Mid-Infrared Observations of Neptune and Uranus: Recent Discoveries and Future Opportunities

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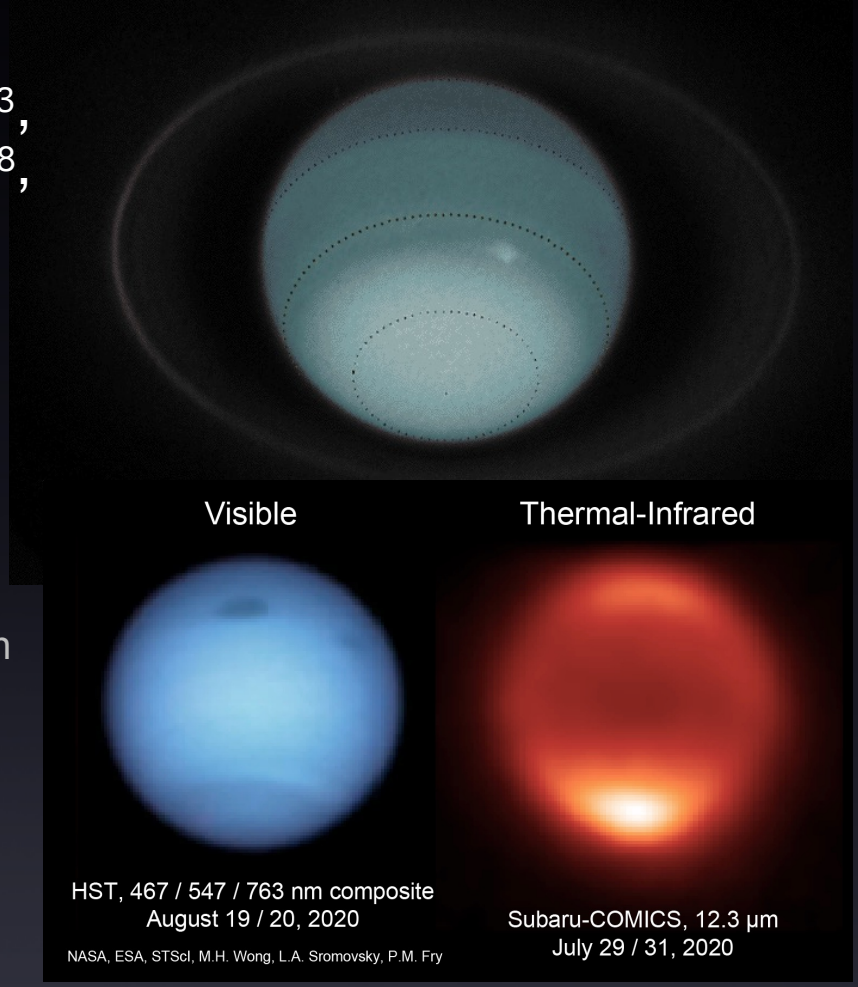

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Mid-Infrared Observations (8-25 μm)

- Primarily VLT-VISIR, +previously Subaru-COMICS; Keck-LWS; Gemini (N&S)-Michelle & T-ReCS

