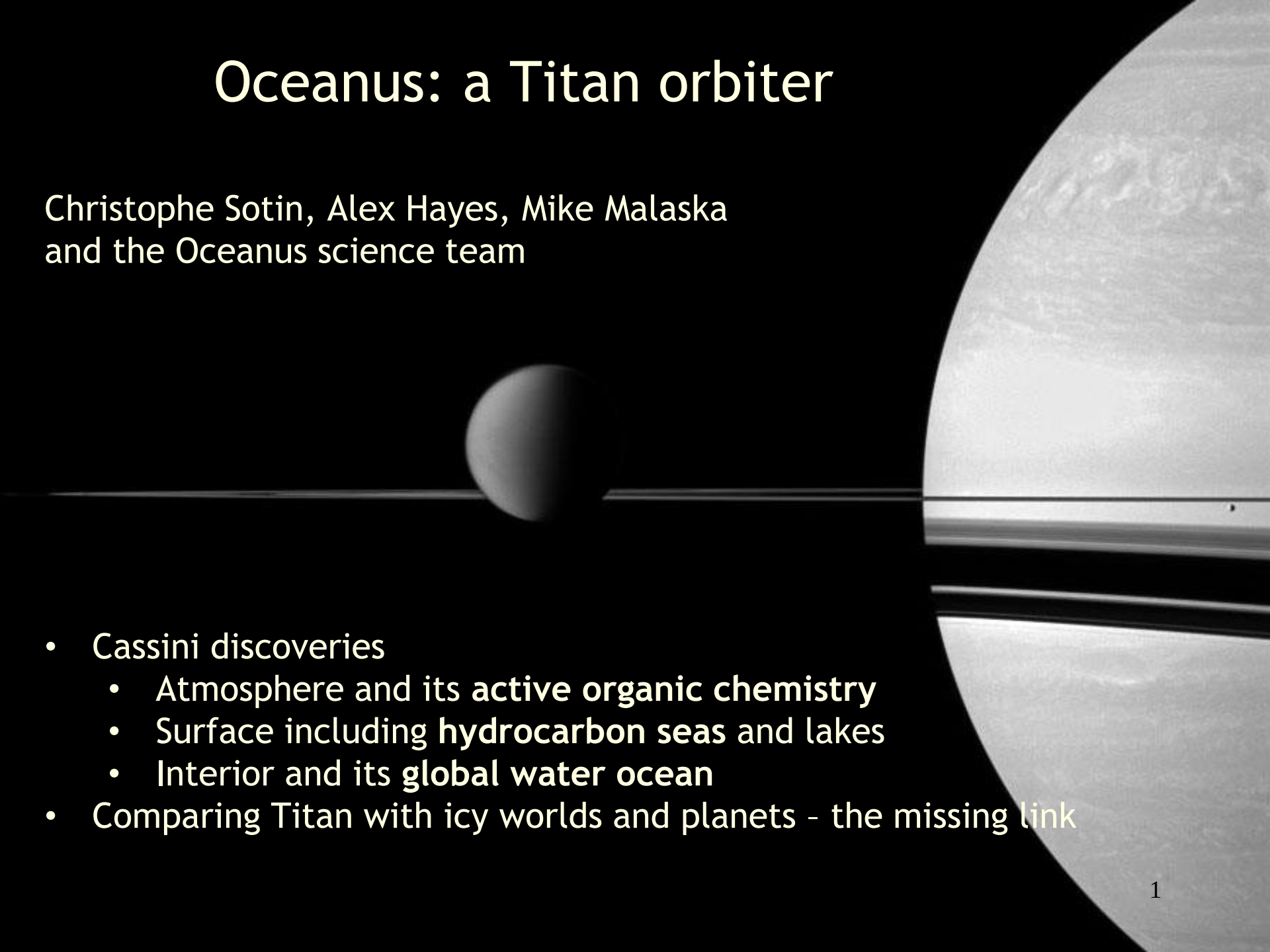
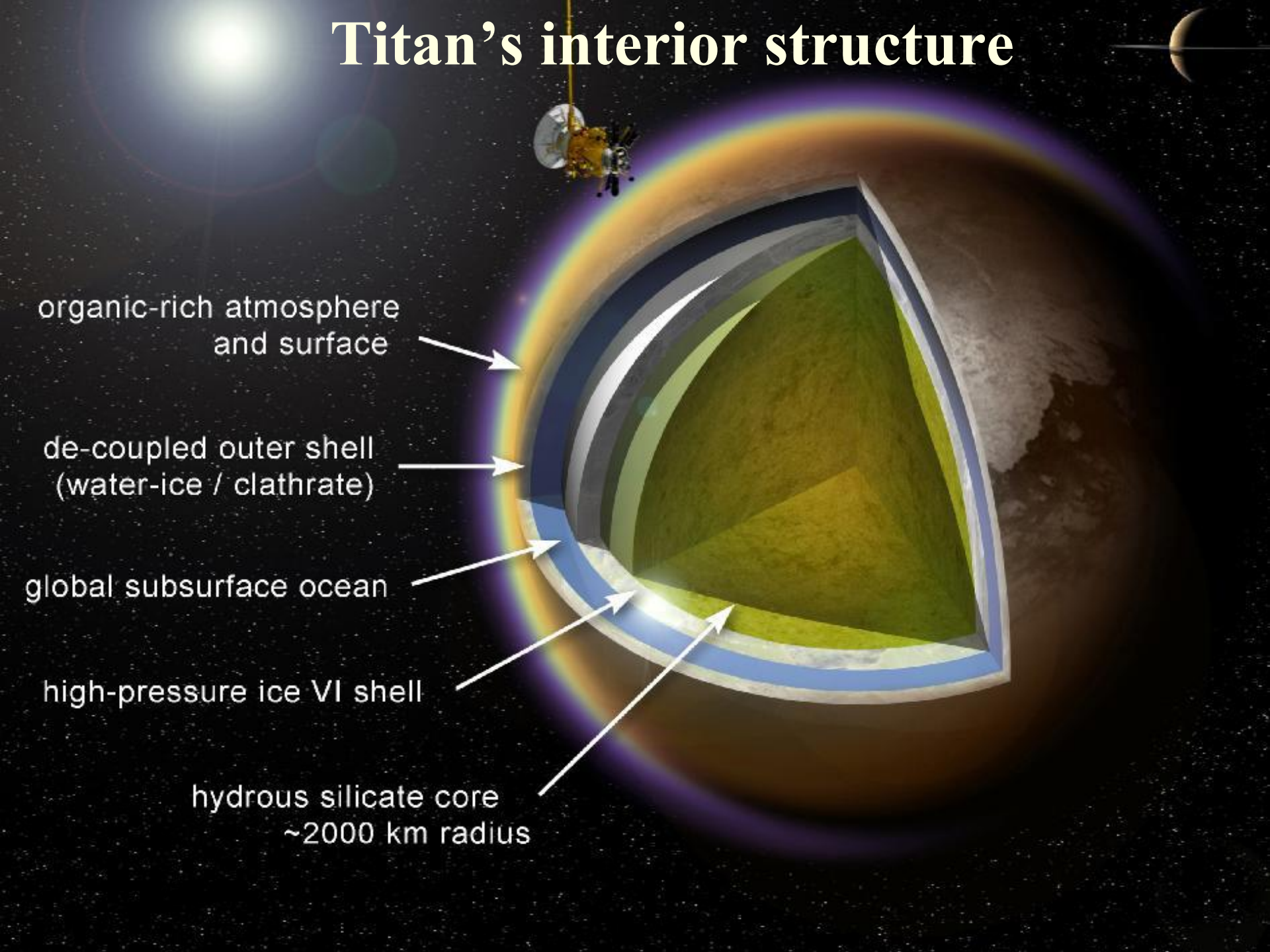
Oceanus: a Titan orbiter

