

# Amateur astronomy support to current and future space missions:

From the 2010s to the 2030s

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Candice Hansen<sup>4</sup>, John H. Rogers<sup>5</sup>, Olivier Mousis<sup>6</sup>, Marc Delcroix<sup>7</sup>, and Manuel Scherf<sup>8</sup>

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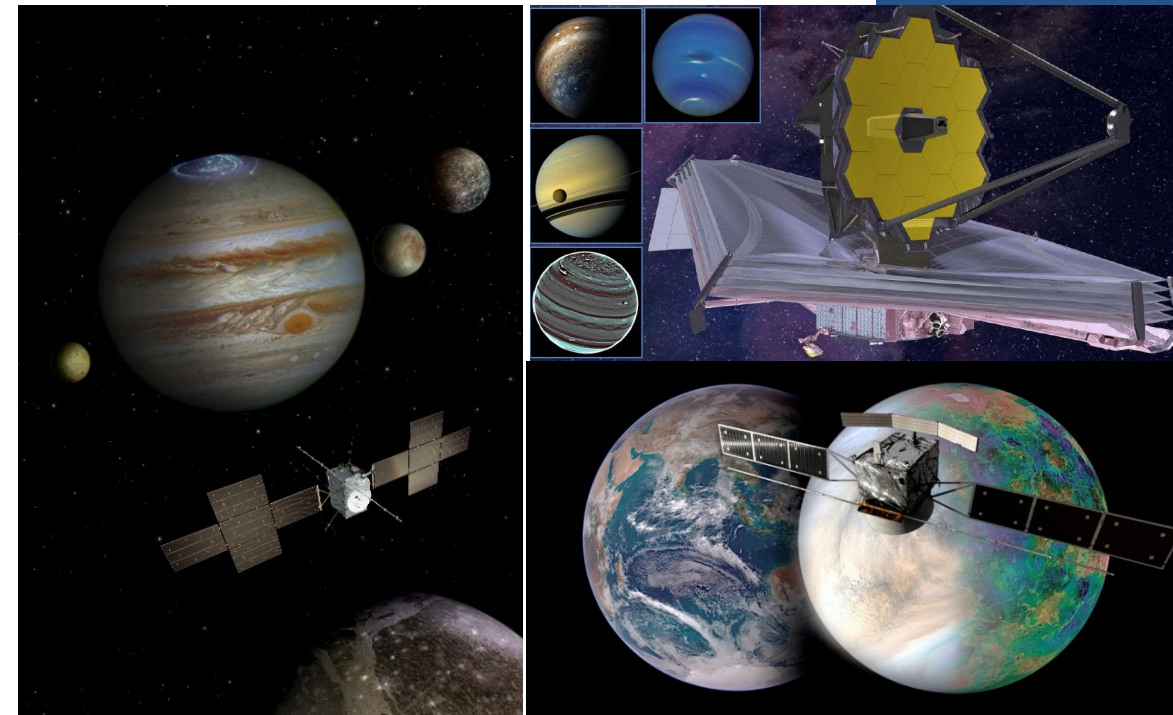
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UNIVERSITY OF  
LEICESTER

JPL

Jet Propulsion Laboratory  
California Institute of Technology



# The need for **amateur** ground-based observations

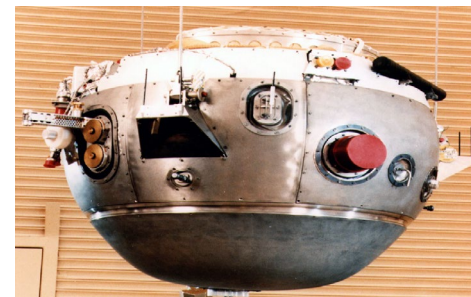
## GROUNDBASED data in support of space missions

- Spectral resolution (large ground-based telescopes)
- Spatial & Temporal resolution (Amateur contribution is astronomy in the time domain)

**In the 80s: The International Jupiter Watch** (Russell et al., Adv. In Space Res. 1990). An informal organization set-up in the US in the 80s largely inspired in *The International Halley Watch* (1985). Later grew into the **IOPW: International Outer Planets Watch** and its PVOL database.

- Recognition of the need to monitor Jovian activity for long periods of time including atmosphere, satellites, magnetosphere and the important contribution that can be made by a network of amateur observers.
- An important testimony of the power of amateur observations to study Jupiter in the famous “**The Giant Planet Jupiter**”, John H. Rogers (Cambridge University Press, first published: 1995; still widely used).

