

Amateur astronomy support to current and future space missions:

From the 2010s to the 2030s

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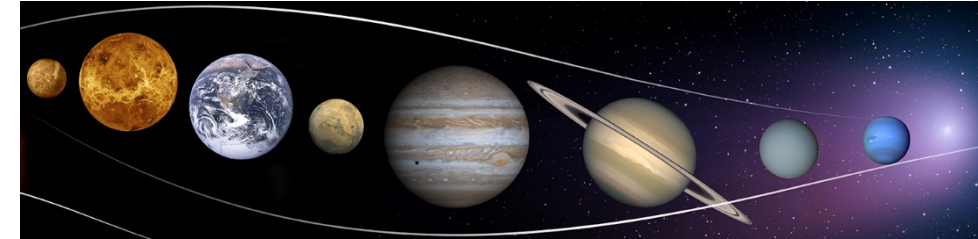
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The need for ground-based observations

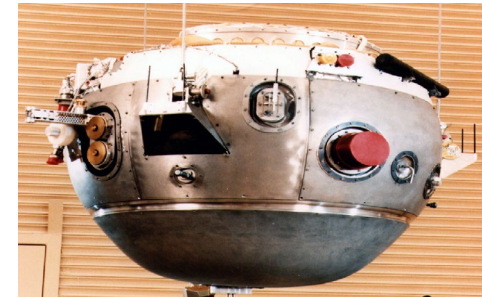
Astronomy in the time domain

- Spectral resolution (large ground-based telescopes)
- Spatial & Temporal resolution (Amateur contribution)

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 contribution from an amateur network of observers.
- An important testimony of the power of amateur observations to study Jupiter in the famous “**The Red 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