Christophe Sotin, Alex Hayes, Mike Malaska
and the Oceanus science team



- Cassini discoveries
  - Atmosphere and its **active organic chemistry**
  - Surface including **hydrocarbon seas** and lakes
  - Interior and its **global water ocean**
- Comparing Titan with icy worlds and planets – the missing link

Titan's interior structure

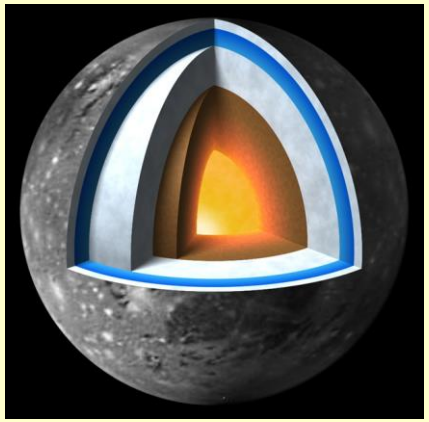


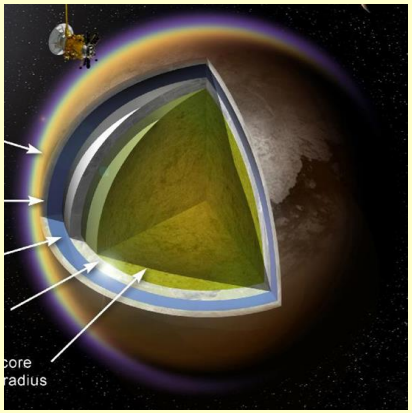
Cassini has Demonstrated that:

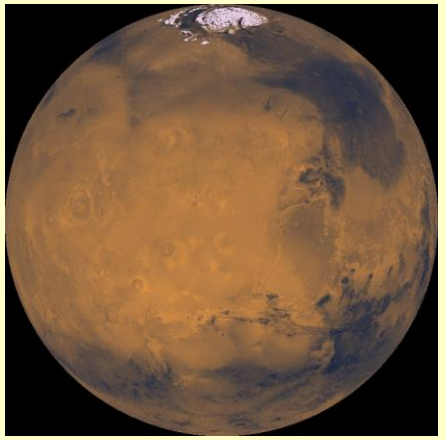
- **Heavy organic molecules**, ions and neutrals, are formed at high altitude (950 – 1400 km)
- Titan's surface is **geologically rich** with lakes, seas, river networks, dune fields, mountains, impact craters, plains, labyrinths, putative cryovolcanic features…
- Titan's surface is **geologically young**
- A **global deep salty water ocean** is present below the ice crust
- **Hydrated silicates** are postulated to have been in contact with the ocean
- Possible **exchange processes** between the silicate core and the surface (^{40}Ar) have happened in a **geologically recent past**