**Fundamental motivation:** To support the investigations to be done by the **Galileo Mission** (launch: 1989; Science: 1995-2003)



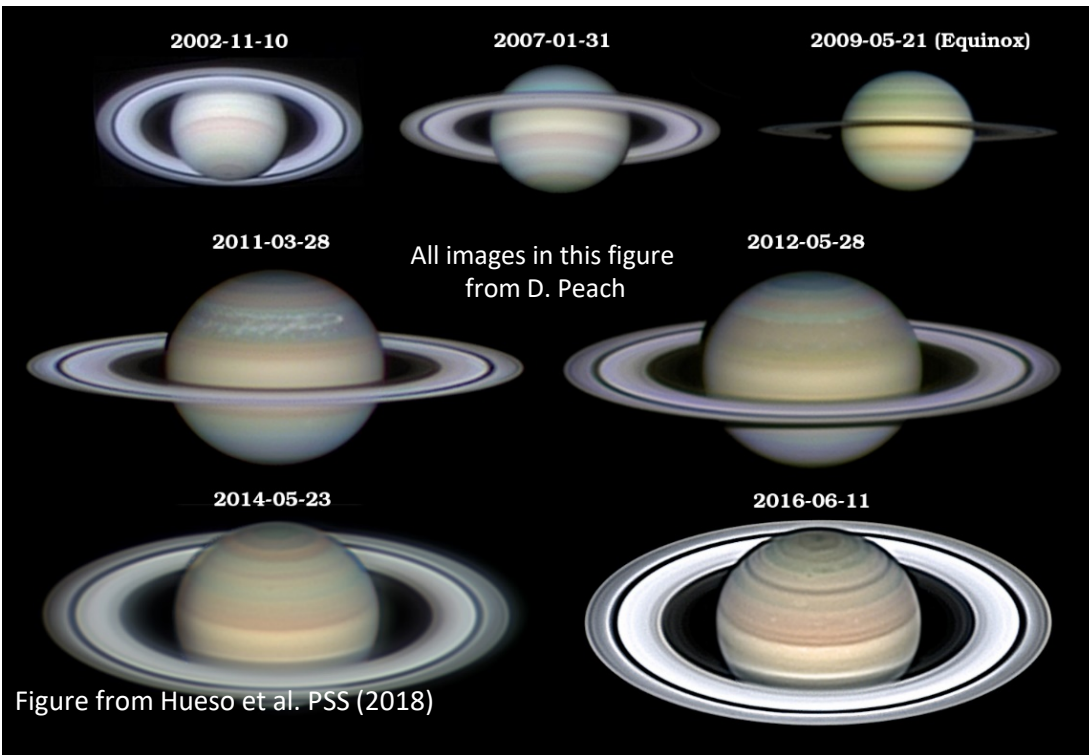
The  
Galileo Probe



21 years ago  
(image by a very  
young Damian  
Peach, UK)



# A Jump in technology: In Missions and in amateur astronomy technology

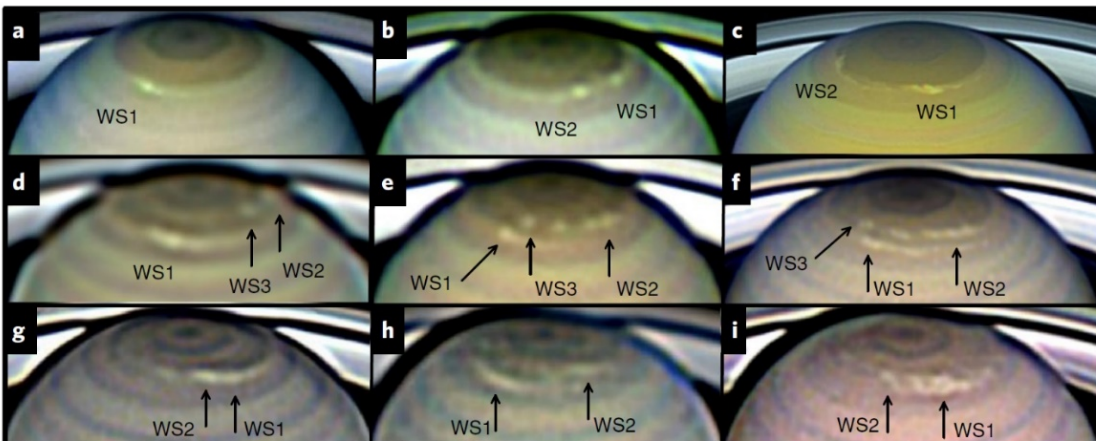


## Continuous improvement in observations quality

***A huge field in development!***  
*Possibilities in all solar system planets and other solar system topics & Exoplanets*

Mousis, Hueso et al., “***Instrumental methods for professional and amateur collaborations in planetary astronomy***”, *Space Sci. Rev.* (2014)  
60 coauthors (including 17 amateurs)

*PRO-AM collaborations in a wide number of missions from Venus Express or Akatsuki, to New Horizons, Rosetta and Cassini.*





## ***Saturn after Cassini***

**Modern (2018) HST & Amateur views of Saturn's atmosphere**


*Figure from: Sánchez-Lavega et al. Nature Astronomy (2020)*  
*See also: Hueso et al. Icarus (2020)*



# A recent revolution from the successful approach by the Juno Mission

 MENU


<https://www.missionjuno.swri.edu/junocam>




**CITIZEN SCIENTISTS:  
DATA FOR THE WORLD**

The images processed by citizen scientists range from detailed scientific imagery and analyses, to beautiful works of space-themed art.