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

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

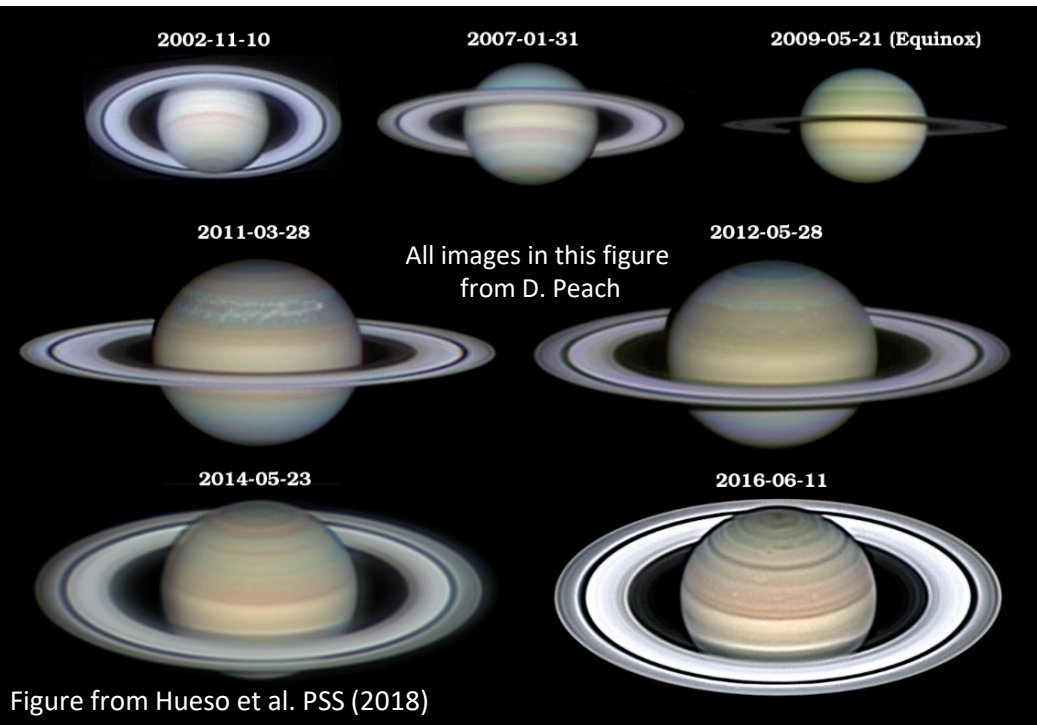


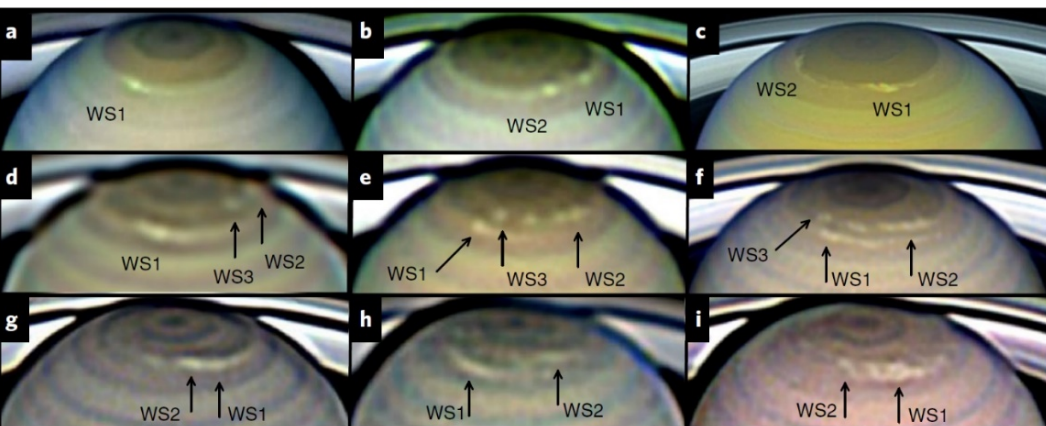
Figure from Hueso et al. PSS (2018)

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

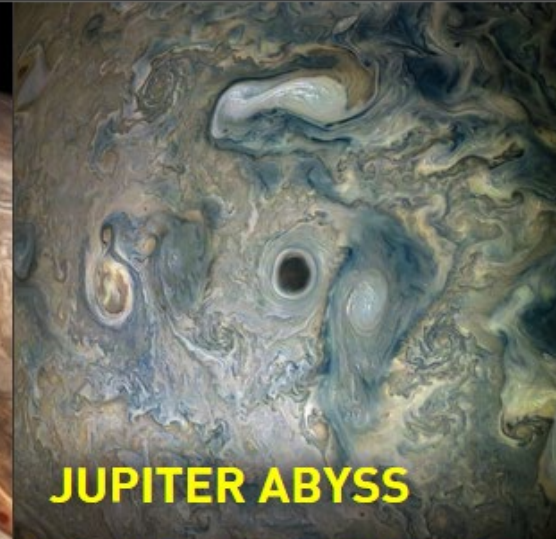


<https://www.missionjuno.swri.edu/junocam>

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



Amateurs are key players in the Ground-based support of the Juno Mission!

*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)

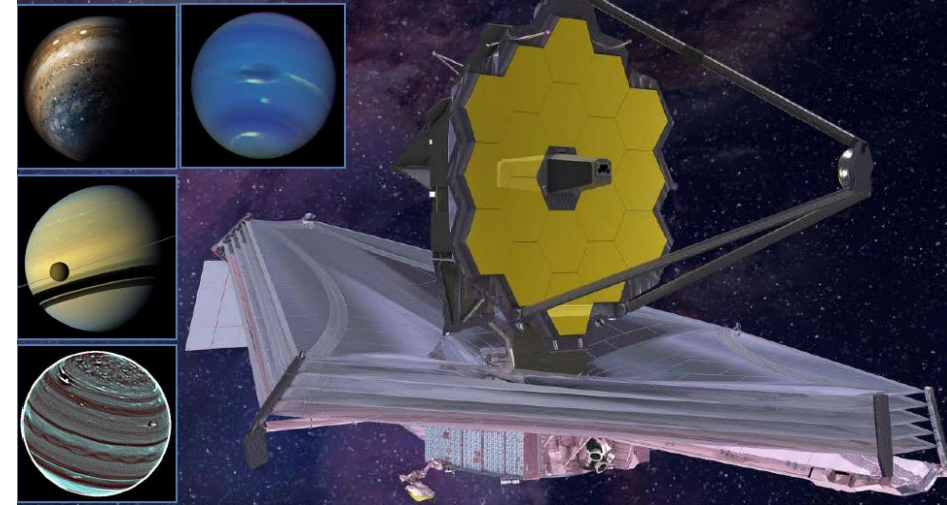
EPSC2021-39 [OPS3](#) [The JWST Giant Planet Atmospheres Programme](#)