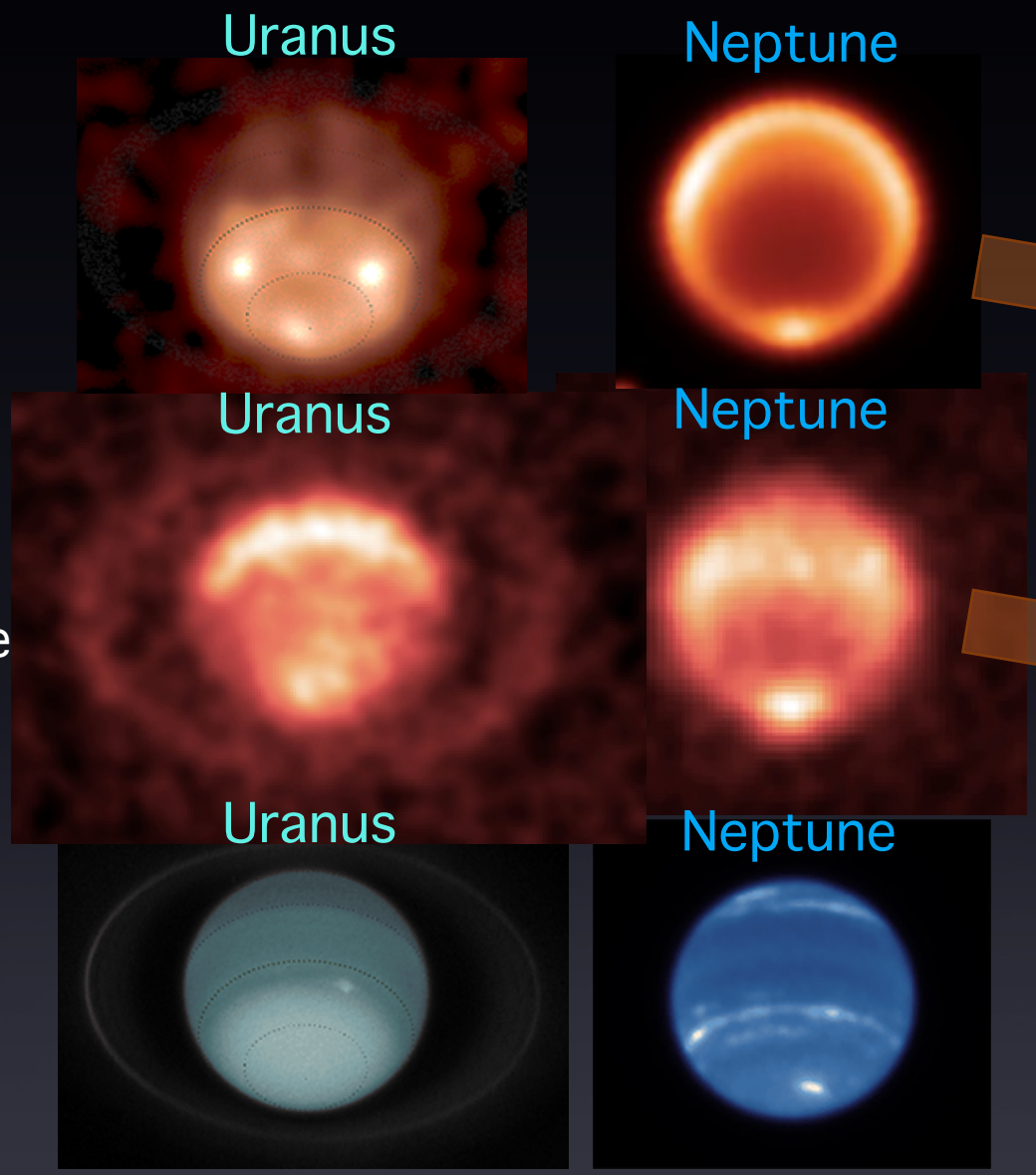
8-13 μm →

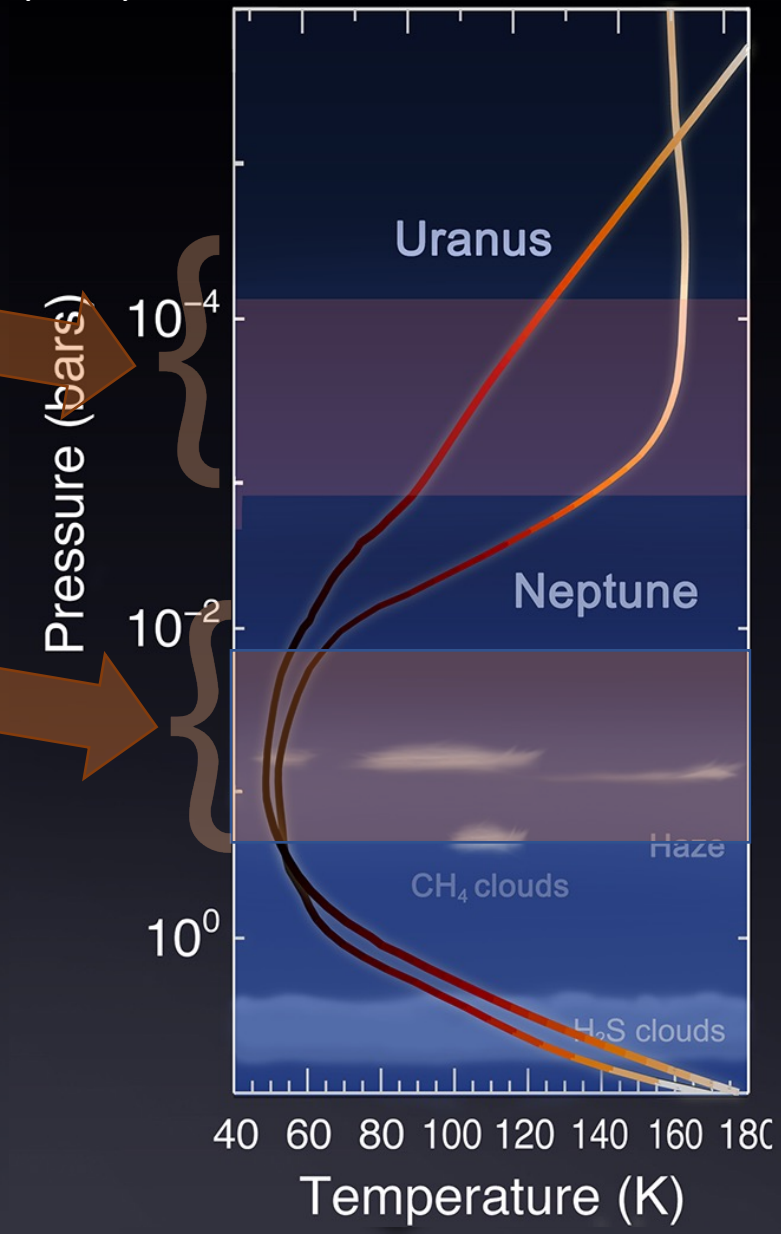
- Stratosphere
- Hydrocarbons
- Very Dissimilar
  - Unclear why
  - Temperature or chemistry?

