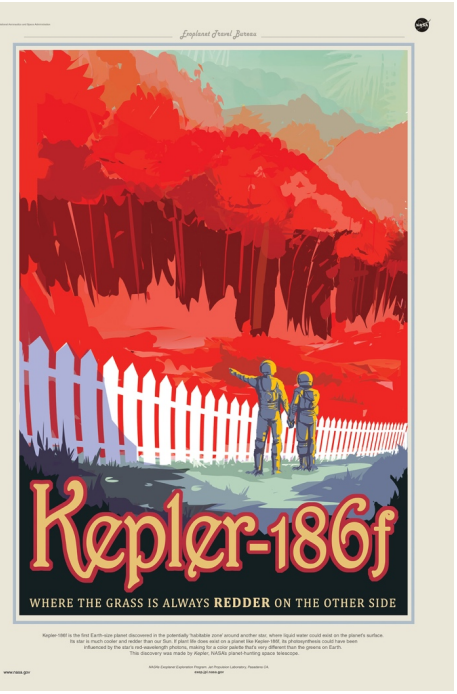


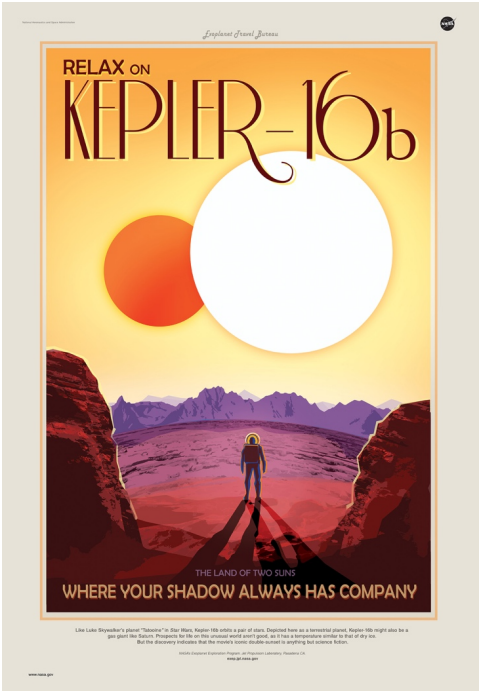
Exoplanet Travel Bureau

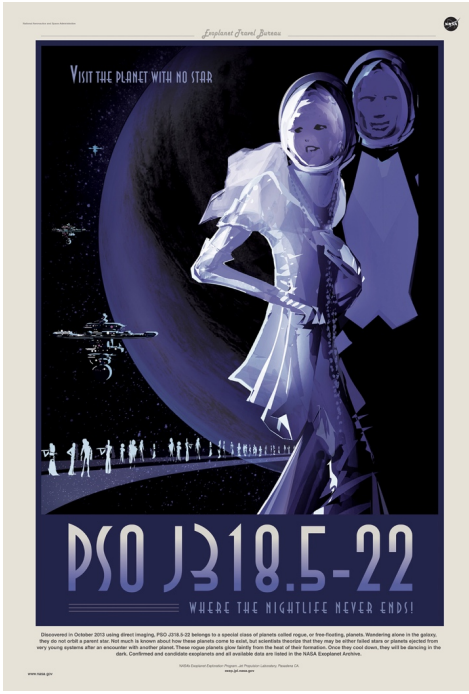
Earth Size Planets in Habitable Zone: 25

Confirmed Planets: 3,483

Planet Candidates: 2,250



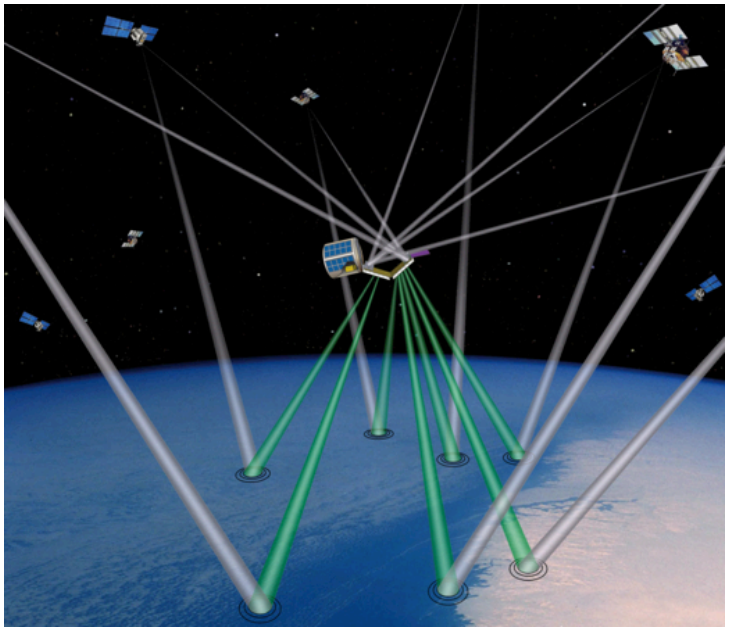




Global Navigation Satellite Systems Reflectometry (GNSS-R) for Wetlands Observations