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

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

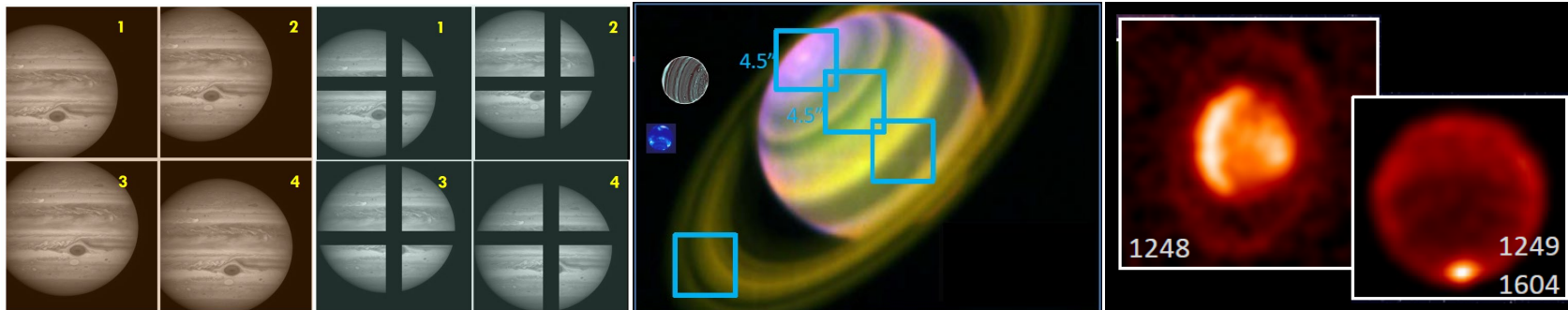
Convener: Leigh N. Fletcher | Fri 24 Sep, 17:30-19:30 (CEST)

