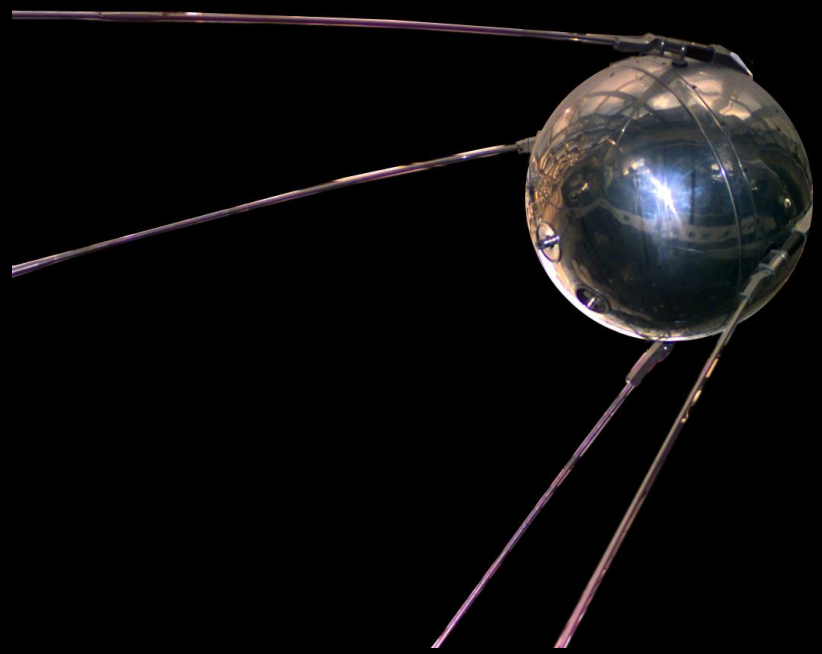
DARE MIGHTY THINGS

Recent Science Achievements From NASA



Jason Hyon
With Contributions from NASA HQ, Renyu Hu, Tiffany Kataria, Christof Sotin, Kevin Hand, Ashwin Vasavada, Lisa Storry-Lombardi
Jet Propulsion Laboratory
California Institute of Technology

NASA Centers

Transferred with NACA

- Langley Research Center, VA
- Ames Research Center, CA
- Lewis (now Glenn) Research Center, OH
- (now Armstrong) Flight Research Center, CA

December 1958

- Jet Propulsion Laboratory, CA, transferred from the US Army

May 1959

- Parts of the Naval Research Laboratory transfer to NASA – becomes the Goddard Space Flight Center, MD

July 1960

- Marshall Space Flight Center, AL, transferred from the US Army

July 1961

- Manned Spacecraft Center, TX, established – renamed Johnson Space Center in 1973

October 1961

- Mississippi Test Facility established – renamed Stennis Space Center in 1988

March 1962

- Launch Operations Center, now Kennedy Space Center, FL, established

National Aeronautics and Space Administration

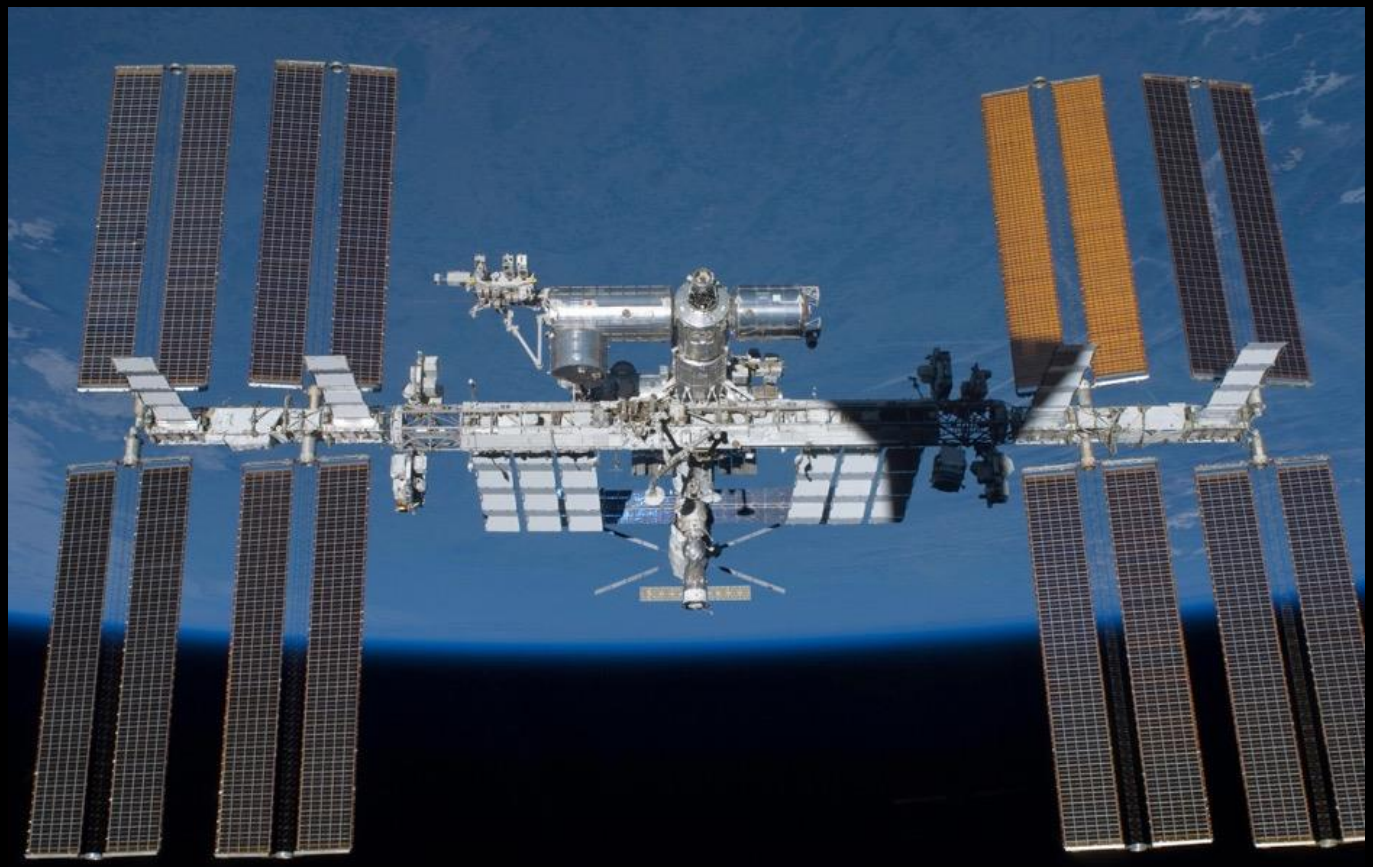
Aeronautics Research

NASA is with you when you fly.

Human Exploration

International Space Station

Off the Earth, for the Earth.

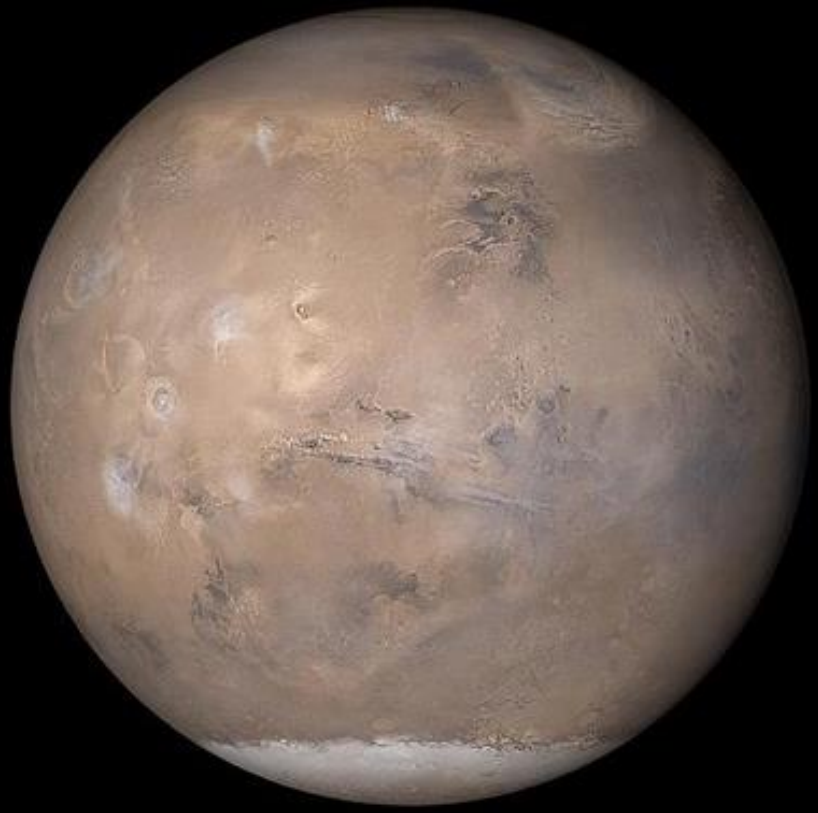


Earth

Your planet is changing. We're on it.

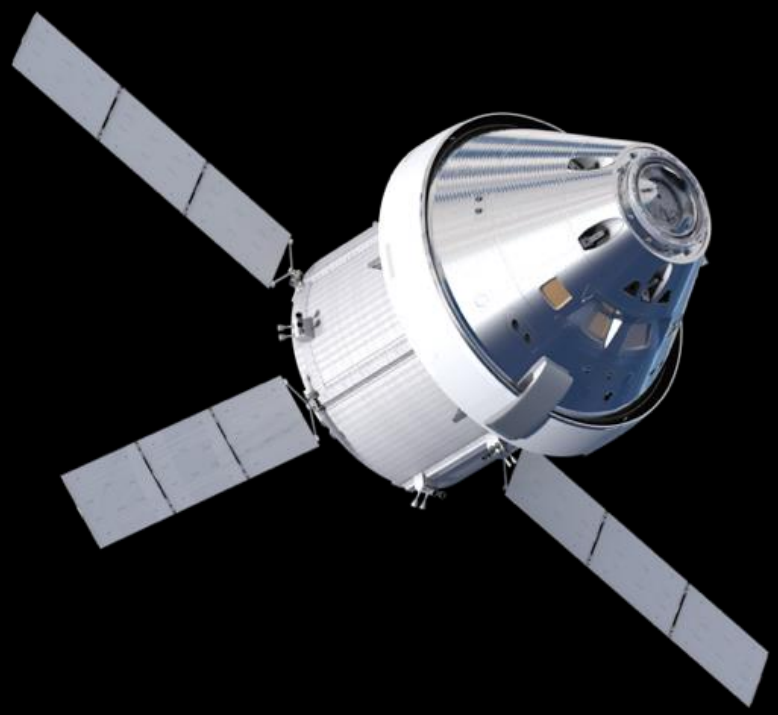
Mars

Join us on the journey.



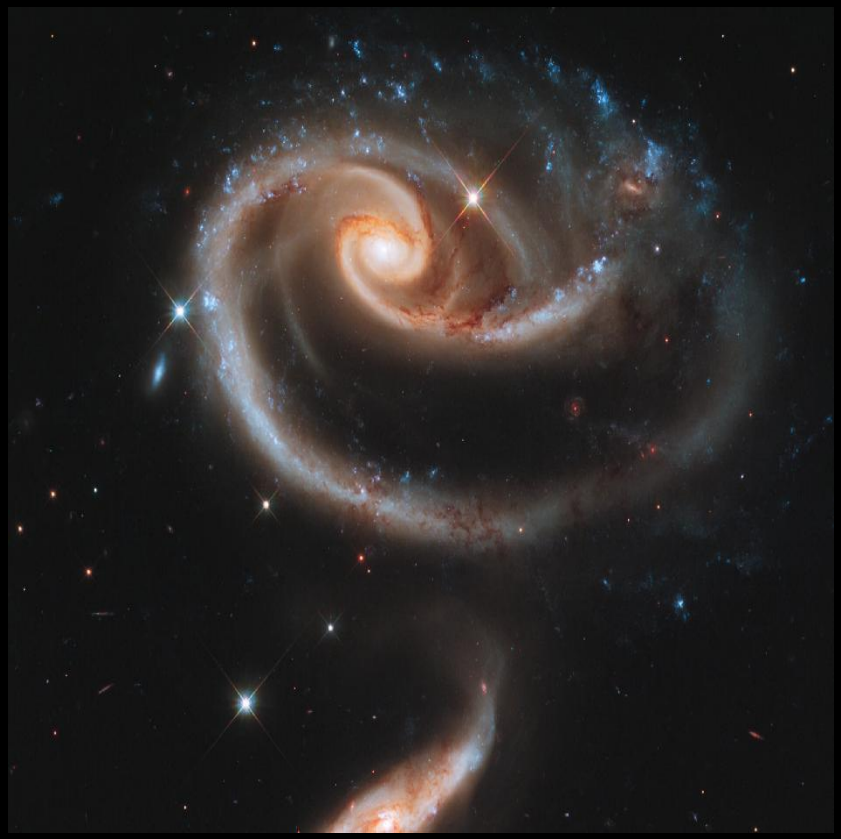
Mars

Join us on the journey.