17-25 μm →

- Upper Troposphere
- Hydrogen (CIA)
- Very Similar

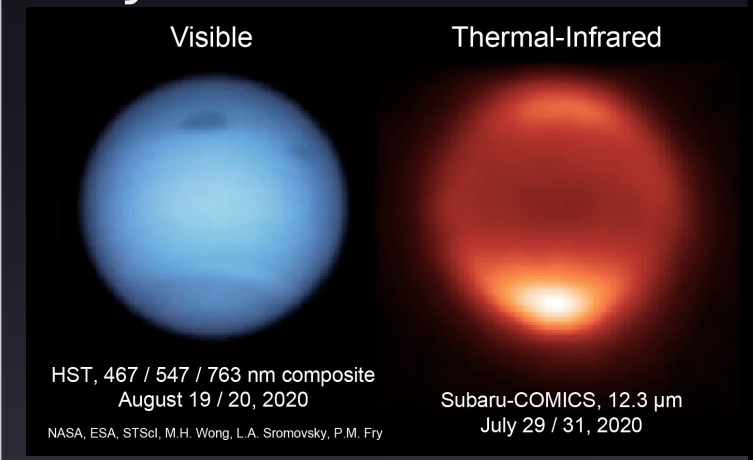
(Visible →)

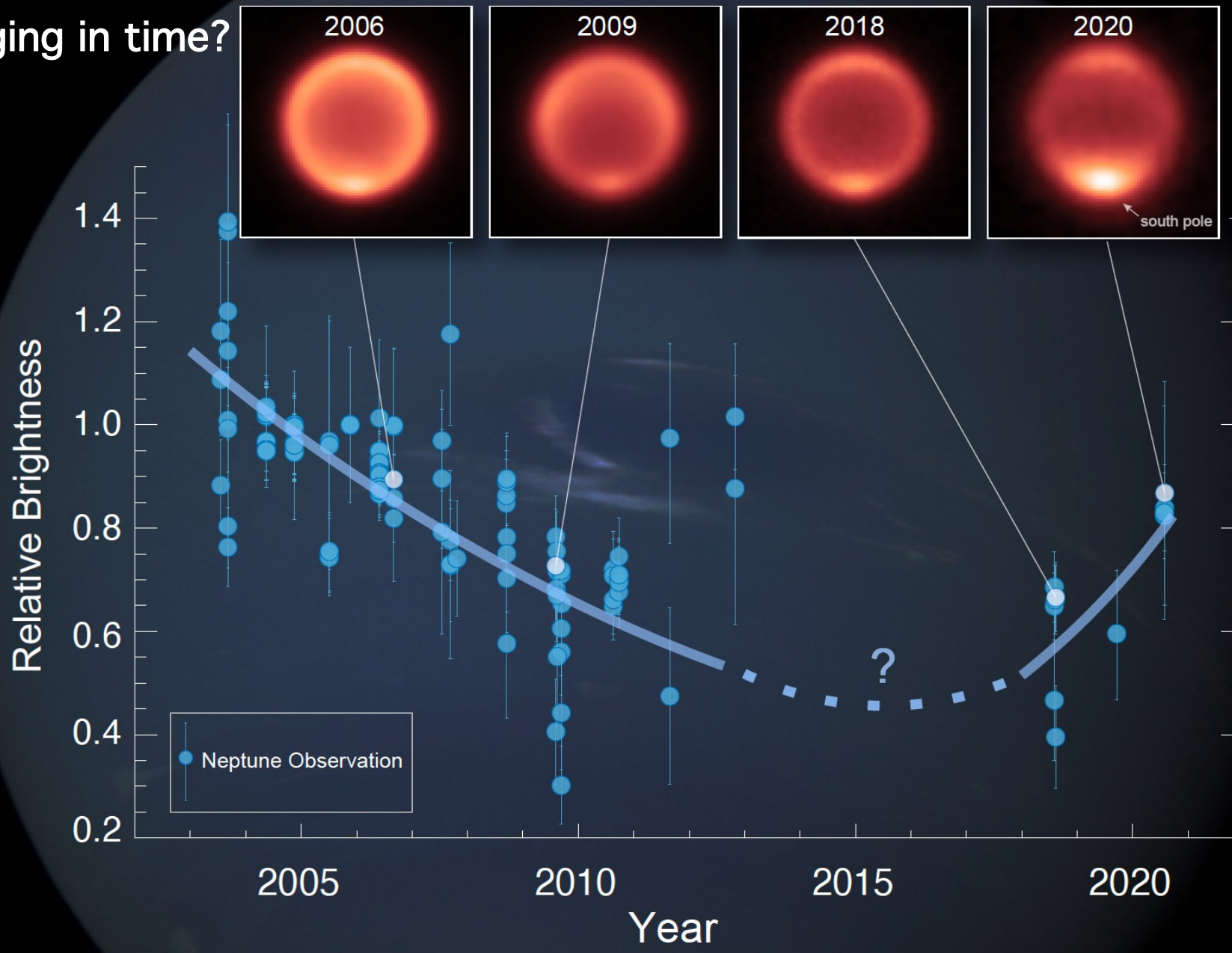




NEPTUNE – how is it changing in time?

- Drop in *stratospheric* radiances over time; troposphere steady