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



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

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

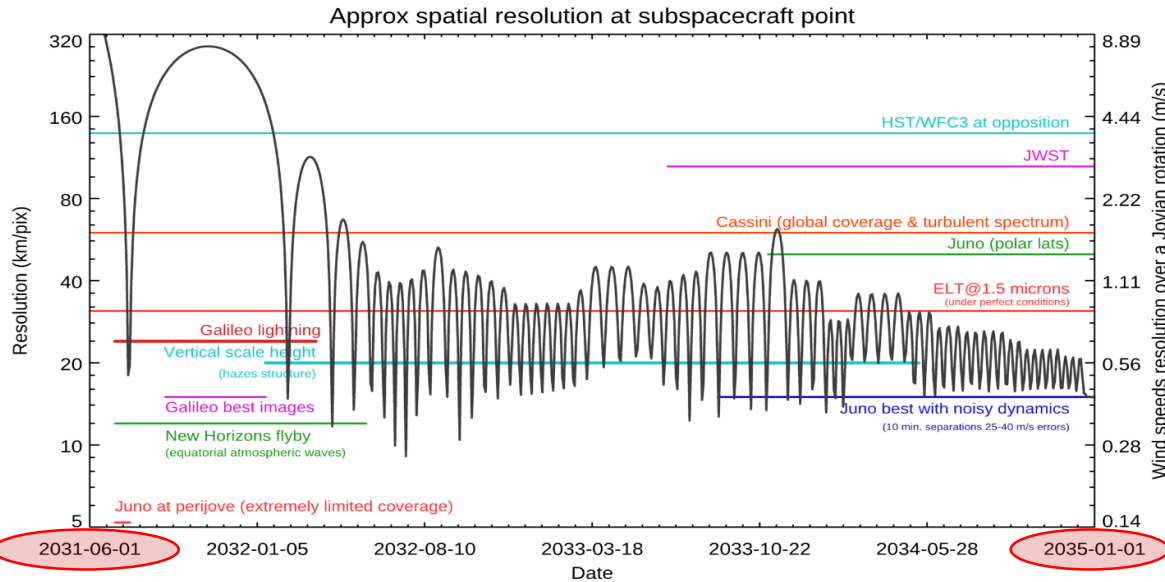
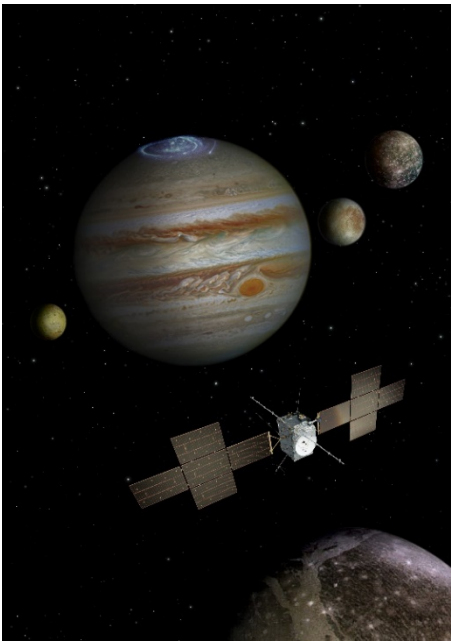


JUICE: JUper ICy moons Explorer (ESA) (Launch May 2022)

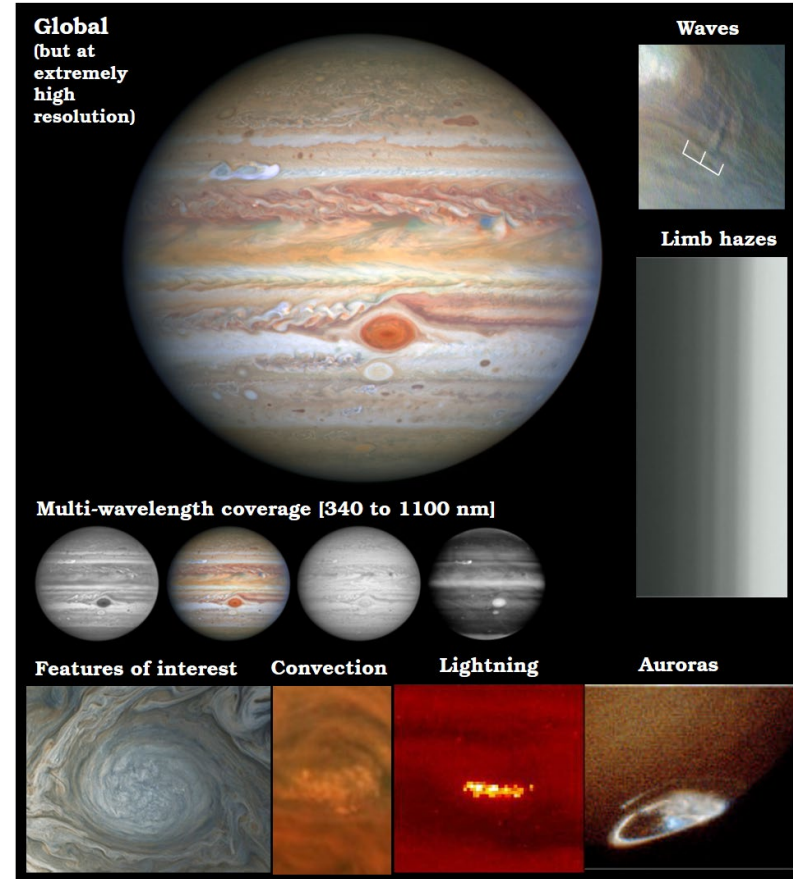


Science on the Icy Satellites with significant Jupiter atmosphere observations: 64 Perijoves over 3.5 years in the 2031-2035 time frame.