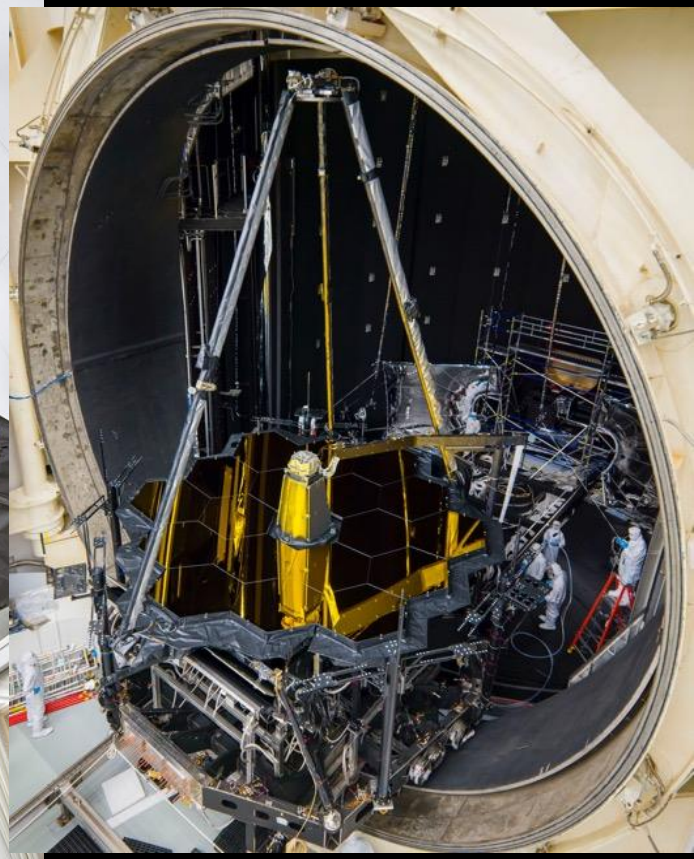
Solar System and Beyond

NASA… We're out there.



Solar System and Beyond

NASA… We're out there.



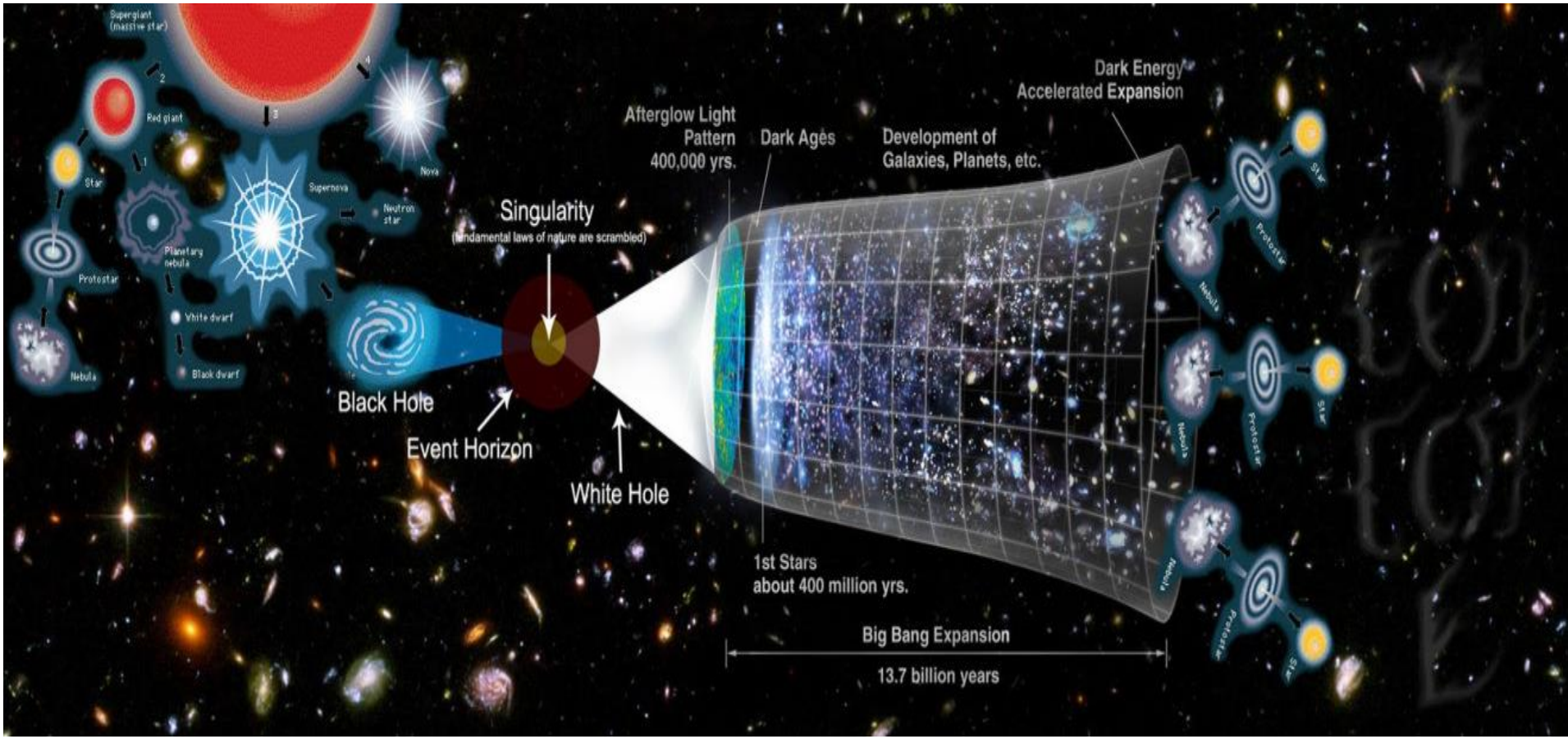
NASA Technology

Technology drives exploration.

Partnership Opportunities

- International Agency
- Small Business
- Aerospace
- Universities
- Postdoc and visiting scientists
- Outreach
- Space Act
- Patent

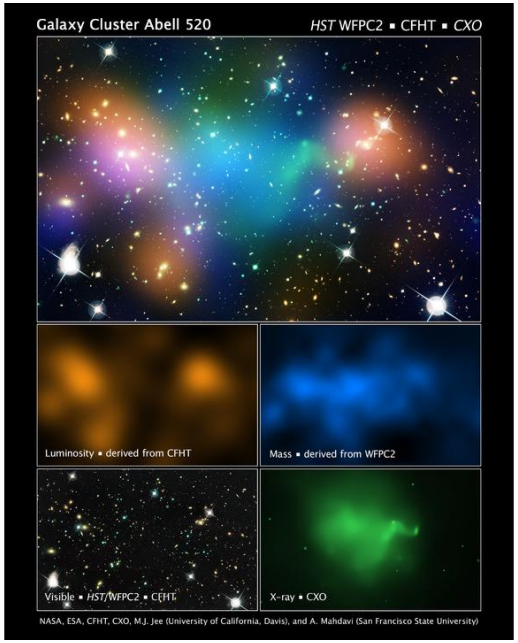
Formation of Universe



https://civitashumana.files.wordpress.com/2014/05/multiverse-graph.jpg

What Forces Govern The Universe?

- Four Forces – 5%
  - gravitation, electromagnetism, the weak interaction, and the strong interaction
- Dark Energy – 68%
  - Expansion of universe
- Dark Matter – 27%
  - Matter fills up space



Hubble Space Telescope

Exoplanets: Big Questions

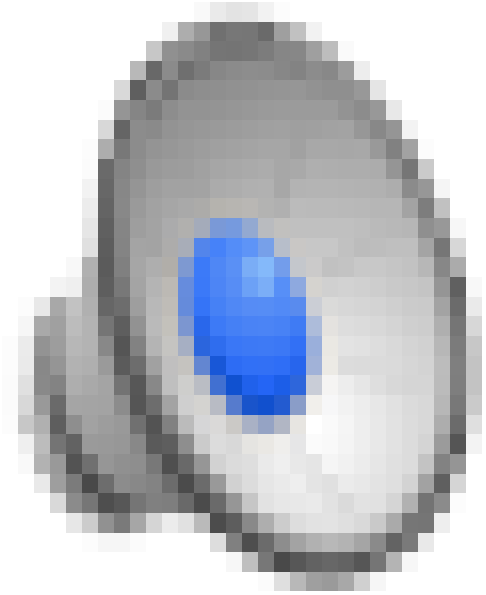
- Where did we come from? Are we alone?

Weather and Climate of Exotic Worlds

Habitability and Biogenic Gases

Spitzer Space Telescope

A Transiting Planet – Venus - 2012



Credit: James Gilbert

TRAPPIST Project

TRAnsiting Planets and Planetesimals Small Telescope

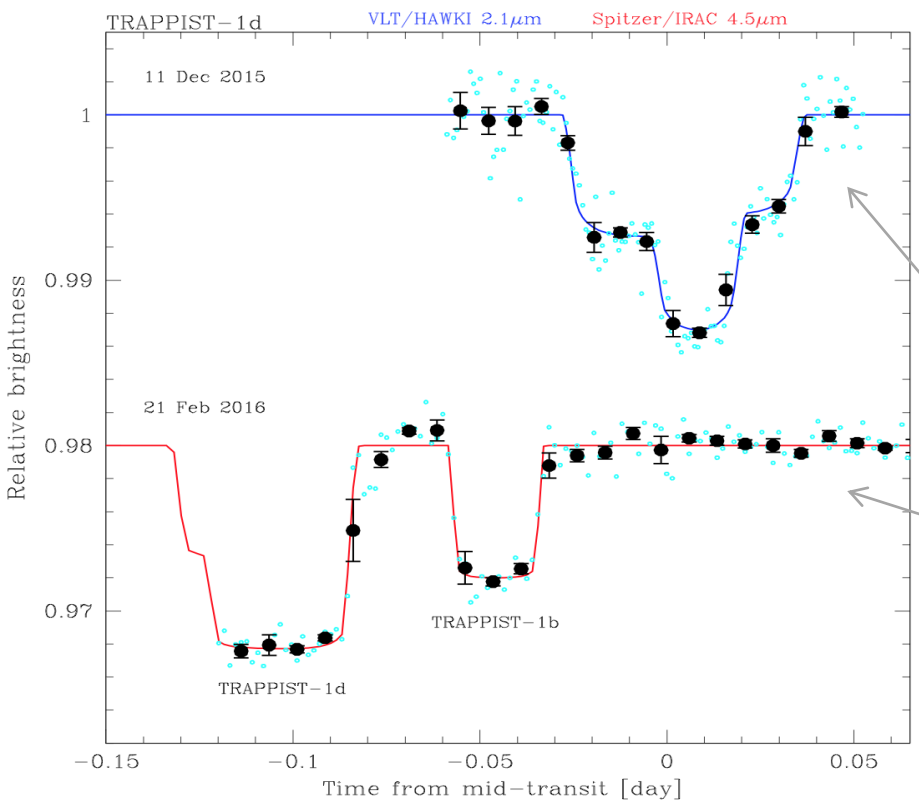
- Managed by Univ. Liège (Belgium)
- PI: Michaël Gillon
- Manager: Emmanuël Jehin
- Two 60 cm robotic telescopes at ESO La Silla (Chile) and Oukaïmden Observatory (Morocco)
- 50 nearest ultracool dwarf stars targeted for monitoring

TRAPPIST-1 (2MASS J23062928-0502285)

- M8V, 8% M_{Sun} (84 M_{Jup}), just above H-burning limit
- R=1.1 R_{Jup}, V=18, d=12 pc
- 245 hr monitoring (TRAPPIST-South) in late 2015 yielded at least 3 Earth-sized planets!

