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M. Cassini

Huygens at Titan

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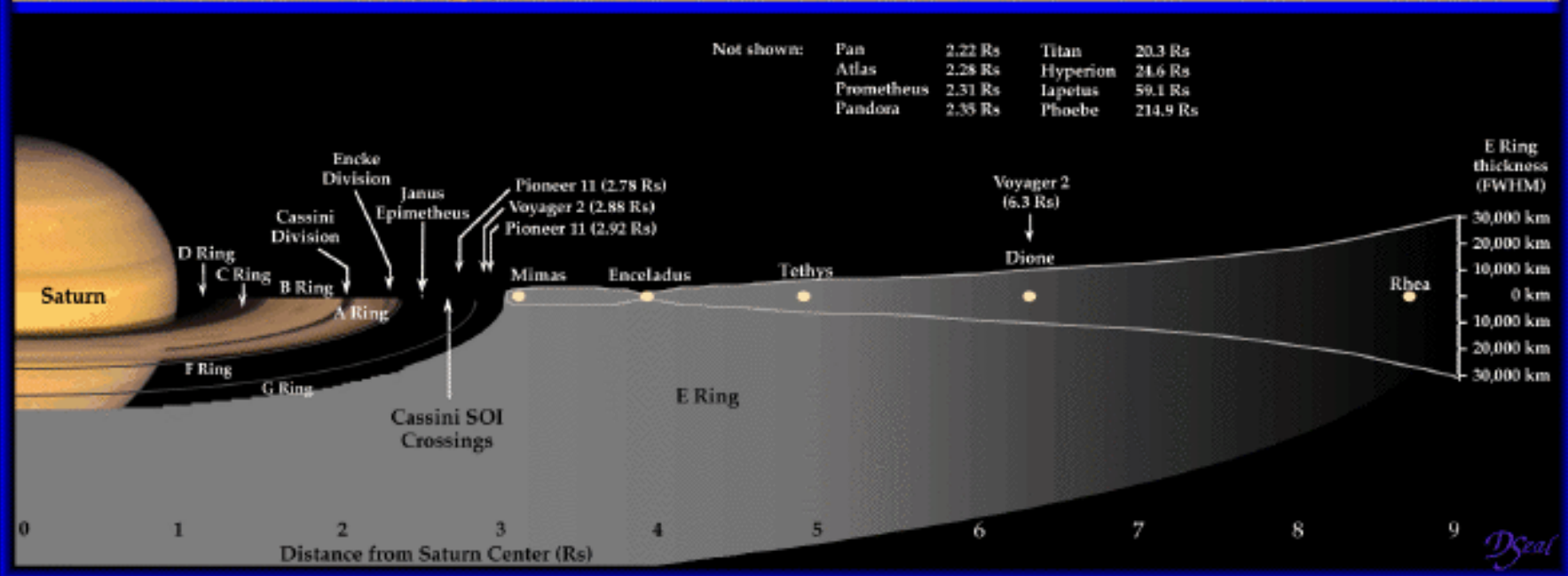
Titan – The big questions
Huygens mission and instruments
First results

MIT EAPS Lunch Talk 2005.02.08

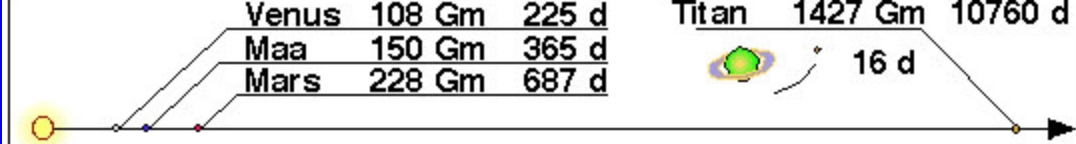
Why Titan?

- Atmospheric chemistry and evolution
- Analogue for Archean atmosphere
- Prebiotic, organic chemistry involving atmosphere, surface, and interior
- Veiled surface
- Active geology?
- Liquids and Earth-like geology?

Saturn's Satellites and Ring Structure



This graphic is available in color if required.



177° 243 d	90 bar	1 bar	23.5° 24 h
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<p>730°K</p> <p>Venus</p> <p>3.5% 96%</p> <p>8.6</p>	<p>288°K</p> <p>Maa</p> <p>21% 78% 1%</p> <p>9.78</p>
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<p>218°K</p> <p>Mars</p> <p>2.7% 1.6% 95%</p> <p>3.72</p>	<p>94°K</p> <p>Titan</p> <p>12% 6% 82% 1% 99%</p> <p>1.35</p>
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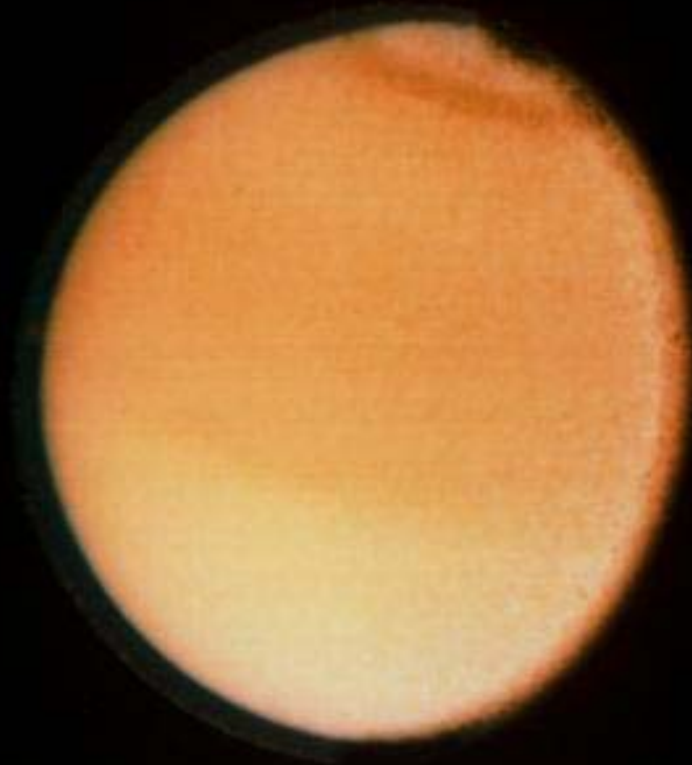
25° 24.6 h	7 mbar	1.5 bar	0° 16 d
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- argon
- hiilidioksidi
- metaani
- typpi
- happi