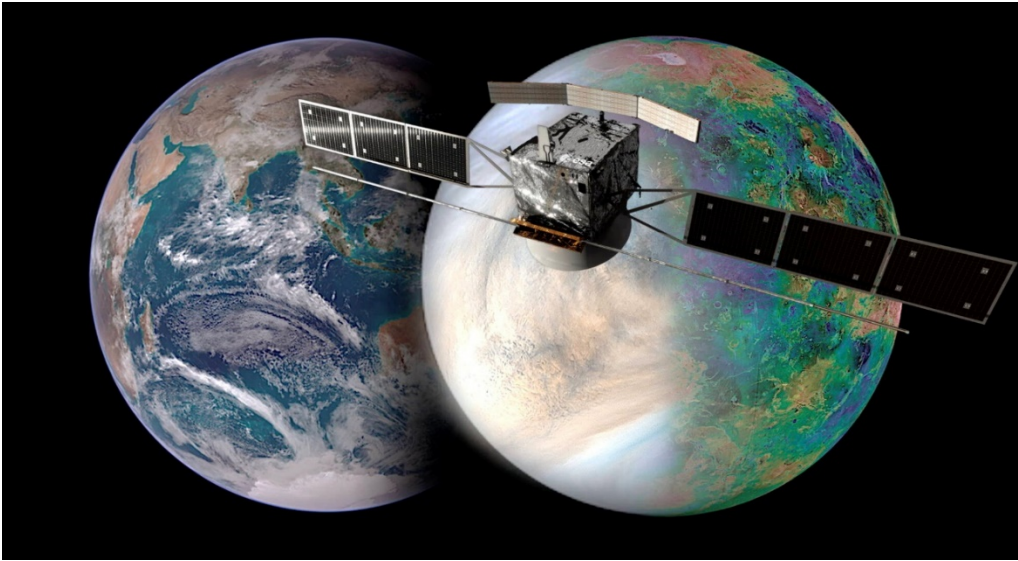
Strong constraints to observe Jupiter (satellites & limited Data Volume). Jupiter observations will benefit tremendously from global temporal coverage from the ground.



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**

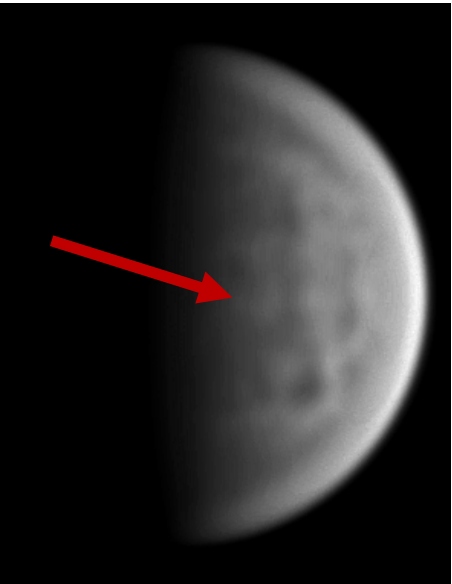


Ideal playground for ground-based support in the UV (and other wavelengths), specially with new detectors and cameras that will become available in the next decade.