Rice fields around Pavia, Italy: Cinzia's wetlands

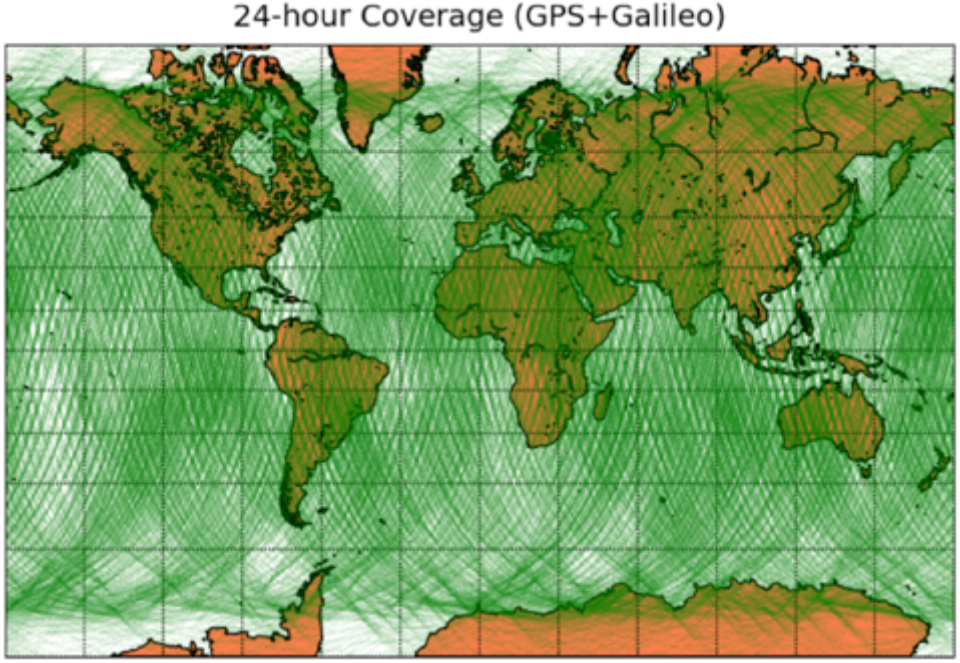
GNSS Reflectometry Concept



Multistatic Radar System

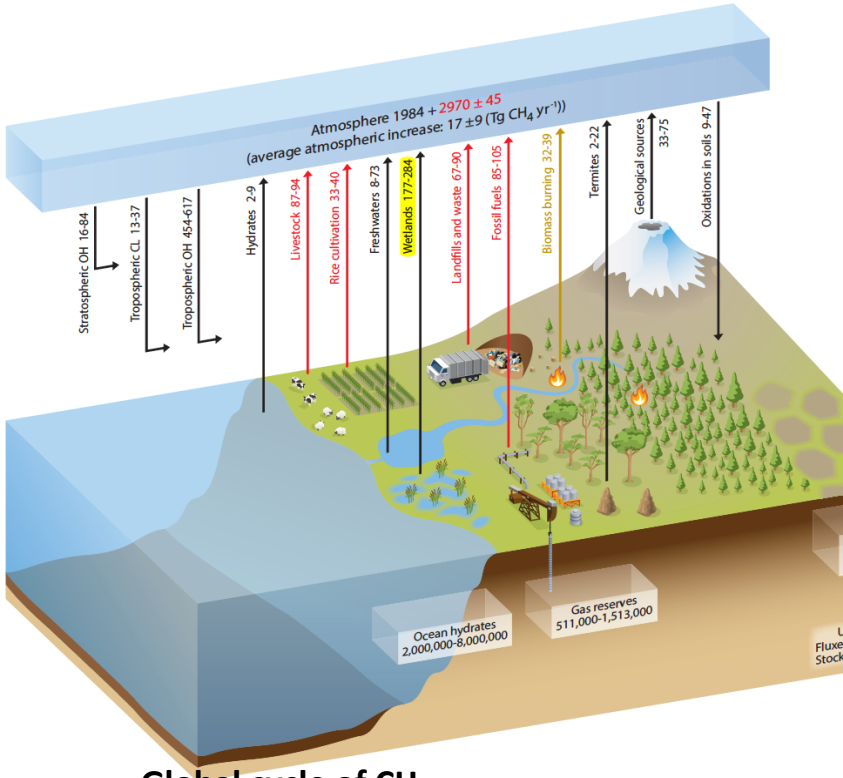
- Receivers are dedicated platforms equipped with specific GPS receiver/processor and antenna system
- Signal path is between transmitter, the Earth surface and the receiver along the forward scattering direction
- Reflected signal is “affected” by surface type, underlying medium and the traversed atmosphere

- Transmitters are Global Positioning and other Navigation Satellites (GNSS)
  - L-band: all-weather
- Multiple, simultaneous measurements
  - Dense spatial/ rapid temporal coverage
  - Randomly distributed ground tracks
- Leverages existing GNSS signals
  - Growing number of GNSS transmitters
  - Provides cost effective instrument



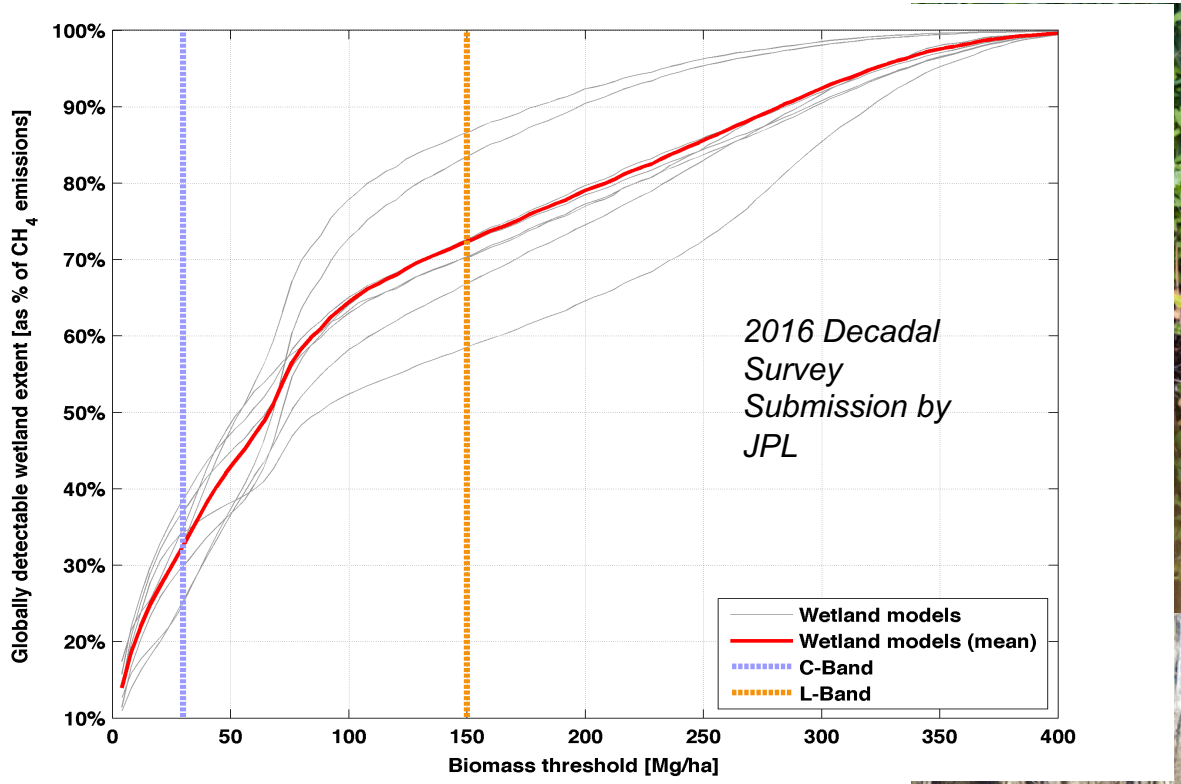
Wetlands as Driver of Methane Emissions

- IPCC AR5 highlights the role of wetlands as a key driver of methane (CH_4) emission
  - CH_4 is one order of magnitude stronger than carbon dioxide a a greenhouse gas in the centennial time scale
- Wetlands are the largest methane emission sources (30%) with the widest uncertainty range of 177-284 Tg(CH_4) yr^{-1}.
  - severely limits the confidence level of climate change projections
- Establish global wetland inventory and monitor its dynamics in days to years and at spatial scales < 1 km
- Mission to globally monitor wetlands not yet on the books; existing instruments have limitations in achieving needed spatial/temporal resolution or seeing through vegetation