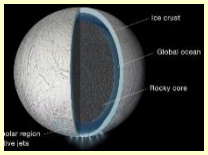
Titan can be compared to terrestrial planets and ocean worlds

atmospheric density at the surface





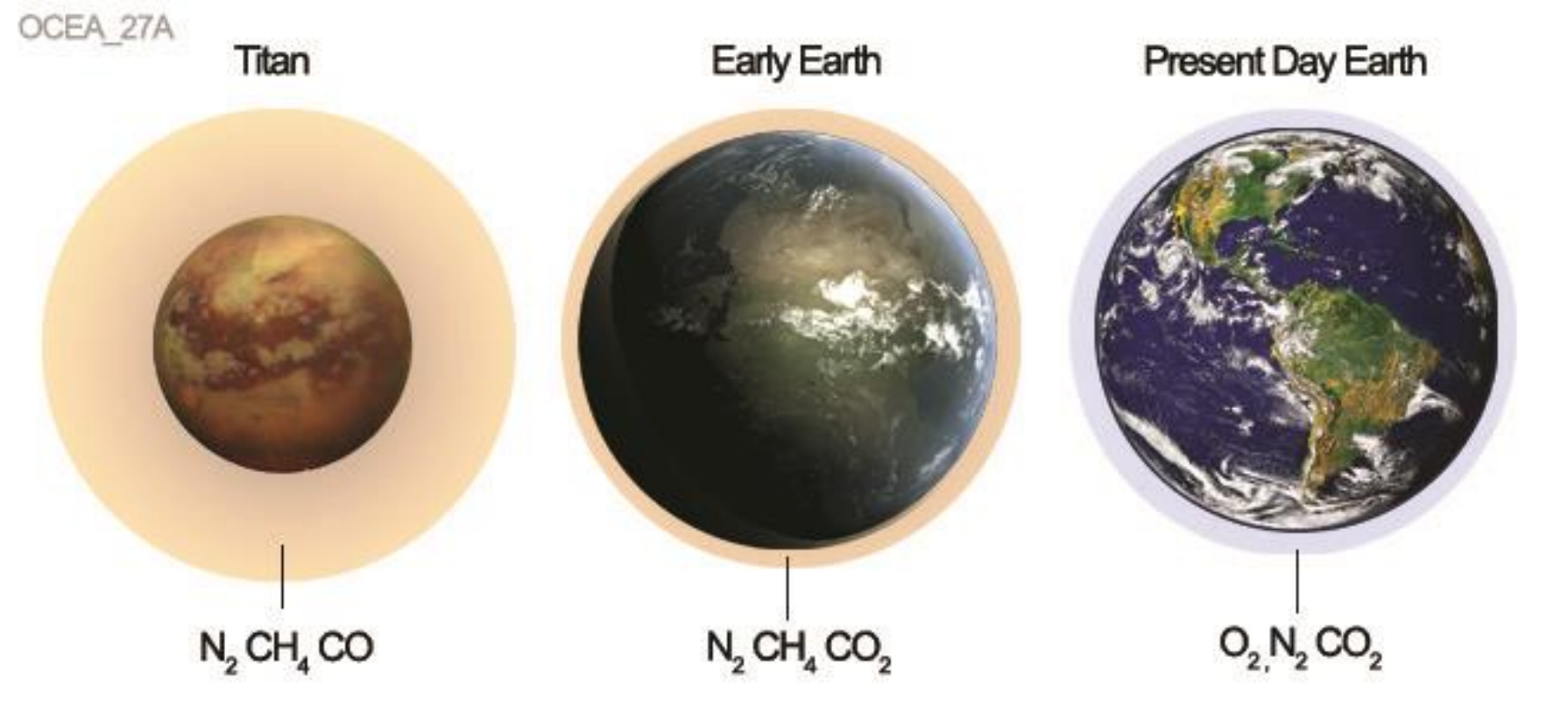




Ocean/rock exchange

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

Very similar organic chemistry between early Earth and Titan



More reduced

More oxidized

?

Why going back to Titan?

- Methane photolysis in Titan's upper atmosphere drives an organic chemical factory that is unique in the solar system.
- Future missions should investigate how this factory works and redefine our understanding of pre-biotic chemistry.
- Titan is a natural laboratory that brings data for understanding early Earth, early Mars, and methane-rich exoplanets

Follow the organics from synthesis to hydrolysis

Comparing Early Earth and present Titan

Understanding the delivery of organic material on Earth both before and after the emergence of life