February – 2016: *'Spitzer observation of a potential binary terrestrial planet'*

Initial TRAPPIST results:
3 transiting temperate Earth-sized planets

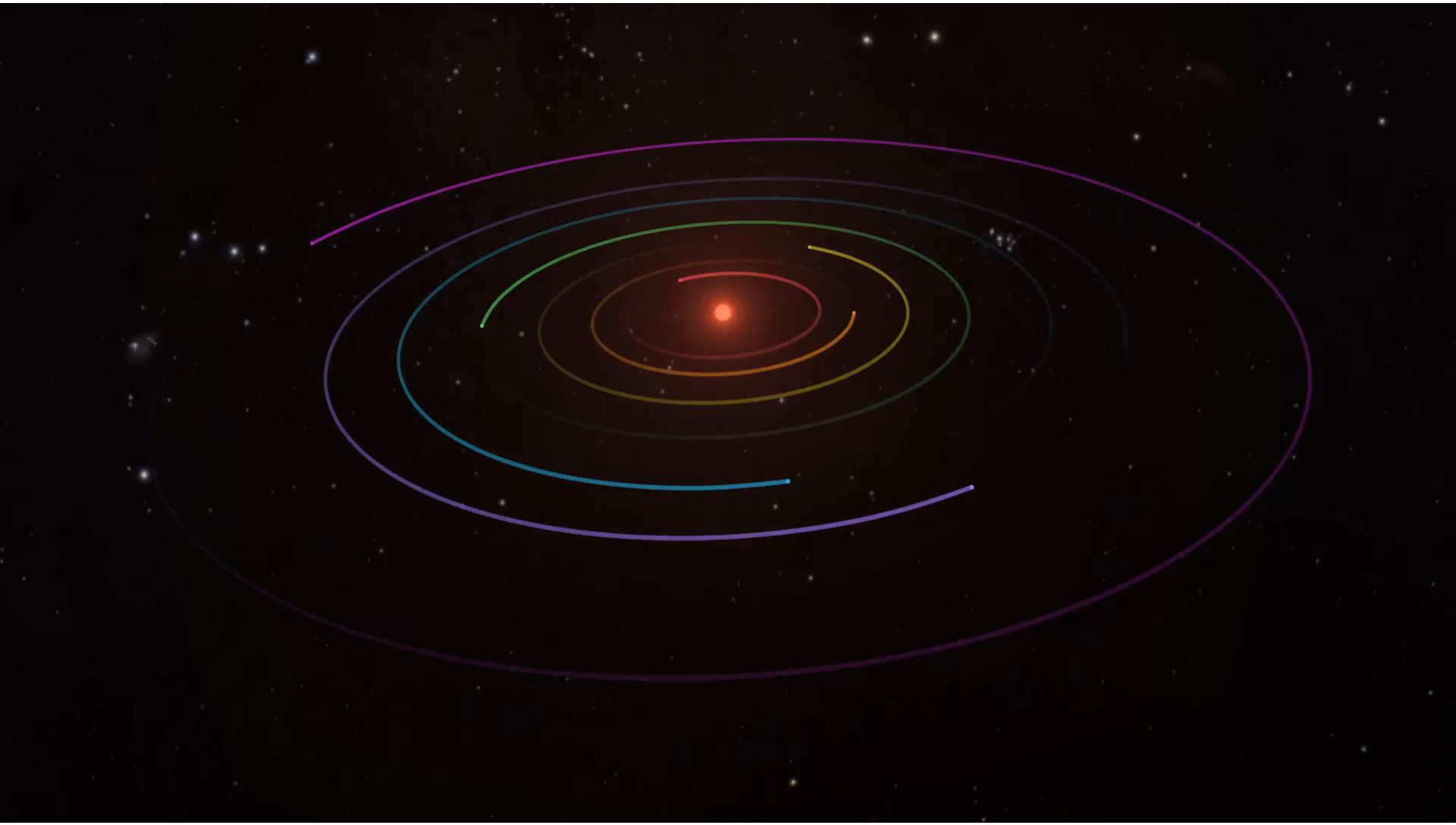


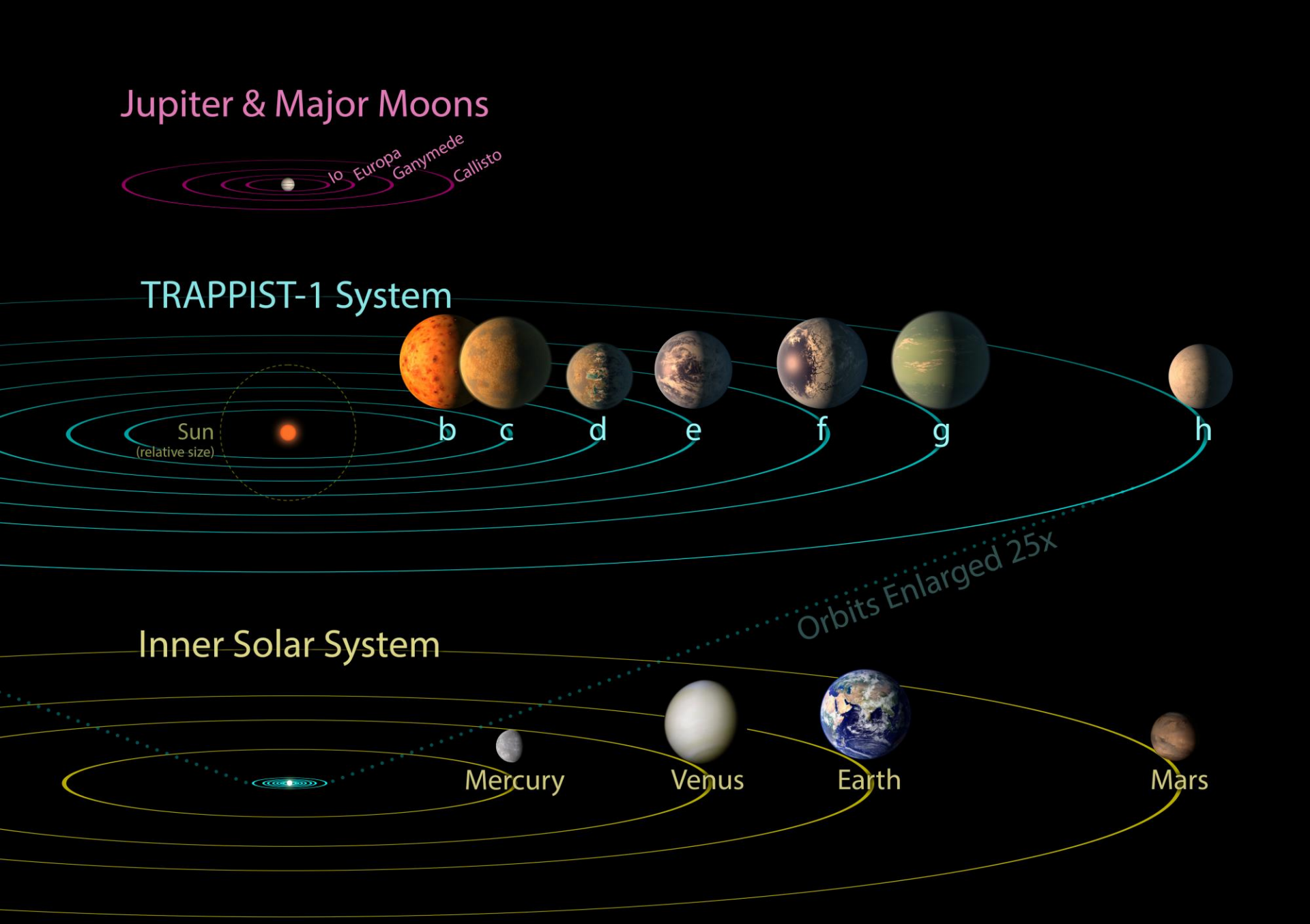
VLT follow-up photometry

Spitzer DDT 21 Feb 2016 (5hrs)

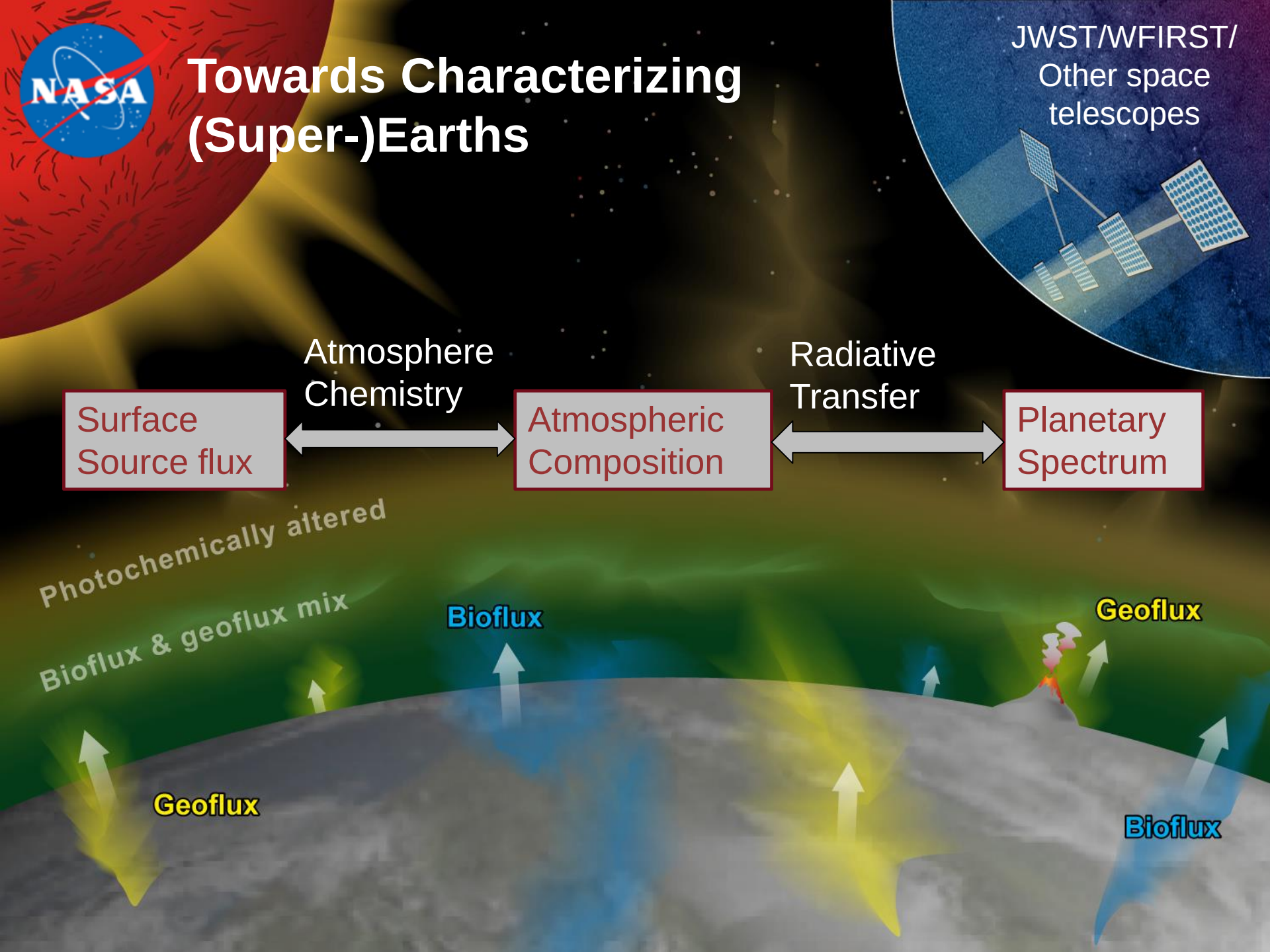
(Gillon et al. 2016, *Nature*)

Seven Planets – Orbits and Transits

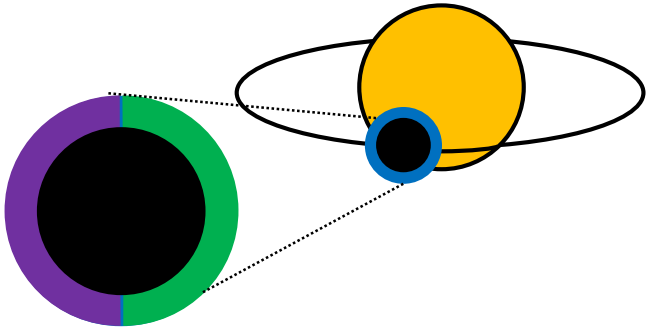


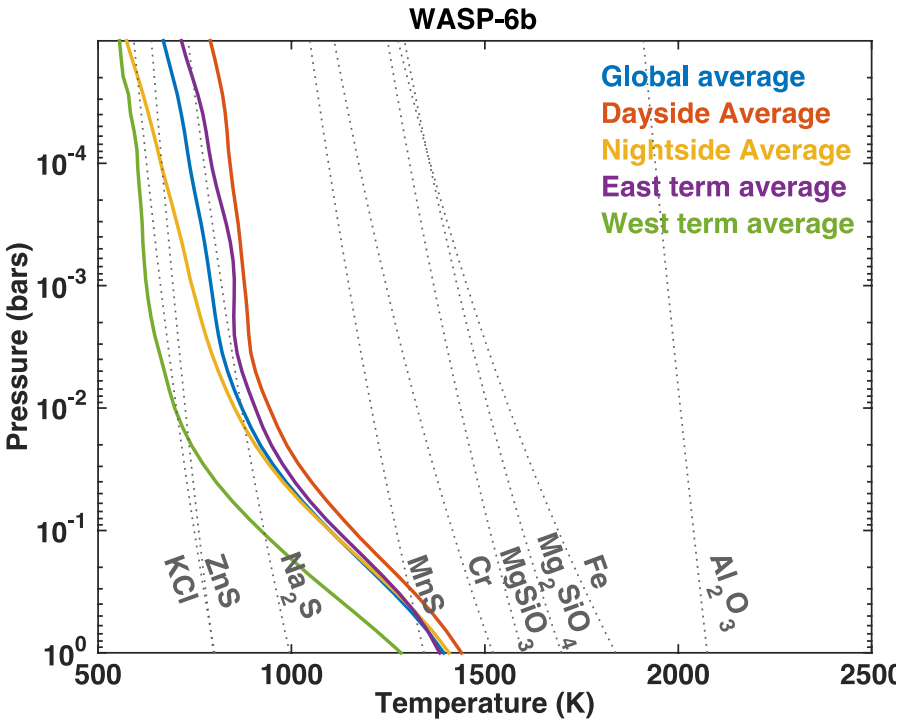

Jupiter & Major Moons
Io
Europa
Ganymede
Callisto
TRAPPIST-1 System
Sun
(relative size)
b
c
d
e
f
g
h
Orbits Enlarged 25x
Inner Solar System
Mercury
Venus
Earth
Mars