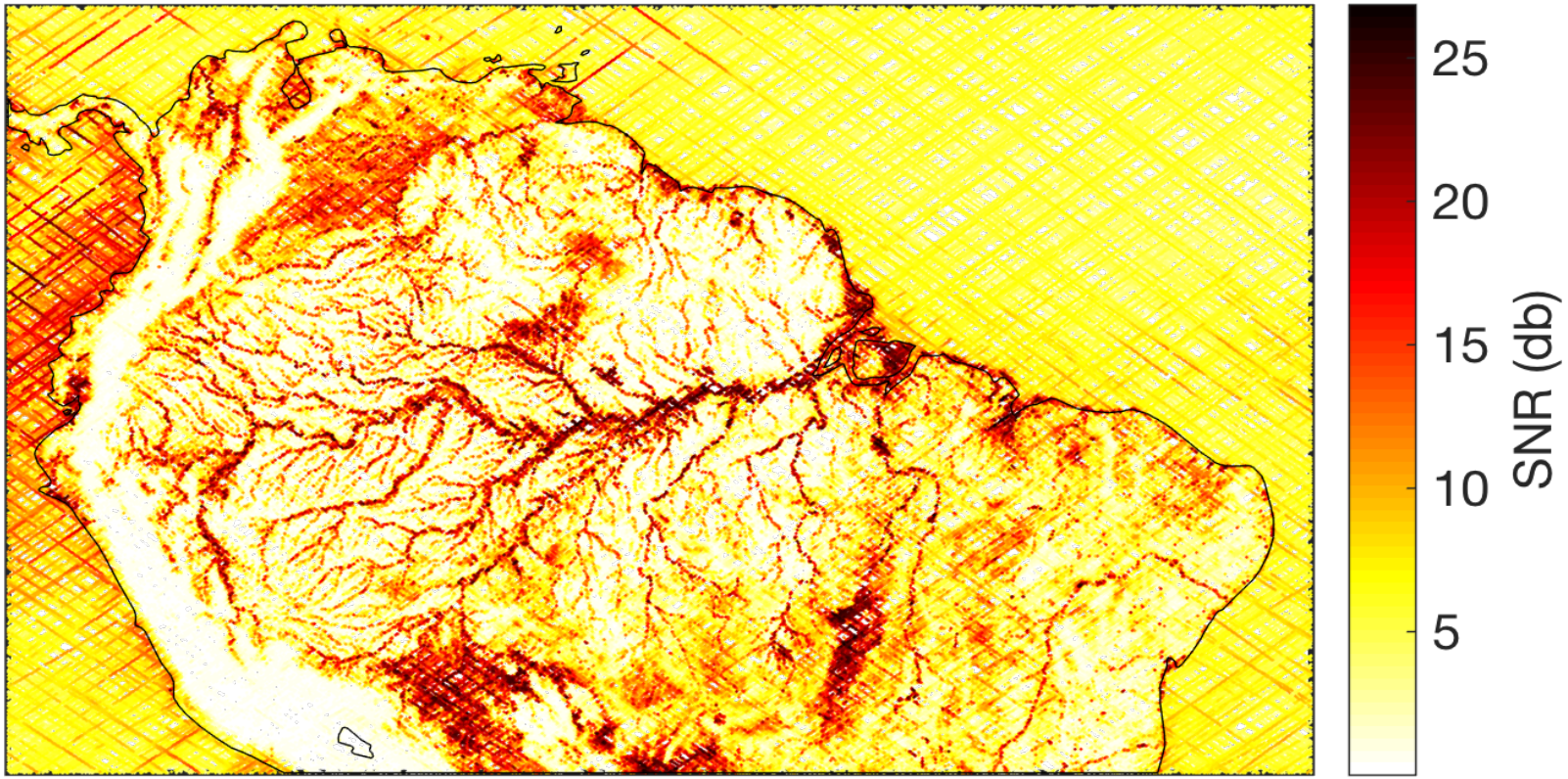
Global cycle of CH_4
Fig. 6.2, *IPCC*, 2013

Wetlands Obstructed by Vegetation



Detecting inundation in densely vegetated areas (up to 100 Mg/ha) is necessary to observe the global wetland areas emitting the majority of global wetland CH_4

GNSS-R Data Over Wetlands



- Data from NASA CYGNSS acquired over two months in 2017
- Forward scattered signal is coherent over wetlands and can penetrate vegetation; big jump in SNR allows detection

INTERNSHIPS AT NASA/JPL

INTERNSHIP OPPORTUNITIES AT JPL

- Portfolio of programs at JPL:
  - SIP – Summer Internship Program
  - YIP – Year Round Internship Program
  - MSP – Maximizing Student Potential
  - SURF – Caltech Summer Undergraduate Research Fellowship
- NASA and/or other sponsors fund Internships
- All internships have a stipend
- Some internships include a housing/travel allowance
- General Requirements
  - 3.0 GPA or higher
  - STEM major
  - Currently enrolled student
  - NASA funded internships require US Citizenship

- Specific to foreign students (at foreign institutions)
  - JVSRP – JPL Visiting Student Research Program
    - Requires students securing funding from their government, institution and/or other sources
    - Requires invitation from JPL researcher serving as host of internship
  - NASA Education Office Programs for foreign students
    - Applicable to students of countries with whom NASA has stipulated an agreement
    - https://intern.nasa.gov/non-us-opportunities/index.html

https://www.jpl.nasa.gov/edu/intern/apply/

(or just Google “JPL internships”)

JOB OPPORTUNITIES FOR GRADUATING STUDENTS

NASA JPL Early Career Hire (ECH)

- Recent graduates (less than 2 years)
- Minimum 3.0 cumulative GPA
- Send an email with resume in editable format to one of us:
  - Jenny.Tieu@jpl.nasa.gov
  - Roslyn.Soto@jpl.nasa.gov
  - Eddie.Gonzales@jpl.nasa.gov

NASA Pathways (all other Centers)

- Recent Graduates (non-Veterans, <2 years; Veterans, <6 years)
- Apply online: www.usajobs.gov

TIPS & ADVICE FOR STUDENTS

- Don't count yourself out! If you are interested, APPLY!
- Review program requirements carefully! Make sure you qualify!
- Adhere to program deadlines and instructions for applying.
- Resumes should include your cumulative GPA, relevant coursework/projects, and specific skills you have (i.e. programming languages, software, foreign languages, etc.)
- Proofread your materials before submitting them!
- If at first you don't succeed, try again! Continue to build your skills, take challenging courses, and learn more about your areas of interest.
- If you are not accepted to a program, you will need to resubmit your materials, UNLESS you applied for a year-round program.
- If you have questions, we are here to help! Contact the leads of the program(s) for which you have interest.

National Aeronautics and Space Administration

Current Postdoctoral Programs

Jet Propulsion Laboratory
California Institute of Technology

JPL Postdoctoral Scholars Program

- *Candidates respond to a specific advisor research AO, but are not required to write an original research proposal. Rather, they are directed to contribute to an existing research project competitively awarded to the advisor*
- Funded by JPL PI

NASA Postdoctoral Program (NPP)

- *Candidates write research proposal in response to advisor AO, and are expected to have a high degree of originality and independence from advisor. Proposal is peer reviewed.*
- Primarily funded by NASA's Science Mission Directorate (SMD) as an institutional research award to the Center/JPL
- *November 1st, March 1st, July 1st @ 6pm ET*
- *Takes approx. 2.5 – 3 months for the peer review cycle and selection to complete*

General Requirements

- *Candidates must have completed all requirements of their PhD (must be within 5 years)*
- *Postdoc appointments are full-time and research must be conducted at JPL*
- *Postdocs are limited to 3 years at JPL, in any combination of appointments*