WATCH THE FILM



**JUPITER ABYSS**



**FEATURED  
JUNOCAM IMAGES**

Amateurs are key players in the Ground-based support of the Juno Mission due to its orbit design.

*New Views of Jupiter: Pro-Am Collaborations during and Beyond the NASA Juno Mission  
Europlanet Workshop, 10-11 May 2018, Royal Astronomical Association, London*



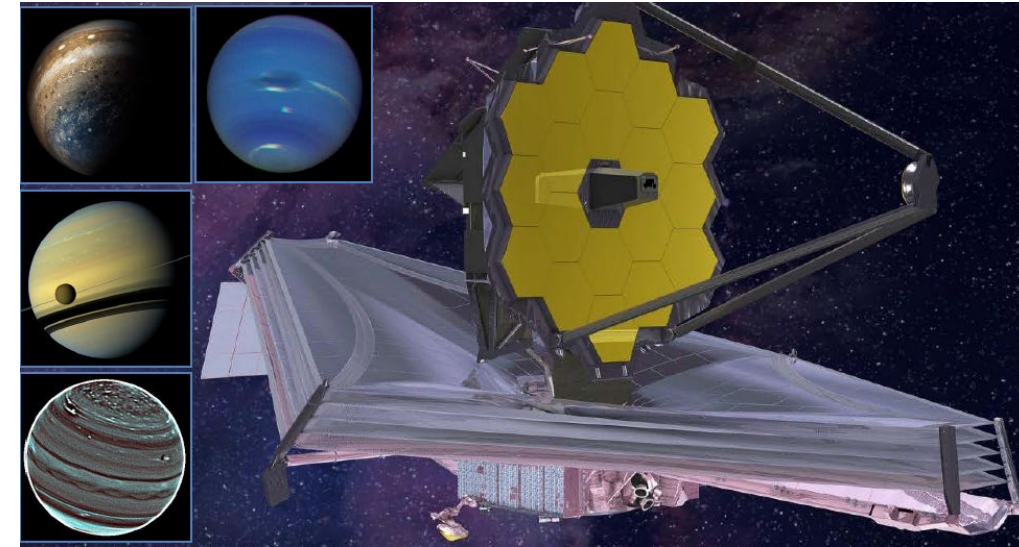
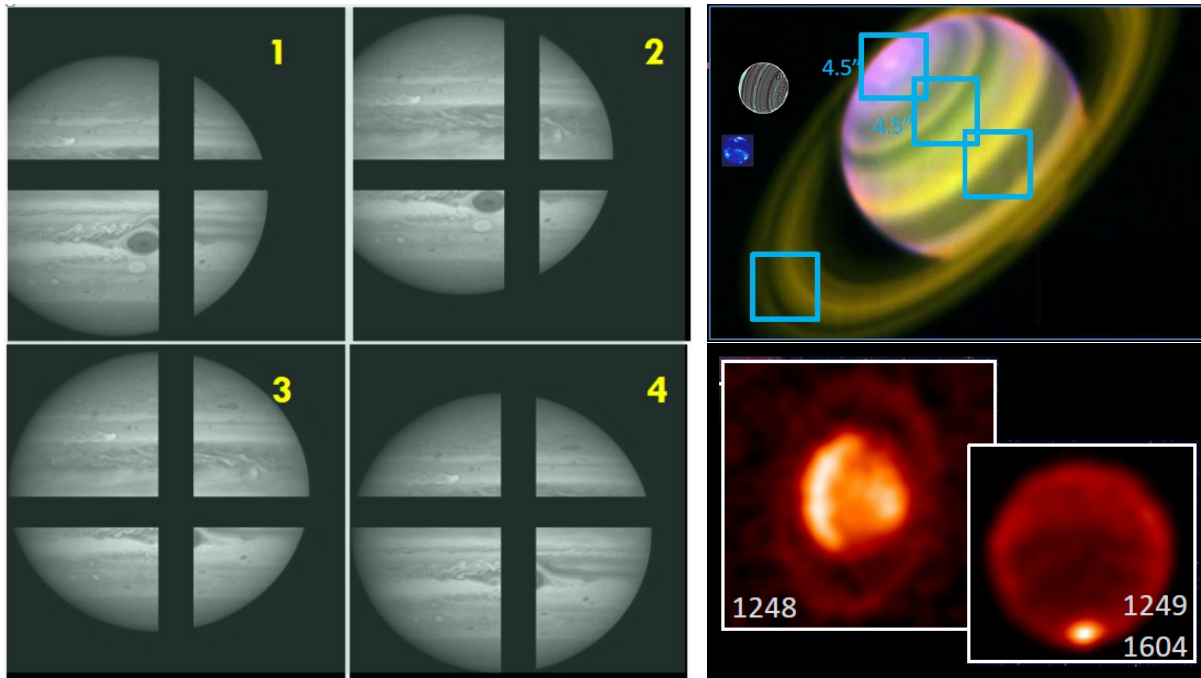
*Meeting organized by L. N. Fletcher (Leicester University), J.H. Rogers (BAA),  
R. Hueso (UPV/EHU), G. S. Orton (JPL), M. Delcroix (SAF)  
with wide participation from Juno & Jupiter-related scientists and amateurs from Europe to Australia*