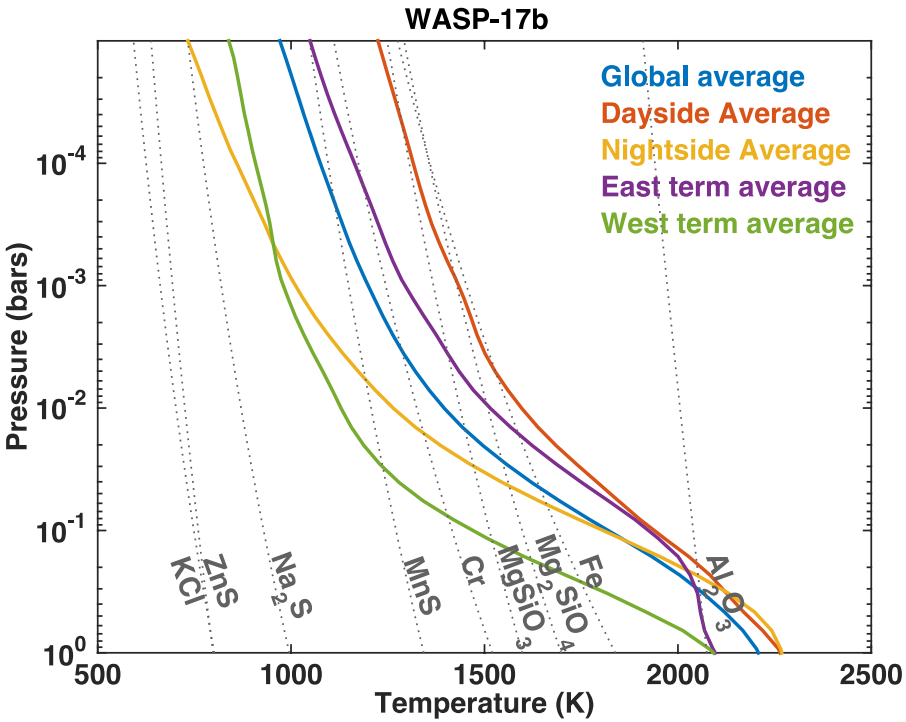
Towards Characterizing (Super-)Earths



Comparative Exoplanetology



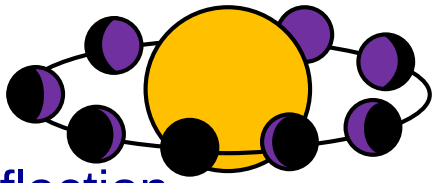




By studying individual planets, we can identify trends in chemistry and dynamics over a range in planetary properties

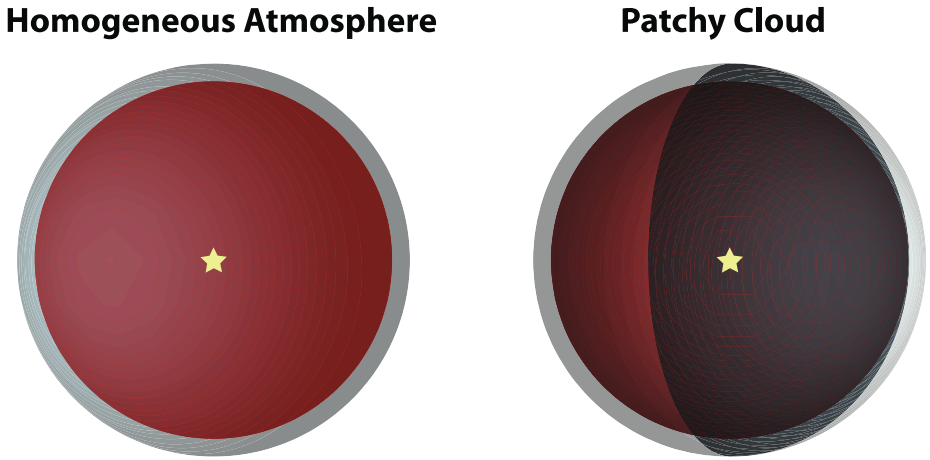
Characterizing Giant Exoplanets

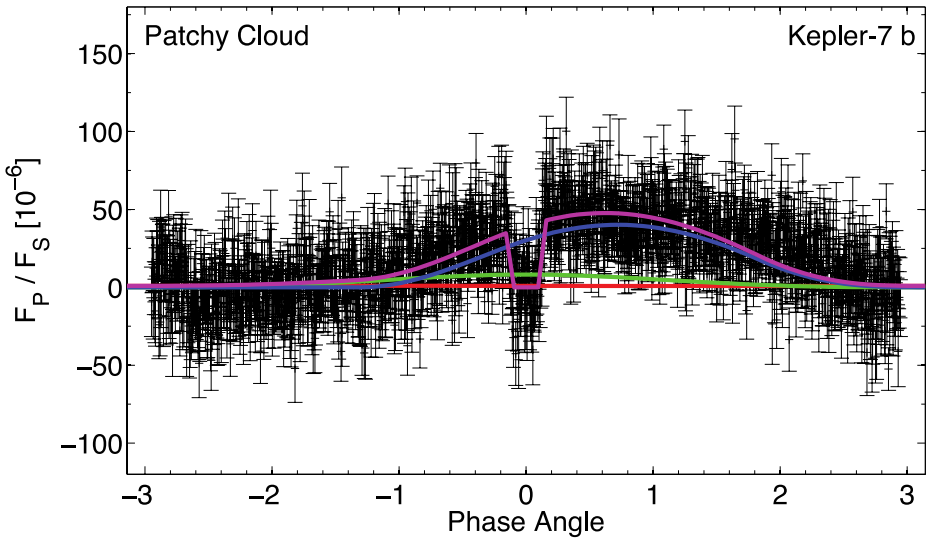
- Optical phase curves



Planetary Flux =

Thermal Emission + Gas Reflection + Cloud Reflection





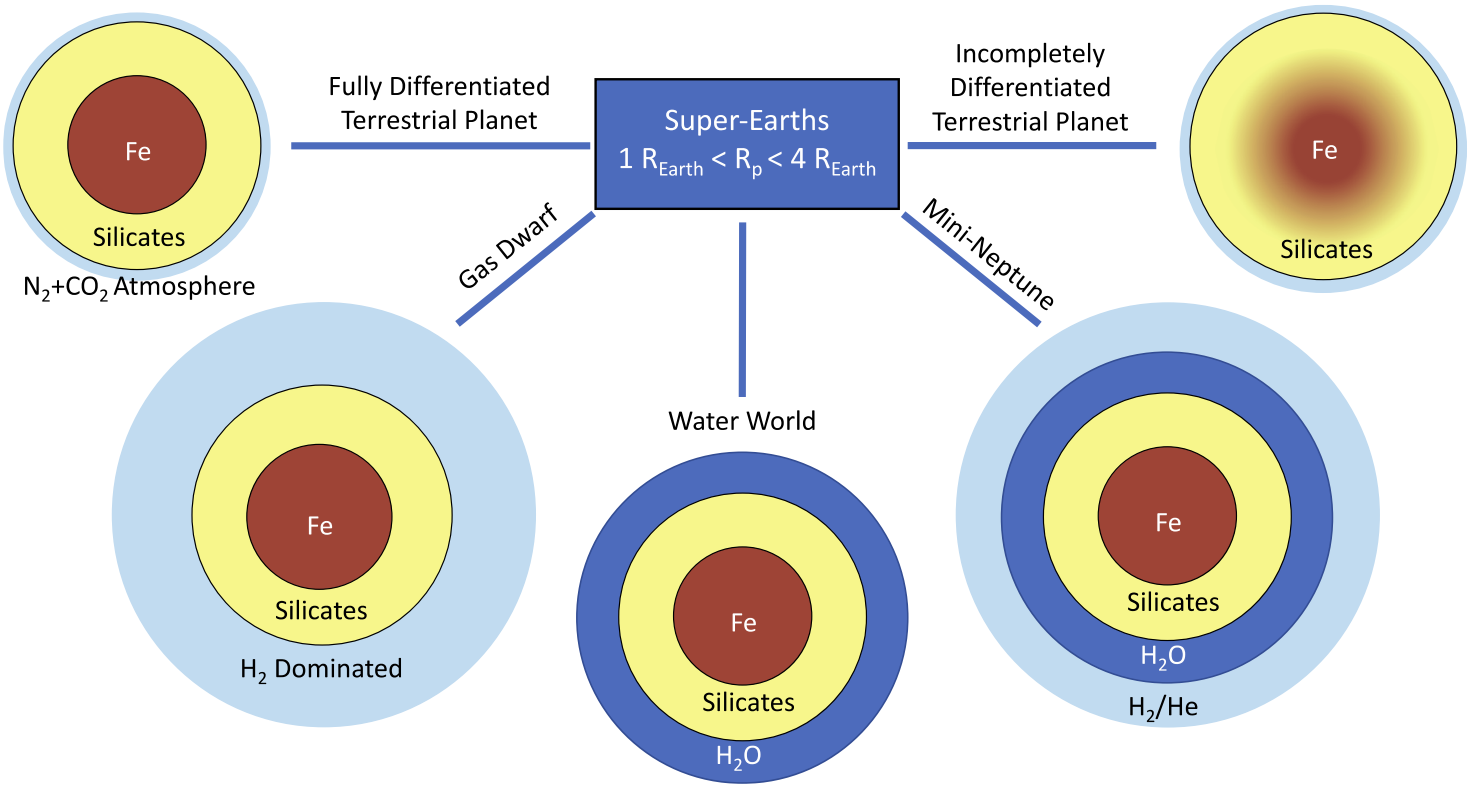
Hu et al. 2015; Shporer & Hu 2015

Three giant planets observed by *Kepler* are found to have patchy clouds, probably made of silicates.

More are expected from TESS (Transiting Exoplanet Survey Satellite, 2018) and PLATO (PLAnetary Transits and Oscillations of stars, ESA 2024) missions

Characterizing Terrestrial Exoplanets

The opportunity of super Earths



Can they be habitable?

How do we tell?

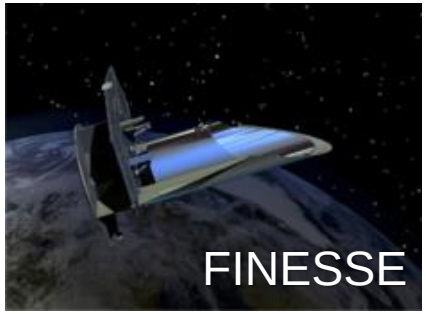
Building a NAI team to determine and detect habitability of super-Earths (PI Hu)

- 22 Co-Is including astronomers, planetary scientists, geologists, and biogeochemists
- 10 U.S. universities and 4 European institutions
- Provide science guidance to 3 of the 4 NASA flagship concepts under consideration for the 2020 Astrophysics Decadal Survey

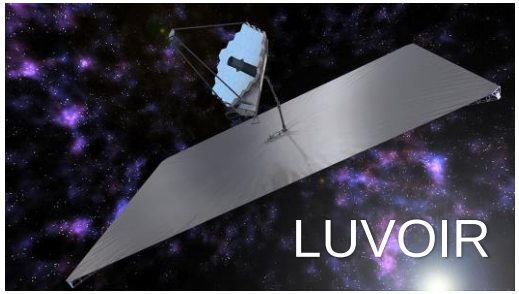
Future Exoplanet Concepts

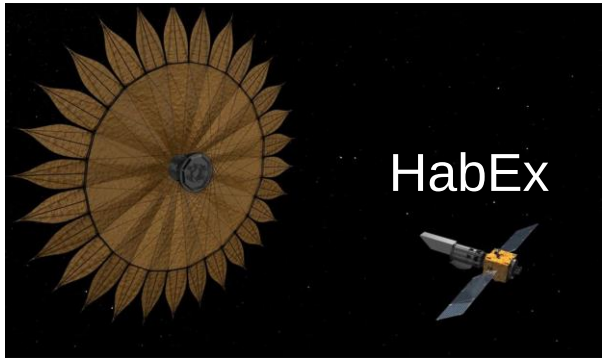
On the cusp of detecting and characterizing habitable worlds

Launch 2018
Finding the nearest, brightest exoplanets



Potential launch 2020s
Dedicated facility for exoplanet characterization





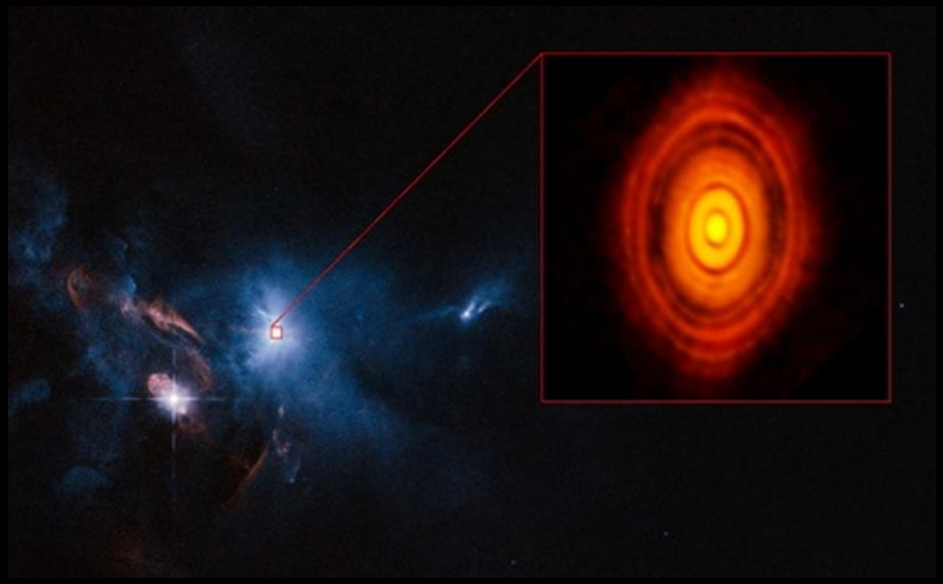
Launch 2018
Exoplanet characterization in HD