Current Postdoctoral Programs

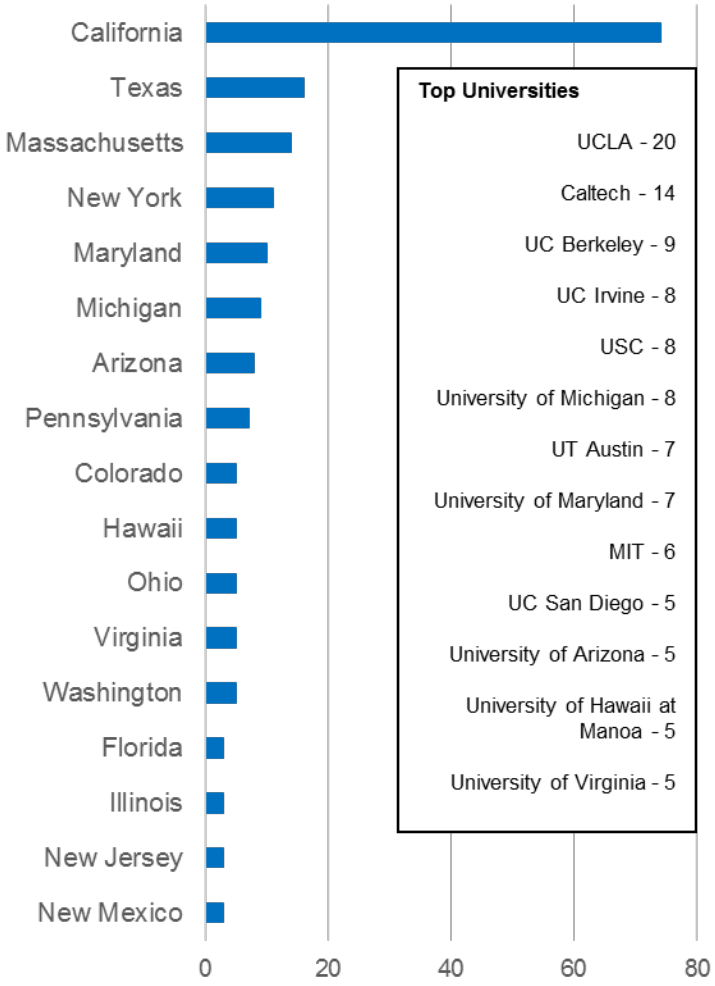
- **Others**
  - Hubble, Einstein, Sagan
    - Astrophysics-theme based fellowships, funded by NASA
  - JIFRESSE *(Joint Institute for Regional Earth System Science & Engineering)*
    - UCLA-employed postdocs funded via collaboration with JPL
  - Visiting Postdoctoral Program
    - For postdocs who come with funding from their home country or institution
      Example: Fulbright
    - Contact Postdoc Office for invitation letter & coordinate with JPL International Office

National Aeronautics and Space Administration

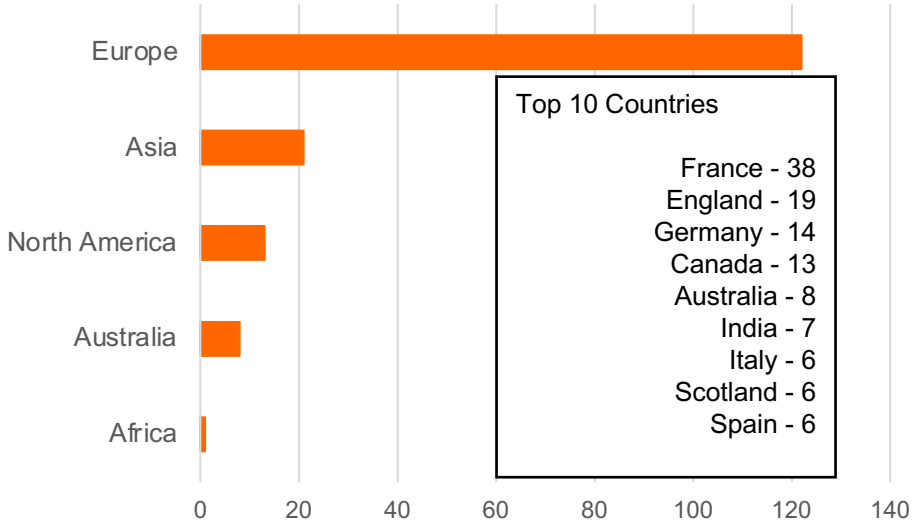
Jet Propulsion Laboratory
California Institute of Technology