Organic haze on Titan and the early Earth

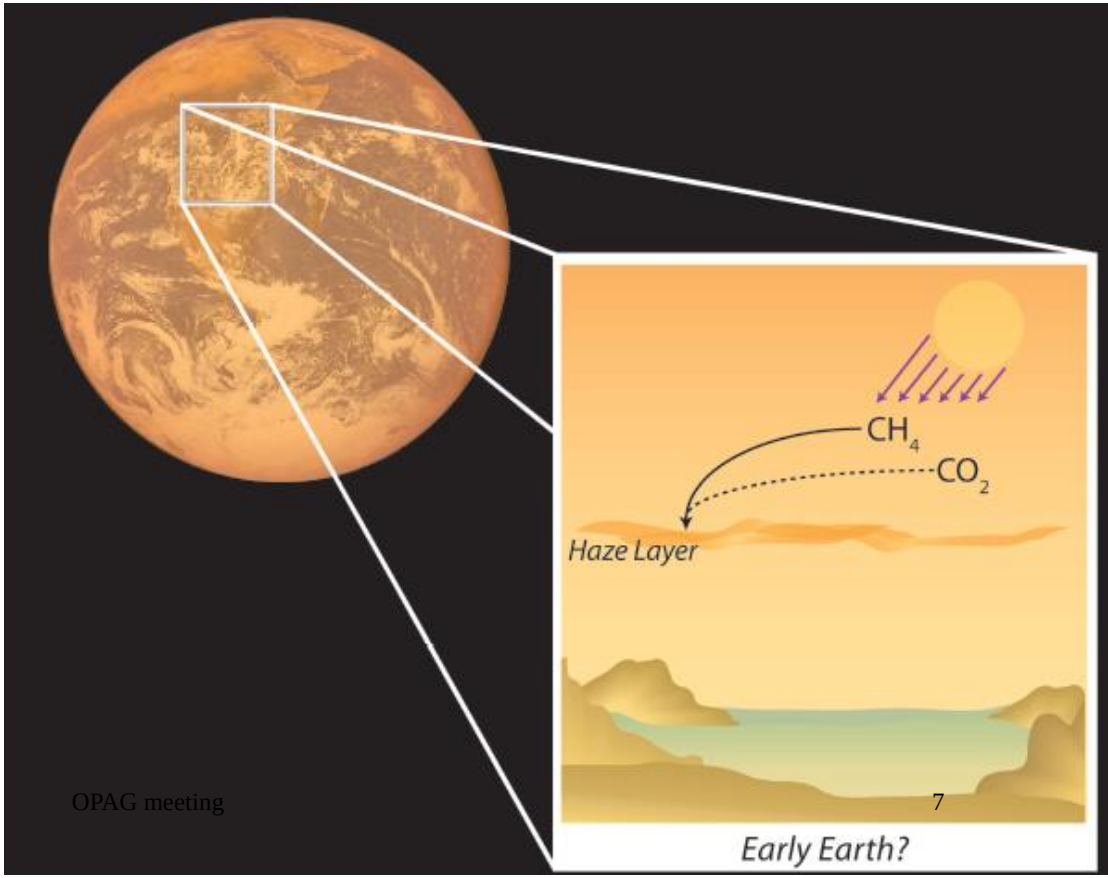
Melissa G. Trainer*, Alexander A. Pavlov†, H. Langley DeWitt‡, Jose L. Jimenez‡, Christopher P. McKay§, Owen B. Toon¶, and Margaret A. Tolbert‡‖

Goal 1: Determine how organic molecules are synthesized in Titan's atmosphere

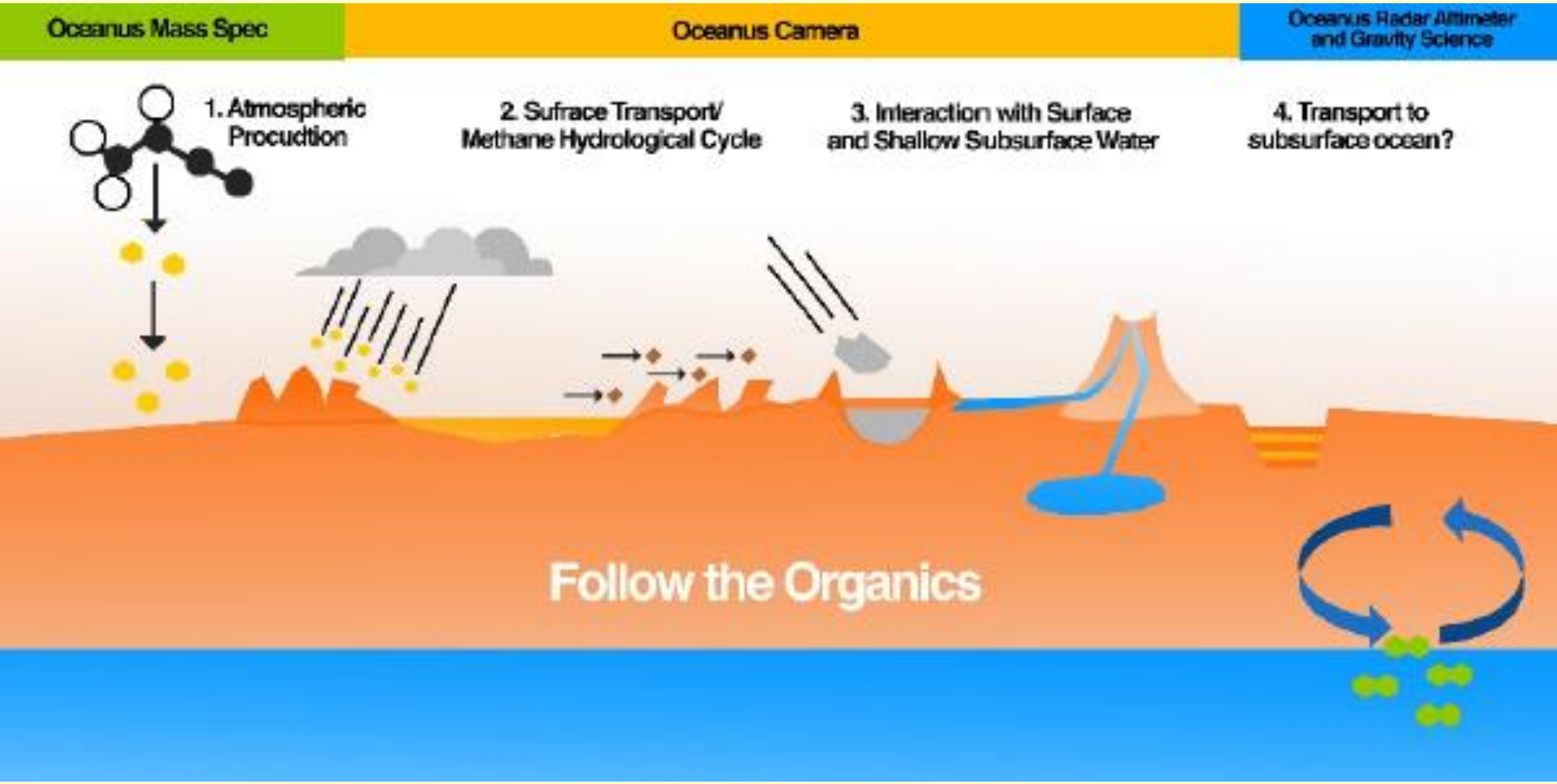
Goal 2. Determine how organic material is transported at the surface

