ESA's Space Science & Robotic Exploration Programmes

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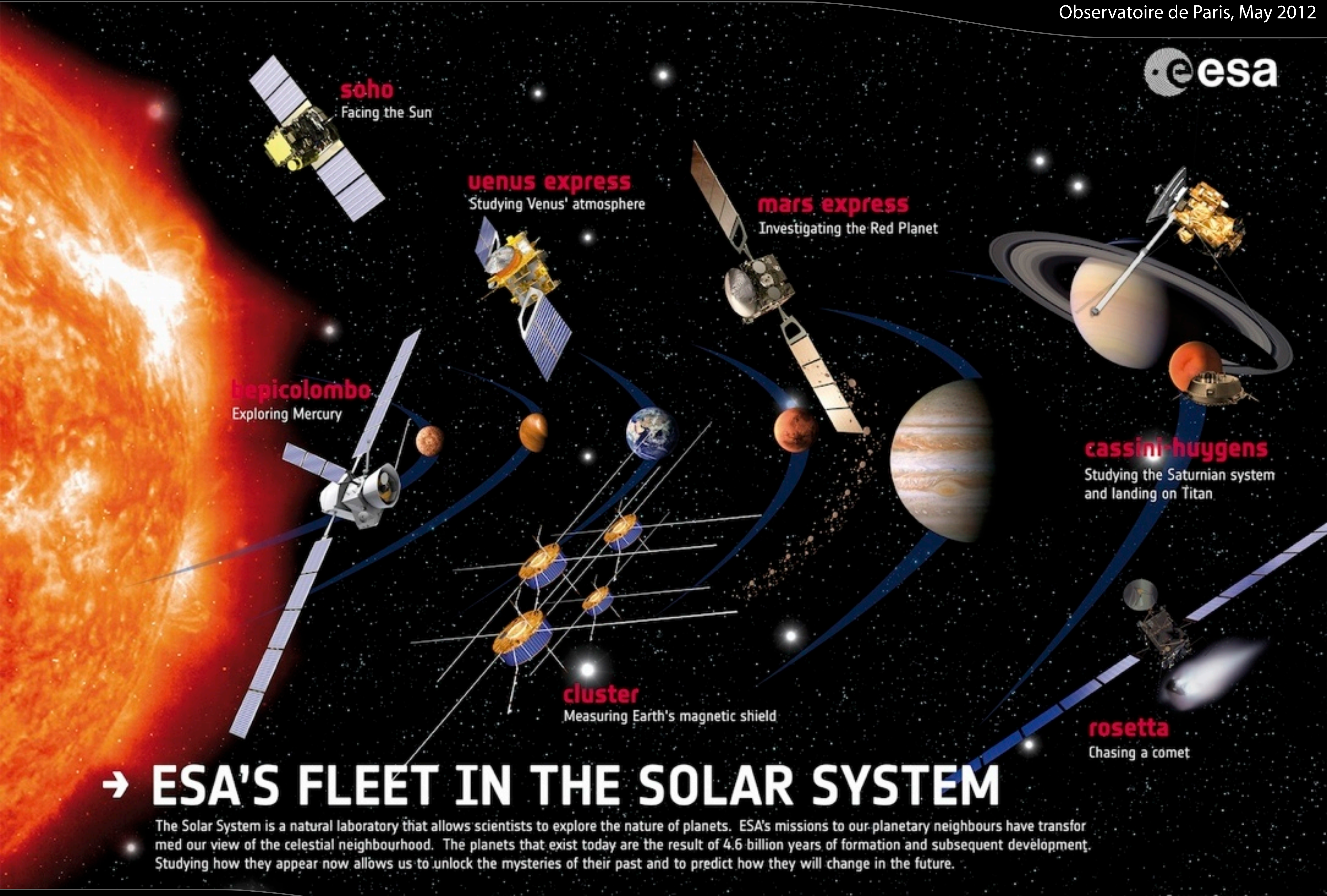
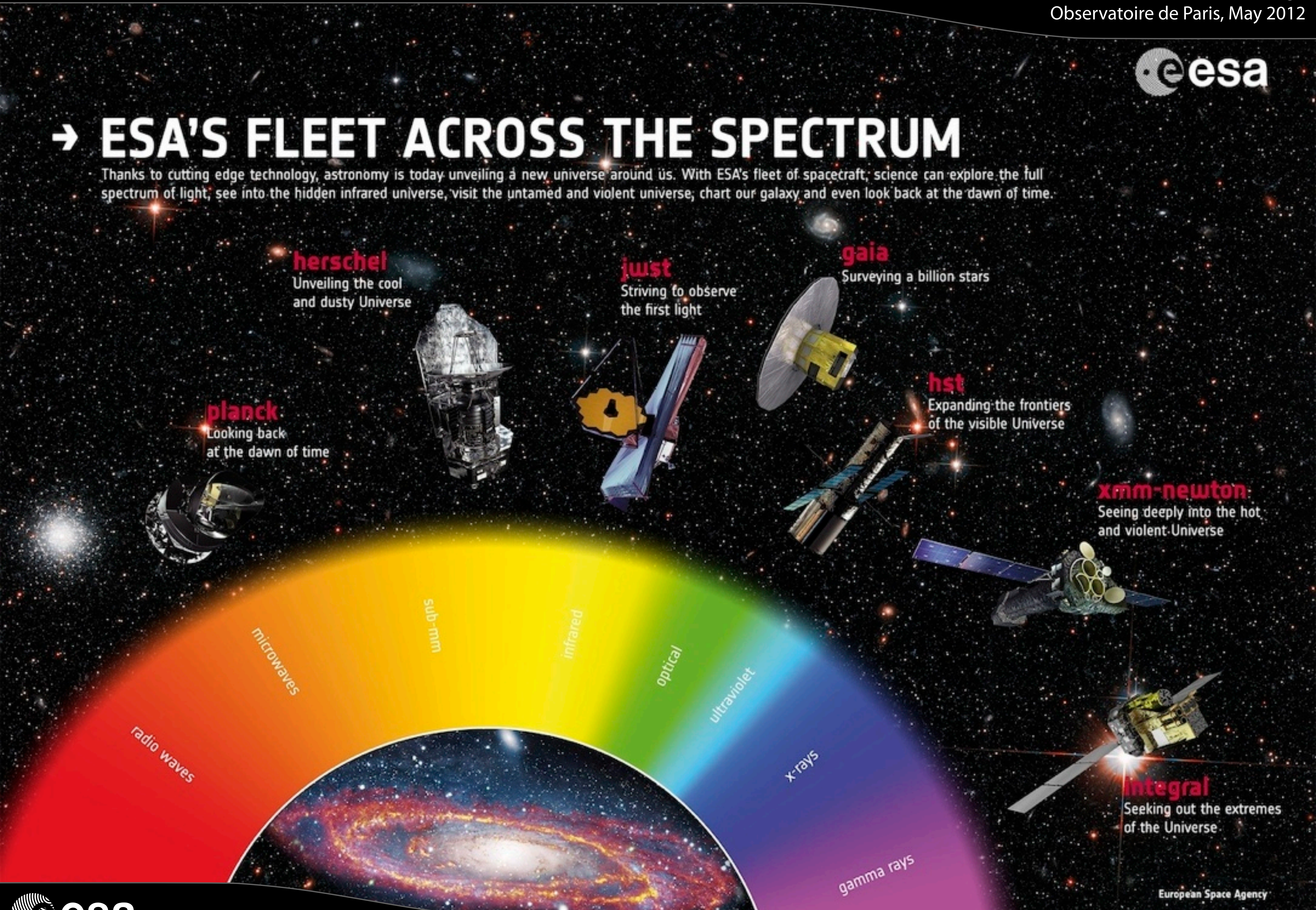
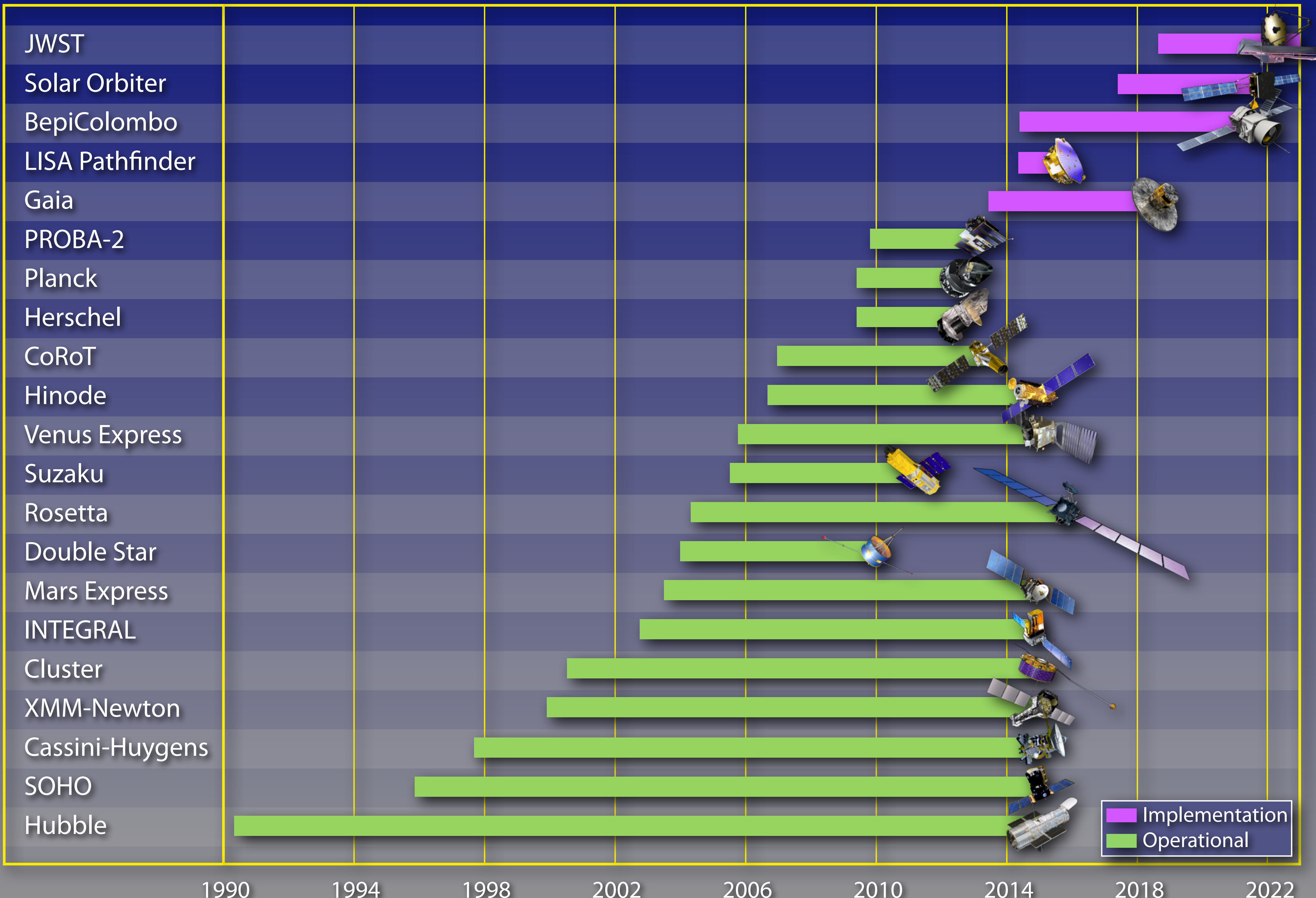

esa
soho
Facing the Sun
venus express
Studying Venus' atmosphere
mars express
Investigating the Red Planet
bepicolombo
Exploring Mercury
cassini-huygens
Studying the Saturnian system and landing on Titan
cluster
Measuring Earth's magnetic shield
rosetta
Chasing a comet
→ ESA'S FLEET IN THE SOLAR SYSTEM
The Solar System is a natural laboratory that allows scientists to explore the nature of planets. ESA's missions to our planetary neighbours have transformed our view of the celestial neighbourhood. The planets that exist today are the result of 4.6 billion years of formation and subsequent development. Studying how they appear now allows us to unlock the mysteries of their past and to predict how they will change in the future.
European Space Agency


esa
→ ESA'S FLEET ACROSS THE SPECTRUM
Thanks to cutting edge technology, astronomy is today unveiling a new universe around us. With ESA's fleet of spacecraft, science can explore the full spectrum of light, see into the hidden infrared universe, visit the untamed and violent universe, chart our galaxy and even look back at the dawn of time.
herschel
Unveiling the cool and dusty Universe
jwst
Striving to observe the first light
gaia
Surveying a billion stars
planck
Looking back at the dawn of time
hst
Expanding the frontiers of the visible Universe
xmm-newton
Seeing deeply into the hot and violent Universe
integral
Seeking out the extremes of the Universe
radio waves
microwaves
sub-mm
infrared
optical
ultraviolet
x-rays
gamma rays
European Space Agency

Current ESA space science missions



Future ESA space science missions

Missions in implementation

- Gaia
- LISA Pathfinder
- BepiColombo (with JAXA)
- ASTRO-H (with JAXA)
- Solar Orbiter (with NASA)
- JWST (with NASA, CSA)