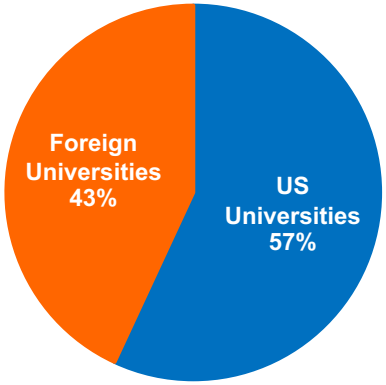
Universities of Origin

84 Universities Across 38 States



107 Universities Across 24 Foreign Countries



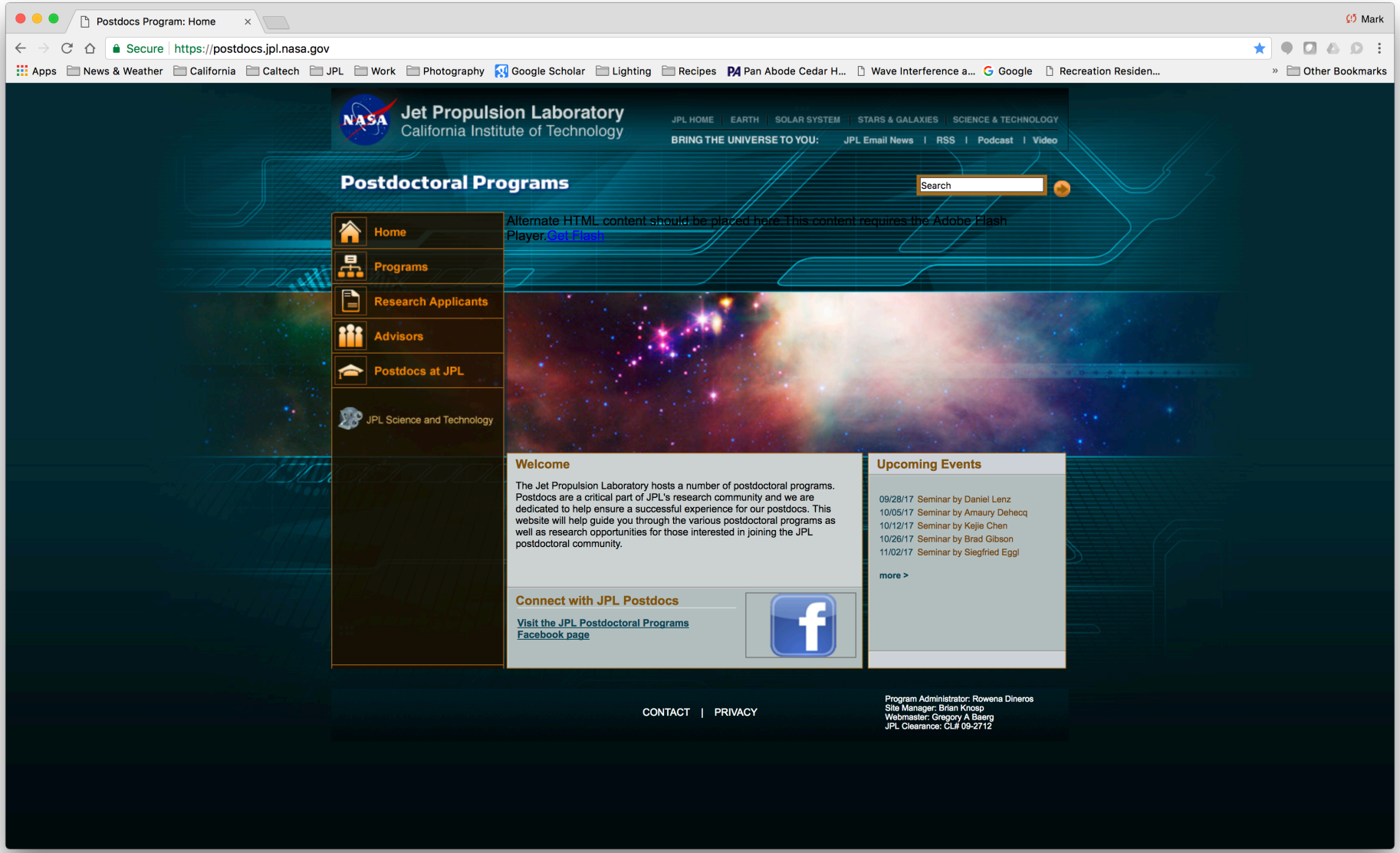


2015 Data

National Aeronautics and Space Administration

http://postdocs.jpl.nasa.gov/

Jet Propulsion Laboratory
California Institute of Technology

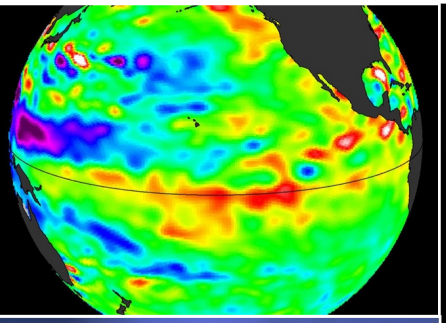


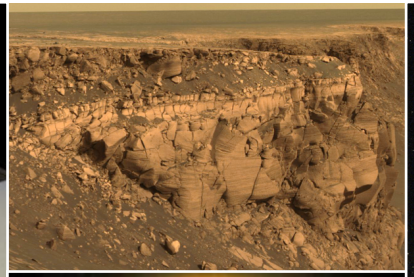

NASA
JPL
Caltech

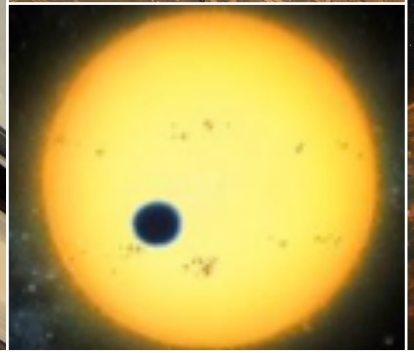
JPL’s Mission for NASA

Robotic Space Exploration

Mars • Solar system • Exoplanets • Astrophysics • Earth Science • Interplanetary network