Goal 3. Determine where and how extensively liquid water has existed in the subsurface

Goal 4. Determine if there is or was a potential pathway for transport of surface organic material to the subsurface water ocean

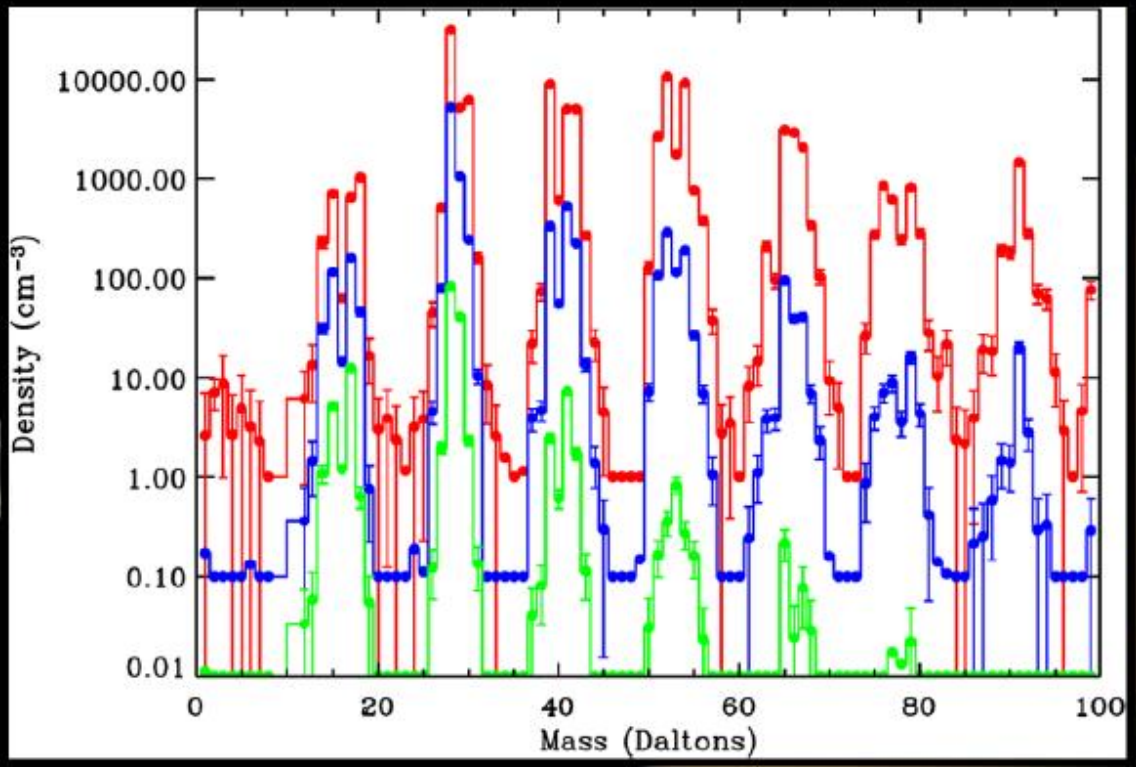


Three instruments + Radio-science
Chemistry – Geology – Geophysics - Astrobiology



Active organic chemistry in the upper atmosphere

Cravens et al. GRL (2006); Crary et al. PSS (2009)



Ion Neutral Mass Spectrometer

CAssini Plasma Spectrometer

Ion Beam Spectrometer

- Concentration de l'ordre du ppm
- Résolution en masse unitaire

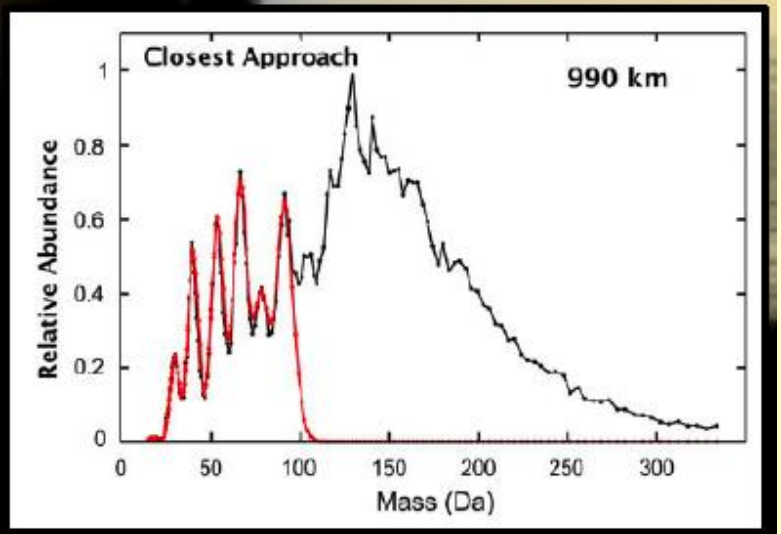
m/z 28 :

N_2^+, $C_2H_4^+$, $HCNH^+$, CO^+

1027-1200 km (× 100)