ExoMars robotic exploration

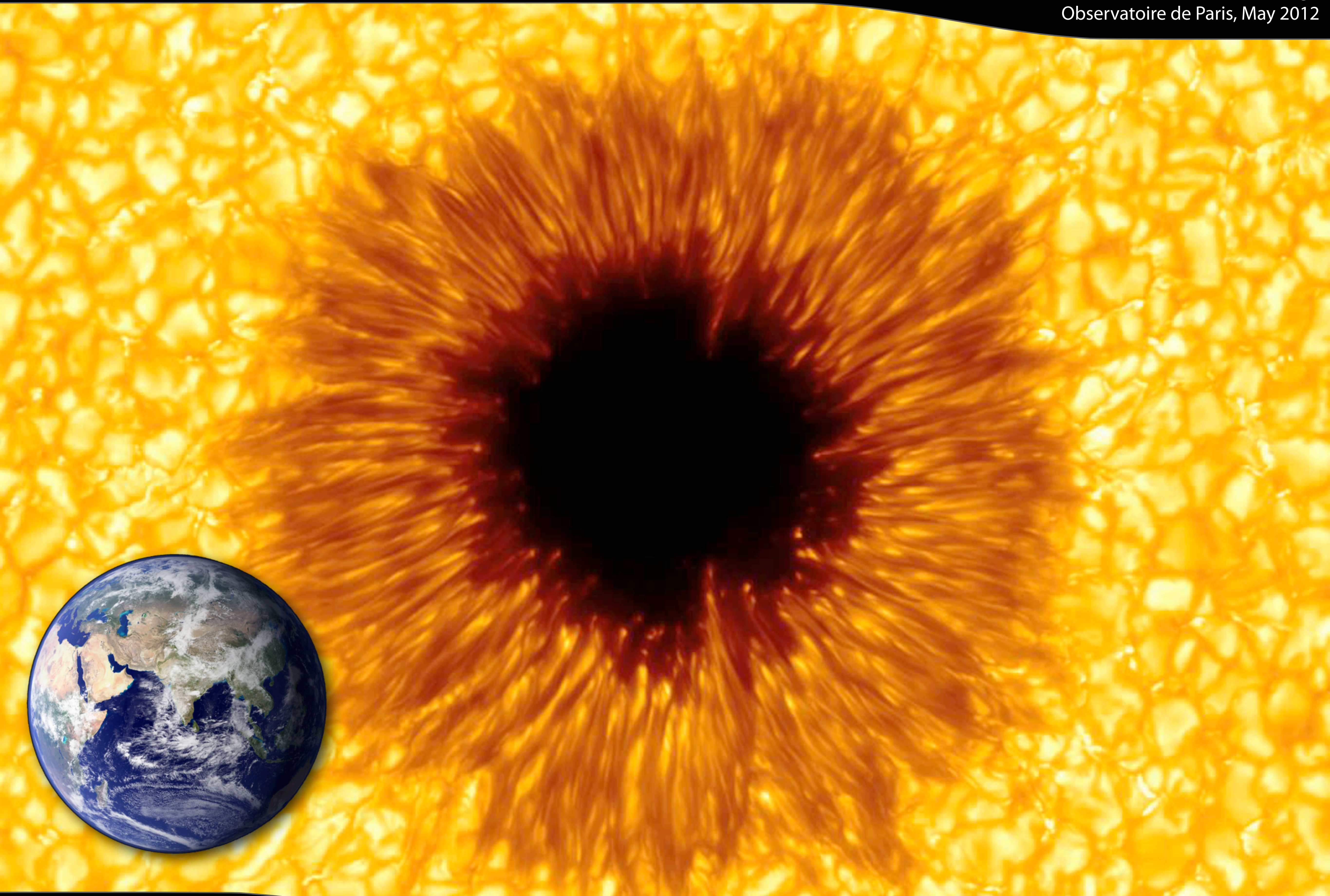
- 2016 Trace Gas Orbiter + EDL
- 2018 Rover mission

Missions under study

- Euclid
- SPICA (with JAXA)
- JUICE
- EChO
- LOFT
- Marco Polo-R
- STE-QUEST

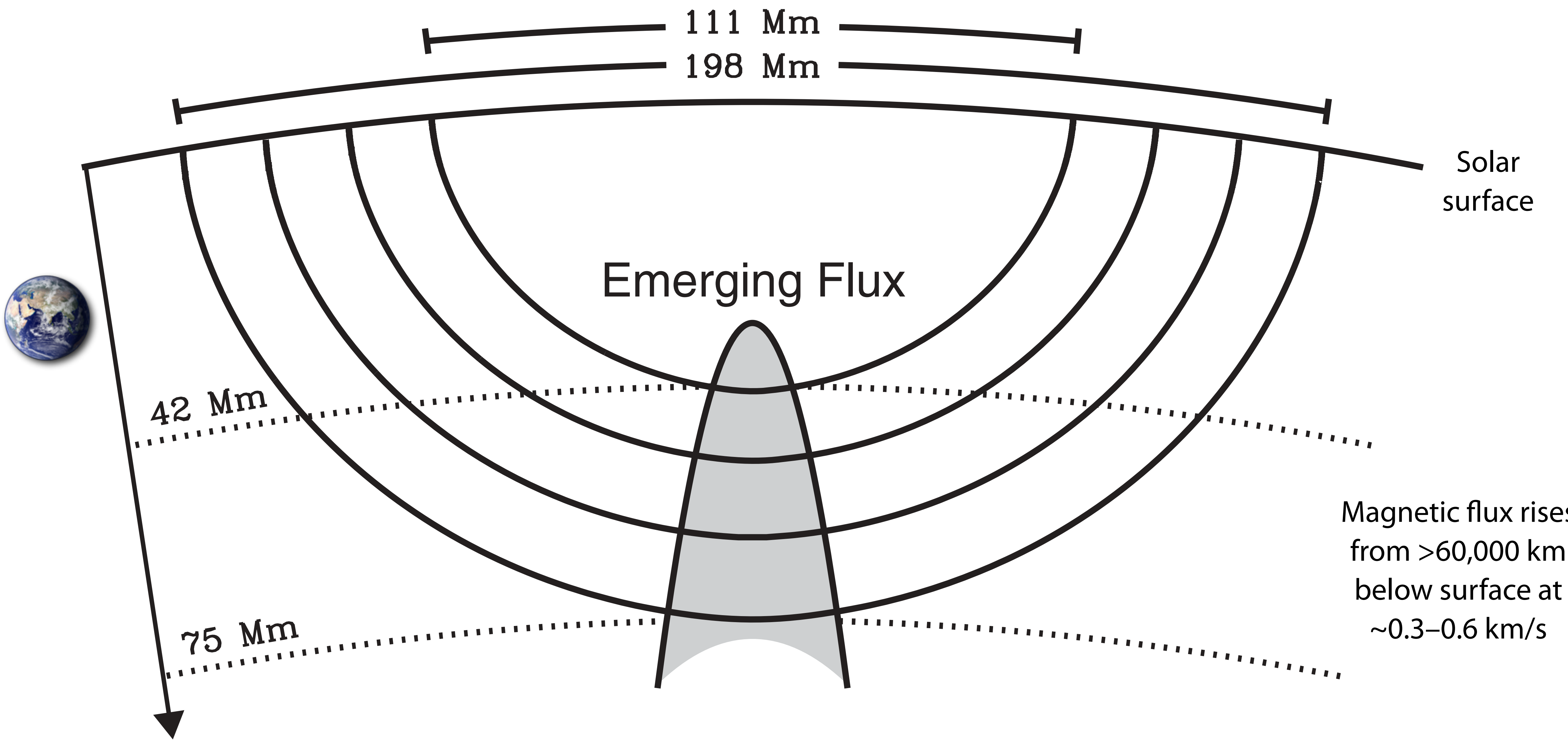
Solar maximum approaching: more sunspots

Continuum image at 450nm, NASA SDO, October 30, 2011



Luc Rouppe van der Voort / Swedish 1m Solar Telescope, La Palma, Royal Swedish Academy of Sciences

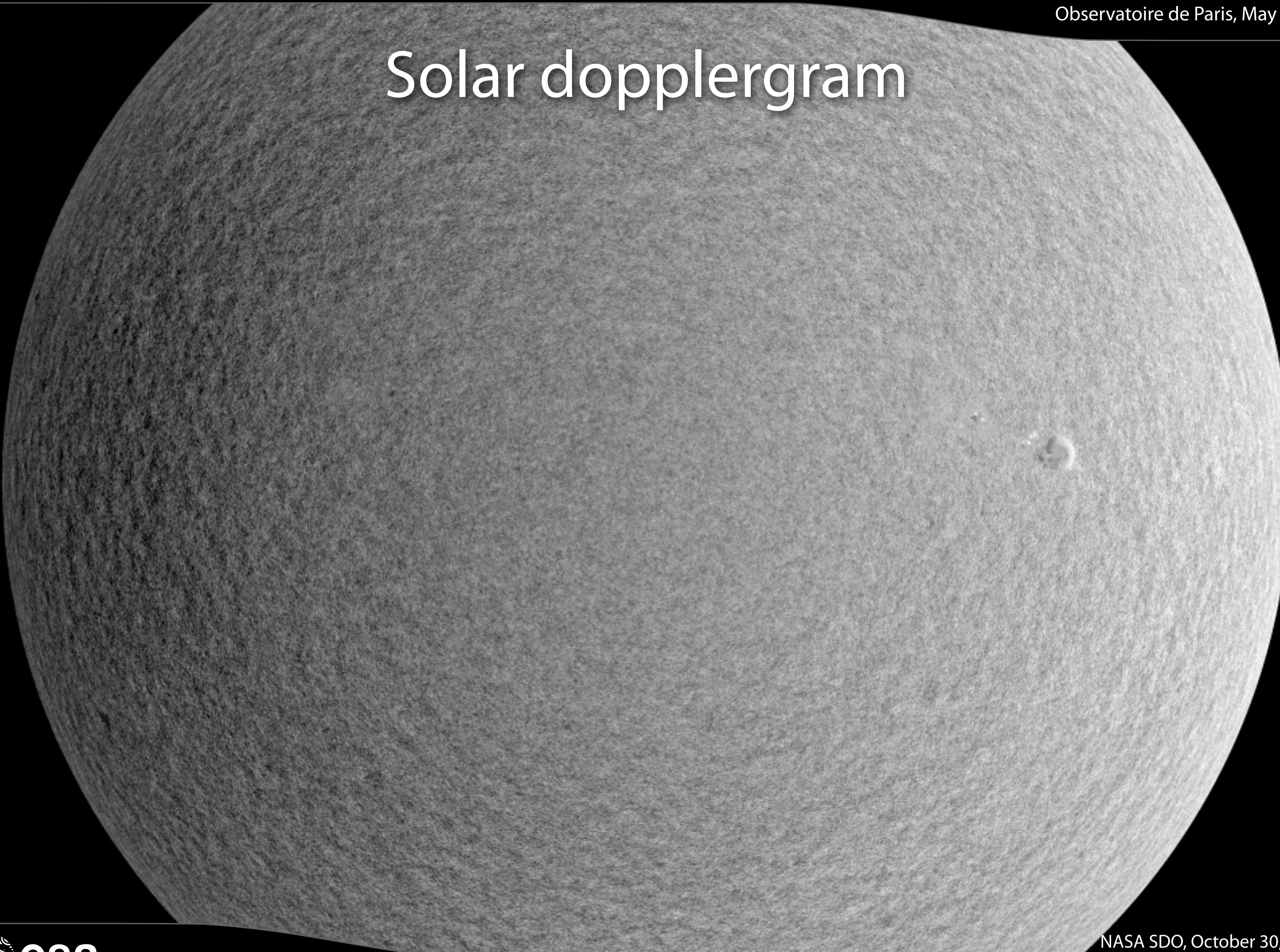
Detecting sunspots *before* they emerge



Turbulent convection caused by rising magnetic flux leads to acoustic perturbations in Sun which can be detected in helioseismology data

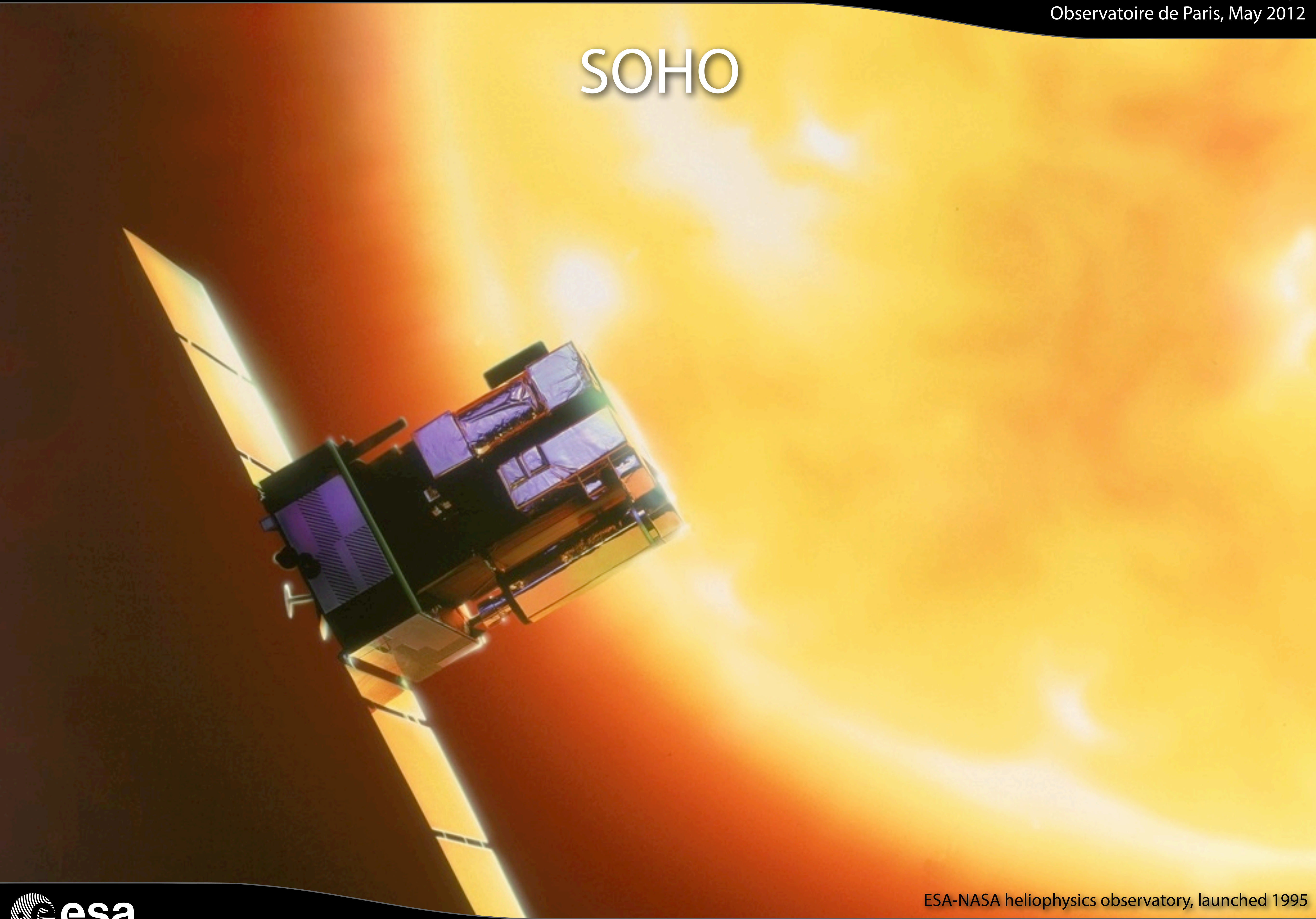
Ilonidis et al. (2011, Science, 333, 993)