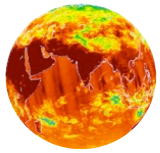




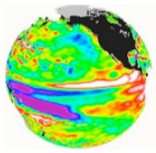


Multiple Ways to View a Changing Earth

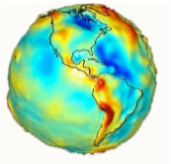
Global • Satellites



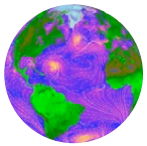
AIRS
atmospheric temperature



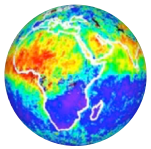
JASON
sea surface height



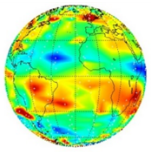
GRACE
gravity



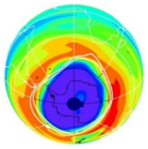
QUIKSCAT
wind



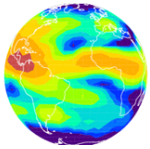
MISR
aerosols



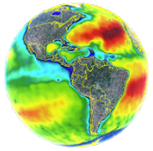
TES
trace gas



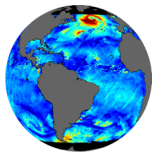
MLS
ozone layer



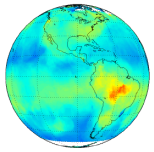
CLOUDSAT water content



Aquarius
sea surface salinity

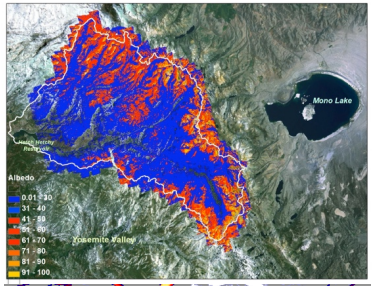


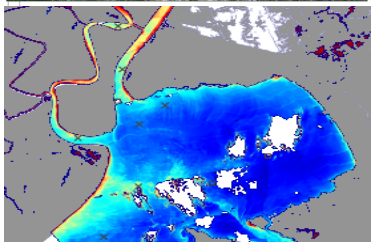
RapidScat
wind



OCO-2
Carbon Dioxide

Regional • Airborne

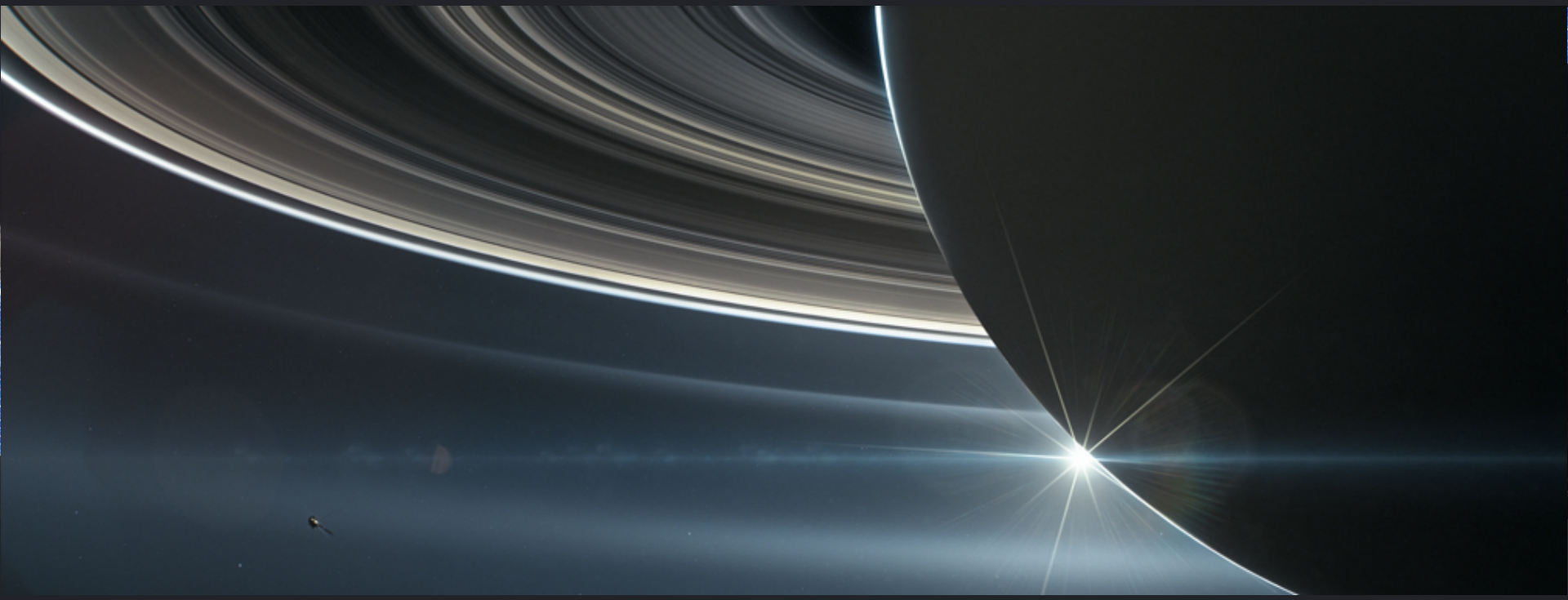




Local • In Situ

Cassini 20th Anniversary

EOM September 15, 2017



JPL

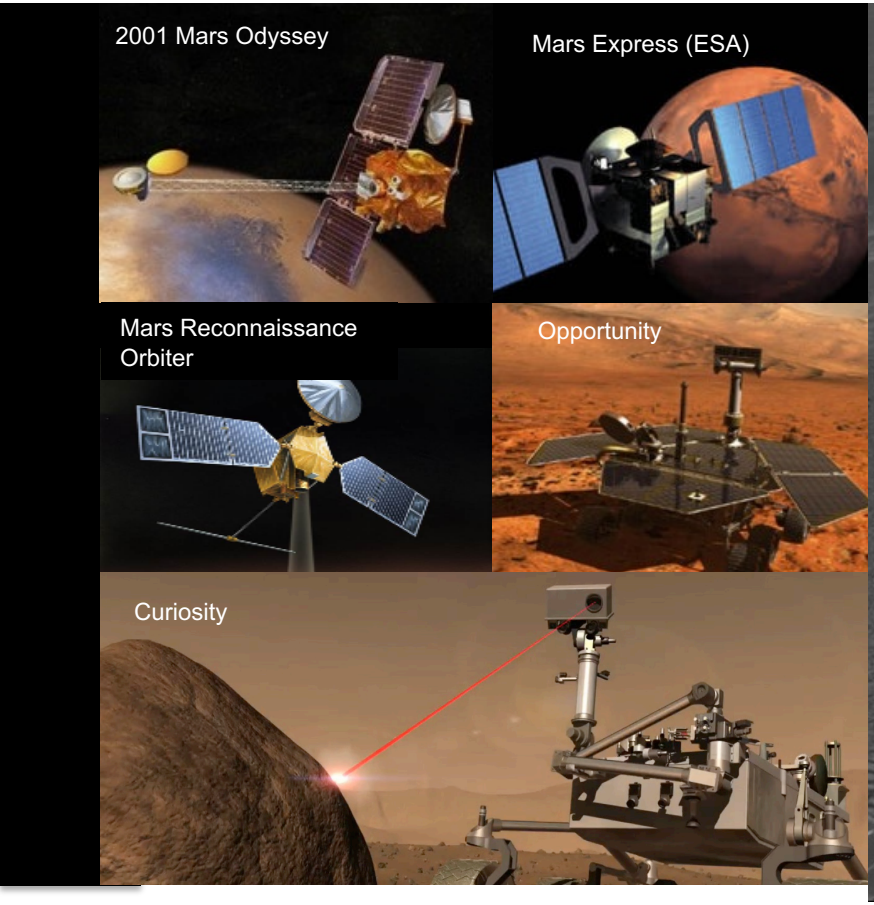
Pathfinder's 20th Anniversary

NASA's first step to demonstrating cost-effective EDL, new technologies for operating a rover on another planet, and scientific observations on the Martian atmosphere, climate and geology