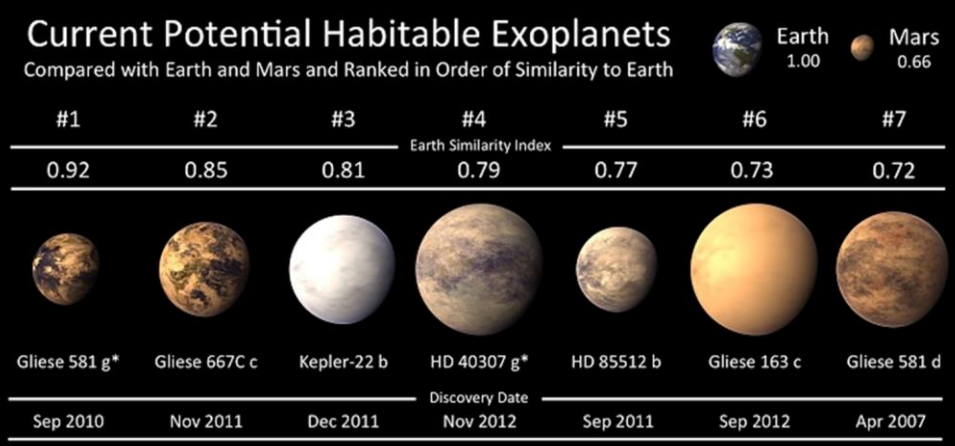
Launch mid-2020s
Imaging planets in reflected light

Flagship concepts for 2020 Astrophysics Decadal Survey

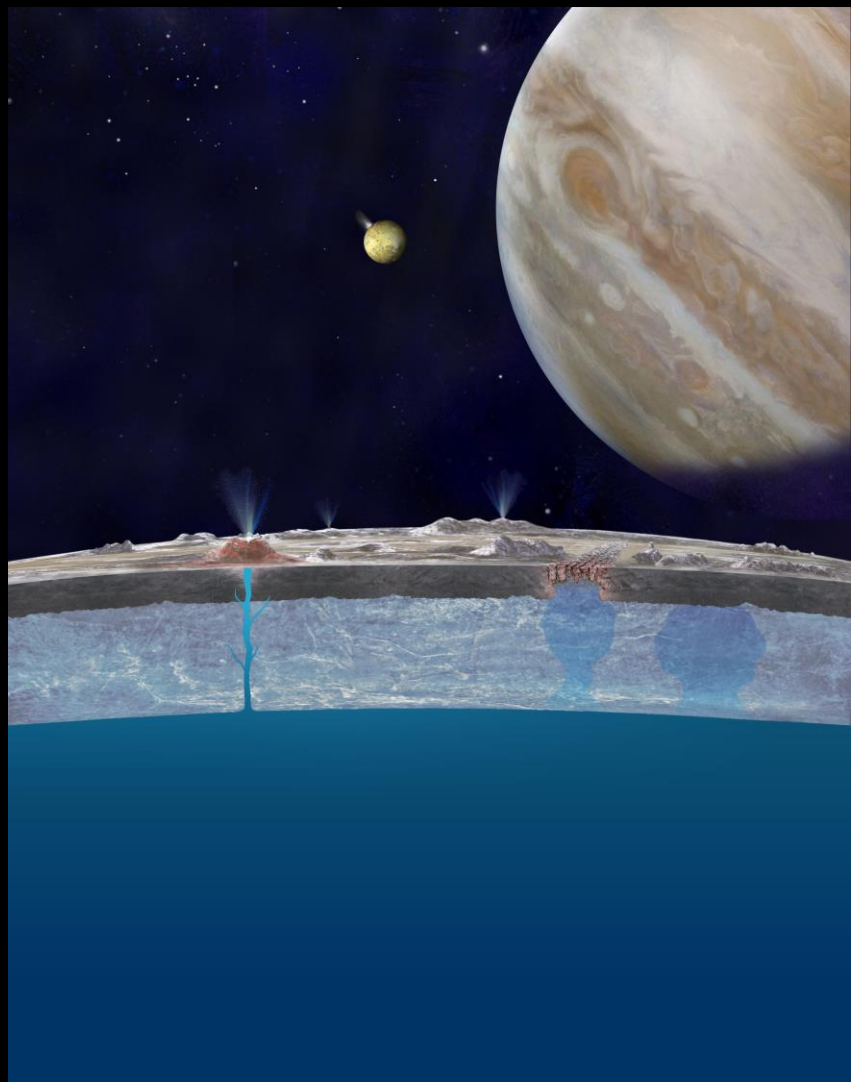
Is there life somewhere else in the Universe

Extra-solar habitable planets





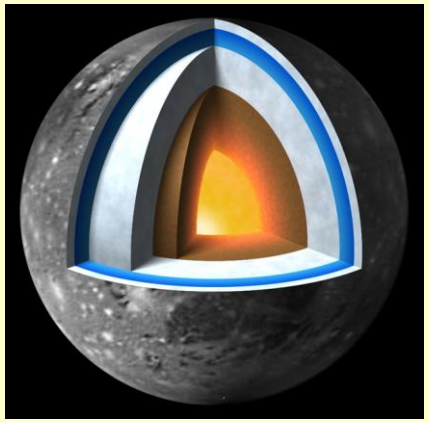
Ocean Worlds Exploration

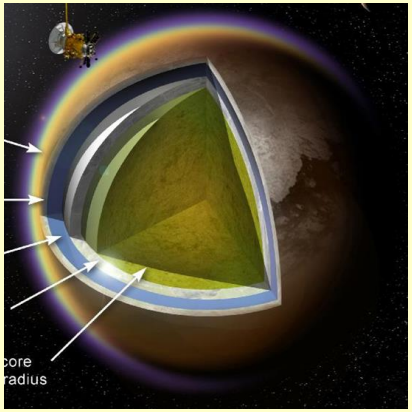


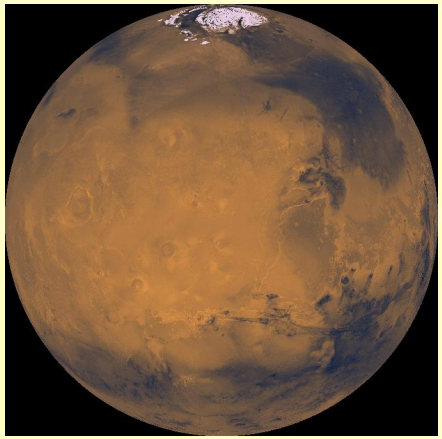
What model for the emergence of life?

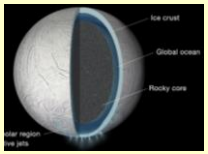
- Darwin's warm little ponds
- Sea floor hydrothermal vents