ILMATIETEEN LAITOS

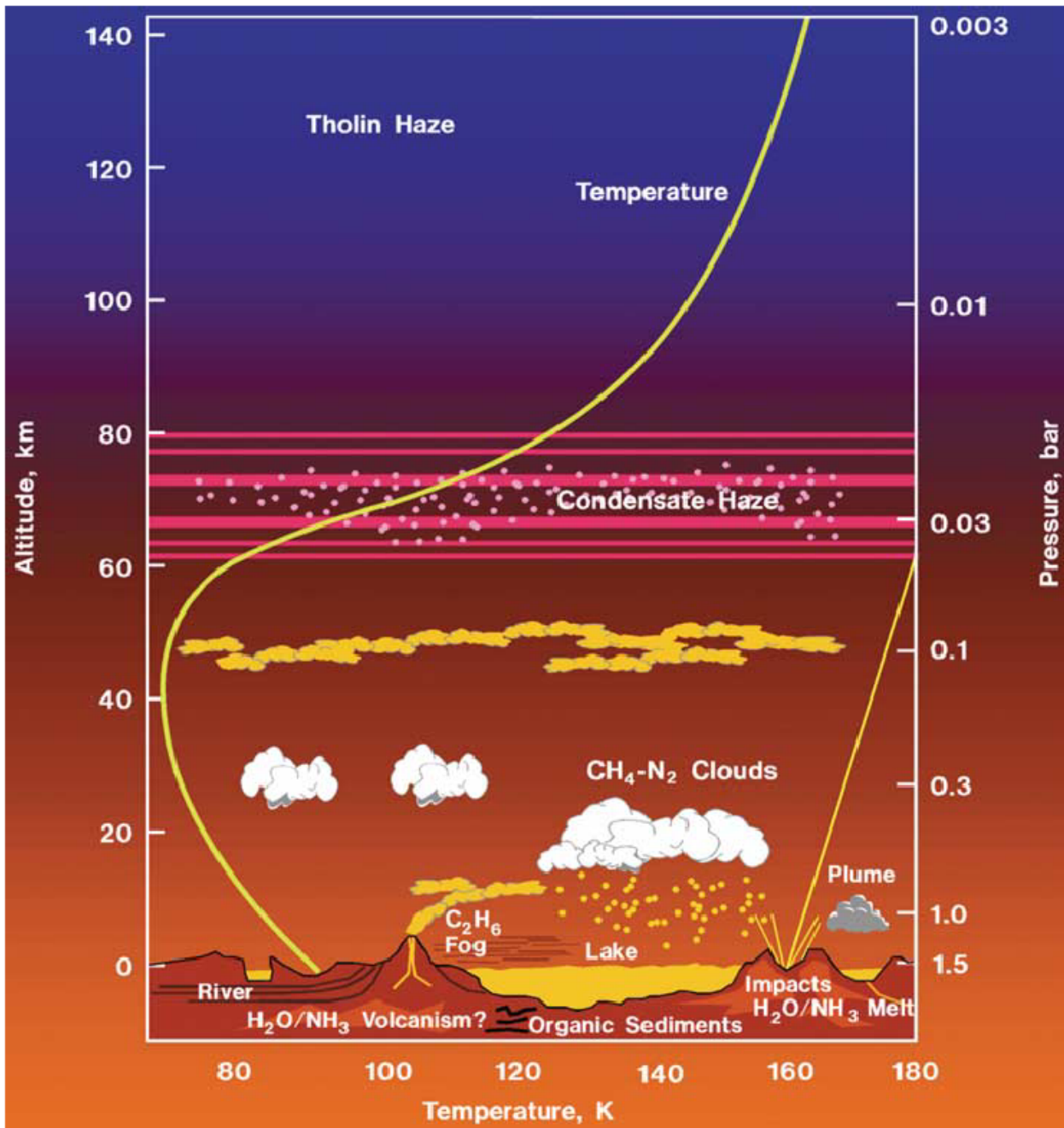


Teemu
Makinen,
FMI





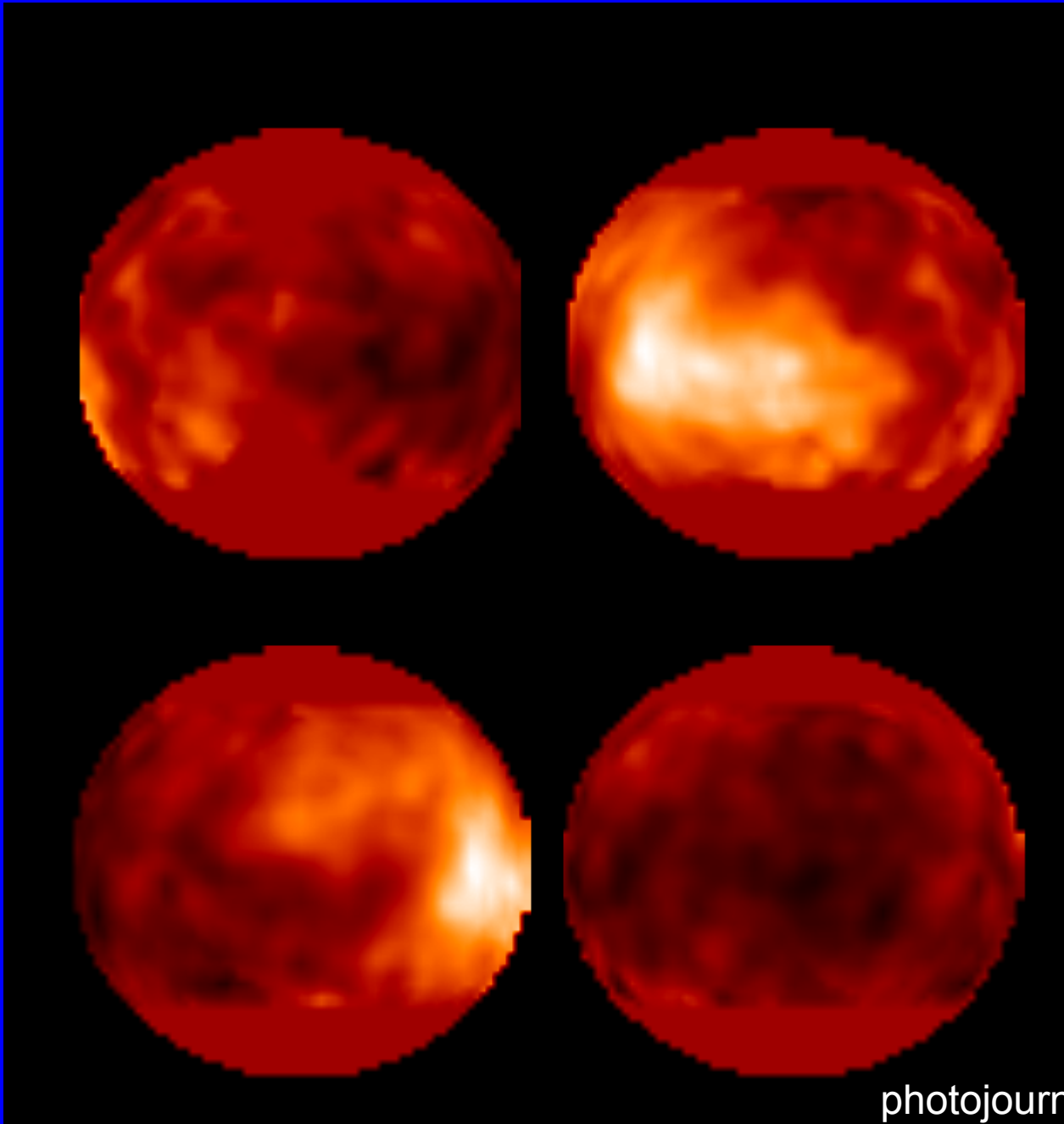
photojournal.jpl.nasa.gov