visible and infrared mapping spectrometer

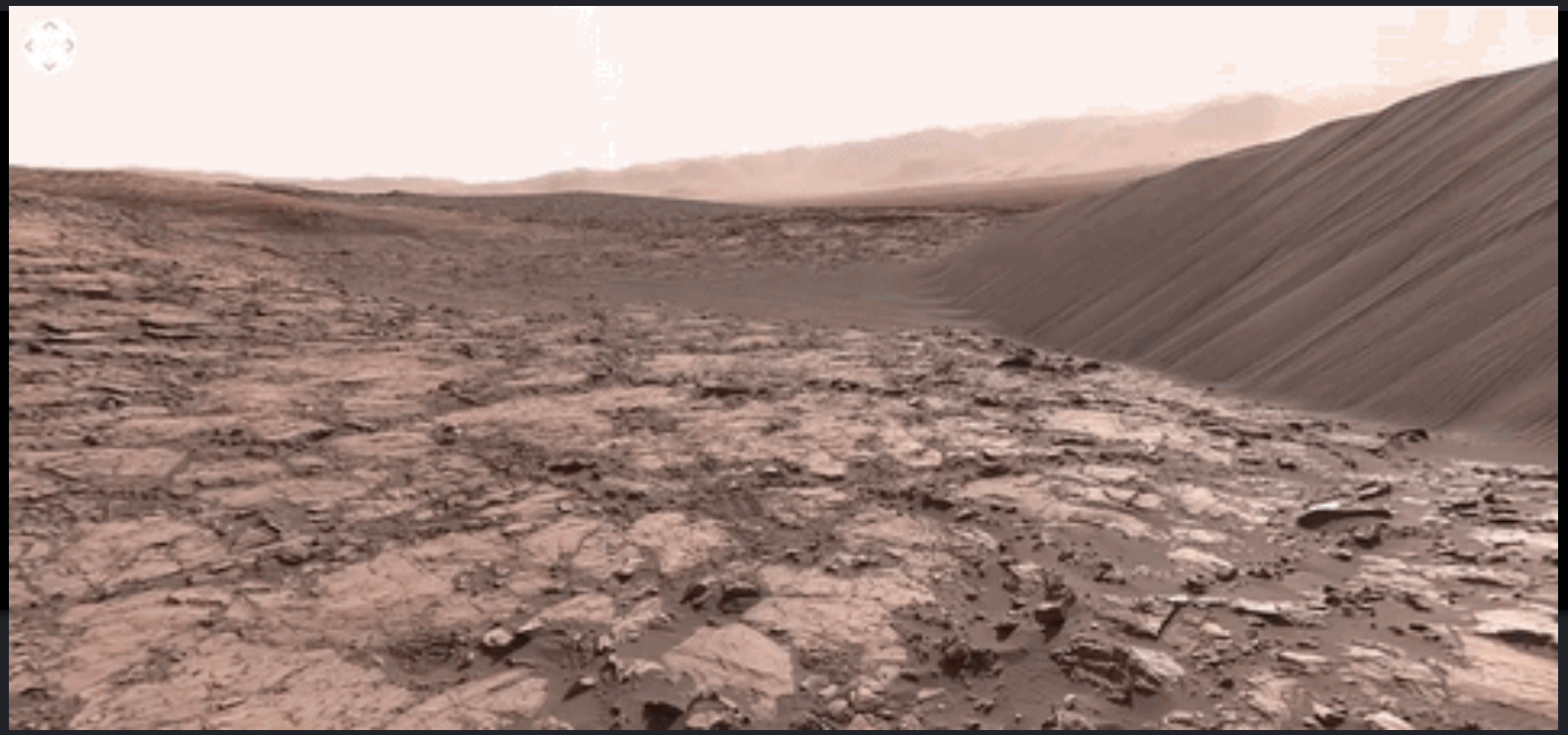
JPL

Continuous Robotic Presence on and In-orbit around Mars



Mars 360

Curiosity near large sand dunes



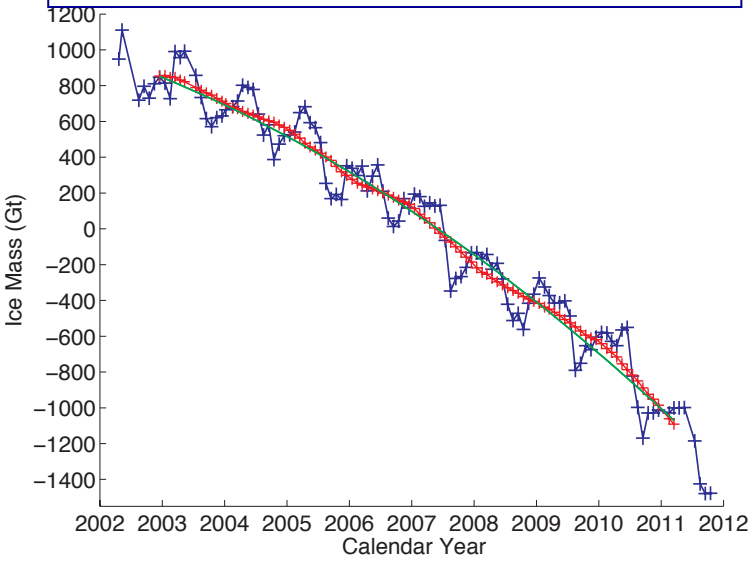
JPL

Finding Habitable Environments

Yellowknife Bay

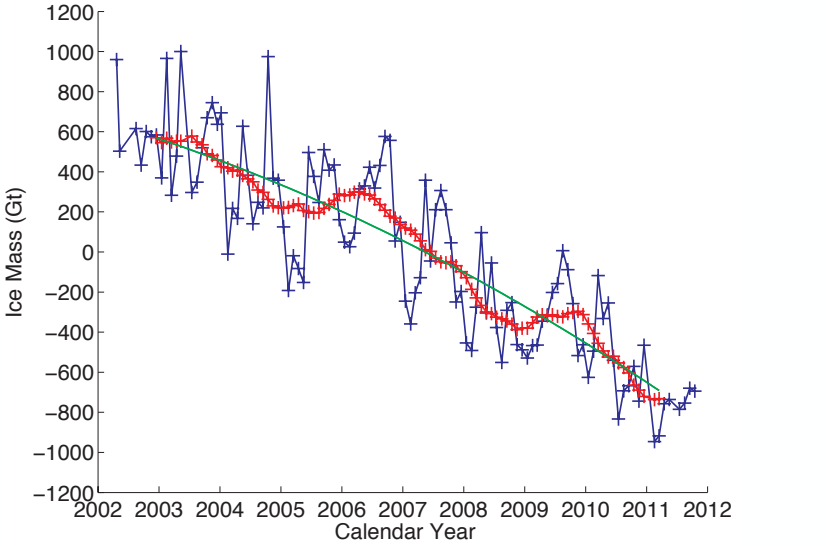
Ice Mass Loss 2002-2011
Grace

Greenland



Trend Apr 2002-Oct 2011:
-220 ± 33 Gigatons/year

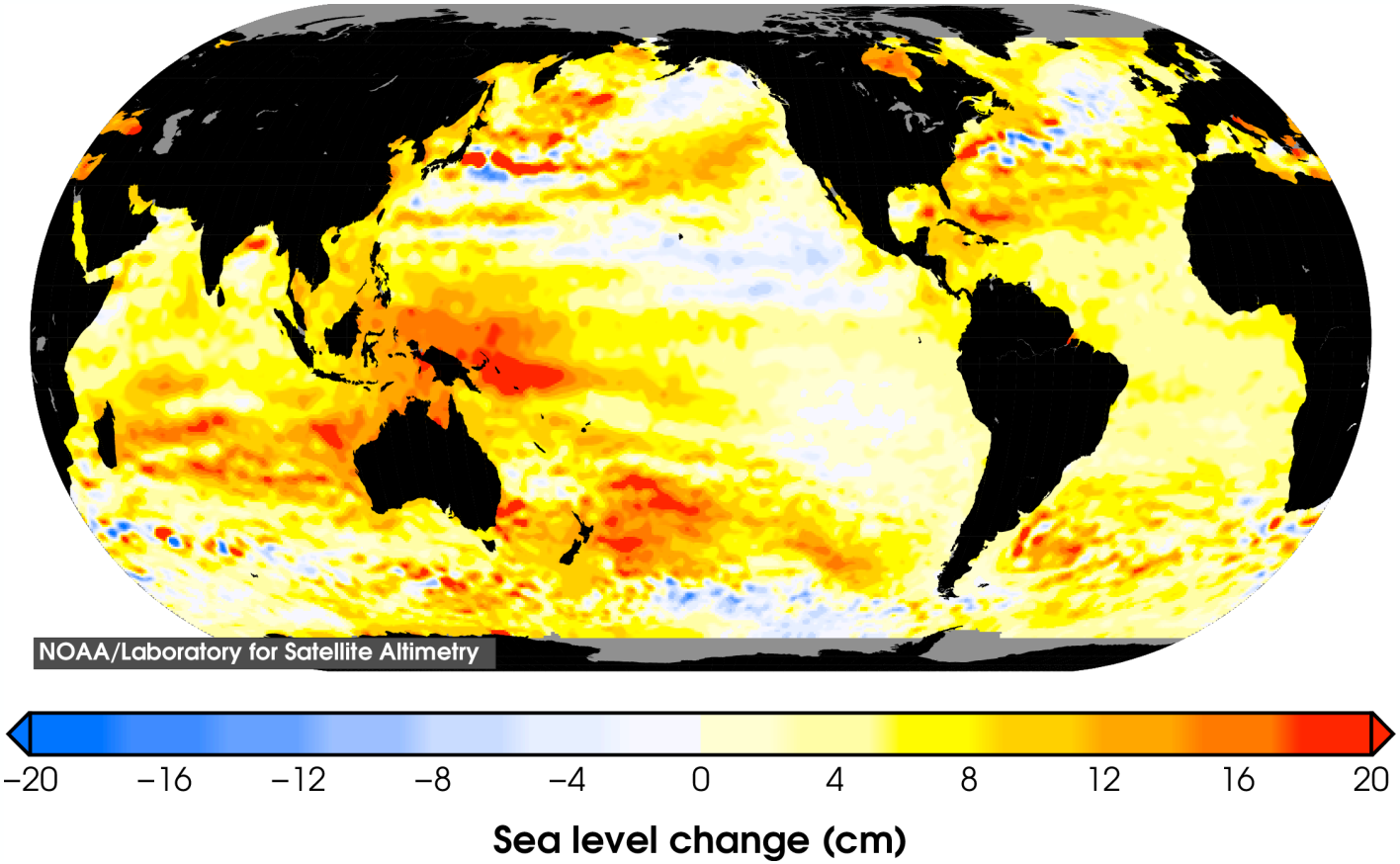
Antarctica



Trend Apr 2002-Oct 2011:
-152 ± 33 Gigatons/year

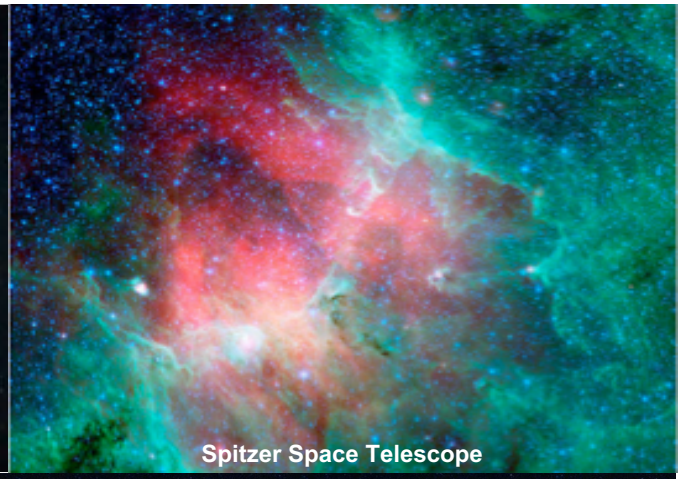
Sea Level Change Since 1993

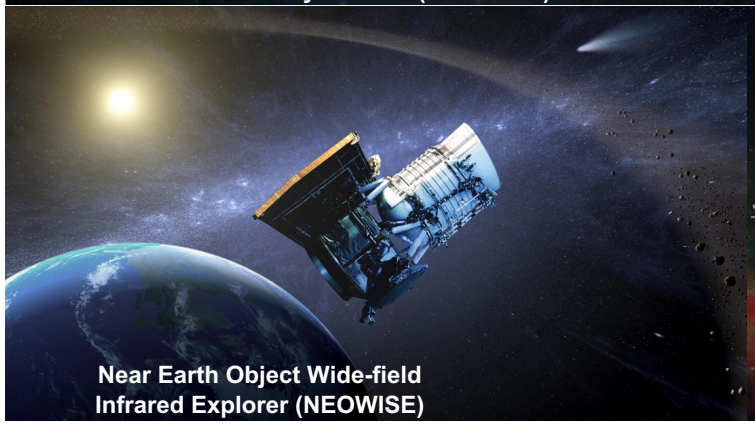
Complex patterns of decadal changes of sea level are key to understanding the ocean's role in climate.