# James Webb Space Telescope (Launch November 2021)

Outer planets will be observed in a **Jupiter Early Release Science Program** (de Pater, Fouchet et al.) & Several Guaranteed Time Observations programs (Hammel, Fletcher), One General Observer Program (Orton).

**Giant Planet Observations through 2022-2023 will require context ground-based observations!**



EPSC2021-39 [OPS3](#) [The JWST Giant Planet Atmospheres Programme](#)

Leigh Fletcher, Thu, 16 Sep, 16:15–17:00

SMW3: Pro-AM collaborations (II): JWST and the exploration of Giant Planets  
Convener: Leigh N. Fletcher | Fri 24 Sep, 17:30-19:30 (CEST)

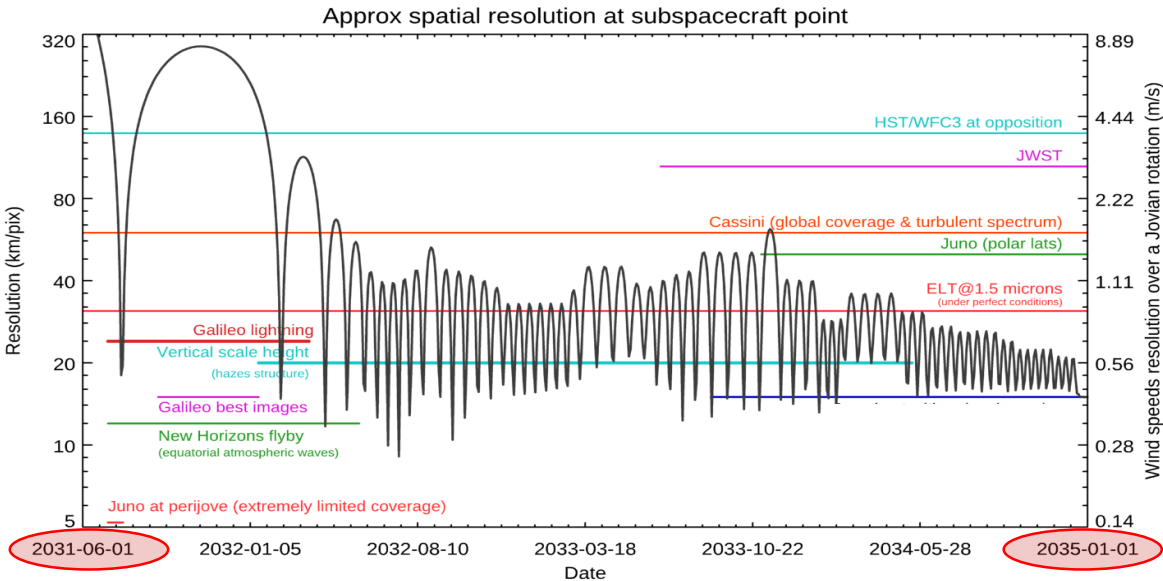
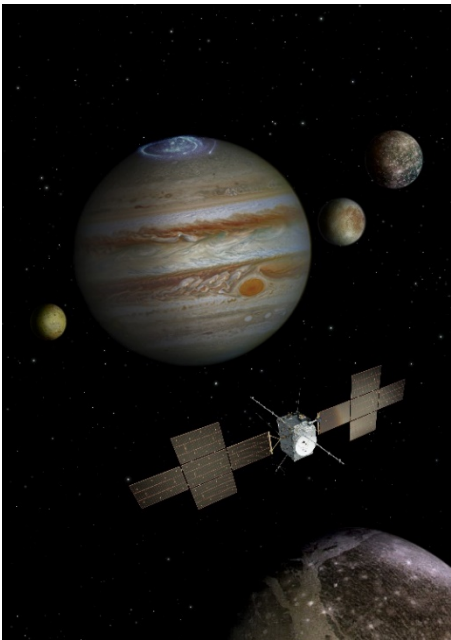
<https://meetingorganizer.copernicus.org/EPSC2021/session/41853>