atmospheric density at the surface





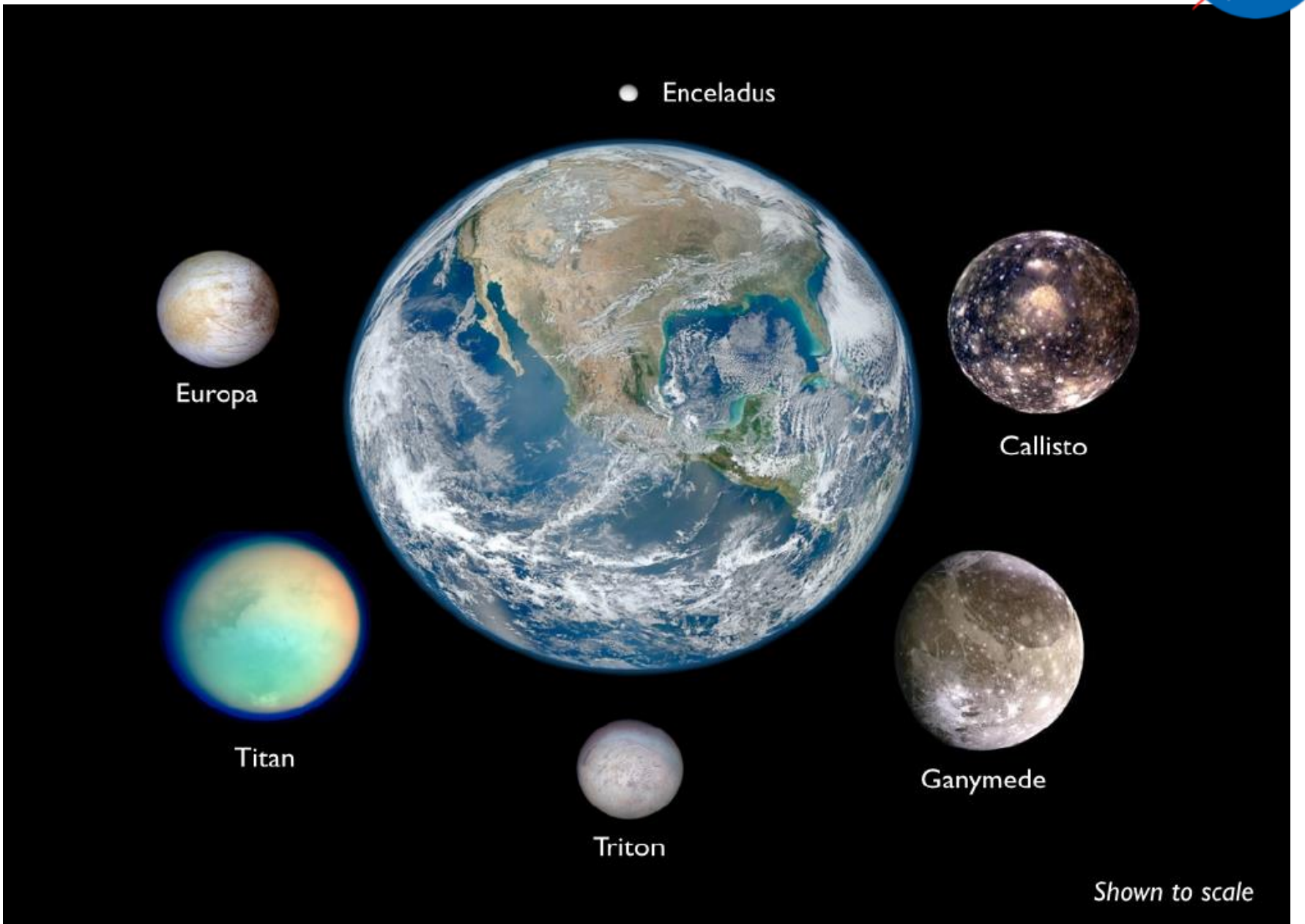


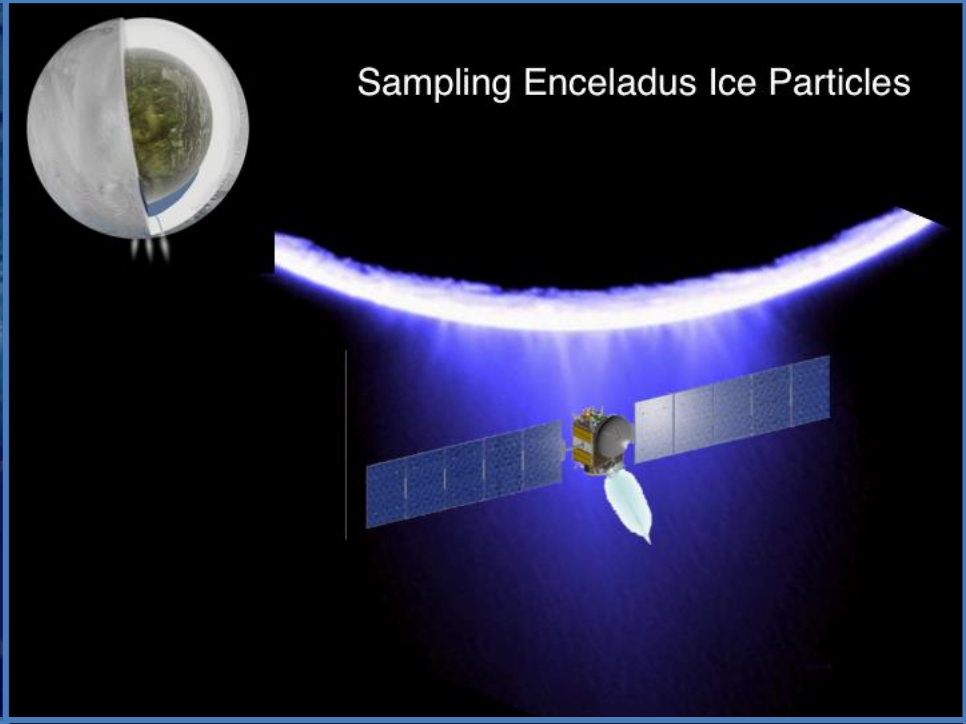


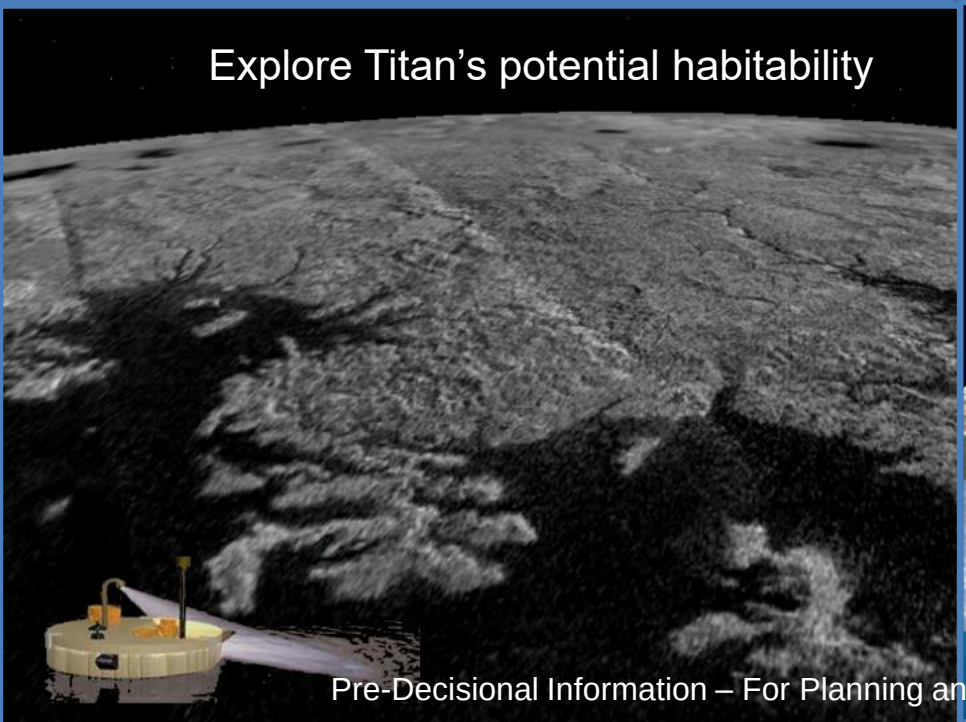
Ocean/rock exchange

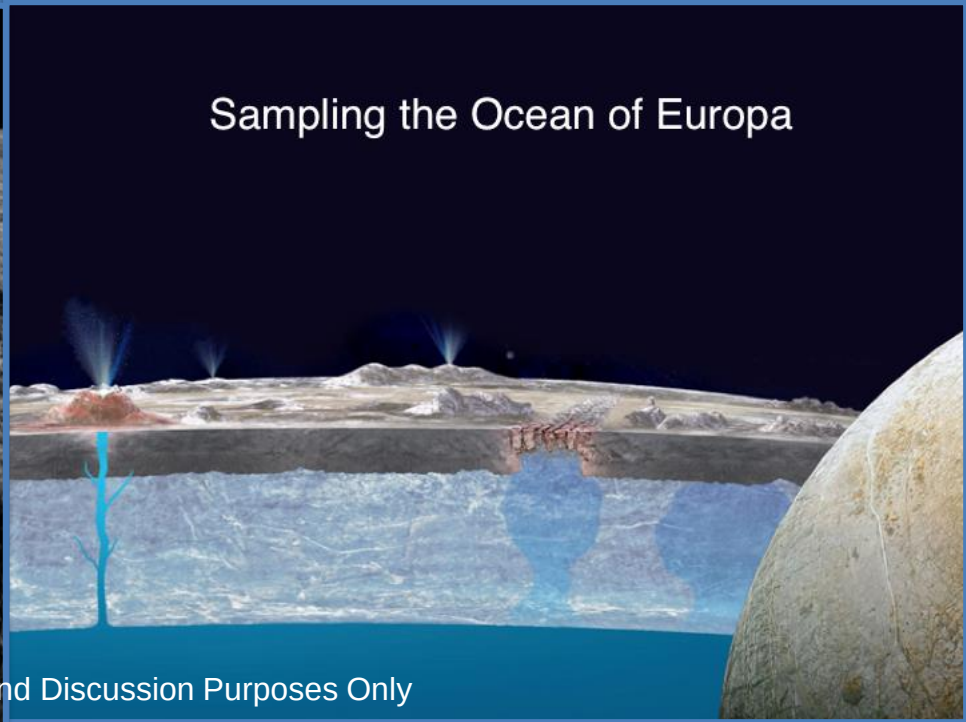
Has life emerged at the rock/ocean interface of icy moons?
Enceladus - Europa - Titan

Ocean worlds







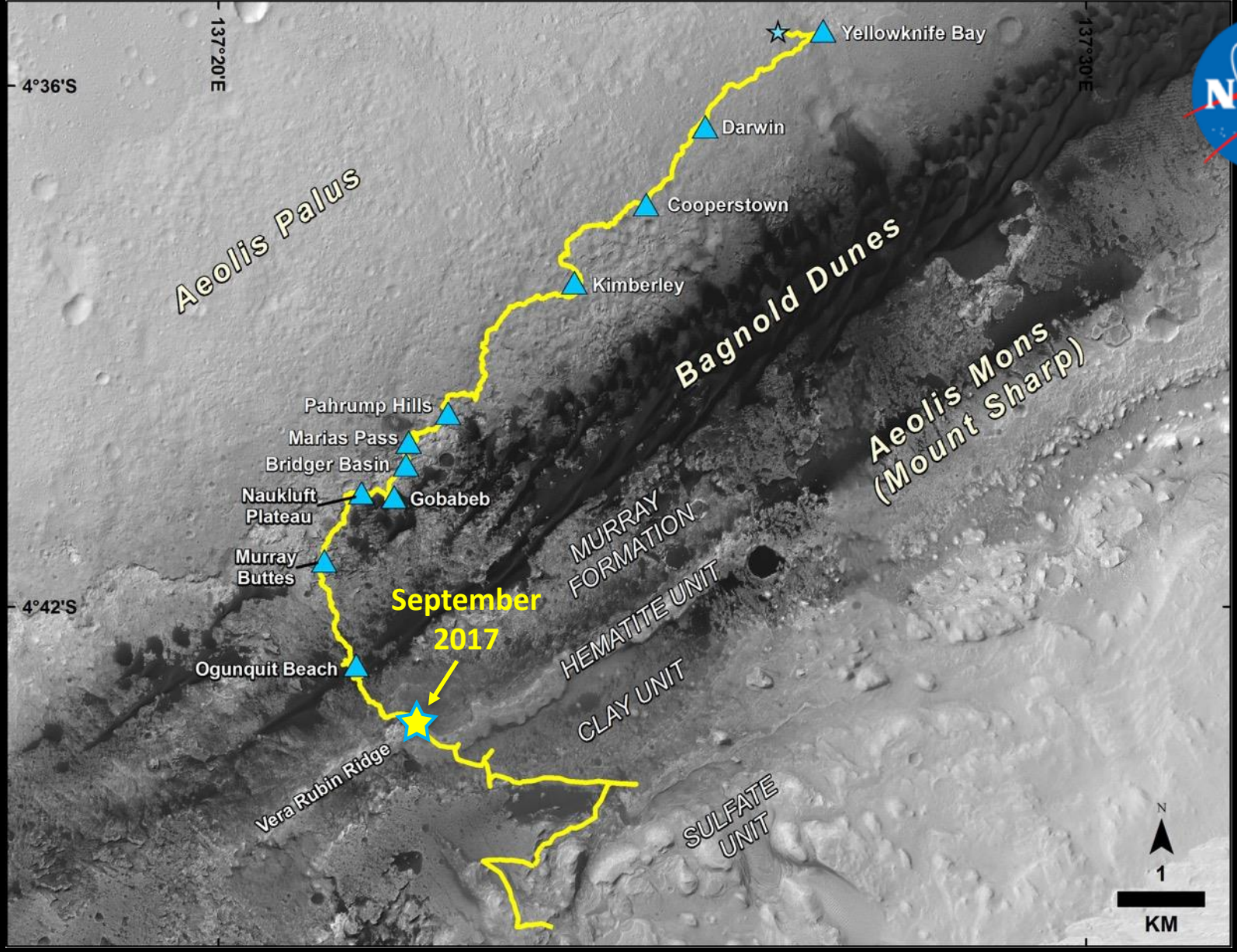


Pre-Decisional Information – For Planning and Discussion Purposes Only

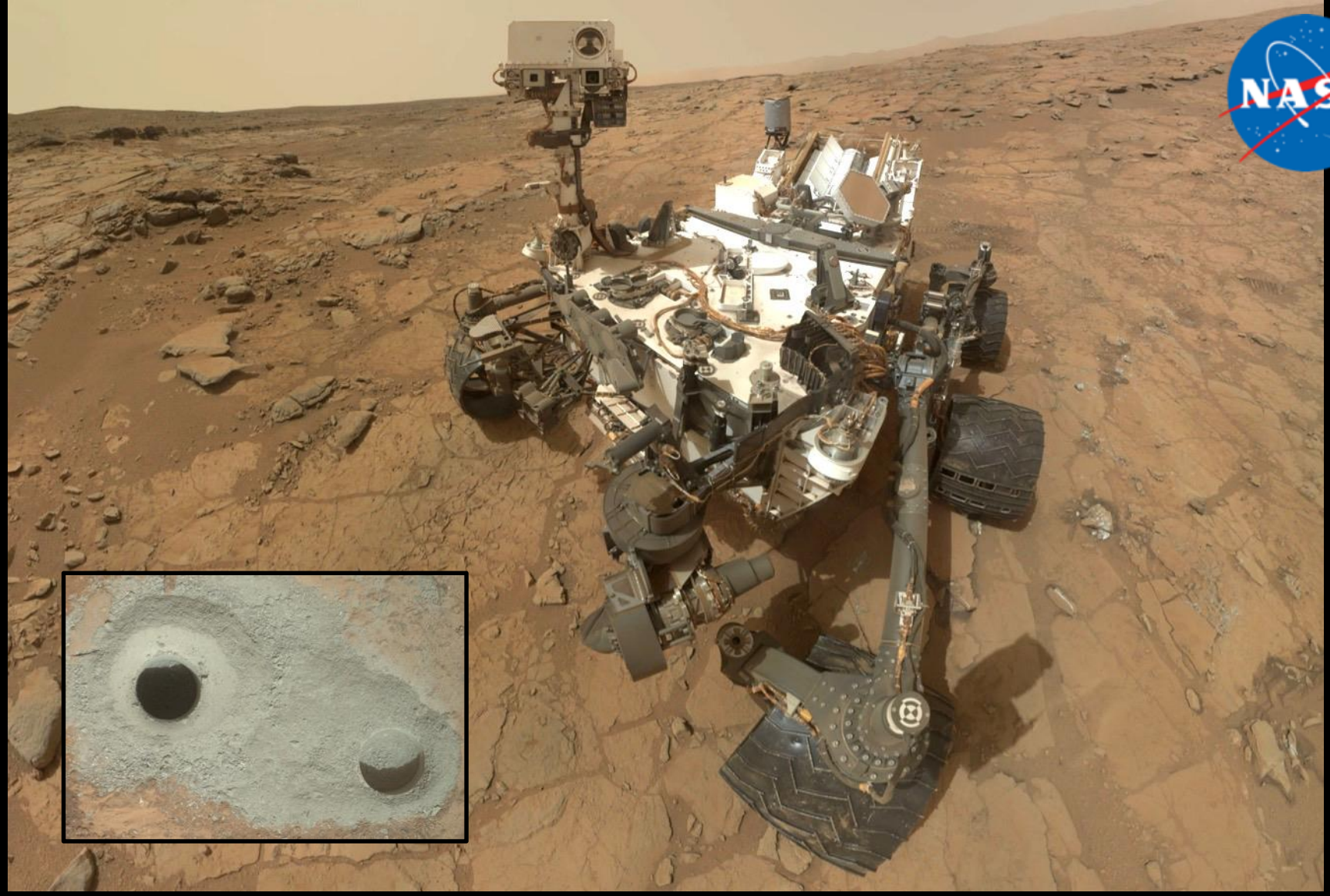
Potential Europa Exploration Sequence

Highlights from the Mars Science Laboratory

- The Curiosity rover celebrated the fifth anniversary of its arrival at Mars on August 5, 2017.
- It has explored over 200 vertical meters of Aeolis Mons, a layered mountain in Gale Crater that contains a record of Mars' ancient environment.
- Curiosity's science team determined that Gale Crater had conditions suitable for life in the early Hesperian, about 3.5 billion years ago. The conditions lasted for millions of years, perhaps much longer.
- Ancient lake and groundwater environments contained liquid water, the key chemical requirements of life, nutrients, and sources of energy for microbial metabolism.
- Organic molecules have been detected at numerous locations, indicating that such materials can be preserved in bedrock for billions of years.