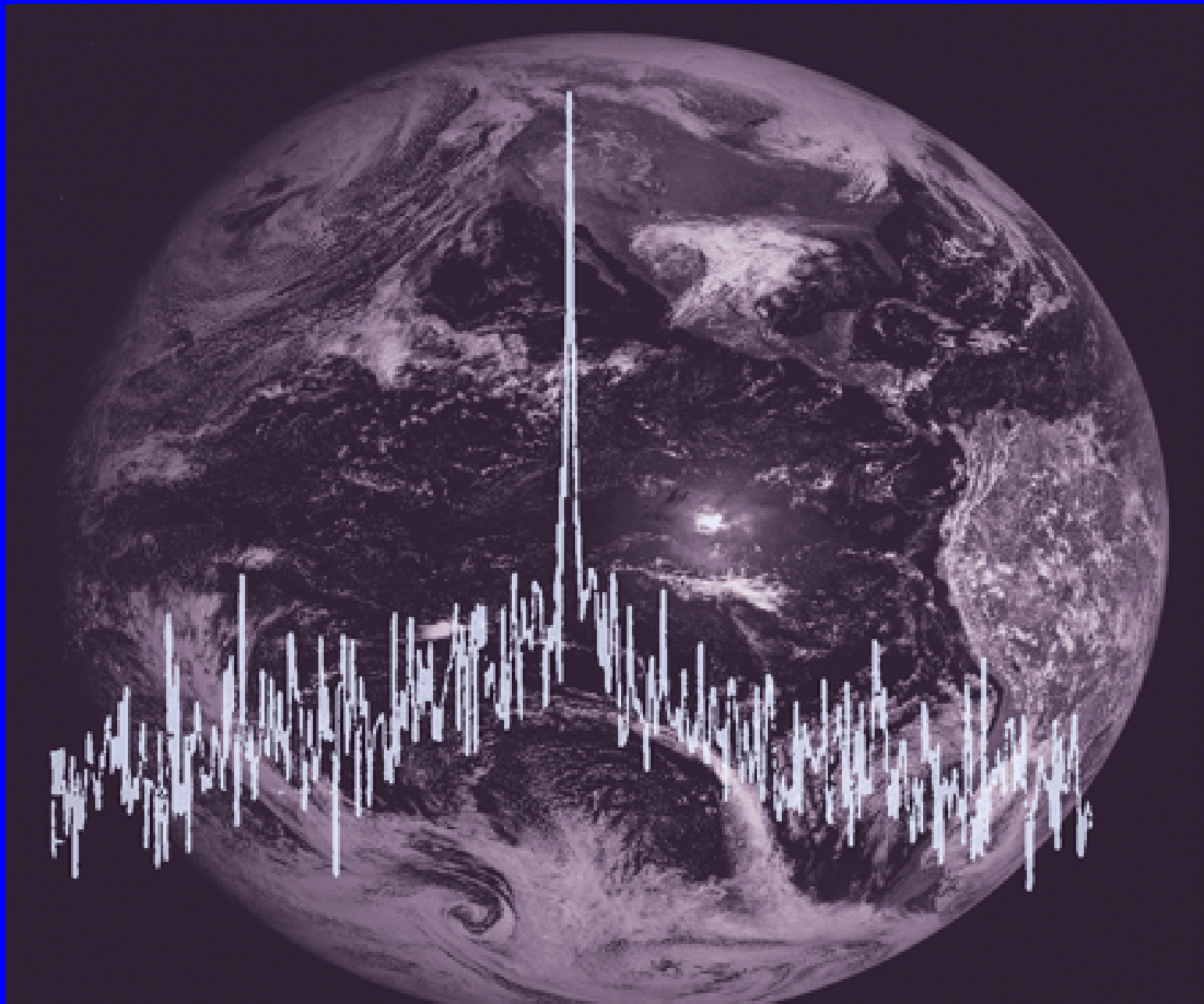


Lebreton
and Matson
2002

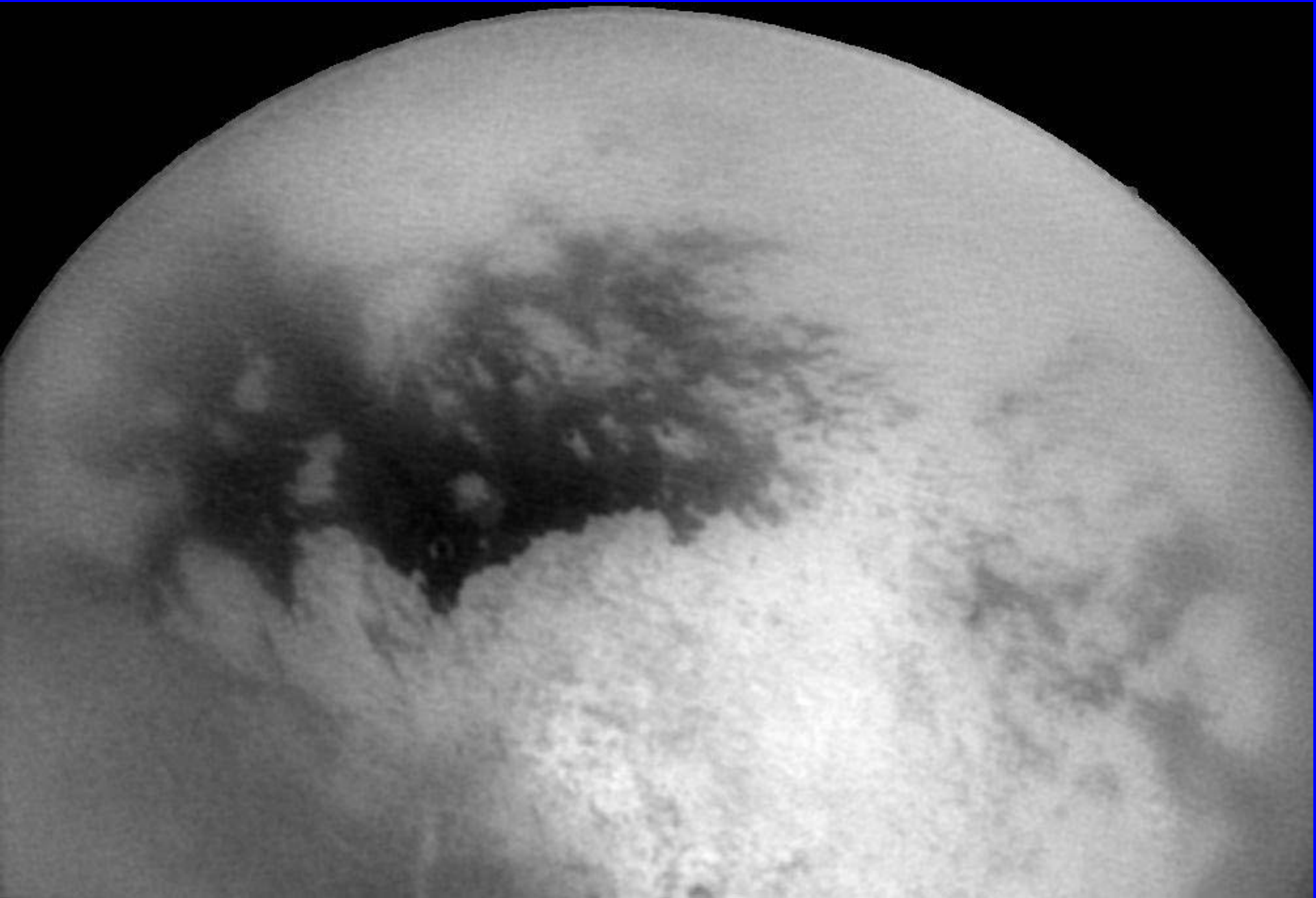
Titan's Atmosphere

- How has it changed over time? Primordial, recent, cyclic?
- What is the source of methane?
- Aerosols, hazes, and clouds
- What is the chemistry like, especially organics?
- Are dynamics like cyclostrophic Venus?