# JUICE: JUper ICy moons Explorer (ESA) (Launch May 2022)

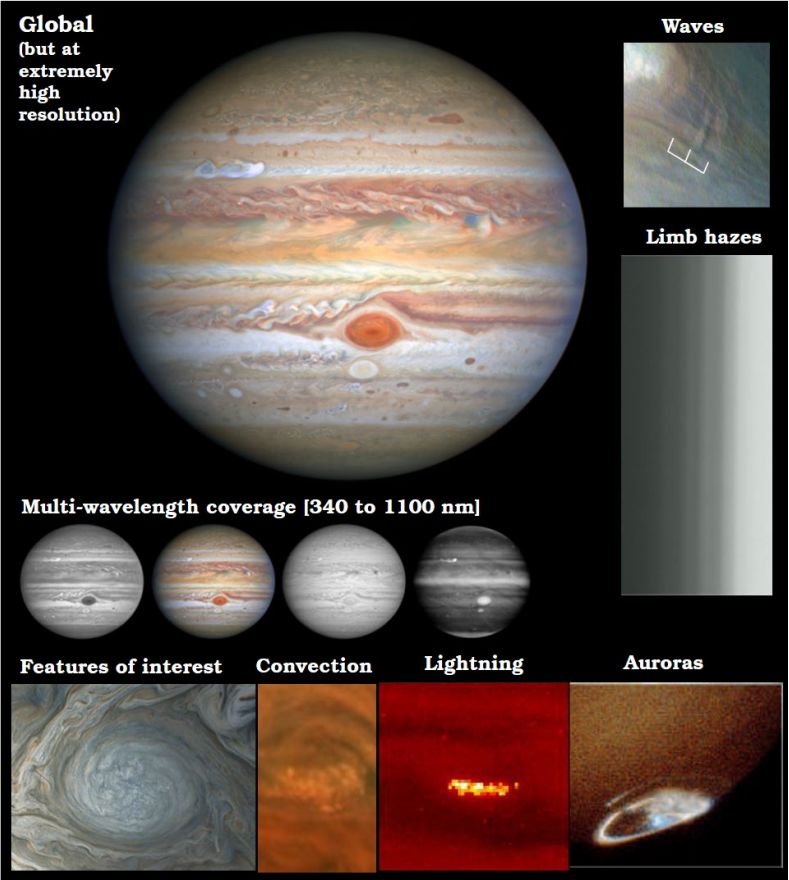


Science on the Icy Satellites with significant Jupiter atmosphere observations: 64 Perijoves over 3.5 years in the 2031-2035 time frame.

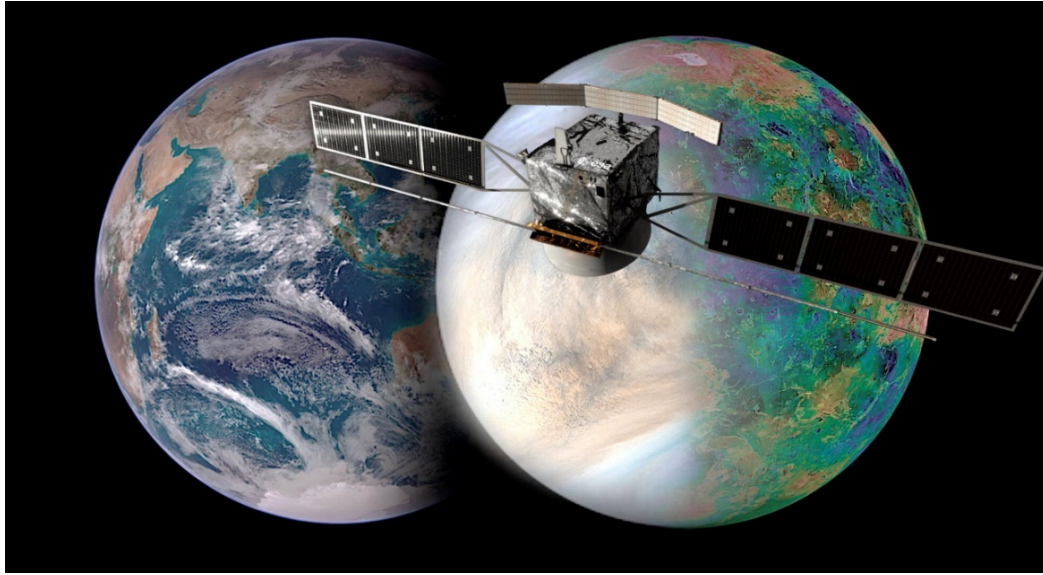
Strong constraints to observe Jupiter (satellites & limited data volume). Jupiter observations will benefit tremendously from global temporal coverage from the ground.