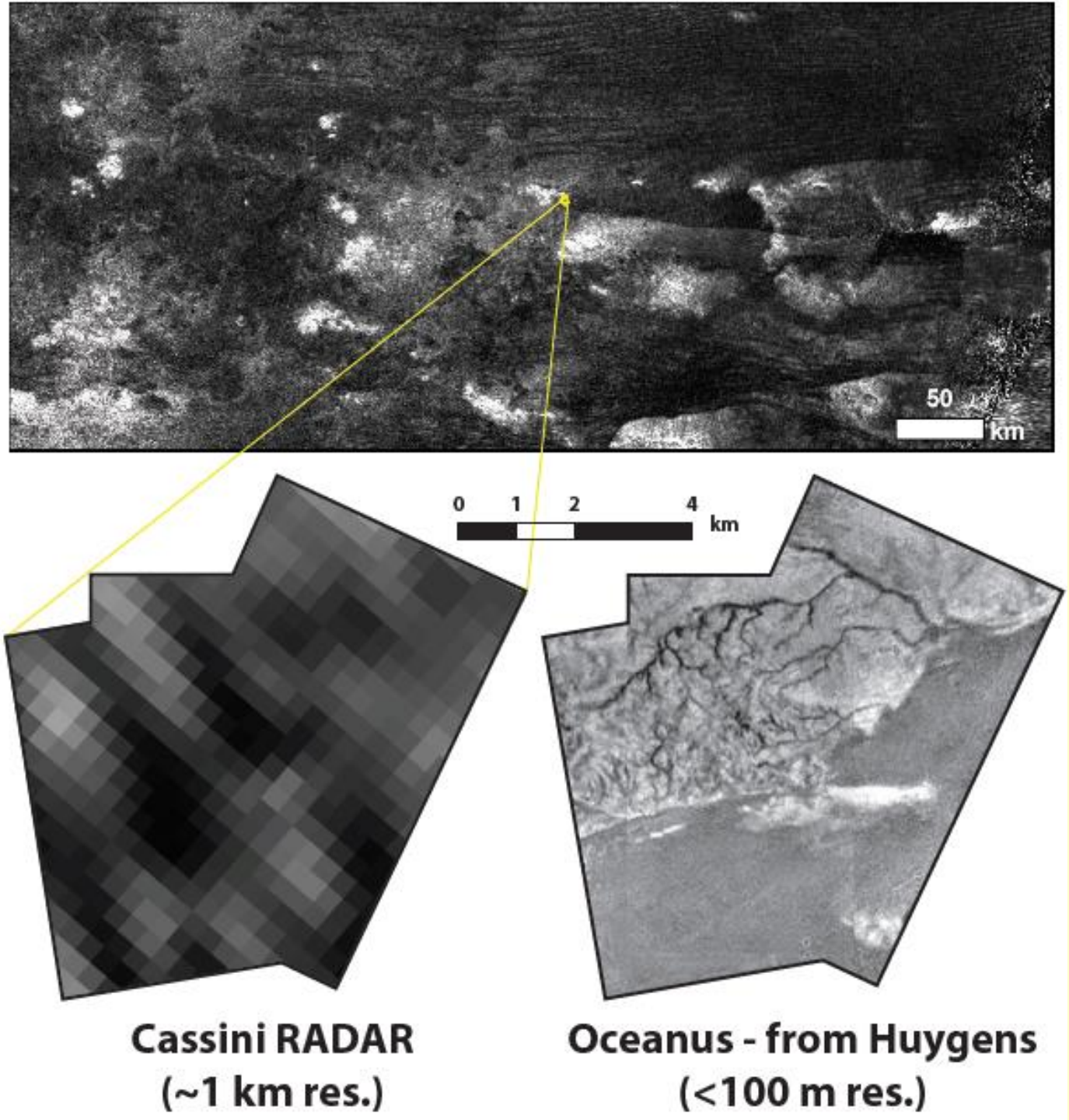
1200-1400 km (× 10)

1400-1600 km (× 1)



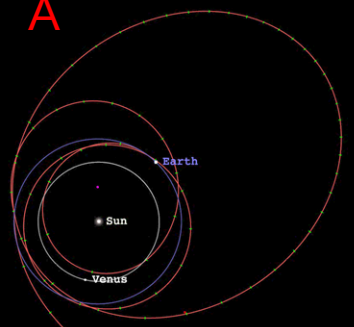
Cassini VIMS demonstrated that we can see through Titan's atmosphere at 5-µm with very little scattering.