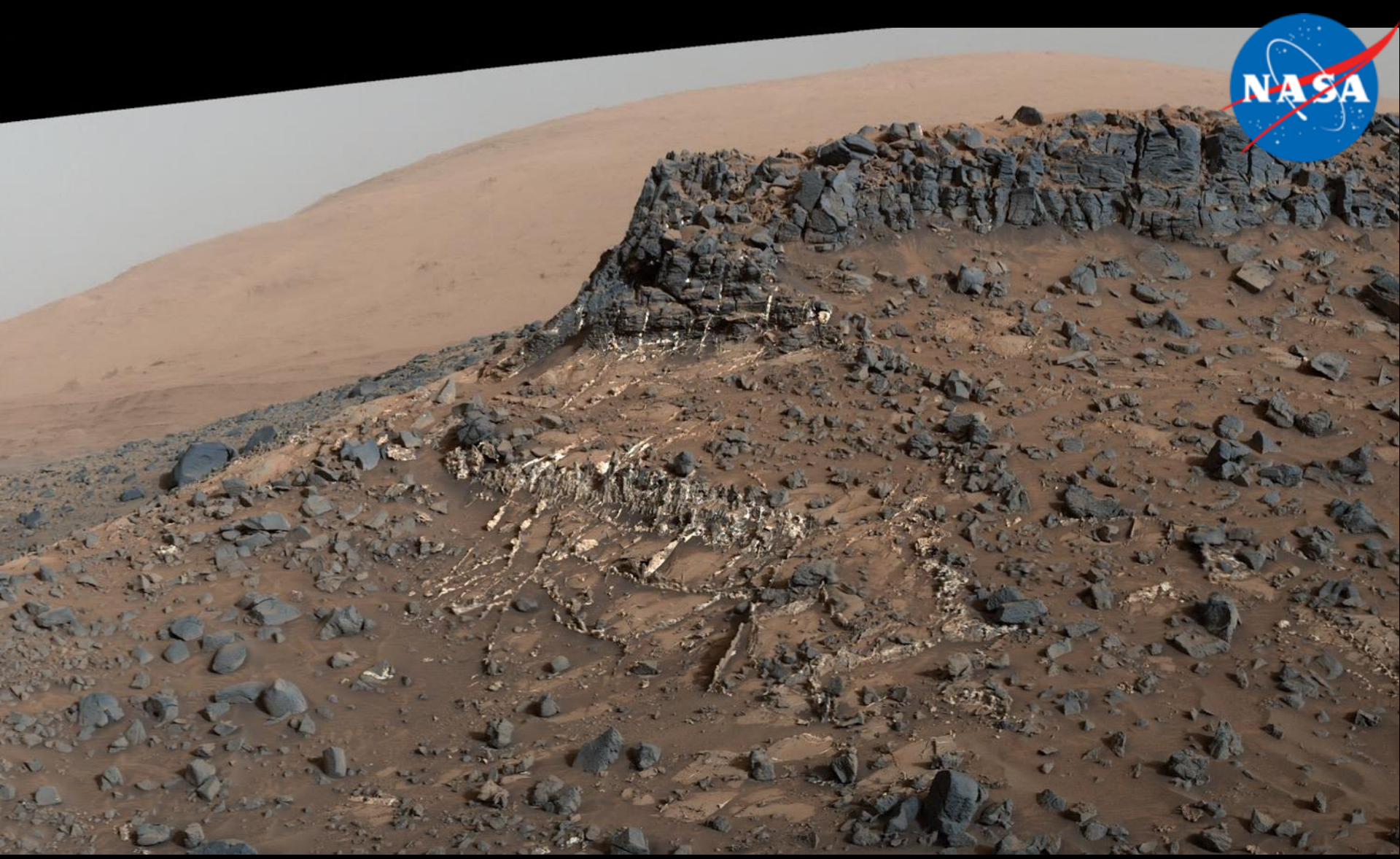


The Mars Science Laboratory mission landed its Curiosity rover in Gale Crater on August 5, 2012. Since then, the rover has traversed 17 km across the plains and up the foothills of Mount Sharp.



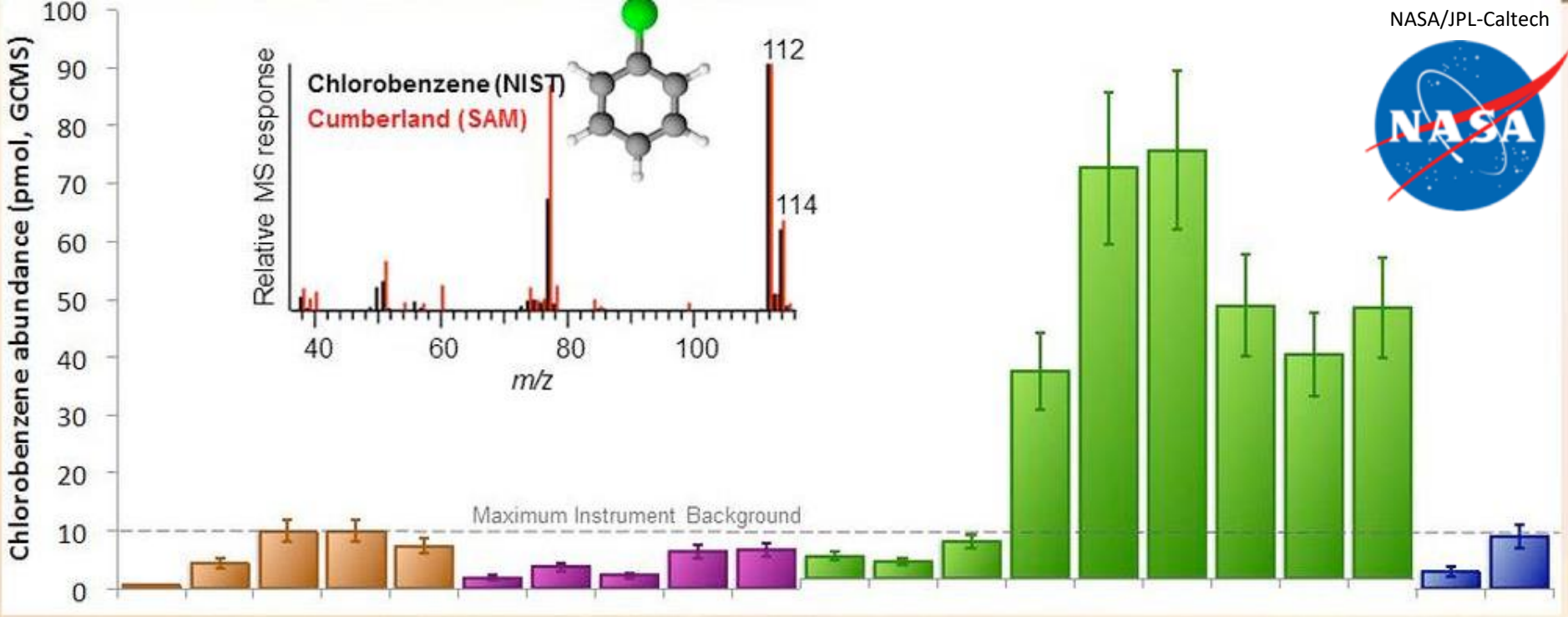
Investigation of the crater plains, including two drilled samples, revealed an ancient lake and groundwater system with near-neutral pH, low salinity, the key chemical elements required by life, and sources of energy for microbial metabolism: a habitable environment.

Curiosity has now explored 200 vertical meters of primarily finely laminated mudstone at Mount Sharp, implying a long-lived series of lakes within the crater and a climate system capable of sustaining liquid water for millions of years.



Habitable conditions persisted after the lake sediments were buried and fractured, as shown by mineral veins of varying composition deposited by groundwater within the fractures.

NASA/JPL-Caltech



ROCKNEST

JOHN KLEIN

CUMBERLAND

CONFIDENCE HILLS

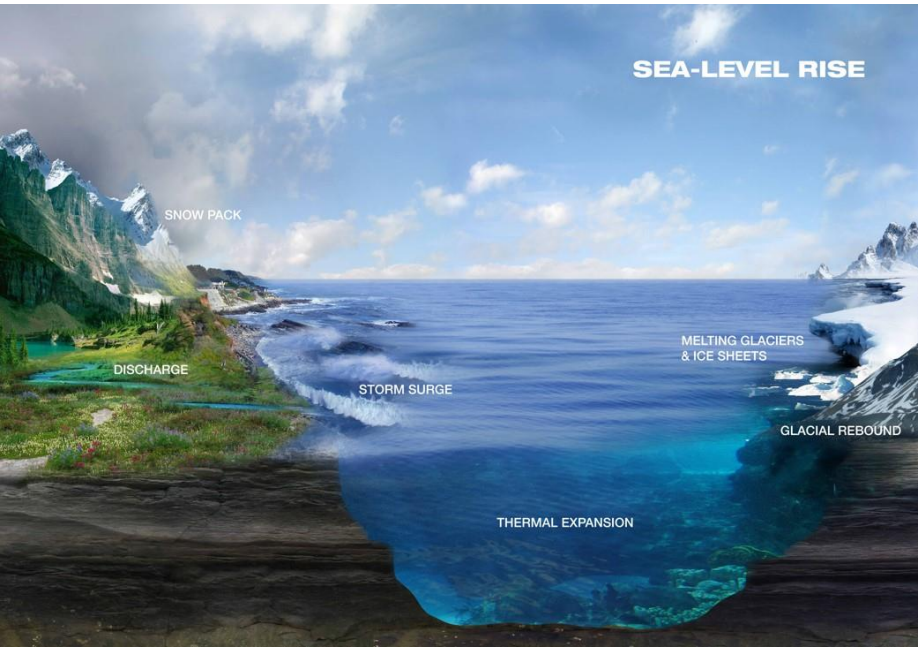
The organic chemical chlorobenzene was first detected in the Cumberland drilled sample. The majority of samples drilled in lakebed mudstone have contained organic molecules.

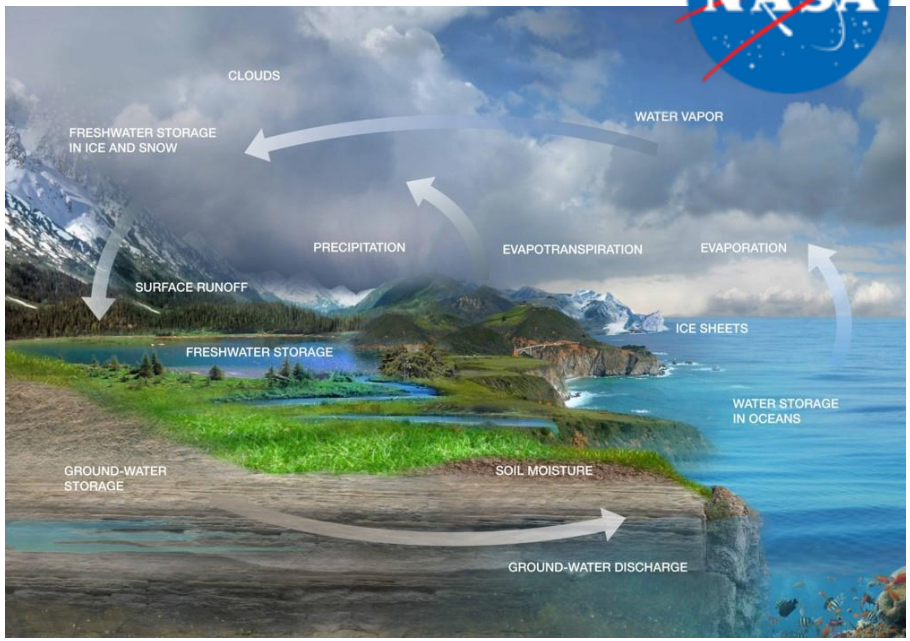
What's Next?

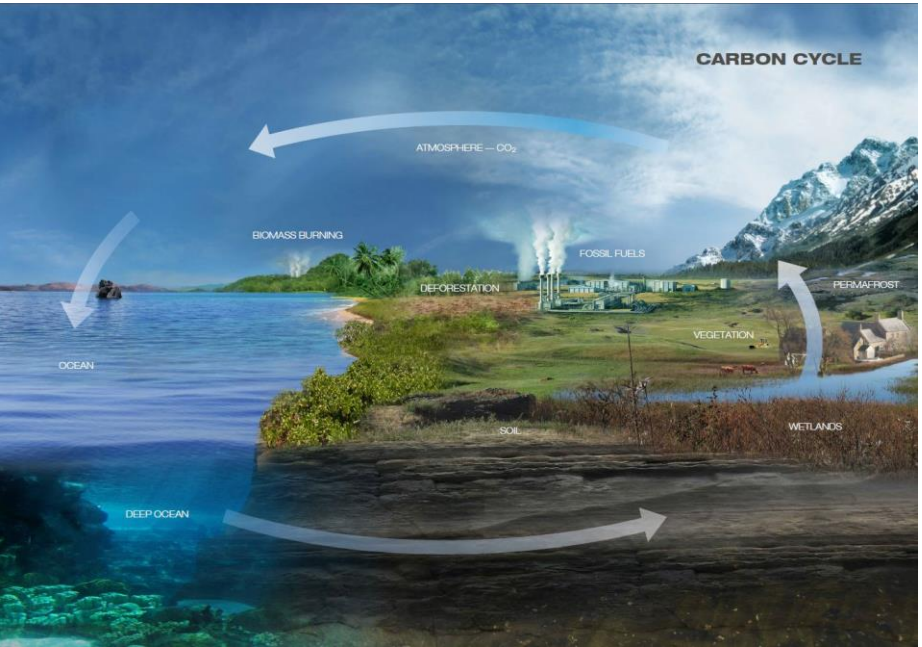
- Ancient Mars was indeed capable of supporting life (i.e., it was habitable), and that these conditions persisted for at least millions of years