Best spatial resolution of Jupiter: 10 km/pix, but lots of observations at 20-30 km/pix!!!



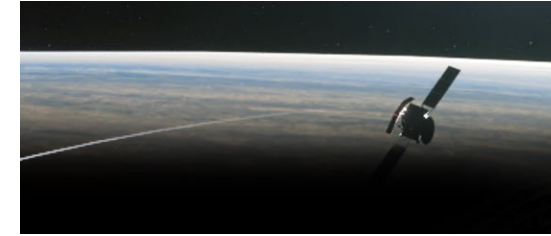
# Venus: EnVision (launch 2032; Venus science 2035-2039)



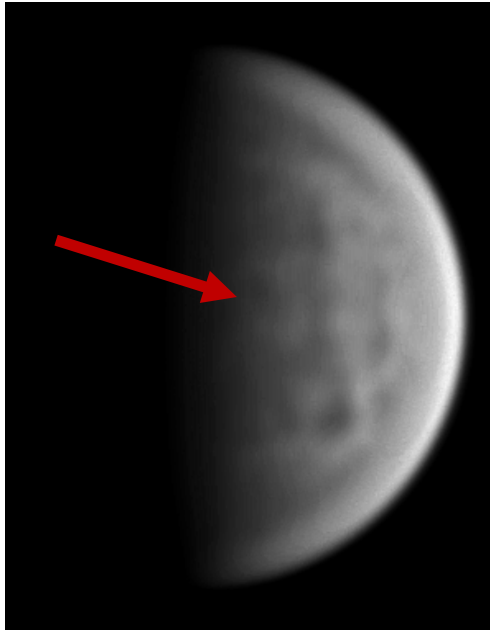
## Venus History, Activity & Climate

### Very close orbit [220-527 km altitude]

- Radar at 10-30 m resolution,
- spectroscopy and imaging at 10 km resolution
- **No global image capability but excellent high-res. observations in the UV**



*Ideal playground for ground-based support in the UV (and other wavelengths), specially with new detectors and cameras that will become available in the next decade.*



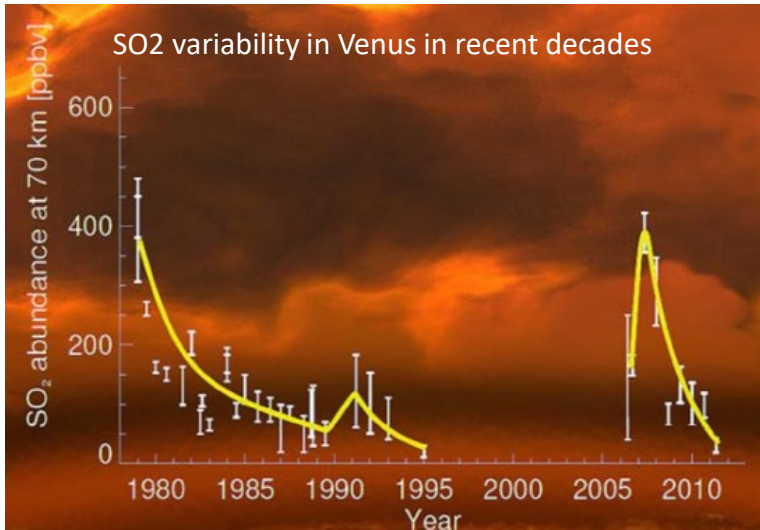
Example of a difficult observation: 5-days period cloud discontinuity at 900nm. Observations from **Manos Kardasis**; feature also observed on different amateur observations in the last 2 years.

Excellent results from the amateur community in recent requests for observational support on recent flybys (Parker Solar Probe, BepiColombo, Solar Orbiter).

See: <http://pvol2.ehu.eus/bc/Venus/> or Garate-Lopez et al. EPSC2020: [Amateur Ground-based Support of the first BepiColombo flyby of Venus](#)