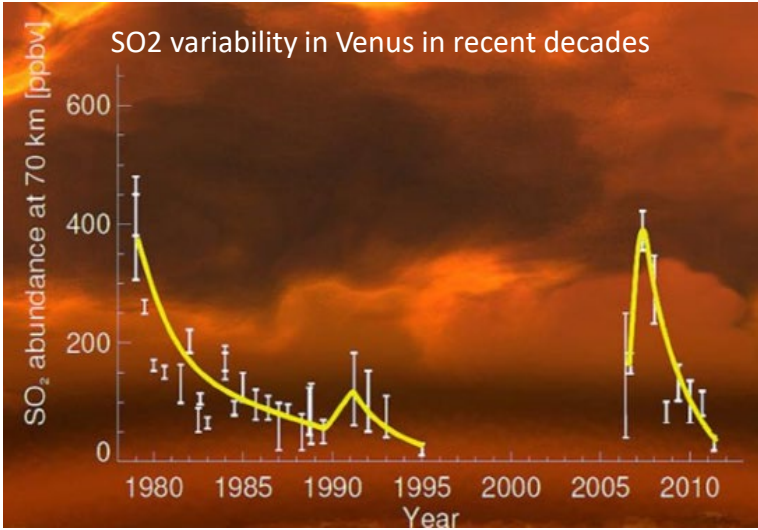
Example of a difficult observation: 5-days period cloud discontinuity at 900nm. Observations from **Manos Kardasis**; feature also observed on different amateur observations in the last 2 years.

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)

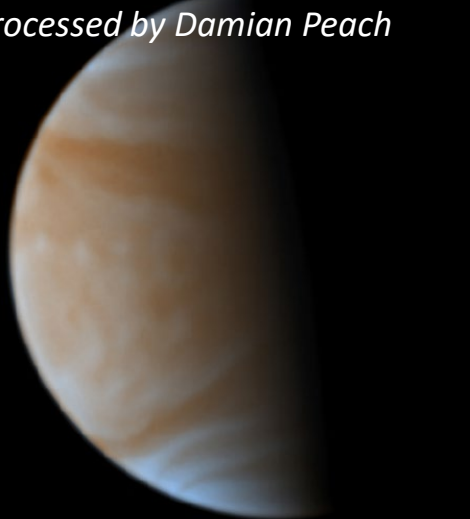


EnVision research on atmospheric composition, cloud features and relations with the surface.