Lorenz (2003) Science, 302, 403-404

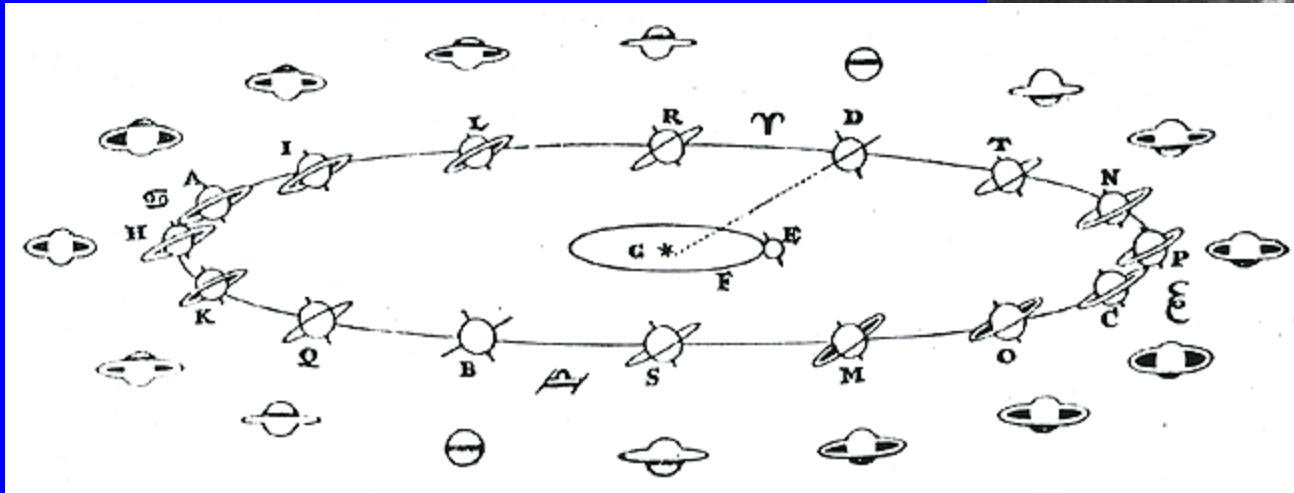
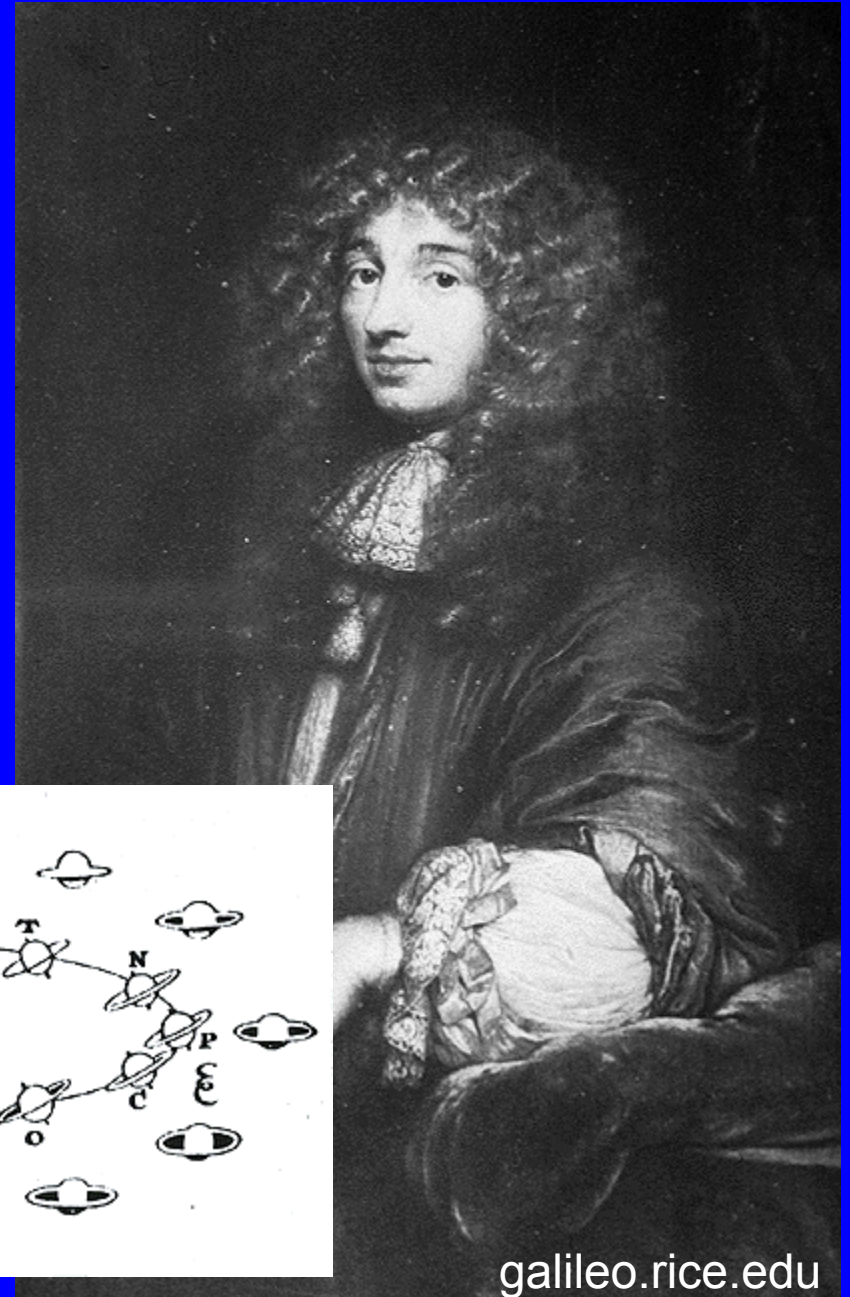


Titan's Surface and Interior

- Are or were liquids present?
- Are there organic sediments from ethane/methane rain?
- How active is surface geology – volcanoes, tectonics, fluvial processes, cratering?
- What is mix of H_2O , NH_3 , rock in interior?
- Subsurface ocean connected to surface?