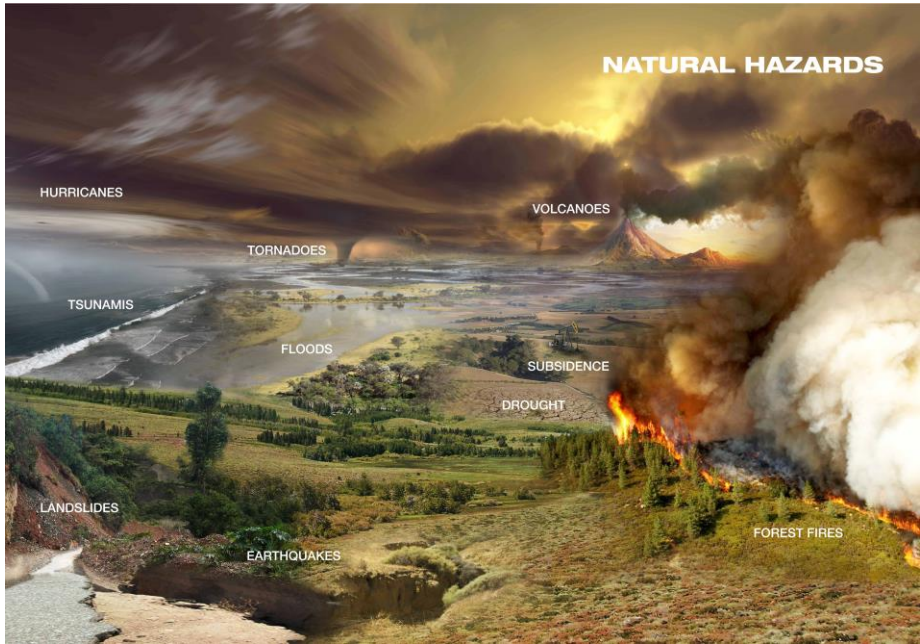
- No life has been detected yet on Mars (all the more mysterious given the above)

Our Complex Planet







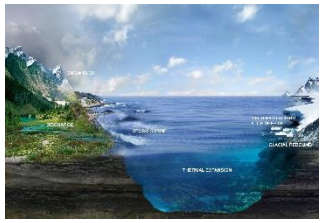


Our Quests:

To Understand How Our Planet Is Changing

To Use Our Unique Technical Expertise to Serve Our Nation and Its People

Sea Level



Improve long-term projections of regional sea level rise and the consequences to urban populations and natural ecosystems.

Water

Forecast water shortages 2 weeks, 2 months, and 2 years in advance with quantifiable uncertainties.

Carbon

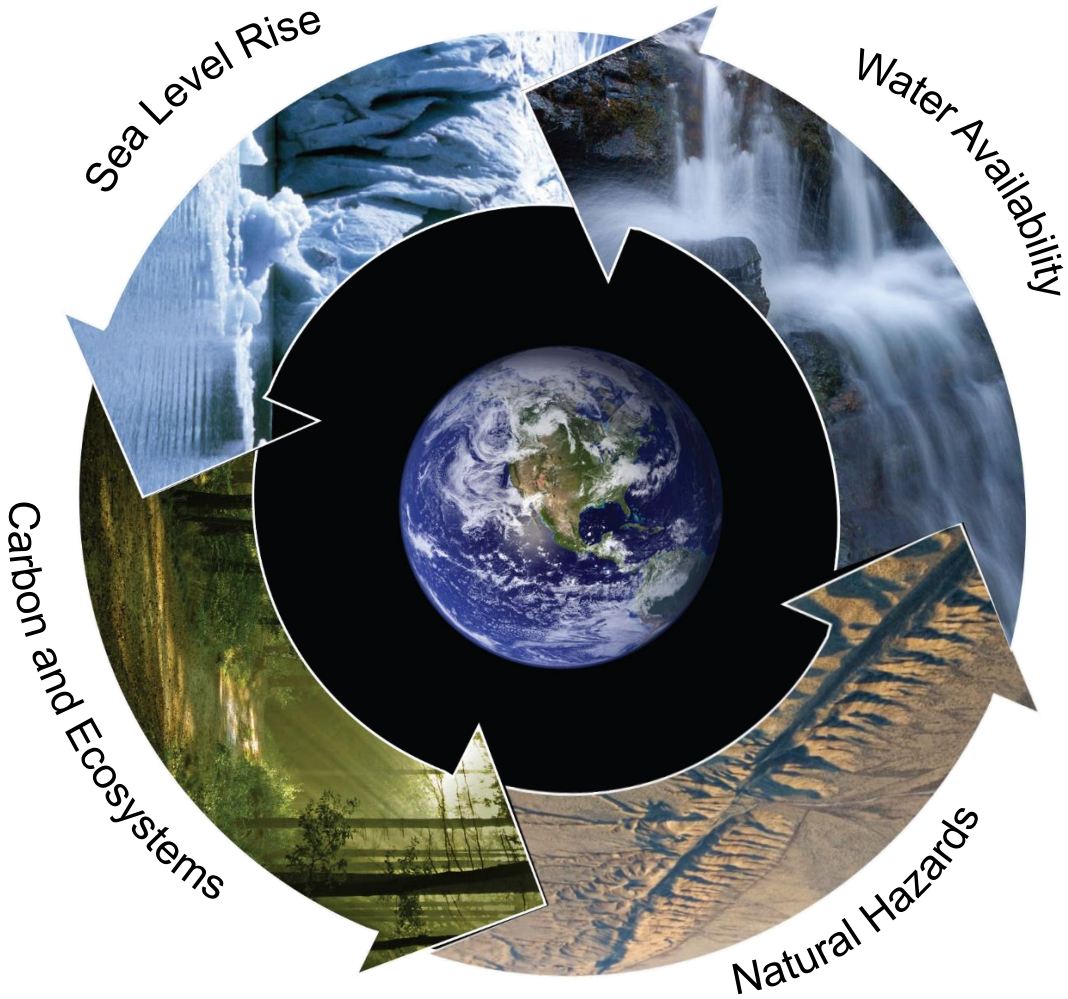
Improve projections of global food security, forest health & disturbance and biodiversity, as well as the climate and ecosystem responses to anthropogenic forcing agents (e.g. CO_2 & CH_4).

Natural Hazards

Increase the lead-time for solid earth, weather and air quality hazards and improve our capabilities for hazard response and preparedness.

Earth Science Grand Challenge

Making Earth's Complexity Tractable



Combining system engineering expertise with advanced technologies and science expertise to provide reliable and accurate information

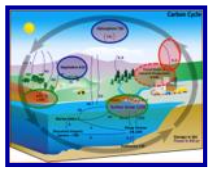
JPL Earth Science

From Science to Actionable Information

Requirements Definition | Observations and Data Analysis | Model Evaluation and Improvements | Uncertainty Quantification | Scientific Basis for Decisions & Investments

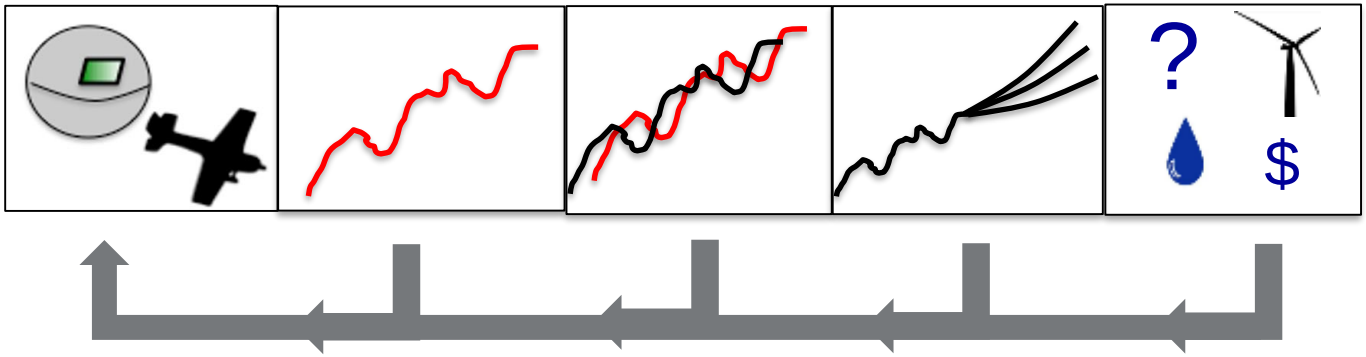
Water Availability

Carbon & Ecosystems



Sea Level Rise

Natural Hazards



Lab / In Situ

Airborne

Satellites

Science

- Atmospheric Composition Weather Oceans & Ice
- Hydrology Ecosystems Earth Surface and Interior

Technology

- Data Science & Modeling
- Instruments & Sensors

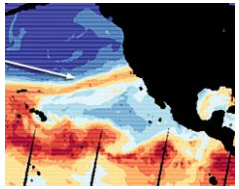
Engineering

- System Architectures
- In situ, Airborne & Satellite Missions

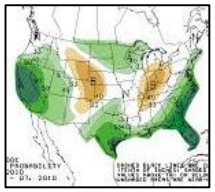
Weather

Results

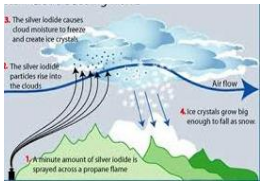
Drought



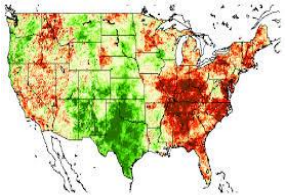
Precipitation Extremes



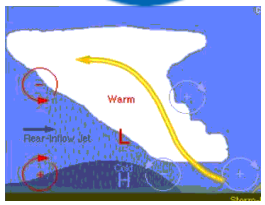
S2S Forecasting



Cloud-Aerosol Interactions

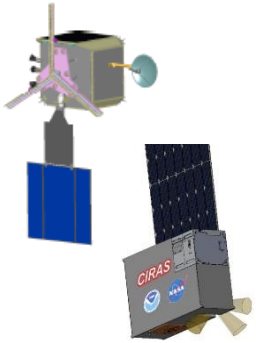


Evapotranspiration

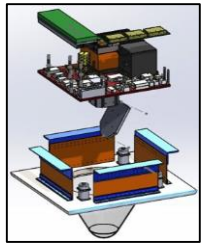


Severe Storms

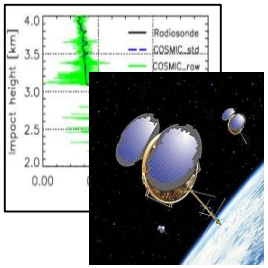
Observations



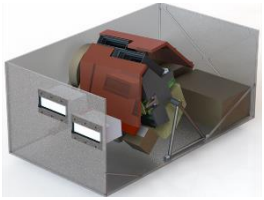
Convection & Water Vapor



Winds

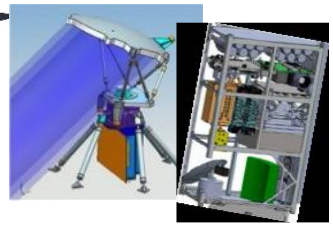


Boundary Layer



Aerosols

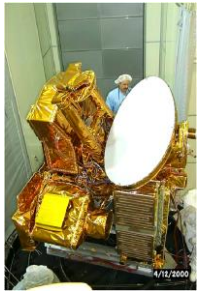
Precipitation



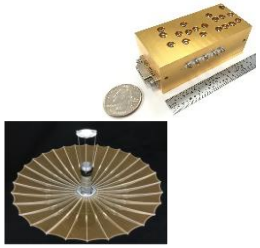
Temperature & Clouds

Technology

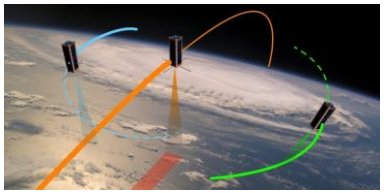
Passive Microwave



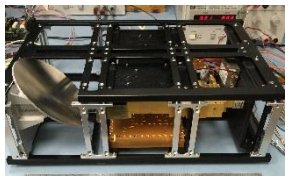
Submm/mm Sensors



Radars



Formation Flying



Miniaturization for CubeSats

WHAT ARE THE TOP WAYS REMOTE SENSING IS BEING USED NOW?

1. Determining soil moisture content using active and passive sensors from space
2. Mapping with laser precision using Light Detection and Ranging technology
3. Catching tax-evaders red-handed by locating new construction and building alterations
4. Spinning the globe with mapping services like Google Earth, Bing Maps and OpenStreetMaps
5. Predicting retail earnings and market share by counting cars in parking lot
6. Snapping aerial photos for military surveillance using messenger pigeons in World War II
7. Charging higher insurance premiums in flood-prone areas using radar
8. Doing the detective work for fraudulent crop insurance claims
9. Searching for aircrafts and saving lives after fatal crashes
10. Detecting oil spills for marine life and environmental preservation

SOURCE: 100 EARTH SHATTERING REMOTE SENSING APPLICATIONS & USES (http://gisgeography.com/100-earth-remote-sensing-applications-uses/)

Conclusion

- NASA can’t do it alone. We need everyone to contribute!
- There are many opportunities to share ideas
- Complex problems can only be solved by collaborations
- Exploration will enable new technology and science, energize industry, and build a competitive capability for the nation

Landing of Curiosity