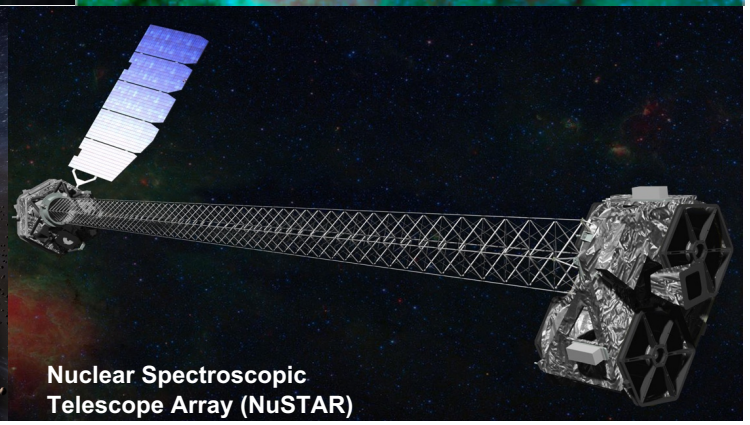


Astrophysics Missions

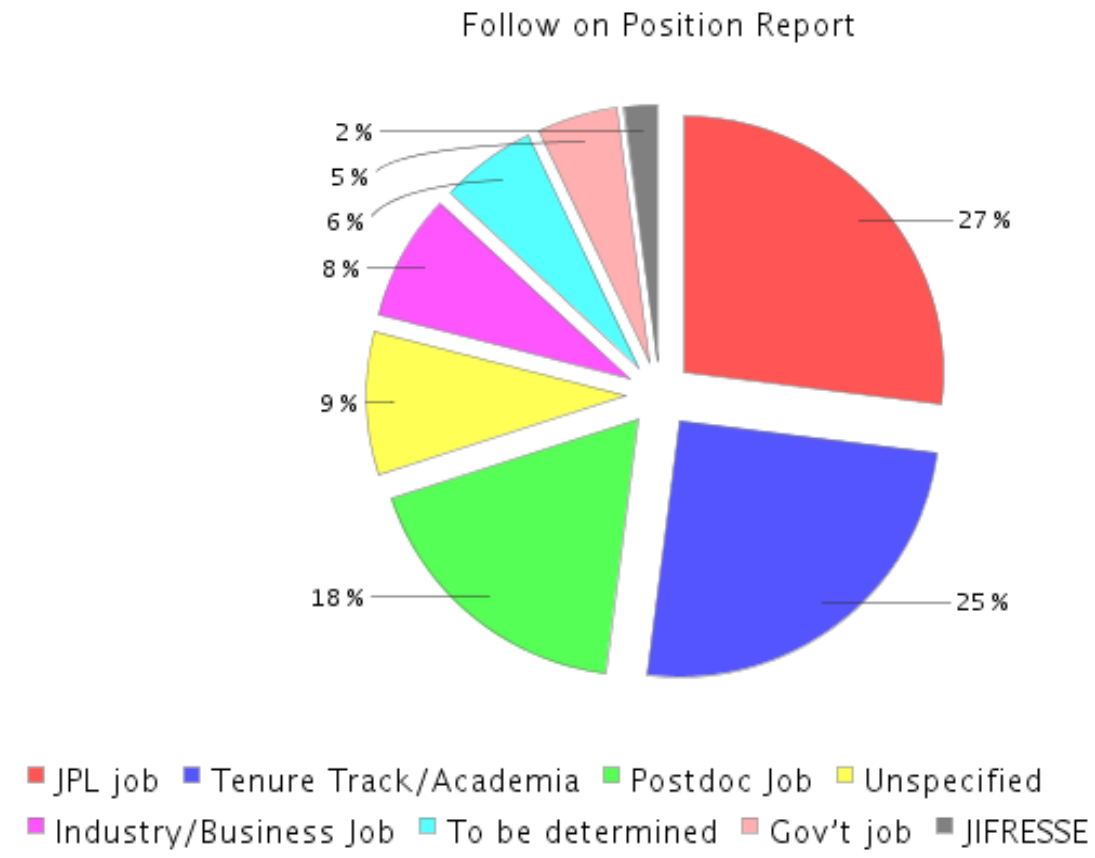

Wide Field/Planetary Camera (on Hubble)


Spitzer Space Telescope


Near Earth Object Wide-field Infrared Explorer (NEOWISE)


Nuclear Spectroscopic Telescope Array (NuSTAR)

Post-Postdoc…



Enrichment Programs for Postdocs

- **Postdoc Seminar Series**
- **Annual Postdoc Research Day**
- **Postdoc Training via Professional Development**

Resources for Postdocs

- **Postdoc website: http://postdocs.jpl.nasa.gov/**
  - *Research Applicants*
  - *Advisors & business support:*
    - Post opportunities
    - NPP advisor application
    - NPP approved advisor list
  - *Active Postdocs*
    - Postdoc roster (profiles)
    - Seminar series schedule and archived presentations