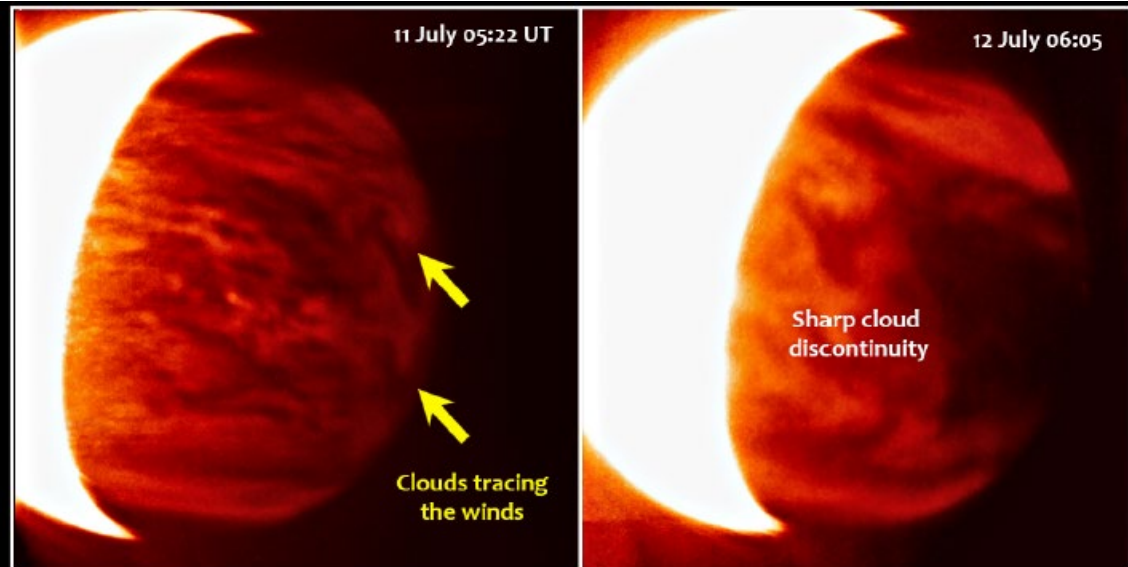
UV cloud features at 8-10 km resolution

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

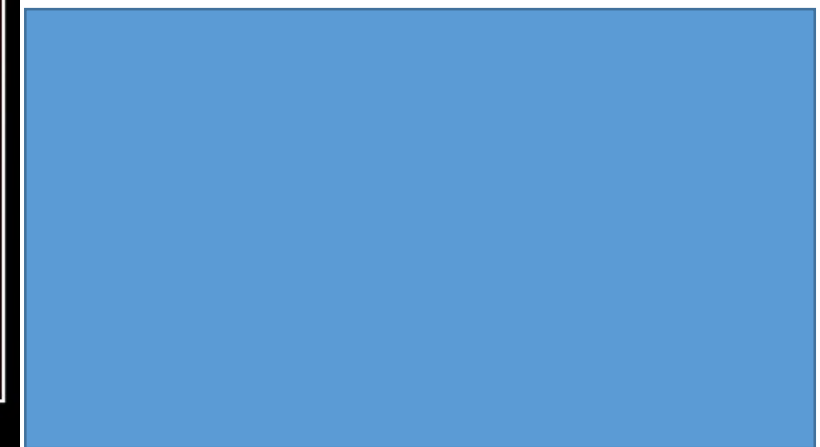
Image obtained at Pic du Midi & processed by Damian Peach



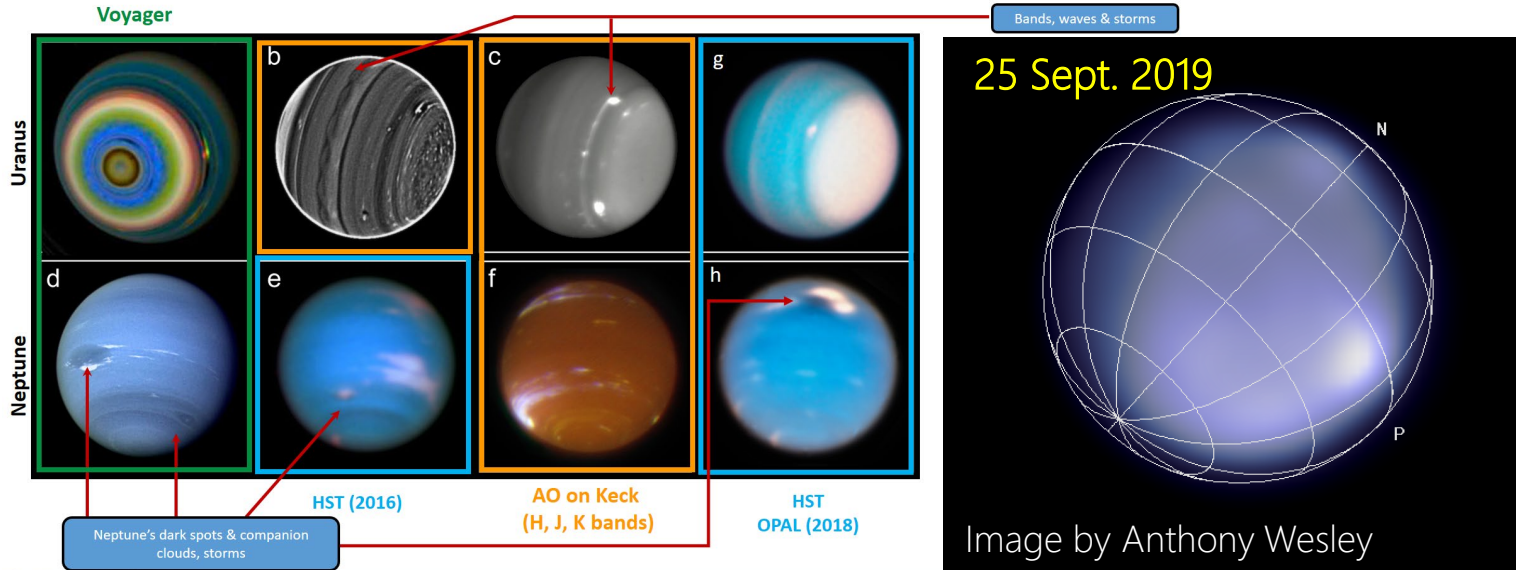
11 June 2017 IR (G) + UV (R,B)