Solar dopplergram



NASA SDO, October 30, 2011

SOHO



ESA-NASA heliophysics observatory, launched 1995

Detecting sunspots *before* they emerge

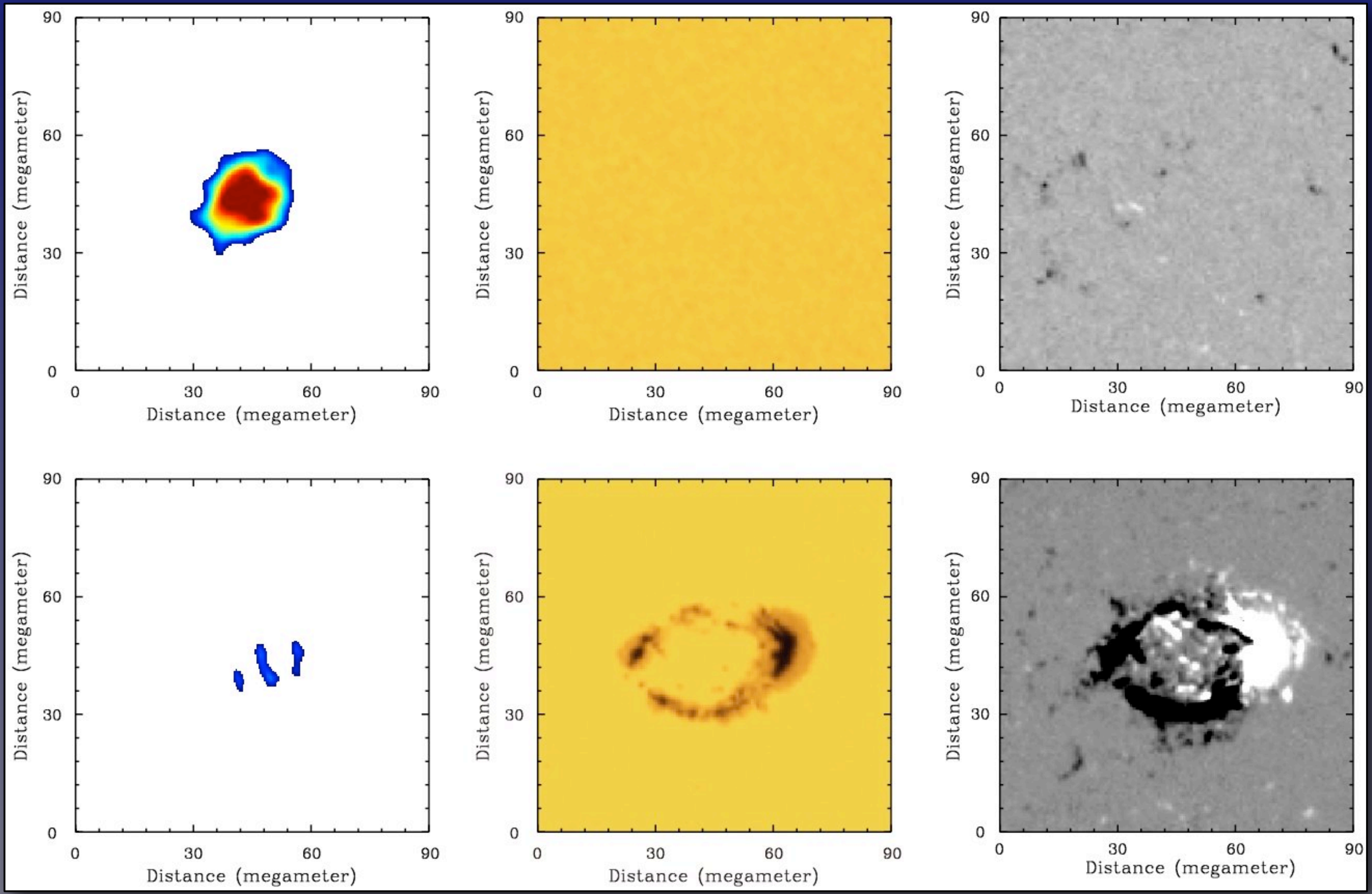
Time-distance helioseismology technique detects rising sunspots up to 65,000 km below surface

1–2 days later, they emerge on surface

Can help improve space weather forecast

26/10/2003

28/10/2003



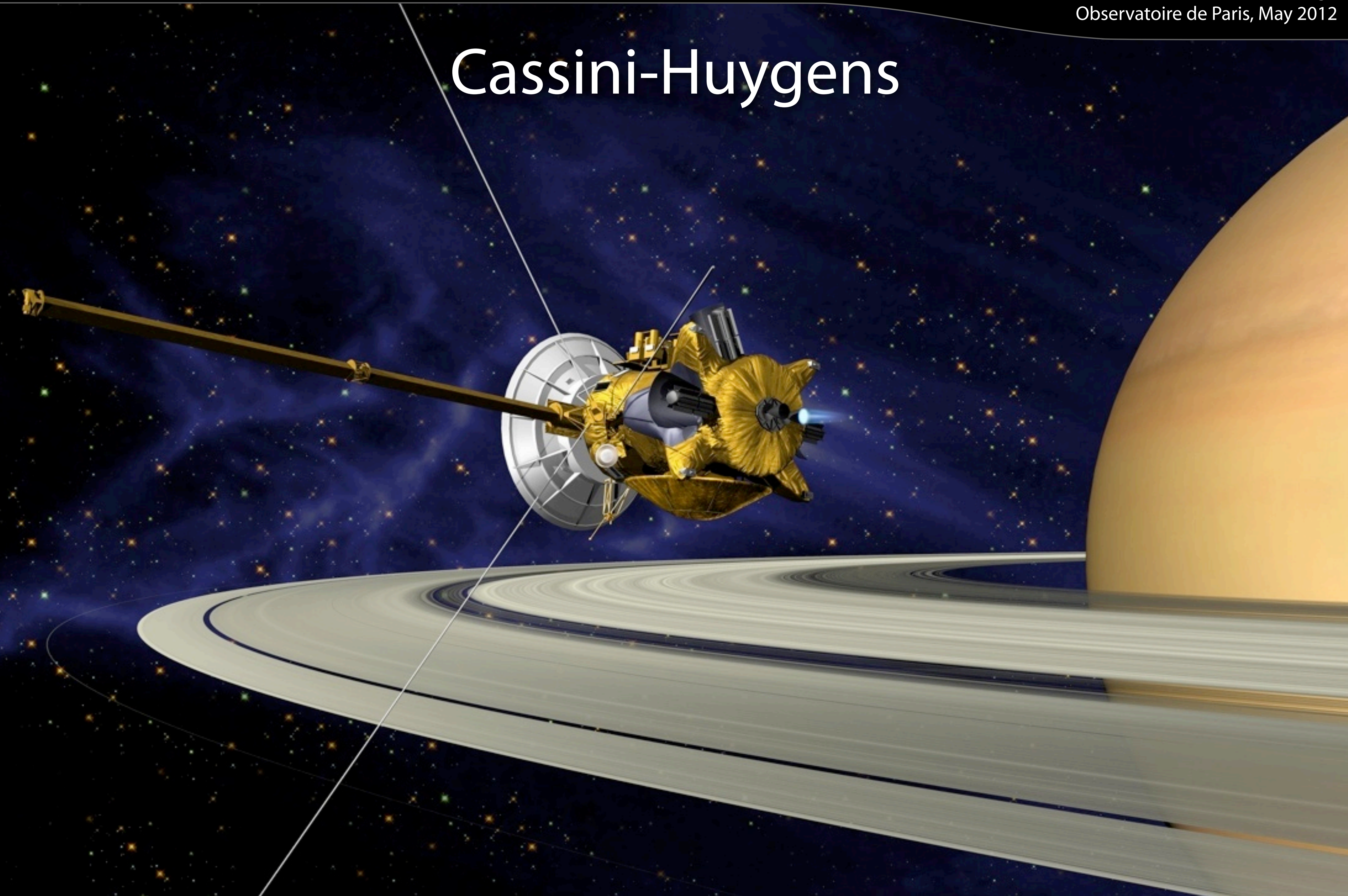
Mean travel-time perturbation map

Solar surface continuum image

Photospheric magnetic field

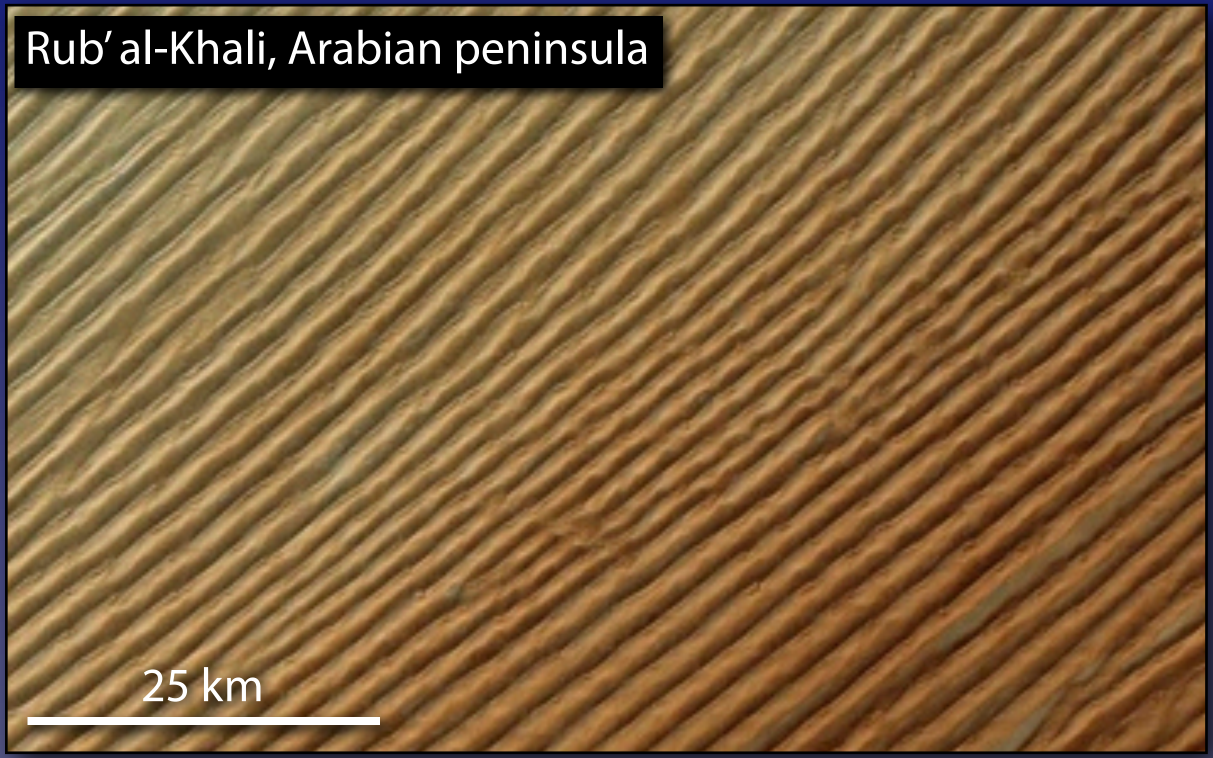
ESA-NASA SOHO MDI data / Ilonidis et al. (2011, Science, 333, 993)

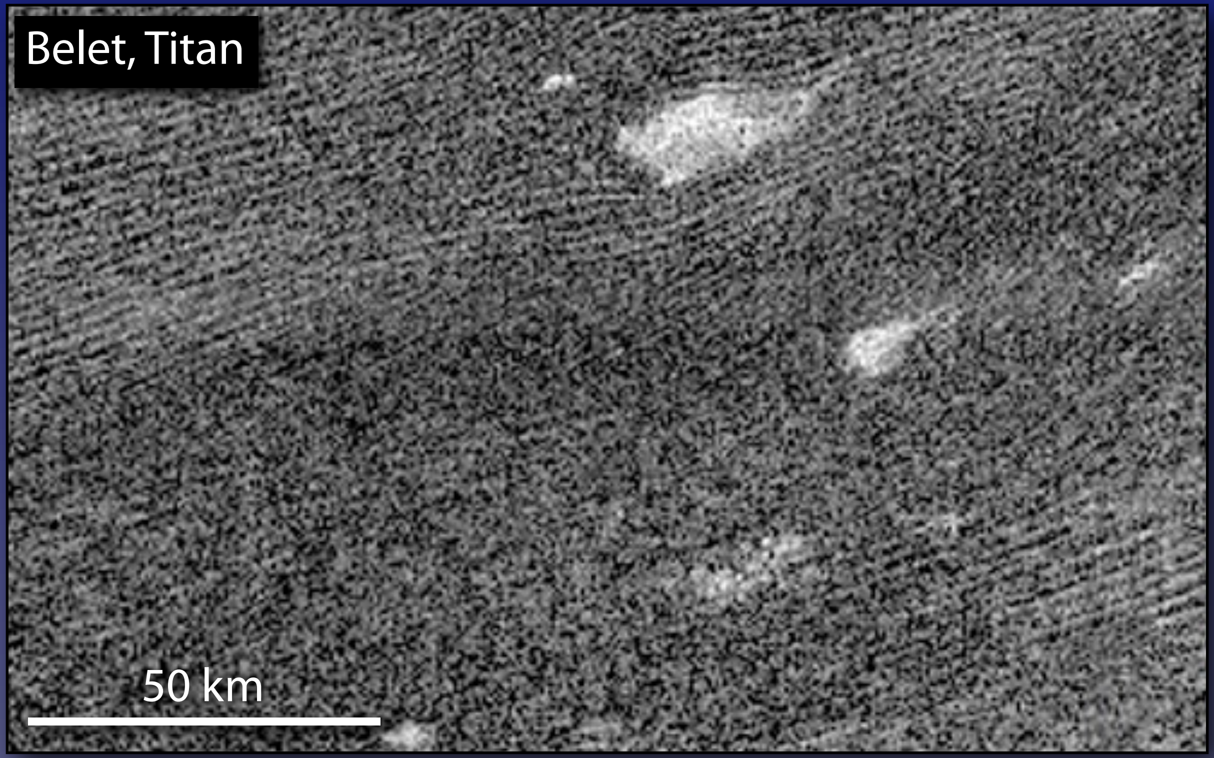
Cassini-Huygens

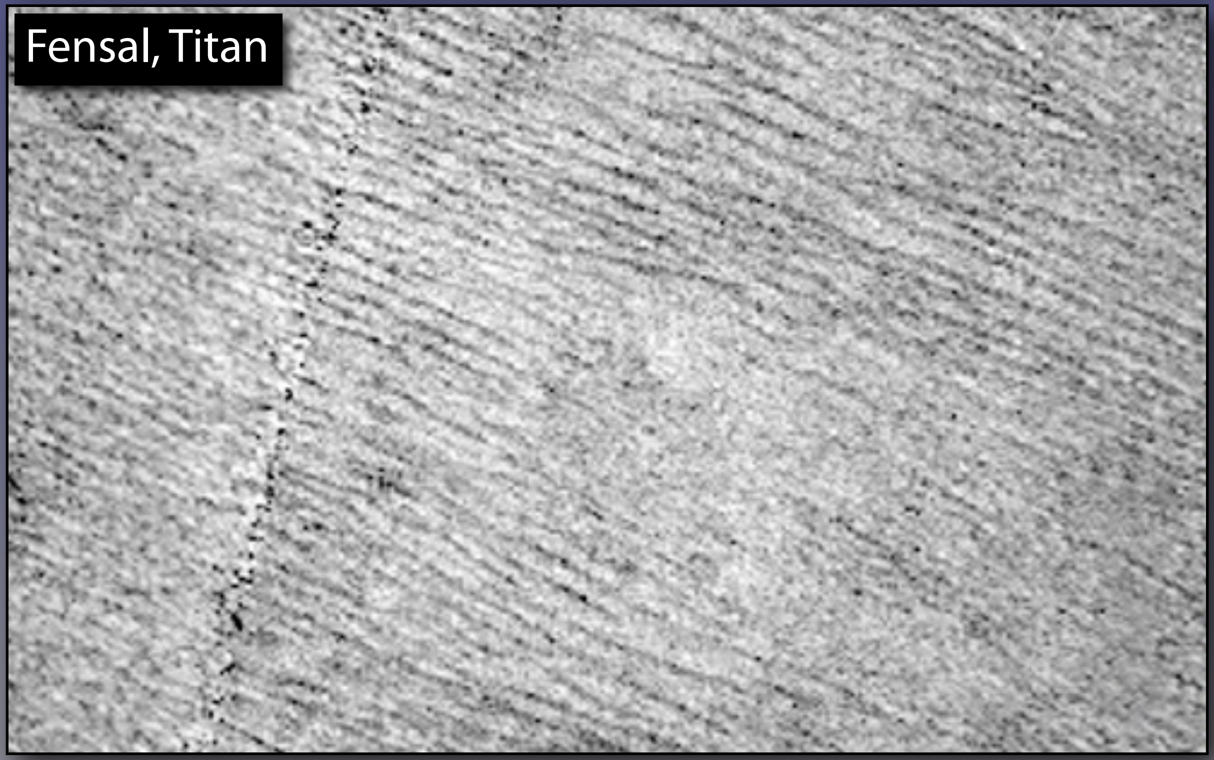


NASA-ESA-ASI mission to the Saturnian system and Titan in particular, launched October 1997