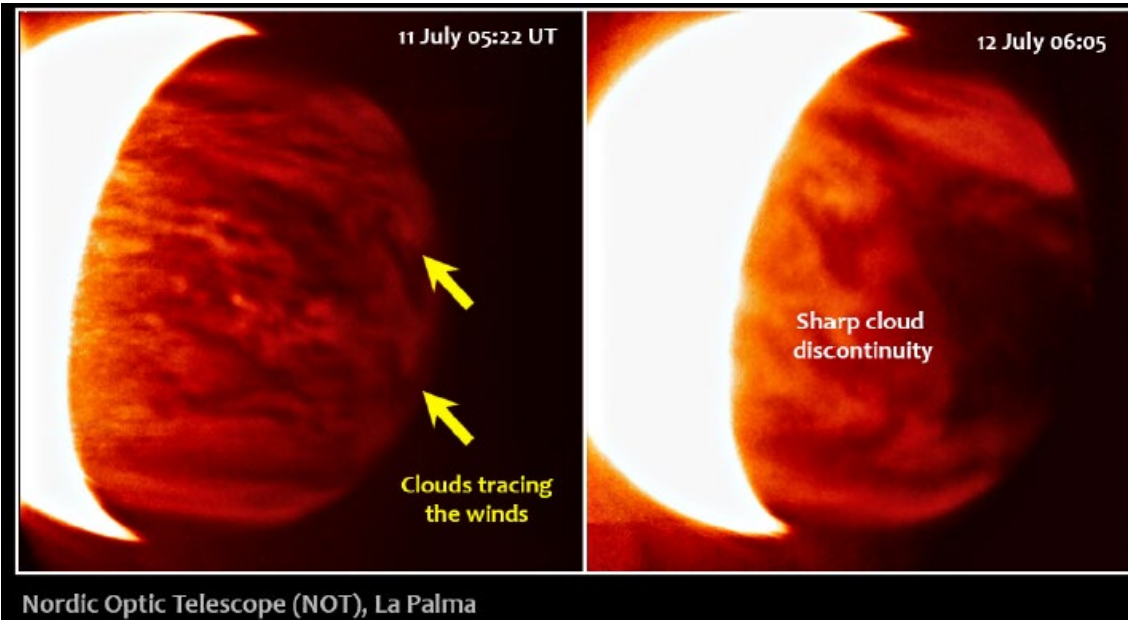
# Venus: EnVision (launch 2032; Venus science 2035-2039)



**EnVision research on atmospheric composition, cloud features and relations with the surface.**

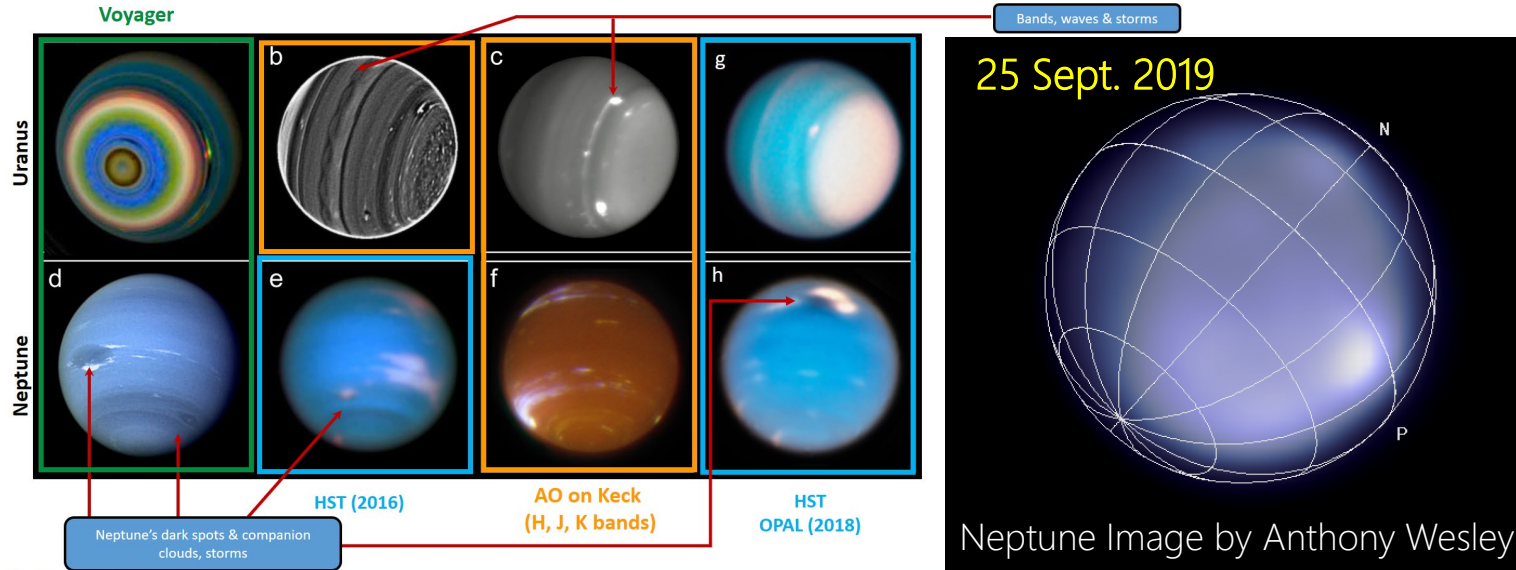
UV cloud features at 8-10 km resolution

But how do these features change when different large-scale morphologies dominate the upper clouds?  
The answer requires comparison with ground-based observations