1655, Christaan Huygens discovers that Saturn has a satellite, Titan

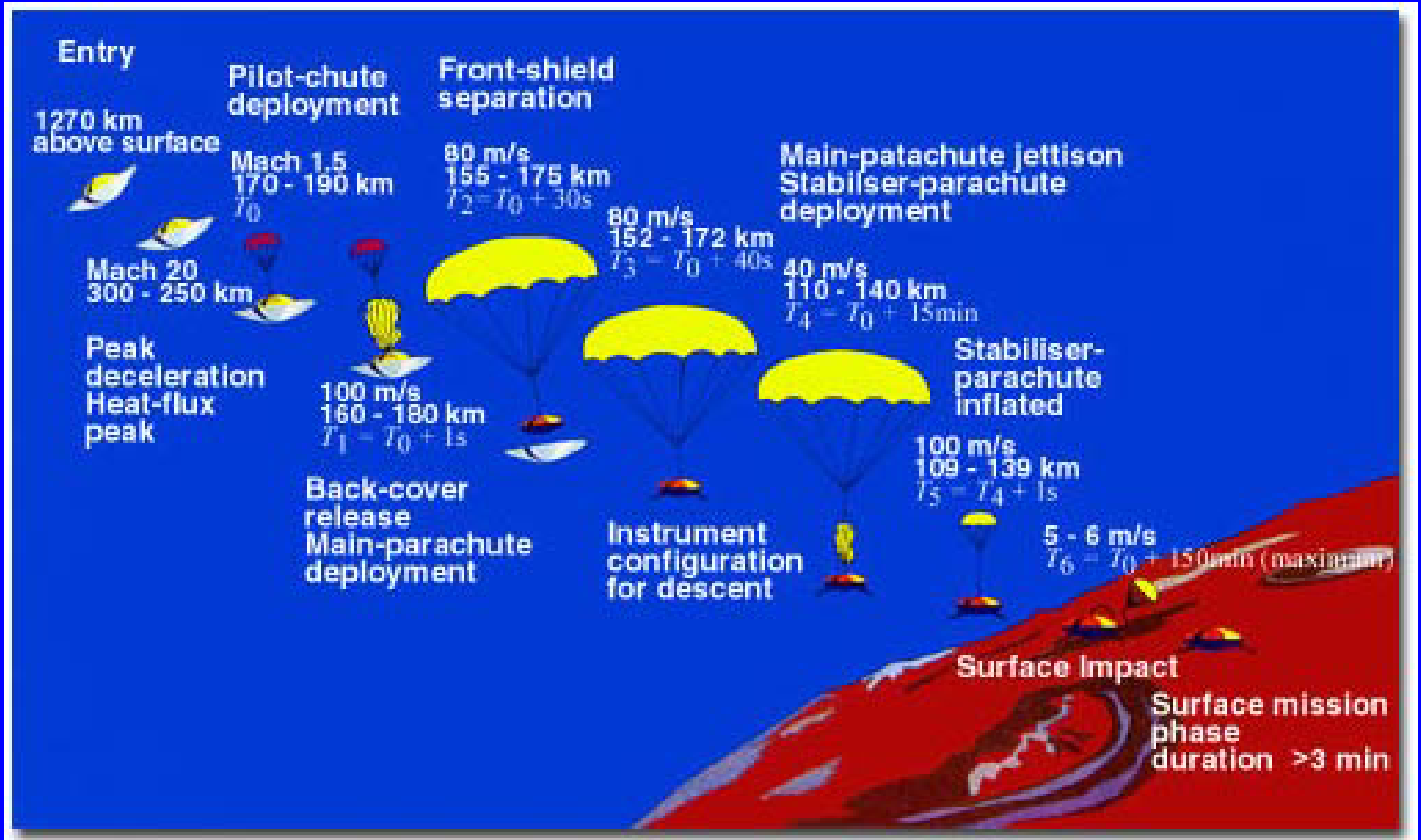
1659, Huygens proposes that Saturn is surrounded by a thin, flat ring

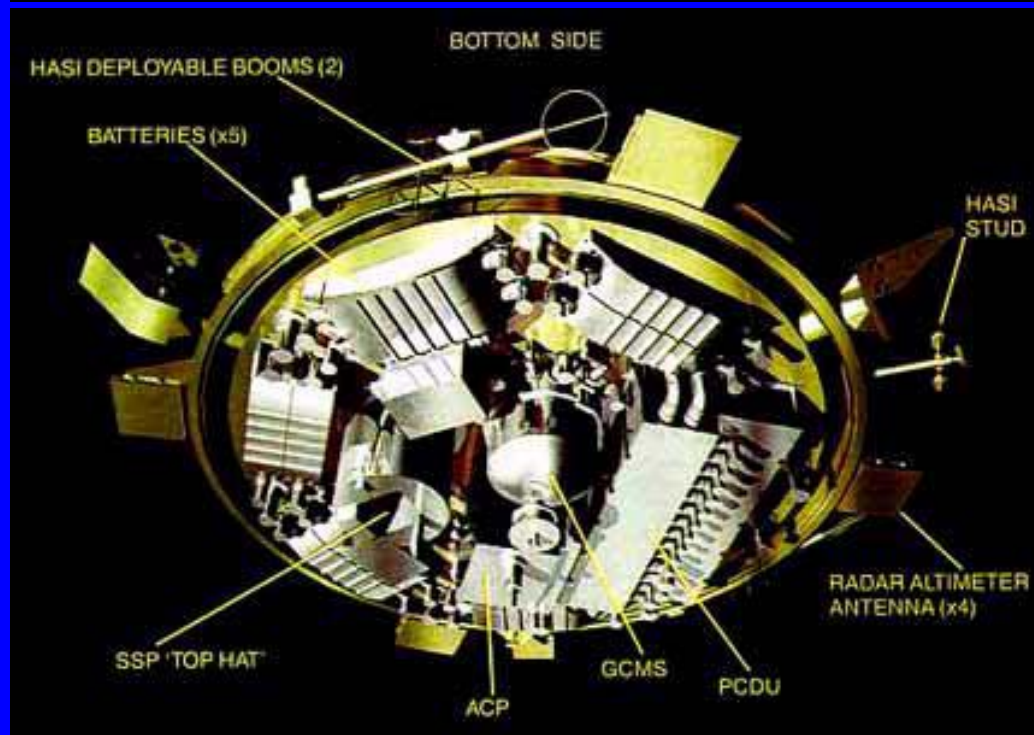
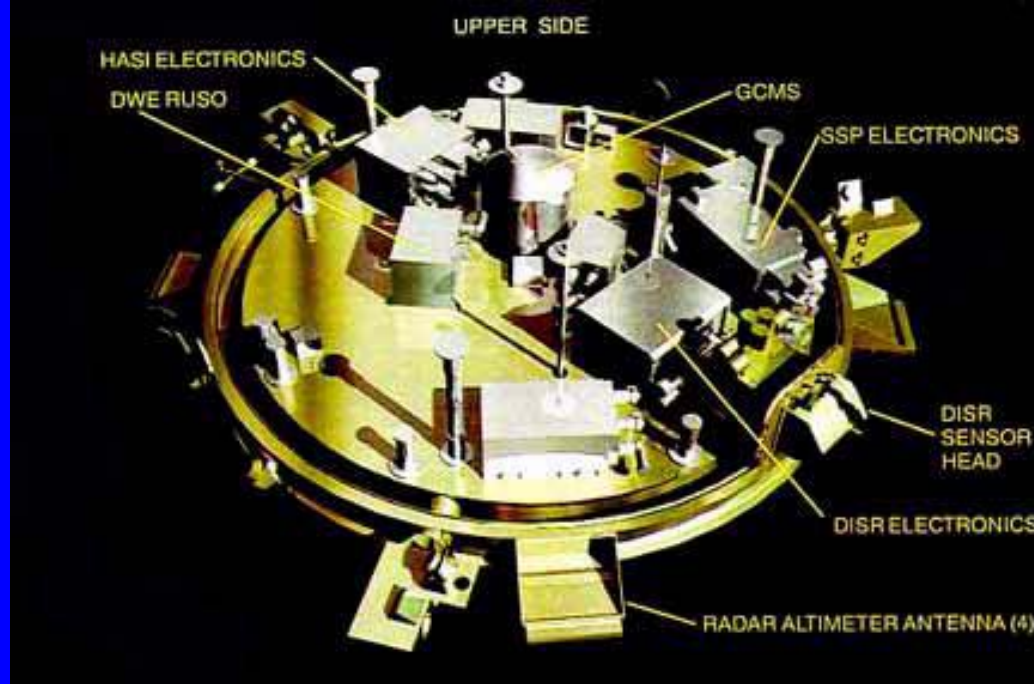