Dunes on Earth and Titan



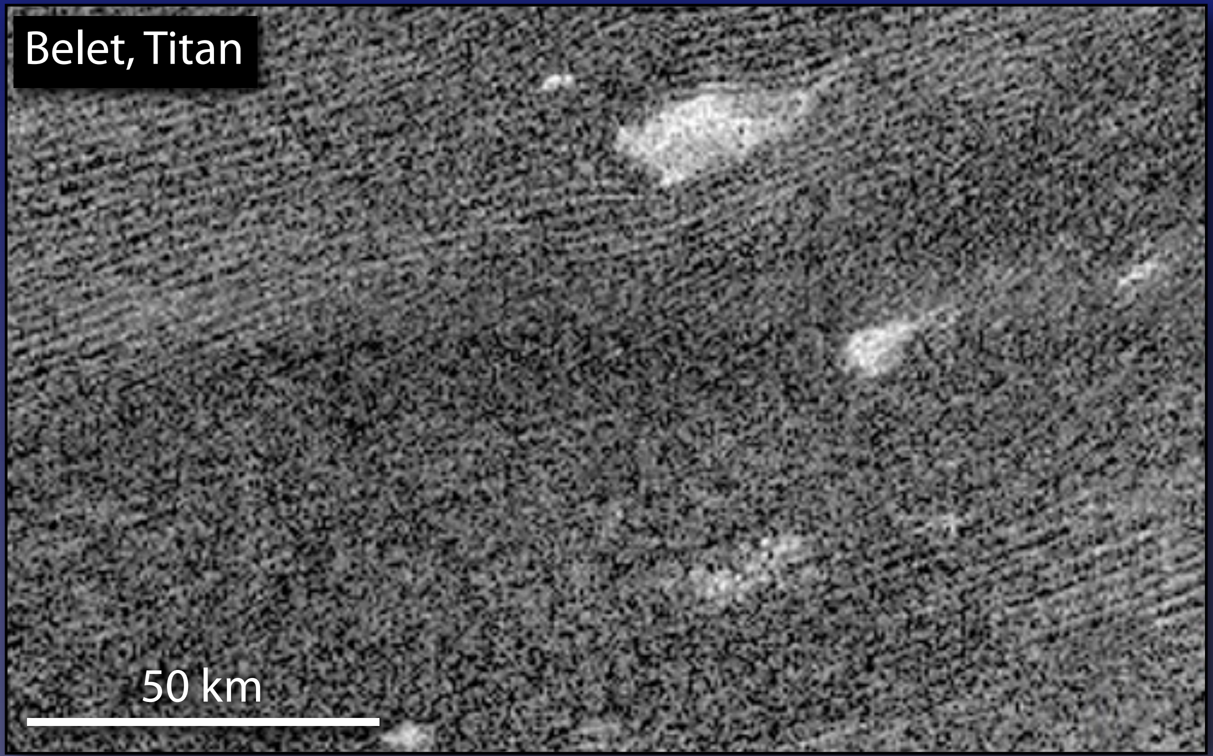


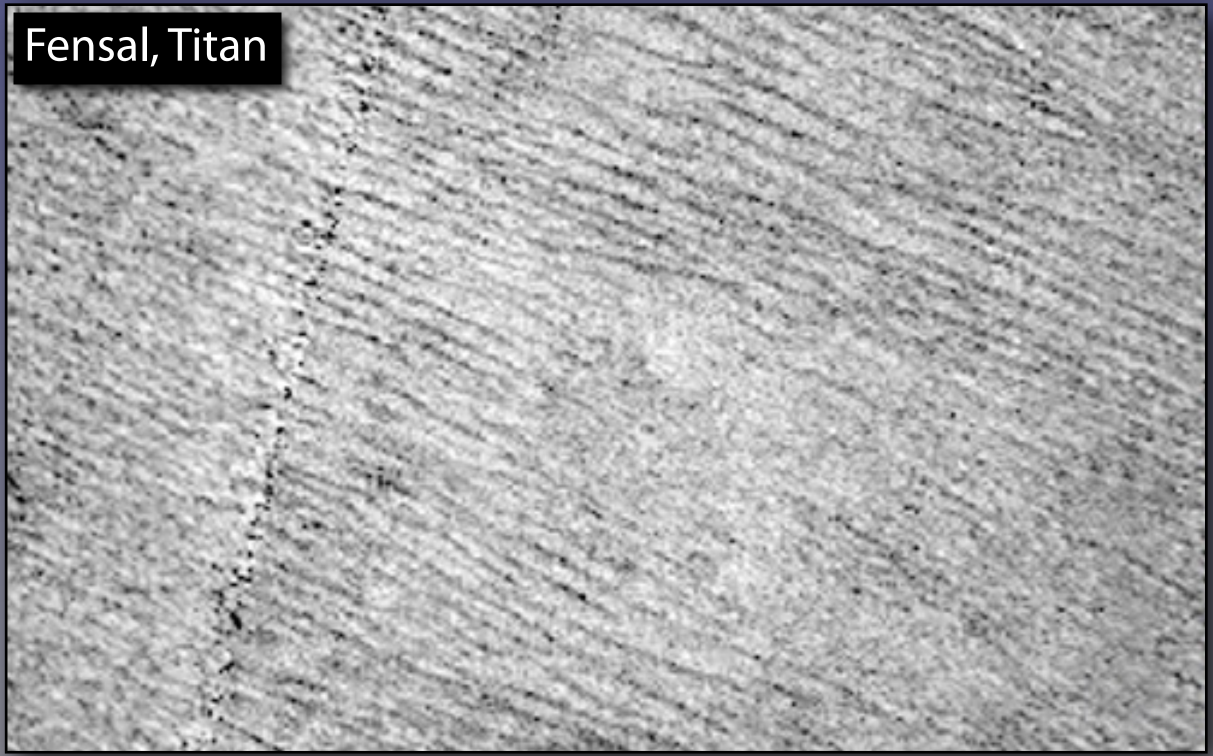


Right: Landsat imagery, USGS / Left: Cassini radar 2.2cm SAR imagery of Titan, NASA/JPL/ESA/ASI

Properties of Titan's dunes

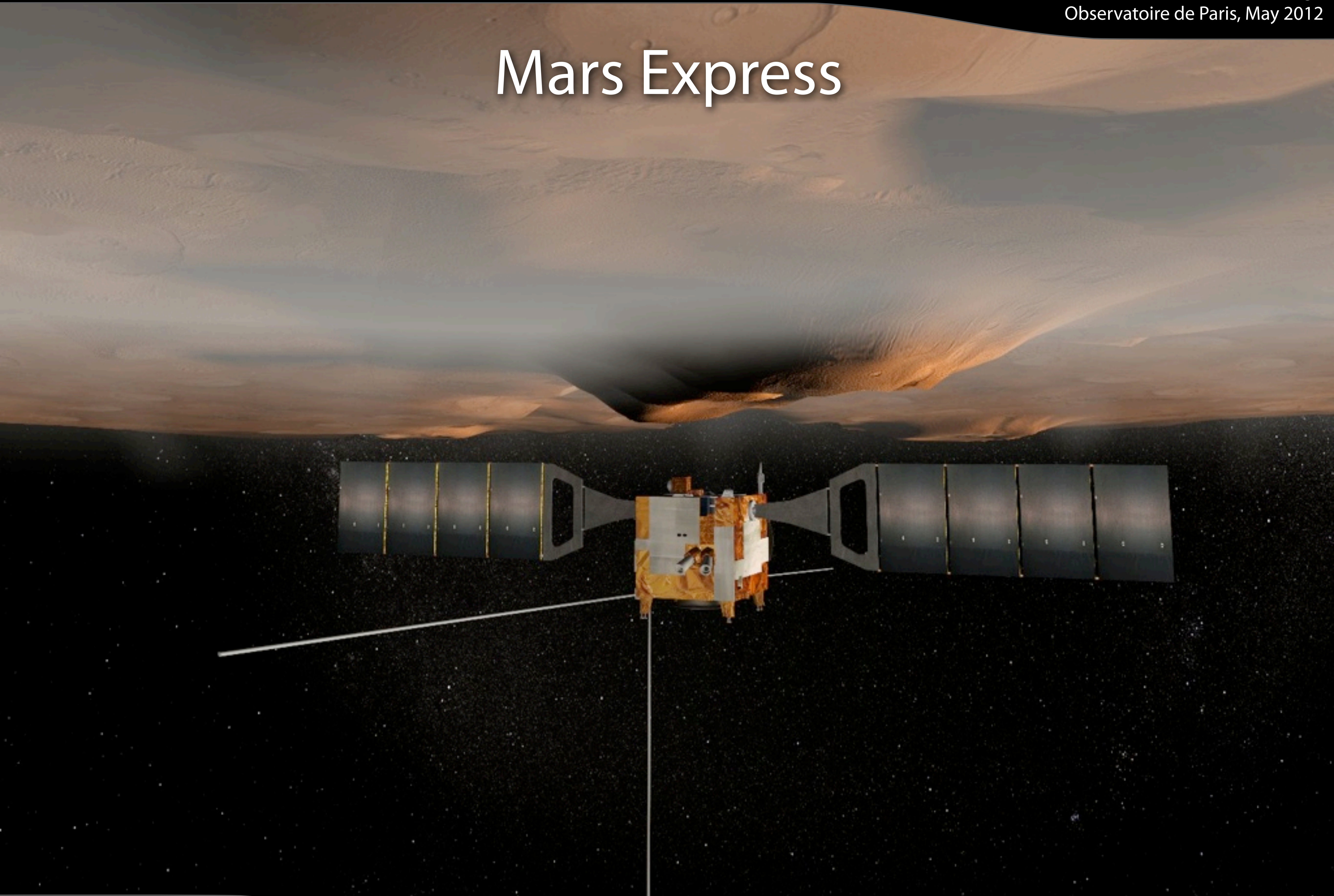
- Dunes cover ~ 13% of Titan surface
  - Important surface-atmosphere interface
  - "Sand" is ~ 1mm hydrocarbon particles
  - Main dune fields in equatorial lowlands
- Properties change with increasing elevation and northerly latitude
  - Dunes become narrower, smaller
  - Space between grows larger, less sand cover
- Elevation dependence:
  - Wind-blown sand collects at lower elevations
  - Less sand to build dunes at high elevations
- Northerly latitude dependence:
  - Saturn's orbit around Sun is elliptical
  - Summer in Titan's south shorter, but hotter
  - Soil in north moister: harder to build dunes