Nordic Optic Telescope (NOT), La Palma



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.

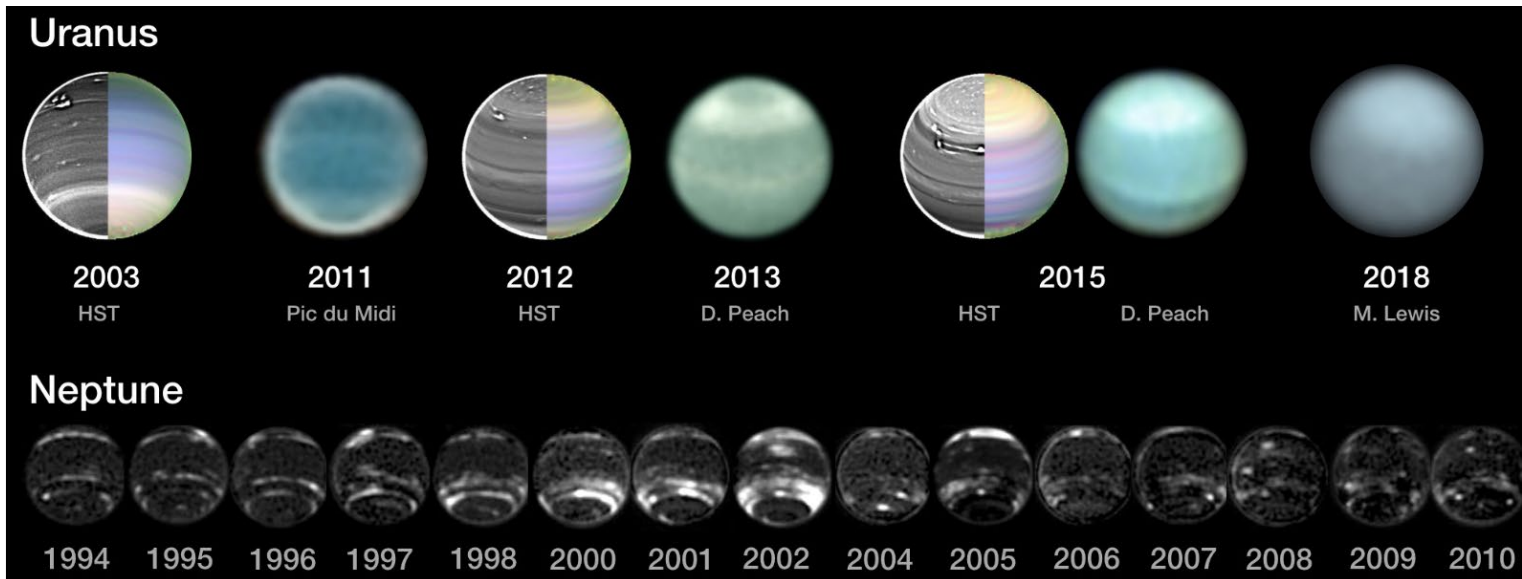


Figure from Guillot, ESA White paper on response to ESA's Voyage 2050 call

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. 18, 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

22.Sept. 2021 18:30 (CEST)

Recordings will be made available after the events