The 5-µm camera will obtain 25 m pixel scale at 1500 km from Titan's surface

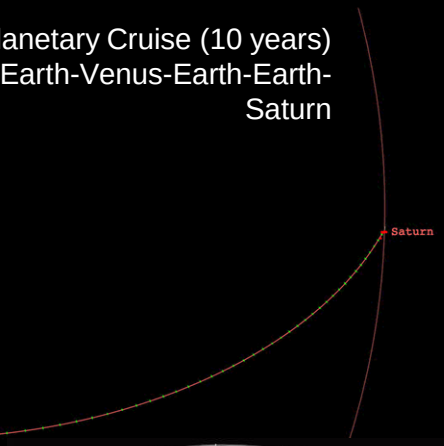


Oceanus Mission Timeline

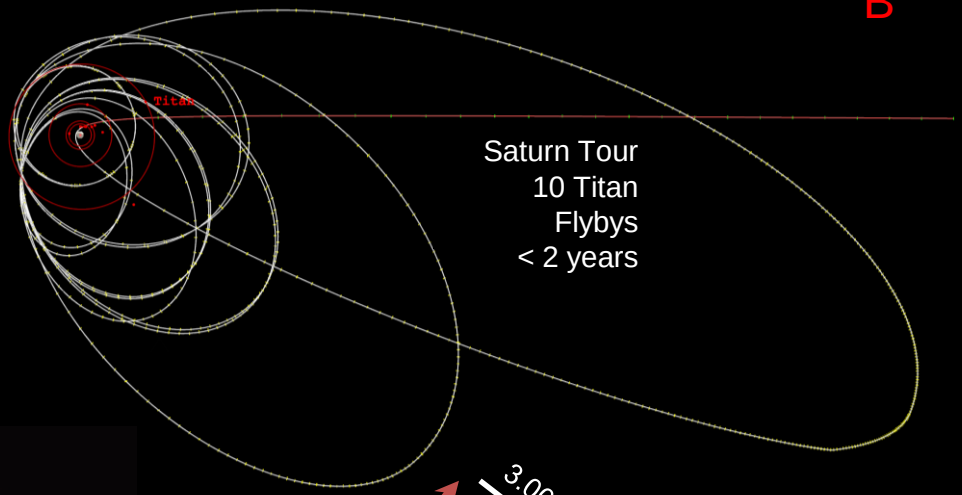
A



Interplanetary Cruise (10 years)
Earth-Earth-Venus-Earth-Earth-Saturn



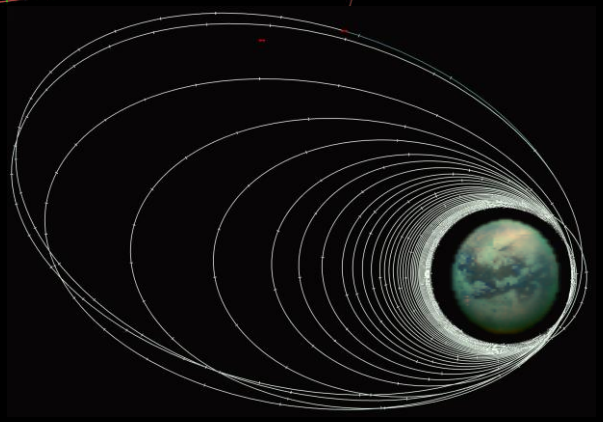
B

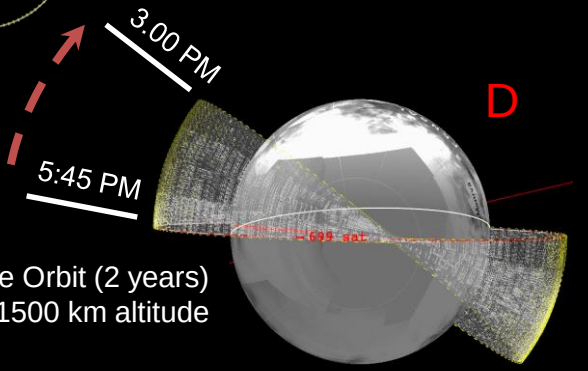


Saturn Tour
10 Titan Flybys
< 2 years

C

Titan Aerobraking /Aero-sampling
~ 20 days

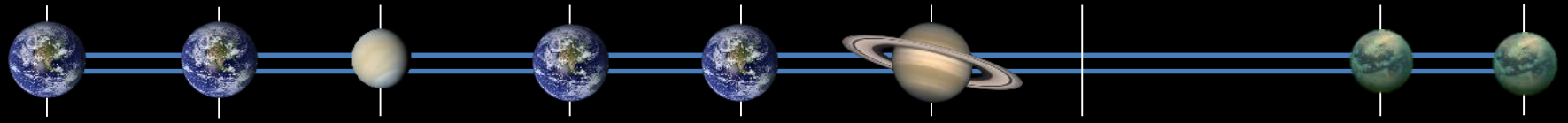




D

Titan Science Orbit (2 years)
1500 km altitude

March, 3 2024 | March 3 2025 | Aug. 22 2025 | July 6 2026 | July 6 2029 | Feb. 25 2034 | May 19 2034 | Jan. 31 2036 | Mar. 2038



Launch | Earth Flyby | Venus Flyby | Earth Flyby | Earth Flyby | Saturn Orbit Insertion | Periapsis Raise | Titan Orbit Insertion + Aerobraking | EOM