Le Gall et al. 2012, Icarus 212, 231

Mars Express

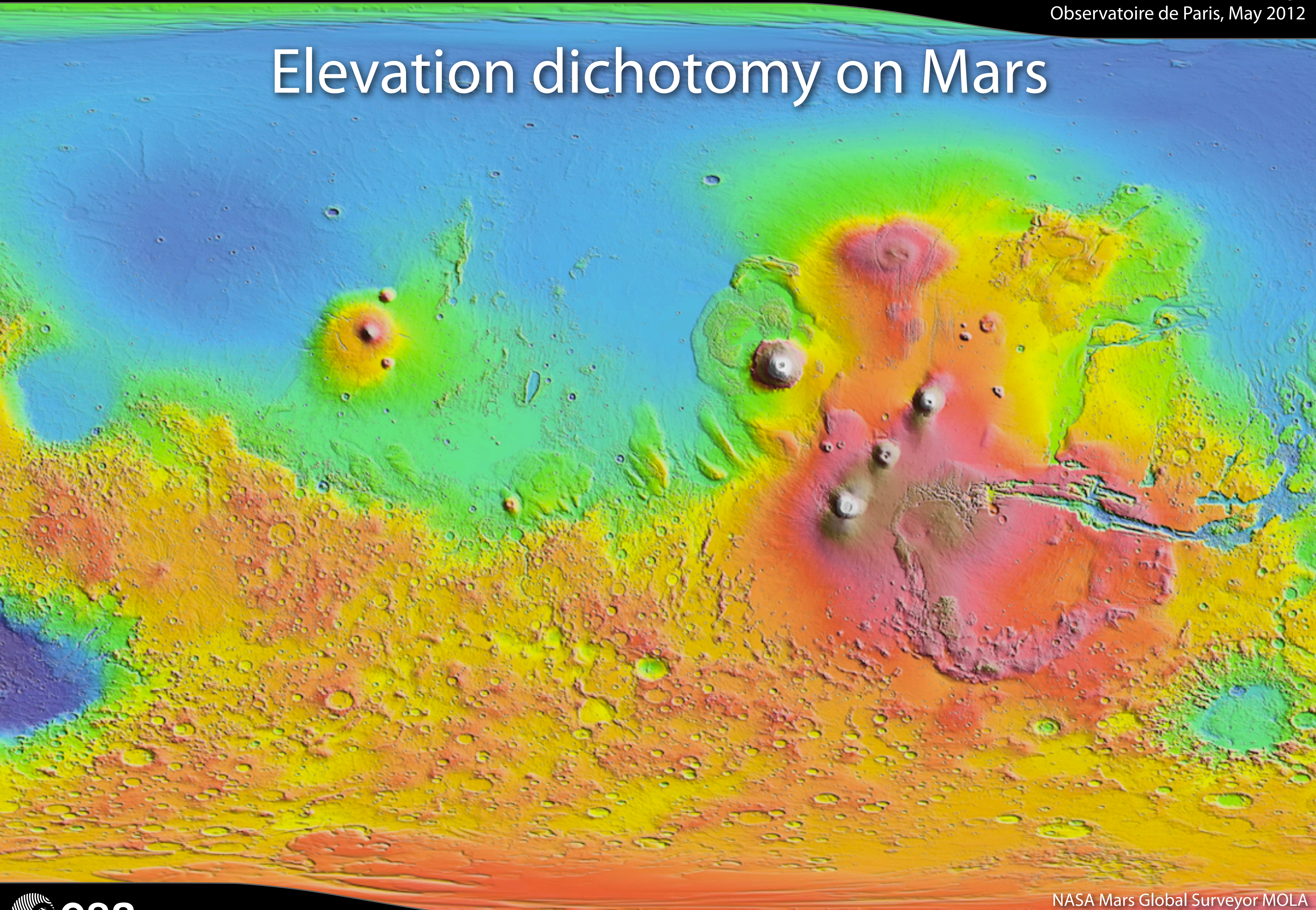


ESA Mars planetary physics mission, launched 2003

Eberswalde crater river delta

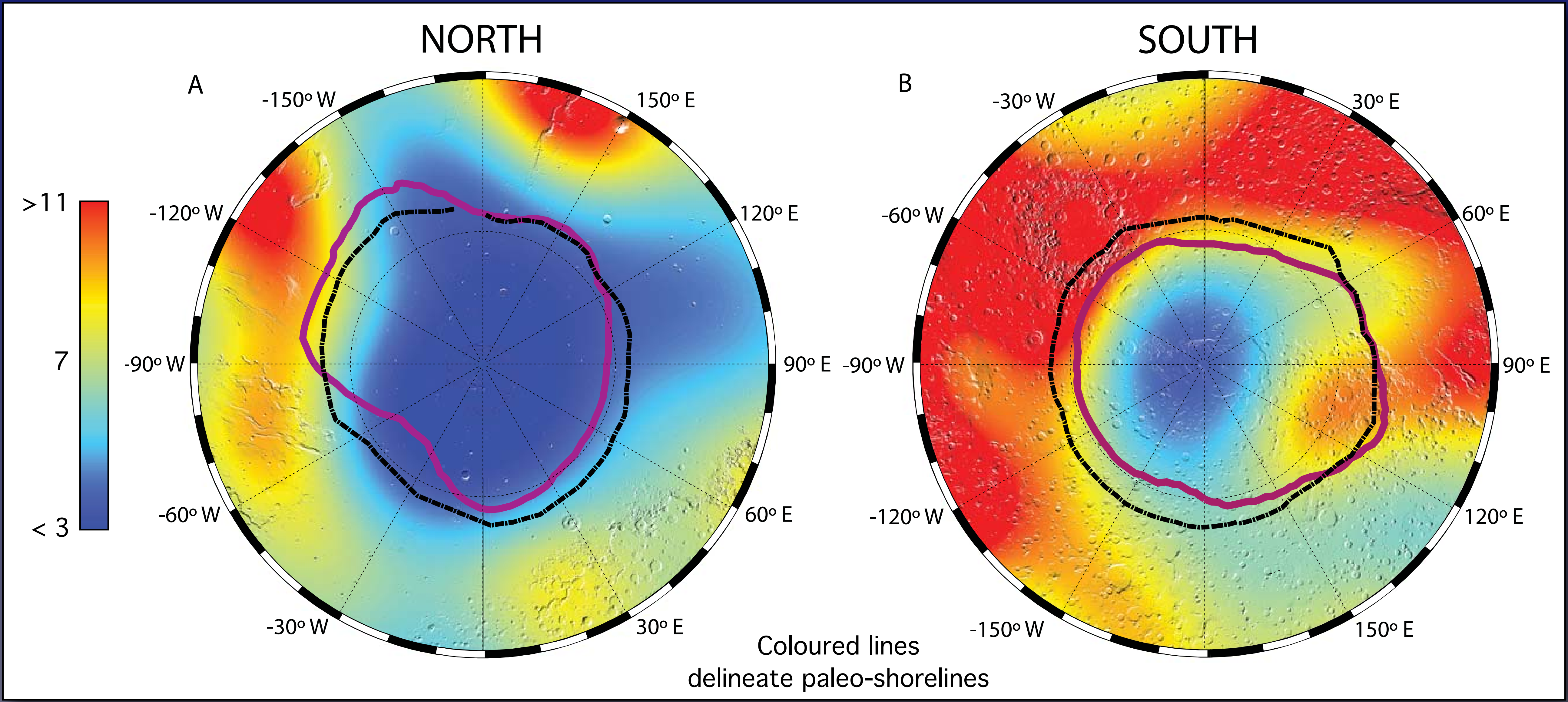
MEX HRSC image release / ESA, DLR, FU Berlin (G. Neukum)

Elevation dichotomy on Mars



NASA Mars Global Surveyor MOLA

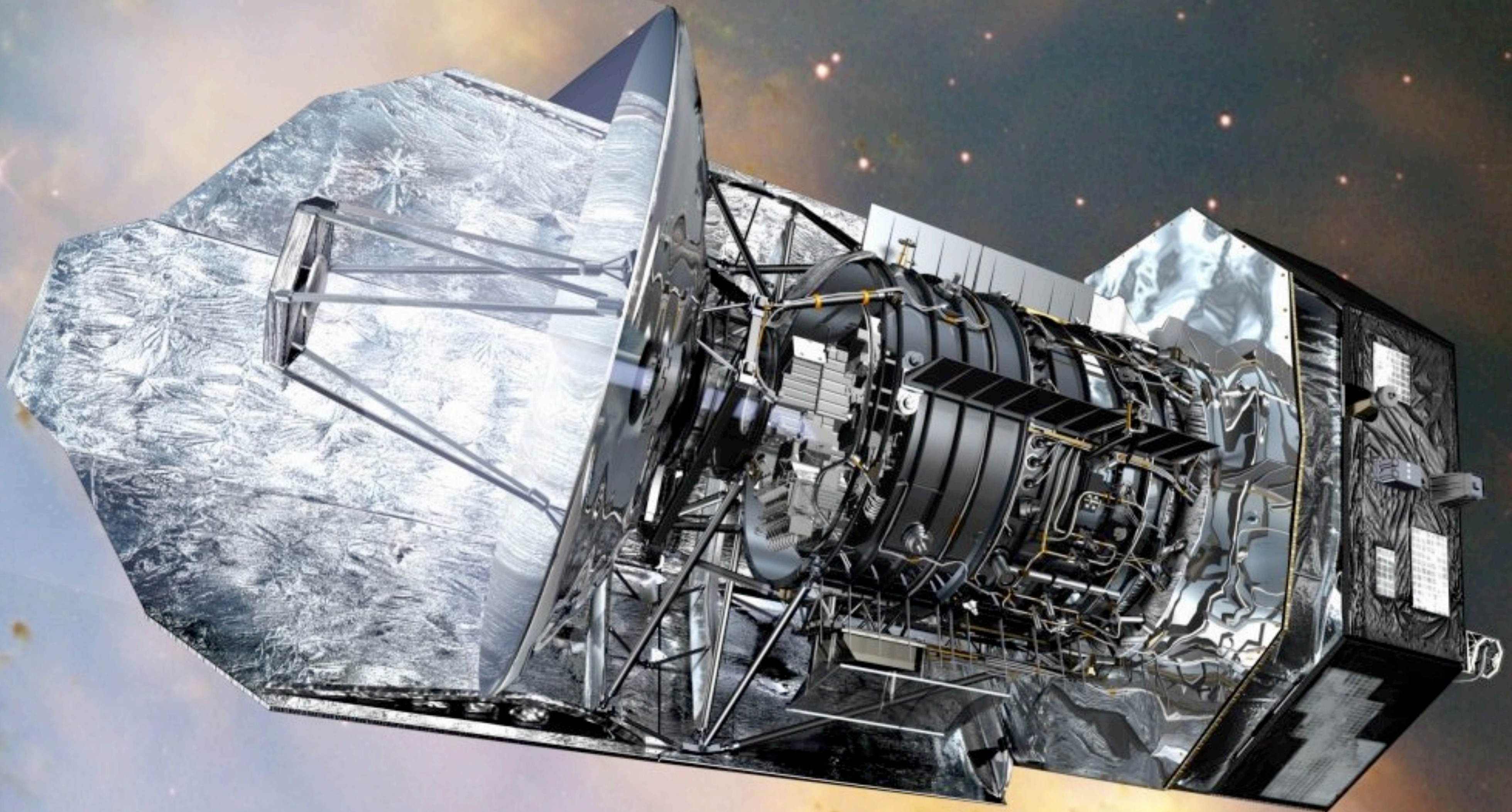
Surface dielectric constant radar mapping



- High in south: high-density volcanic materials
- Low in north: low-density sediments, subsurface ice, or mixture of both
- Result of massive and likely brief inundation ~ 3 Gyr ago: "Oceanus Borealis"

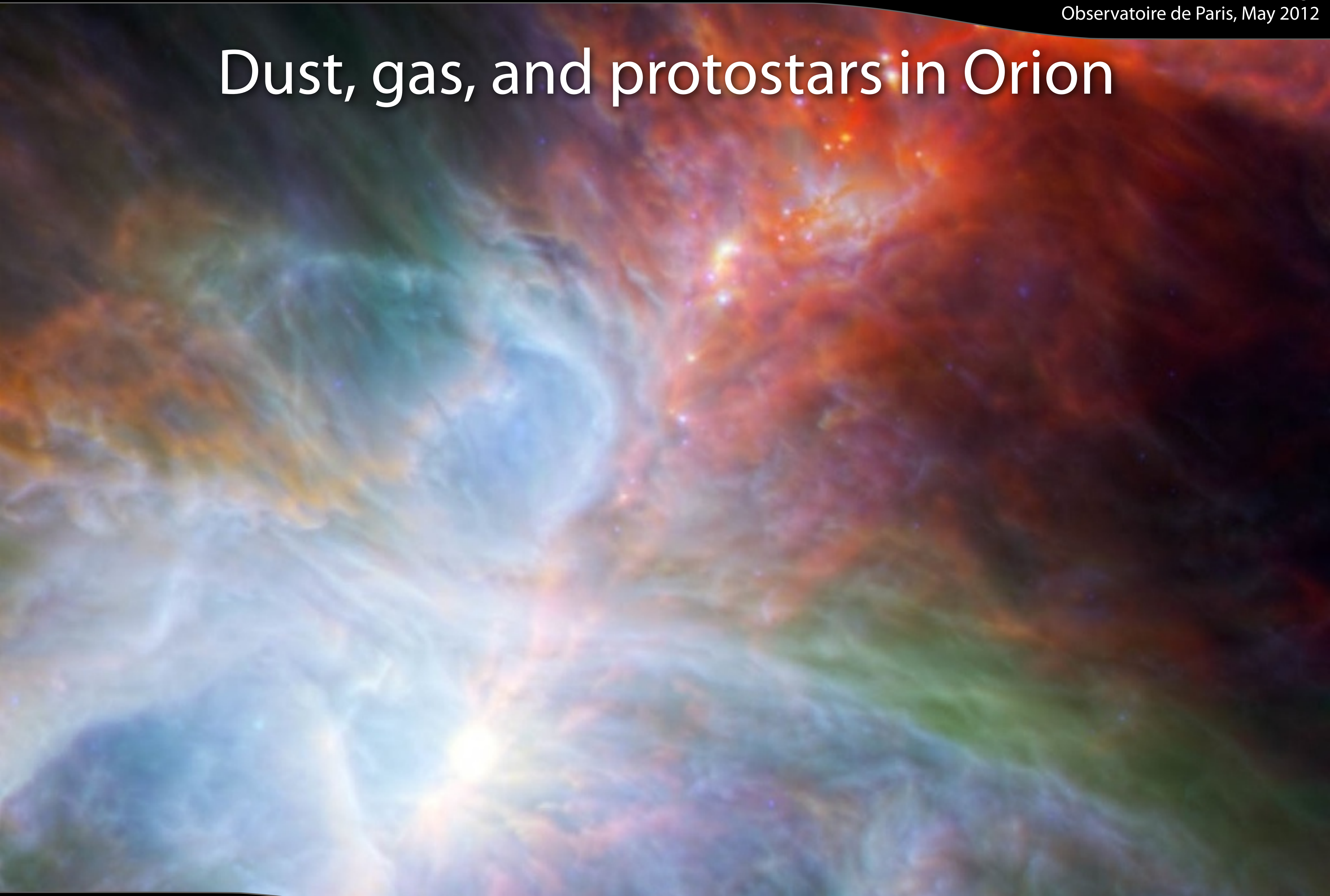
ESA MEX MARSIS / Mouginot et al. 2012, GRL, in press

Herschel Space Observatory



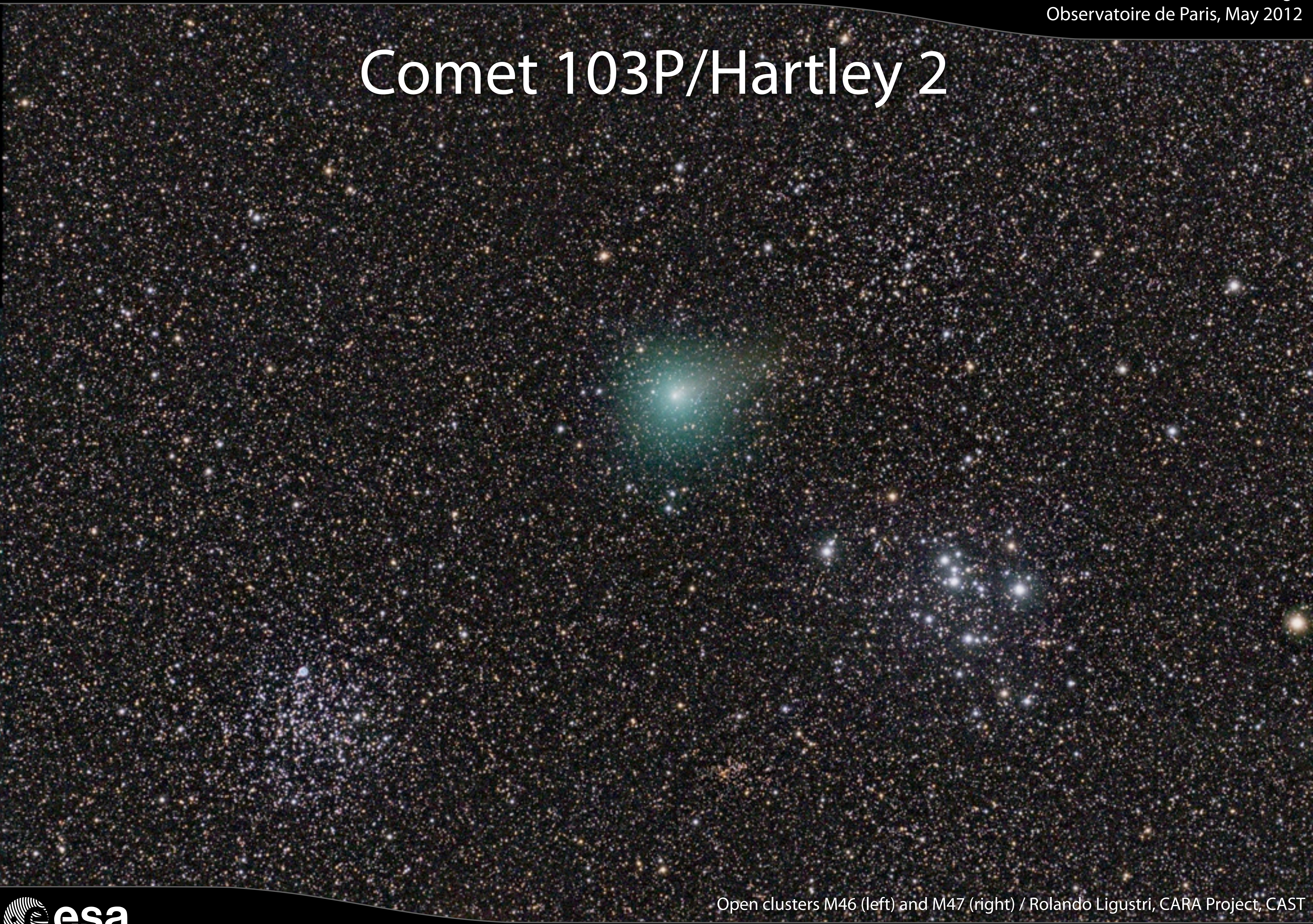
ESA-NASA far-infrared astrophysics observatory, launched 2009