www.esa.int?



- Play `animateddescent90s.mov`





Huygens Atmospheric Structure Instrument (HASI)

- Entry accelerometers - $p, T(z)$ from 1270 km
- Direct p, T instruments
- Thermal balance, dynamics, waves
- Permittivity, wave, and altimetry – AC and DC fields, ion and electron conductivities, sound, electrical properties of surface, surface roughness
- PWA looking at charged particles, lightning

Doppler Wind Experiment (DWE)

- Line-of-sight wind below 200 km from (a) Cassini and (b) Earth-based radio scopes
- Determine zonal wind speed, study dynamics of swinging probe, atmospheric turbulence
- Requires ultrastable oscillator on one of Huygens' two transmission channels

Gas Chromatograph Mass Spectrometer (GCMS)

- Elemental and isotopic composition of gaseous atmosphere below 200 km
- Range is 2 – 141 amu
- Essential for atmospheric chemistry
- C, N isotopes imply atmospheric evolution
- Possibly analyze surface sample as well

Aerosol Collector Pyrolyser (ACP)

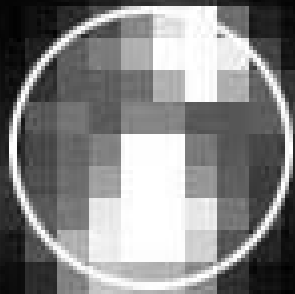
- Pyrolyse aerosol particles from ~50 km and ~20 km altitude, feed to GCMS
- Expect long chain hydrocarbons (CHNO)
- Study cloud chemistry, compare condensed to gaseous abundances
- Context for surface composition

Descent Imager/Spectral Radiometer (DISR)

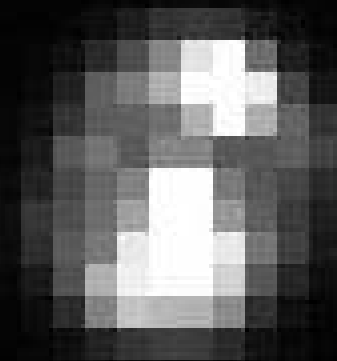
- 14 photometers, VIS/IR spectrometers, imagers
- Surface images for geomorphology
- Measure spectrum of upward and downward flux at two polarisations, monitor solar extinction
- Thermal balance from fluxes, aerosol shape/size/distribution

Surface Science Package (SSP)

- Design for impact in liquid or solid, many small experiments
- Surface temperature, thermal conductivity, permittivity, refractive index, liquid density
- Speed of sound in ocean
- Sonar, plus tilt sensors for attitude/motion
- Penetrometer to characterize impact
- Plus same measurements during descent