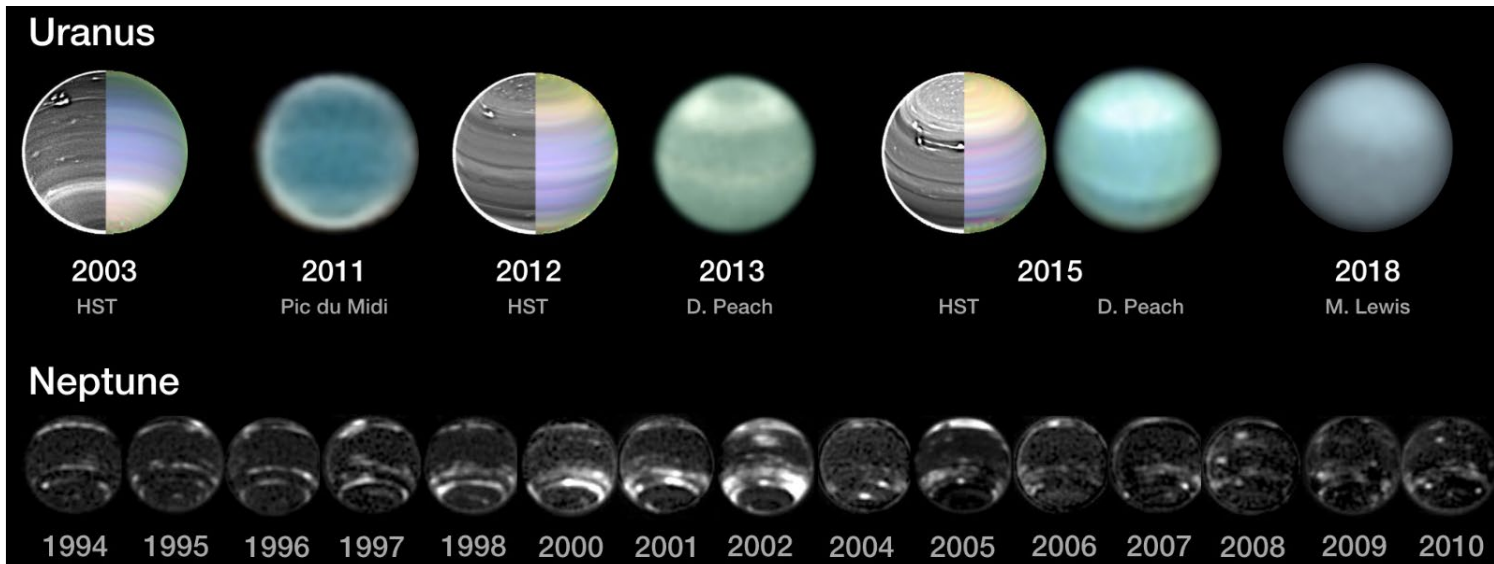
# The Icy Giants in the 2040s...



Several proposals on the last few years to NASA & ESA to develop a new mission to these planets.

Current technology offers cameras with high sensitivity in the  $\lambda > 750$  nm. These are ideal to image Uranus and Neptune and can make worthy contributions through imaging or through spectroscopy.

In the event of a space mission to the Icy giants ground-based observations will play a fundamental role and there will be significant possibilities for amateurs.



# Final thoughts & related events and talks

Amateur astronomy of the Solar System is living a **golden age** with major contributions to modern planetary science. This is a trend that will **continue in the next decades**. It also extends to other Solar System fields. See for instance:

- ❑ EPSC2021-650 | [ODAA5](#) | [ExoClock project: a pro-am collaboration to monitor the exoplanet ephemerides for the Ariel space mission](#)  
Anastasia Kokori | Fri, 24 Sep, 15:10–15:55

Many researchers are now interested in amateur data and many amateur astronomers are providing excellent observations, analysis and software. Institutional support is difficult, but some projects like **Europlanet 2024 RI** provide amateur astronomy activities, workshops and access to facilities such as the **Europlanet Telescope Network**. See:

- ❑ EPSC2021-549 | [ODAA5](#) | [Supporting the planetary sciences community with the Europlanet Telescope Network](#) |  
Manuel Scherf | Fri, 24 Sep, 15:10–15:55

## ADVERTISING EPSC Amateur Astronomy Splinters:

[access details on the EPSC2021 website; events do not require registration in the meeting]

**SMW2: Pro-Am collaborations (I): Juno's Extended Mission at Jupiter**

Sept. 17, 2021 - 17 sept. 2021 17:30 (CEST)

**SMW3: Pro-AM collaborations (II): JWST and the exploration of Giant Planets**

Sep 24, 2021 - 17:25 (CEST)

**SMW5: Pro-AM collaborations (III): The Europlanet Telescope Network and the ExoClock project**

Sept. 22, 2021 - 18:30 (CEST)

*Recordings will be made available after the events*