Dust, gas, and protostars in Orion



Mid- and far-infrared image of the Orion Nebula / Spitzer MIPS, NASA + Herschel PACS, ESA

Comet 103P/Hartley 2

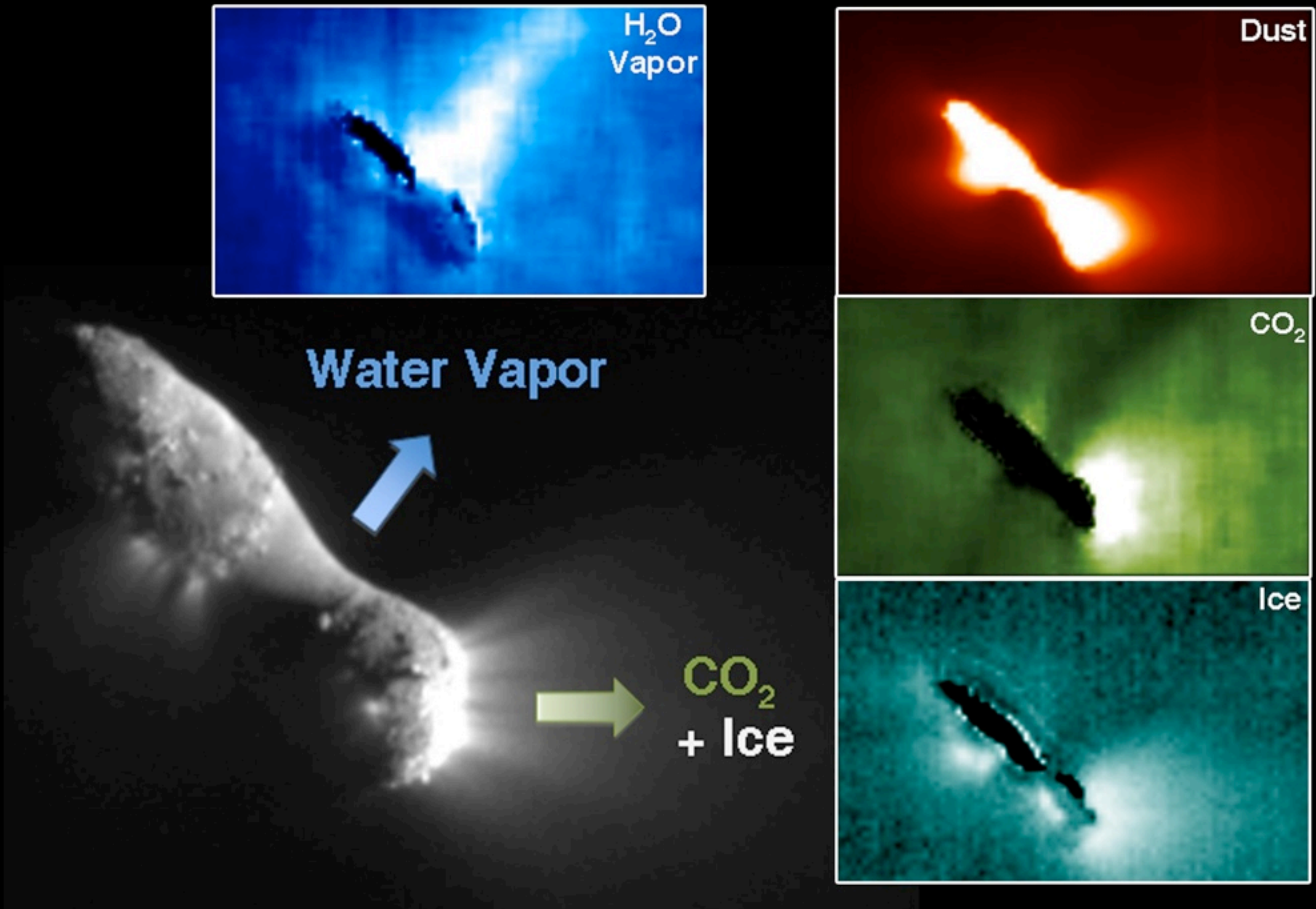


Open clusters M46 (left) and M47 (right) / Rolando Ligustri, CARA Project, CAST

Comet 103P/Hartley 2 close-up

Image taken at 700 km during EPOXI fly-by, November 4, 2010 / NASA, JPL, Caltech, UMD

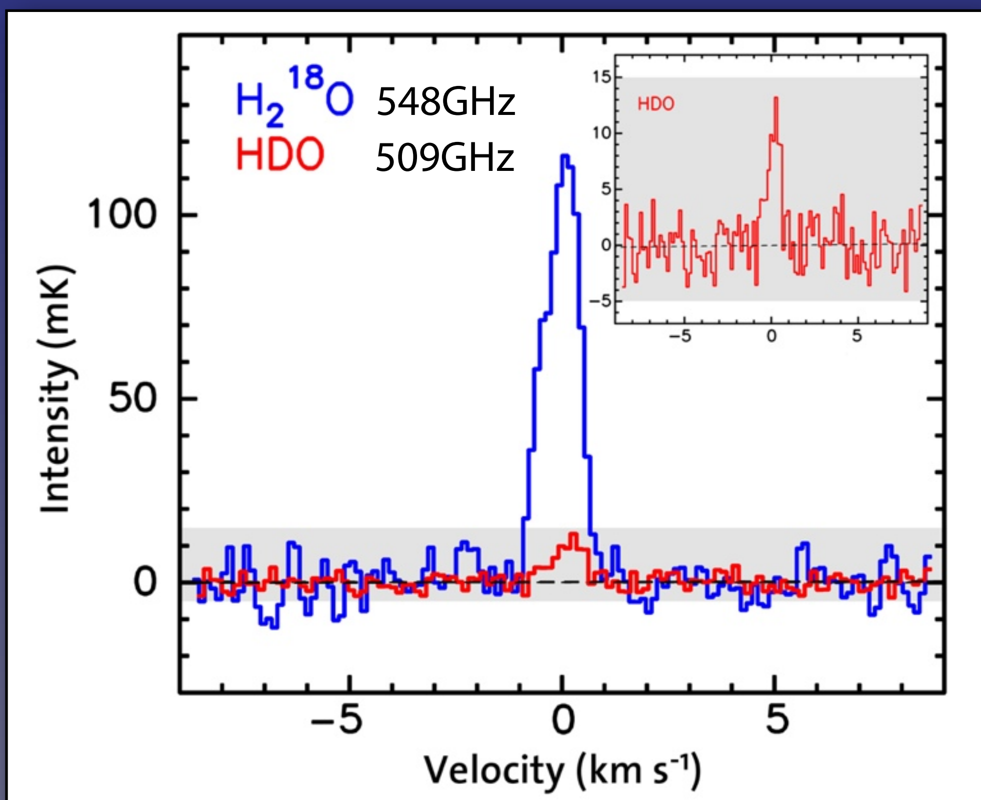
Diagnosing outflows from Hartley 2

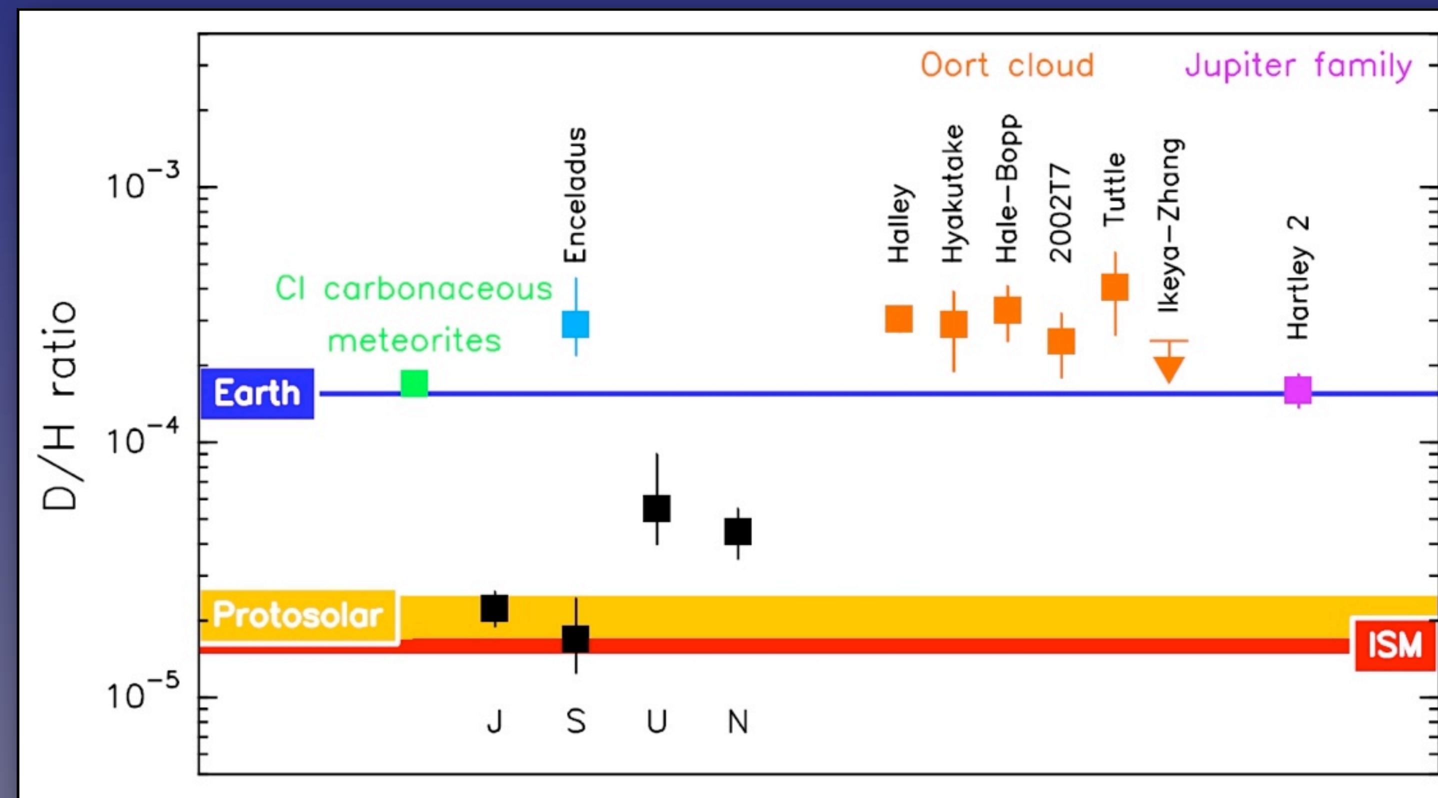


Data taken during EPOXI fly-by, November 4, 2010 / NASA, JPL, Caltech, UMD

Did comets provide Earth's ocean water?

- Young Earth too hot to retain primordial water; must have been later delivery
- Comets obvious candidates, but all measured previously have too high D/H

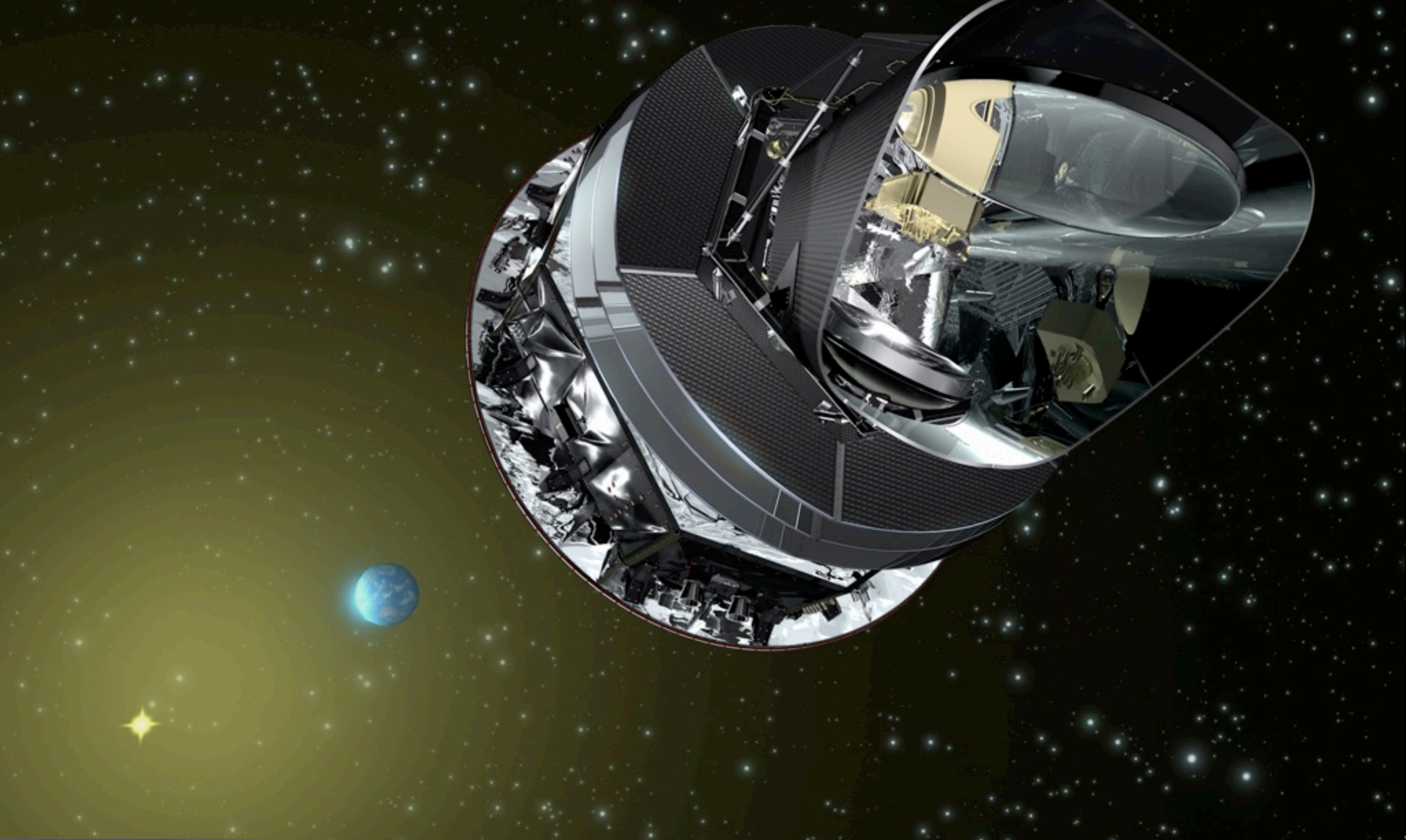




- HIFI data for Hartley 2: first comet with Earth ocean-like D/H ratio
- Jupiter-family comet: formed in outer solar system, migrated in
- Rest are Oort Cloud comets: formed in inner solar system, scattered out
- However, current models predict *increase* in D/H at larger radii: problem?