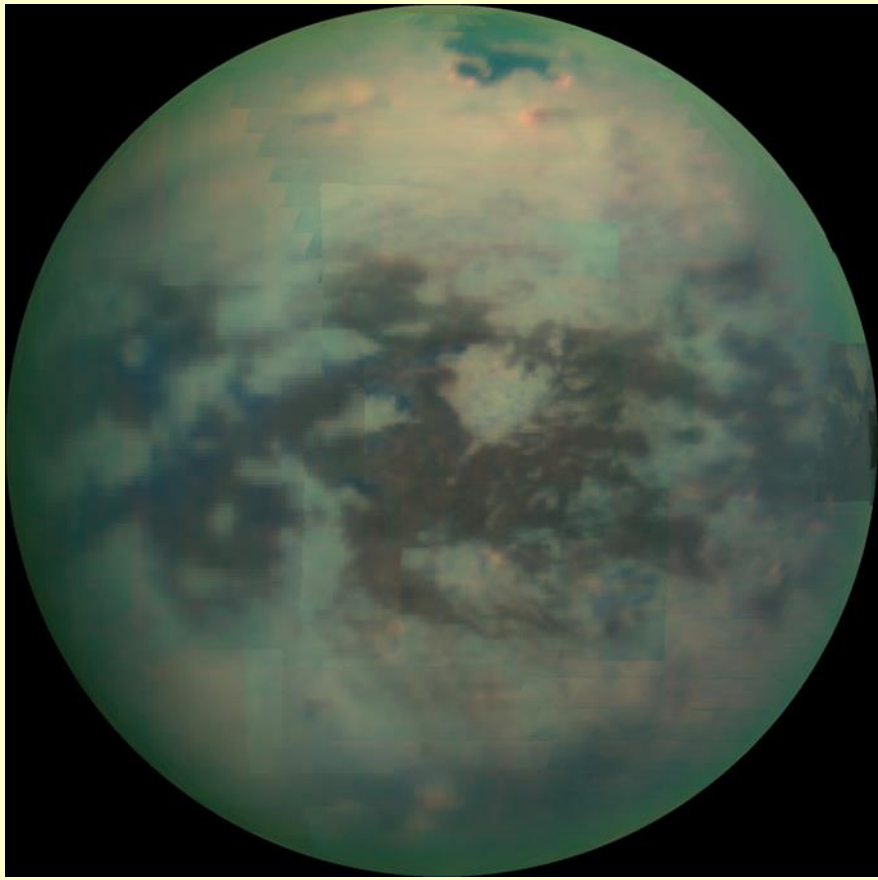
Note: timeline is not linear

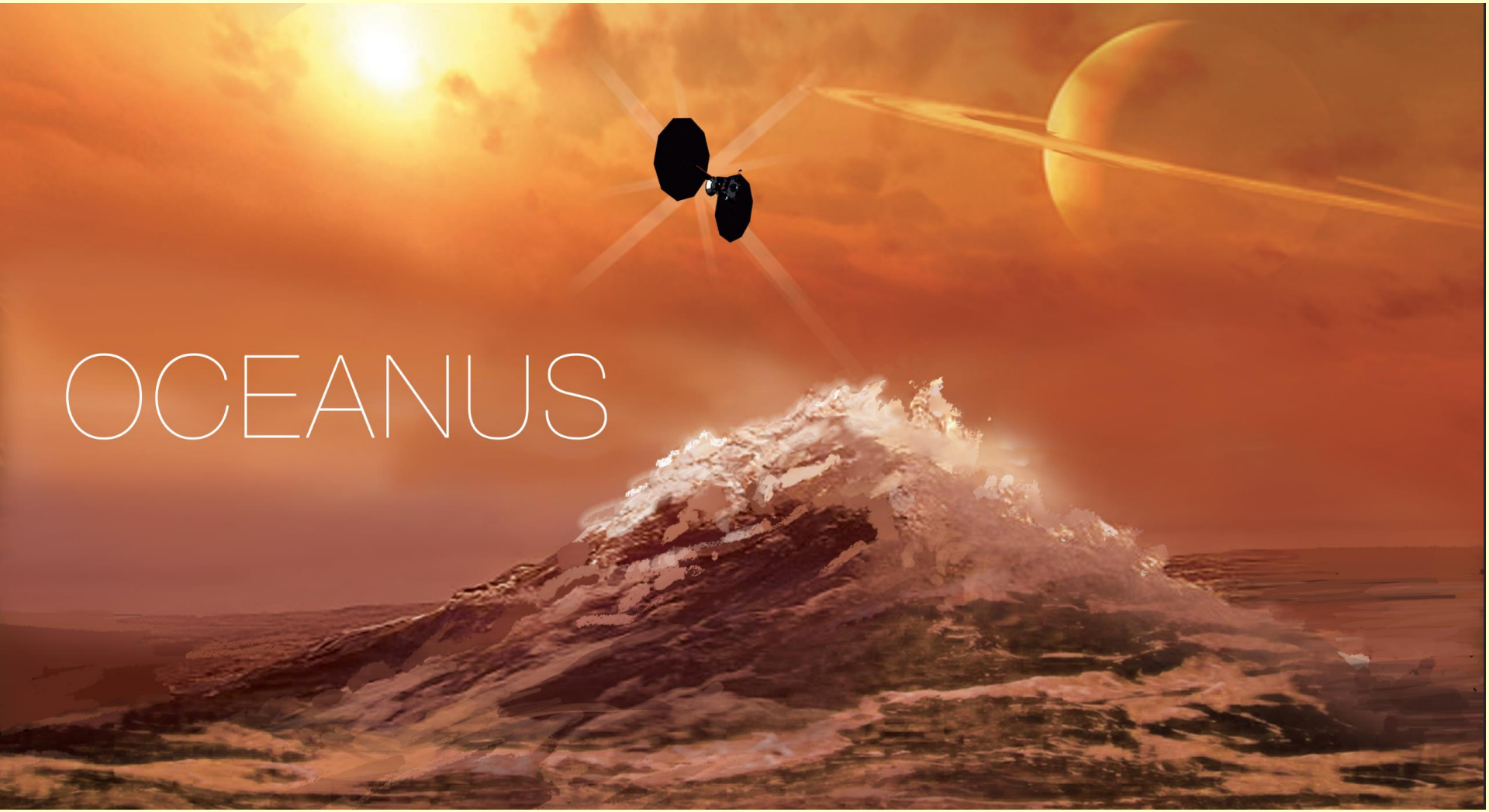
A Titan orbiter such as Oceanus will revolutionize our understanding of an organic world where organics and water can mix, as it was the case on Early Earth, when life emerged.

The data on Titan's organics will provide new data on organic factory. It is a new field of research by itself.

Titan represents a end-member of exoplanets, the methane rich exoplanets.

Geology of an active world at 100 m resolution (10 times better than Cassini) will reveal an Earth-like landscape.




OCEANUS