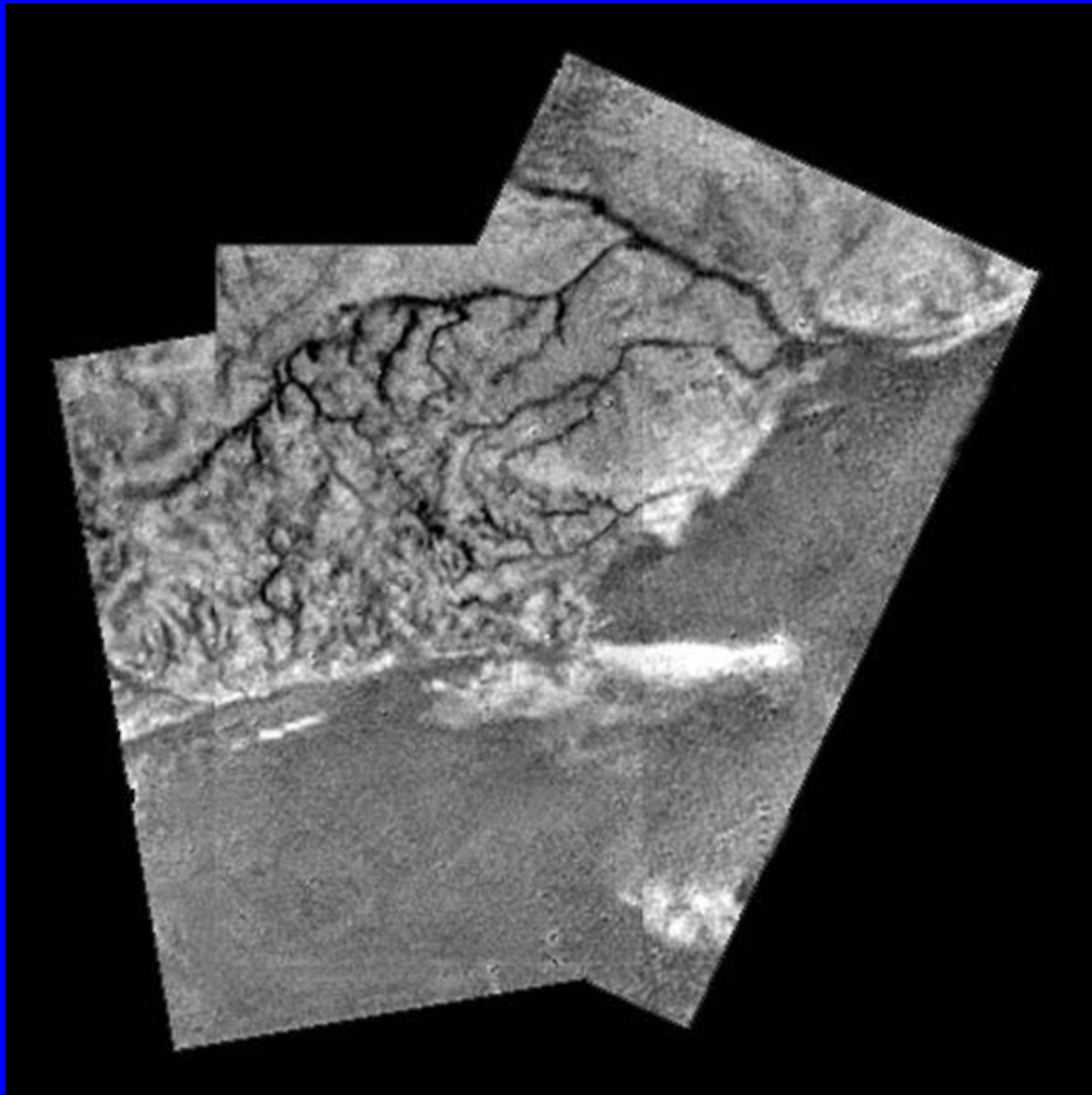
PROBE

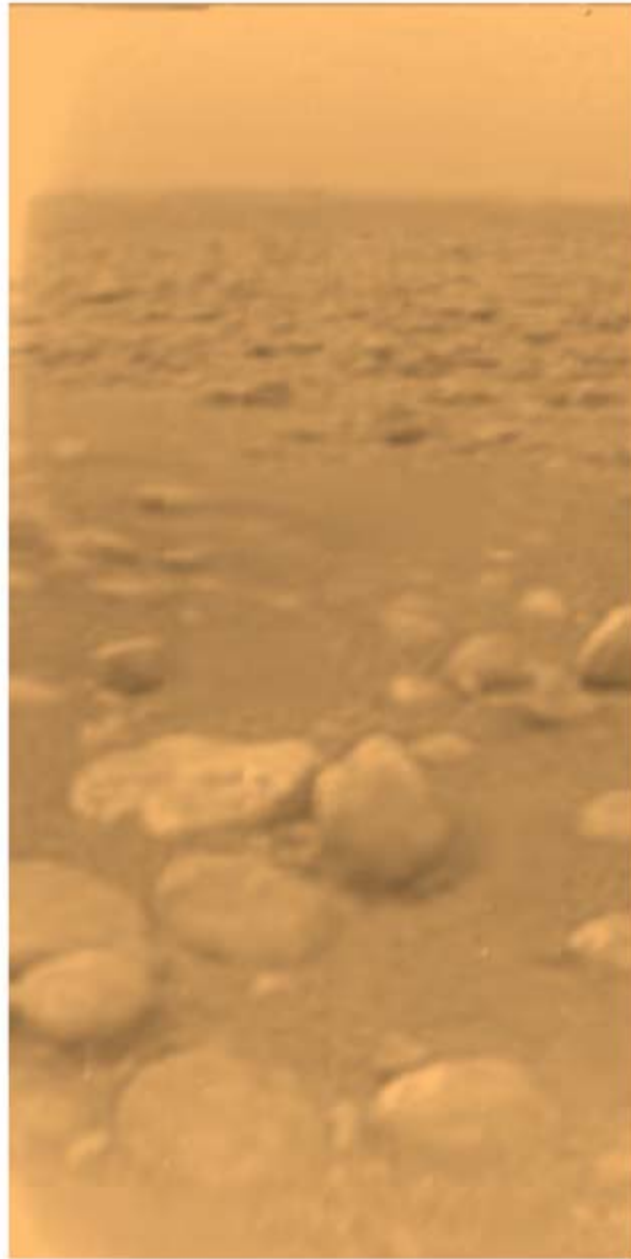


- Play descentcam.mov



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First Results

- Successful entry, survived impact, lasted for hours on surface
- One of two Cassini receiver channels not switched on, DWE got no data
- Rely on ground-based tracking instead
- 350 images returned, 350 lost
- Several other instruments lost some data, but, overall, mission was highly successful

Not Pretty Pictures

- p , $T(z)$ as predicted, plus large (gravity?) waves in upper atmosphere
- 4 minutes entry, 2.5 hour descent
- 5 ms^{-1} impact, 15 g deceleration
- Surface solid, stiff crust above weaker (wet sand-like) substrate – crème brûlée
- Clouds extended lower than expected (30 km, not 50-70 km)
- Liquid methane within few cm of surface

Pretty Pictures

- Orbital images and radar hard to interpret, Huygens images are much easier
- Very active surface, but no obvious liquids
- Flow in channels, around base of pebbles
- Dark areas are low-lying
- Hydrocarbon rain inferred from channels

What Next?

- More press releases – Media, web
- Conferences – LPSC, EGU, AGU
- Papers – 3 month Sci/Nat special issue
- Data Access – Eventually, probably
- Funding – NASA Cassini PS Program, Saturn DAP, plus usual sources
- More data – Cassini tour continues, future Titan mission possible?