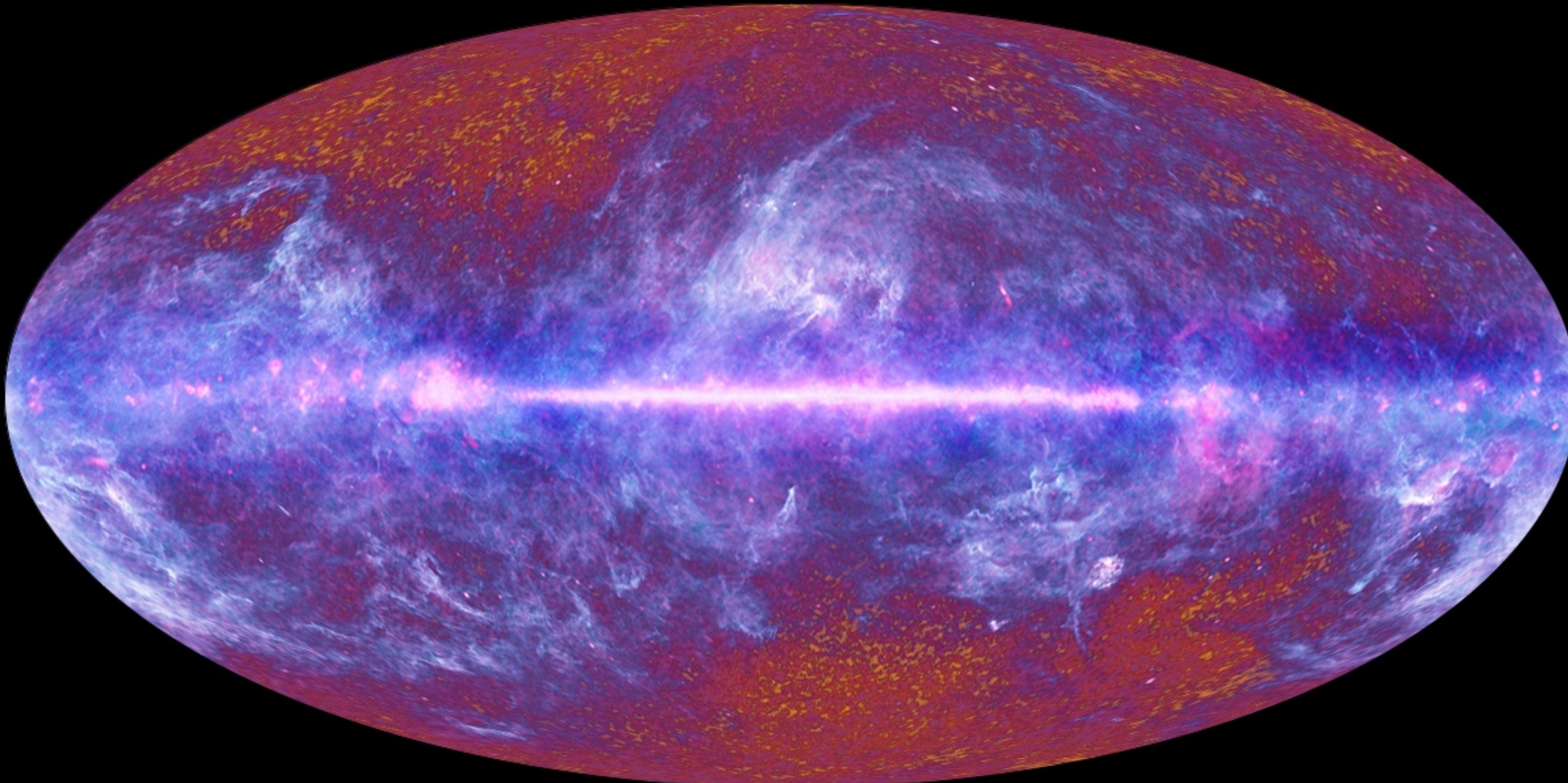
Hartogh et al. (2011, Nature, 478, 4638)

Planck



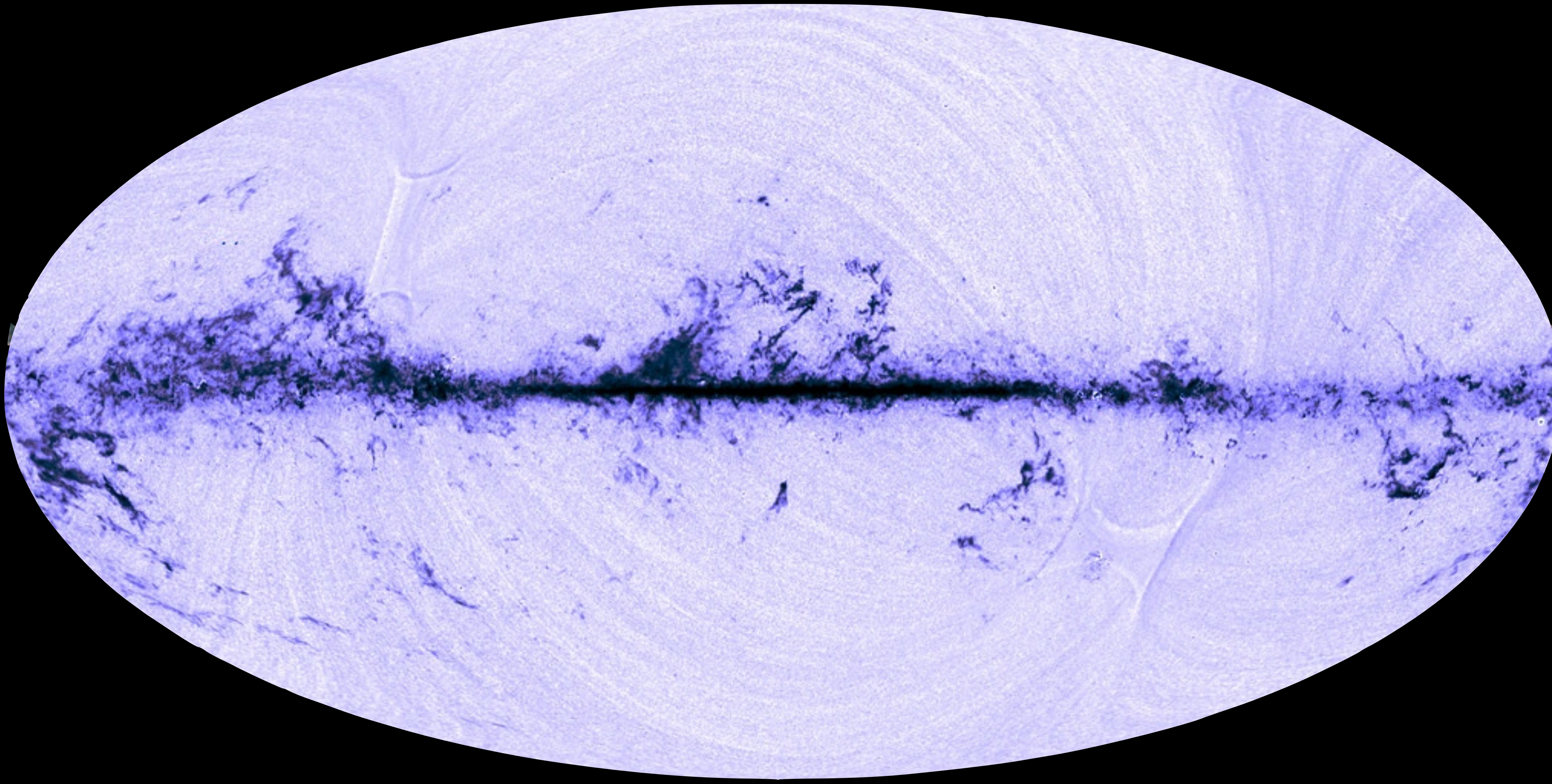
ESA cosmic microwave background experiment, launched 2009

Planck all-sky image



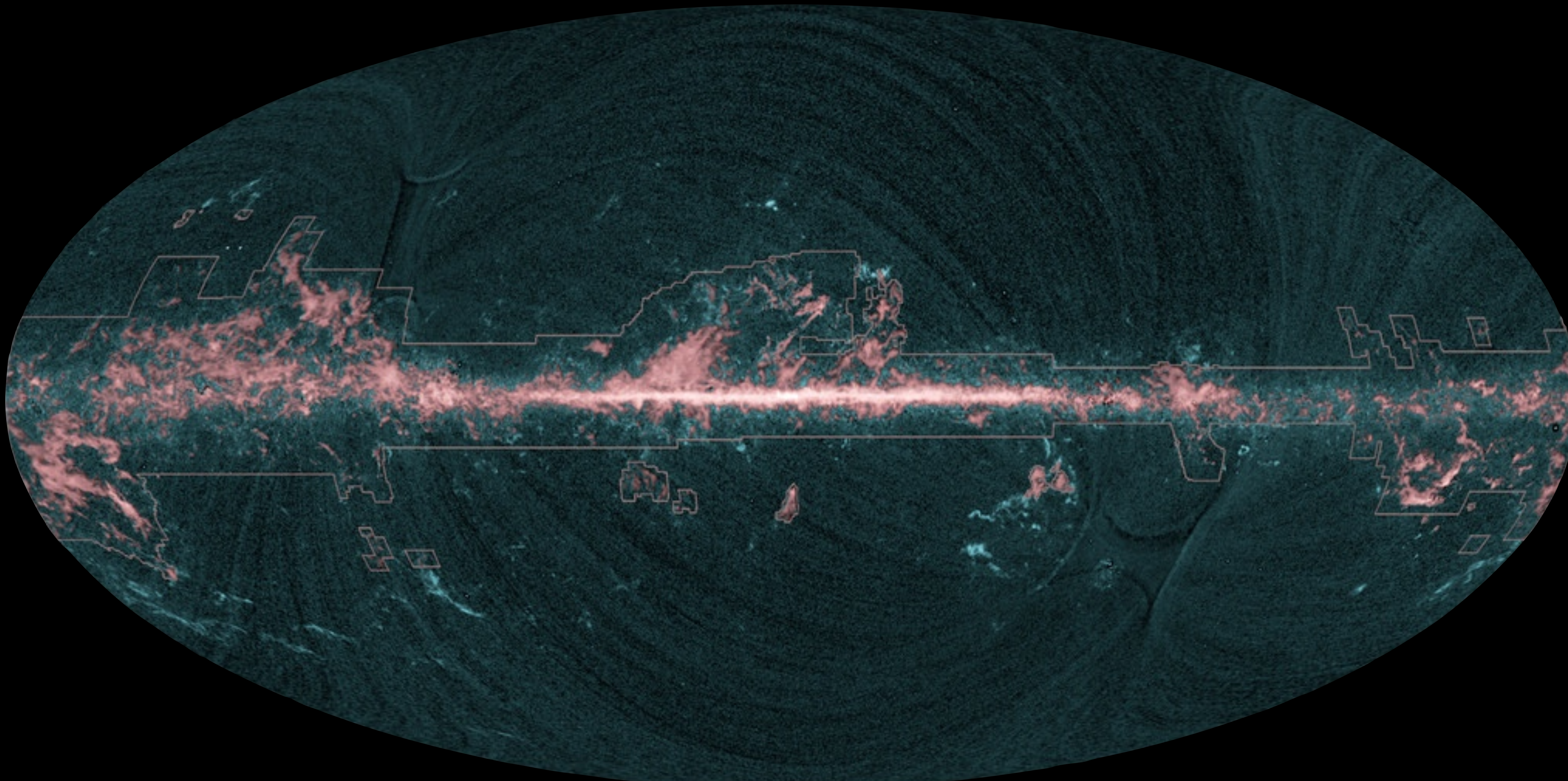
HFI & LFI consortia, ESA; released July 2010

Planck survey of galactic carbon monoxide



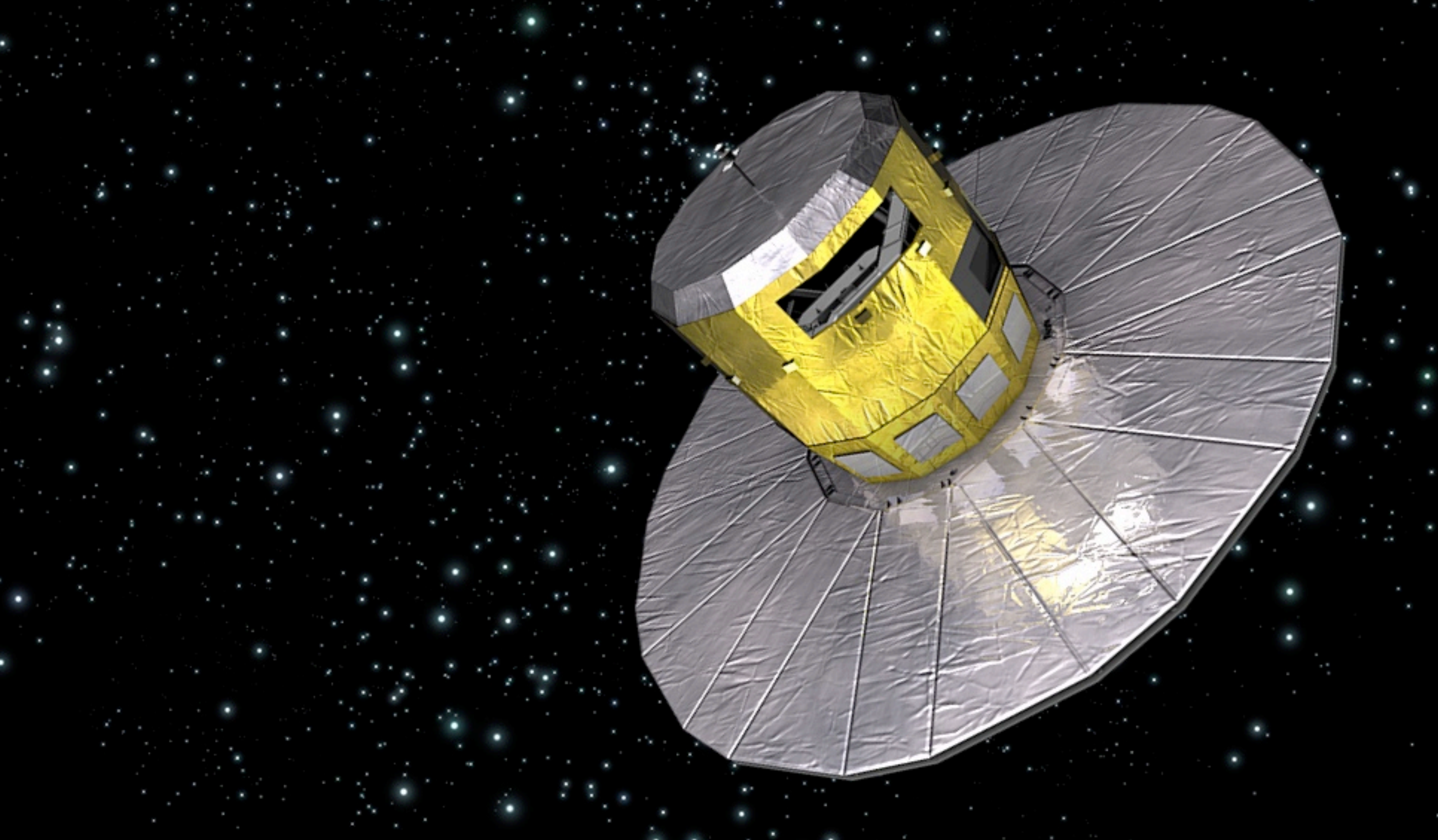
Planck HFI CO map; released February 13, 2012

Carbon monoxide comparison



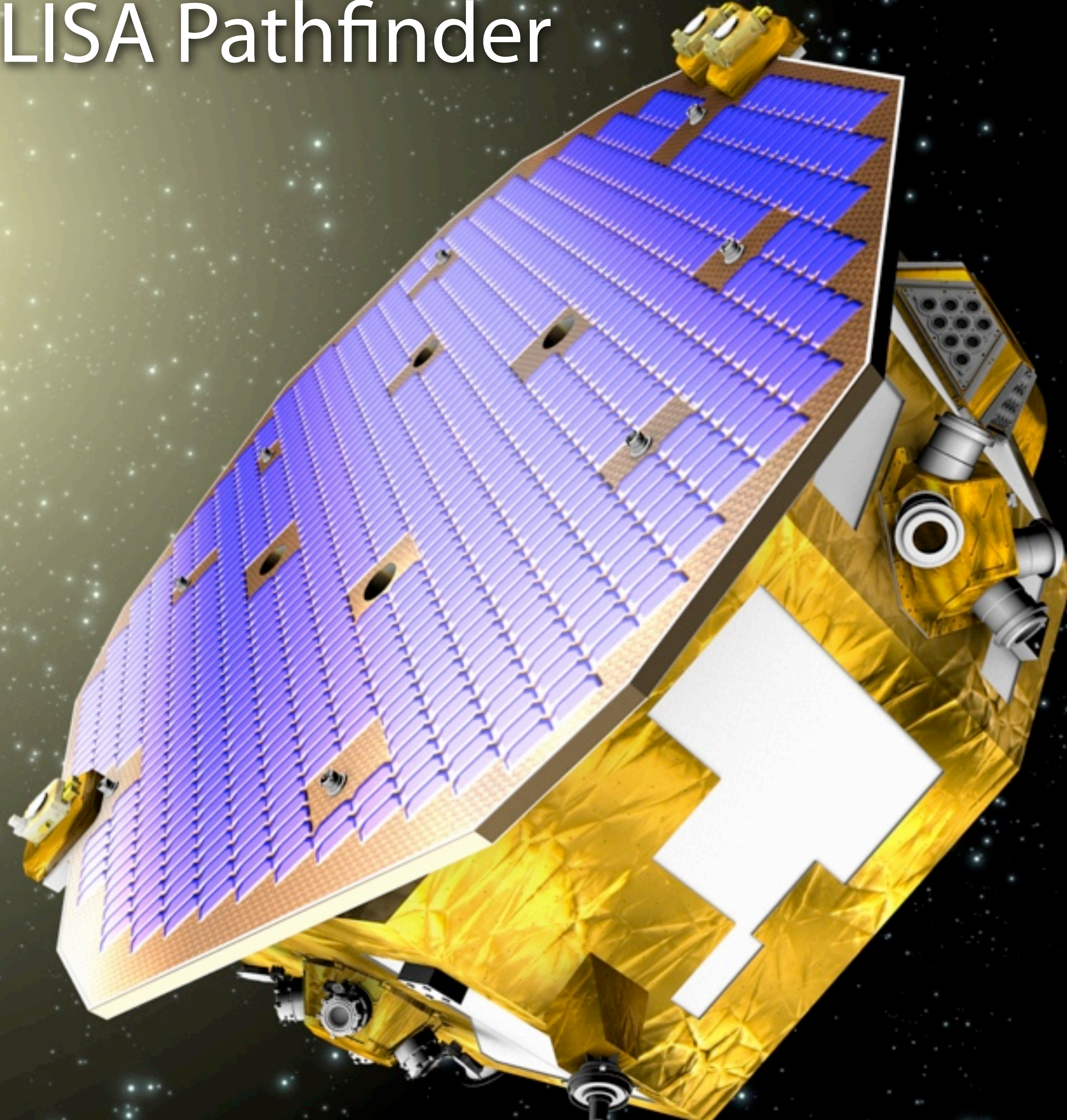
Combined Dame et al. CfA + Planck HFI CO map; released February 13, 2012

GAIA



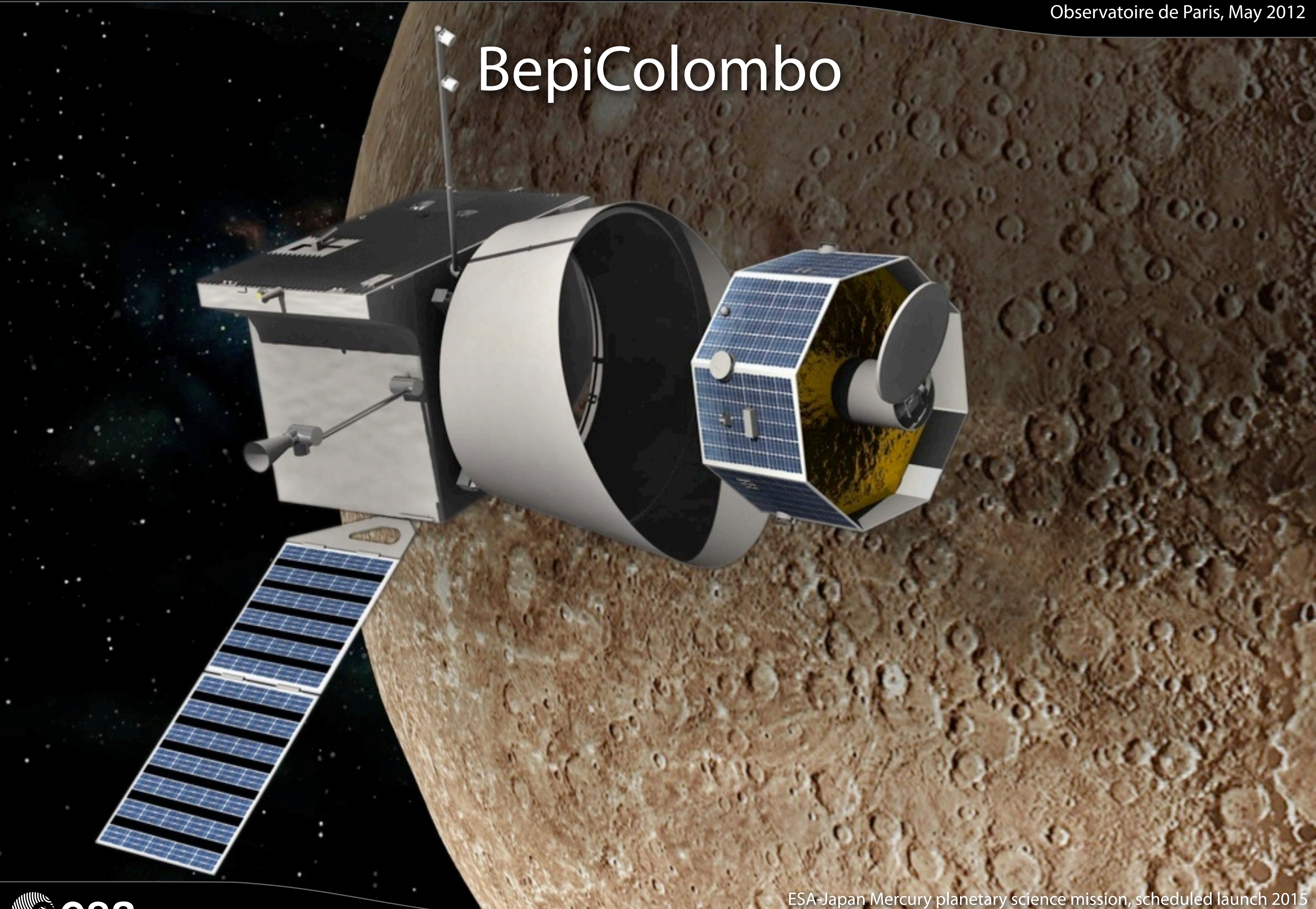
ESA precision astrometry mission, scheduled launch 2013

LISA Pathfinder



ESA gravitational wave detection technology testbed, scheduled launch 2014

BepiColombo



ESA-Japan Mercury planetary science mission, scheduled launch 2015

Solar Orbiter

Cosmic Vision M1 mission

ESA-NASA inner heliosphere mission, launch 2017

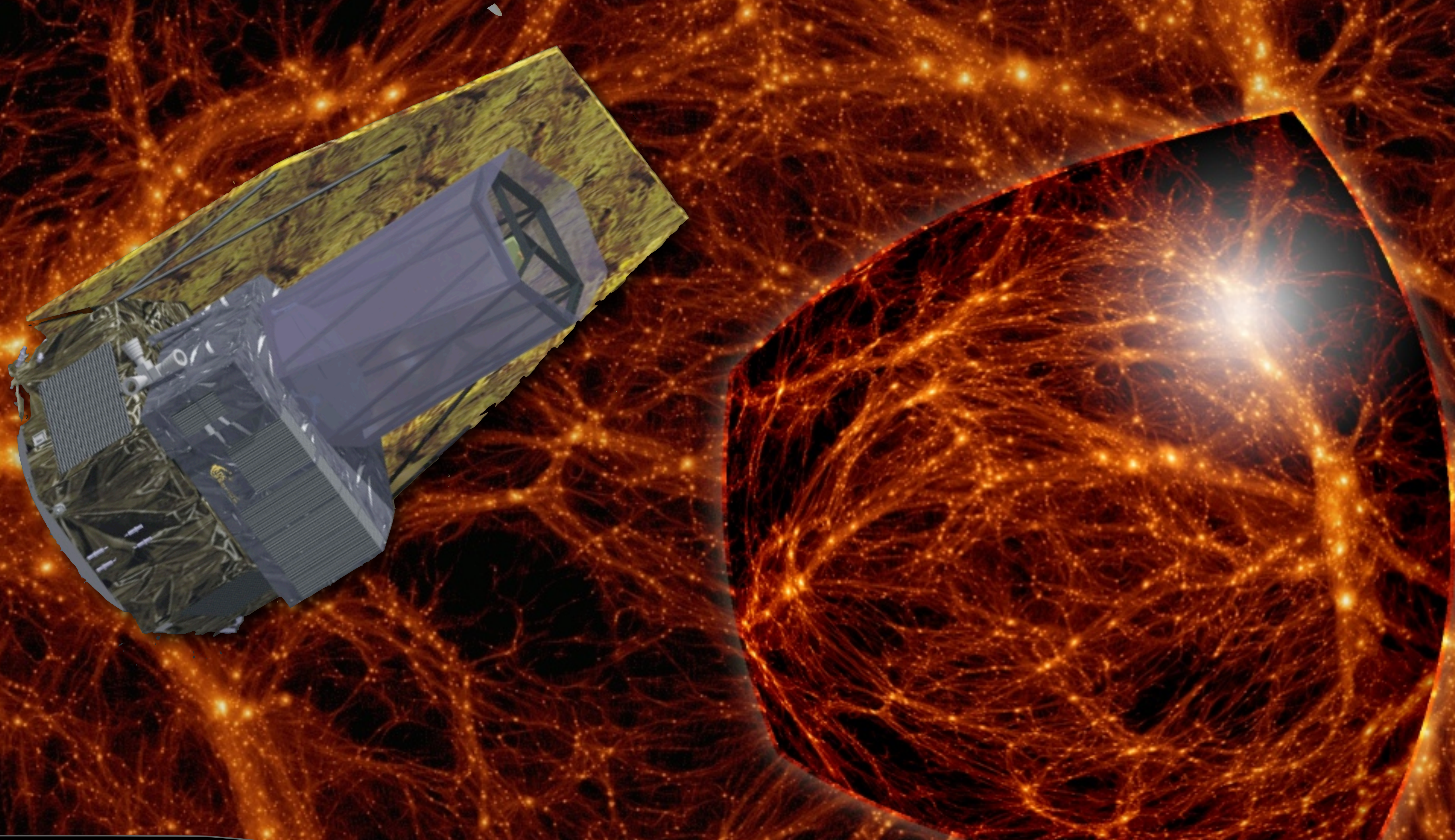
James Webb Space Telescope

Background: ESO/S. Guisard

NASA-ESA-CSA optical-infrared astrophysics observatory, scheduled launch 2018

Euclid

Cosmic Vision M-mission



ESA dark Universe astrophysics survey mission, launch 2019

Jupiter Icy Moons Explorer

Cosmic Vision L1 mission

ESA mission to Jupiter, Callisto, Europa, and Ganymede, launch 2022