- Interpreted as stratospheric cooling (~8 K)
- Rapid brightening at south pole in recent years.





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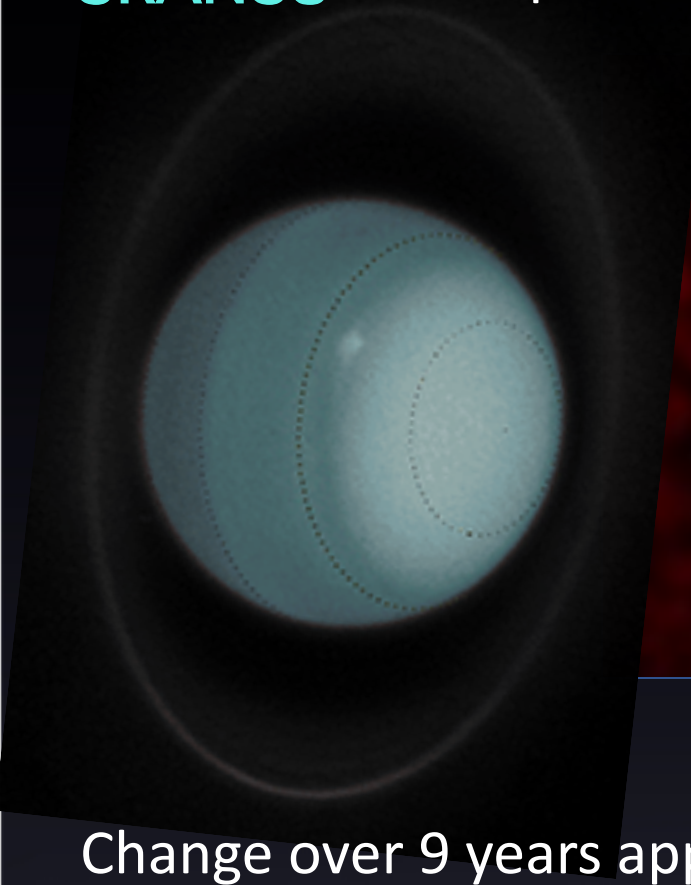
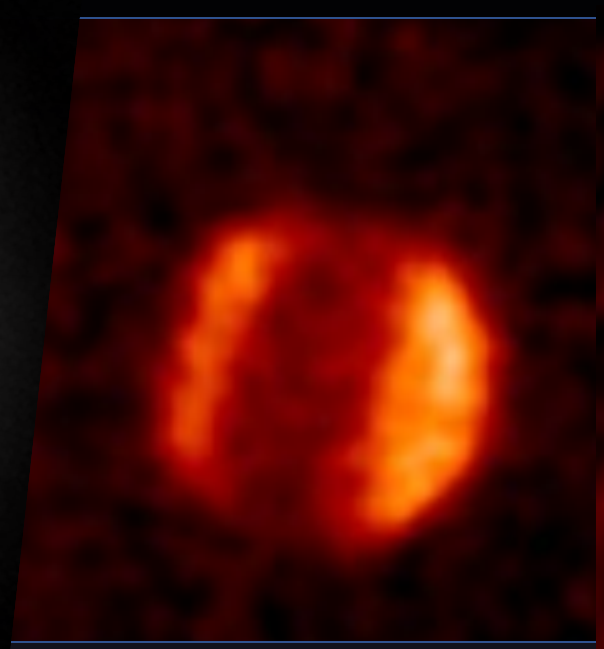
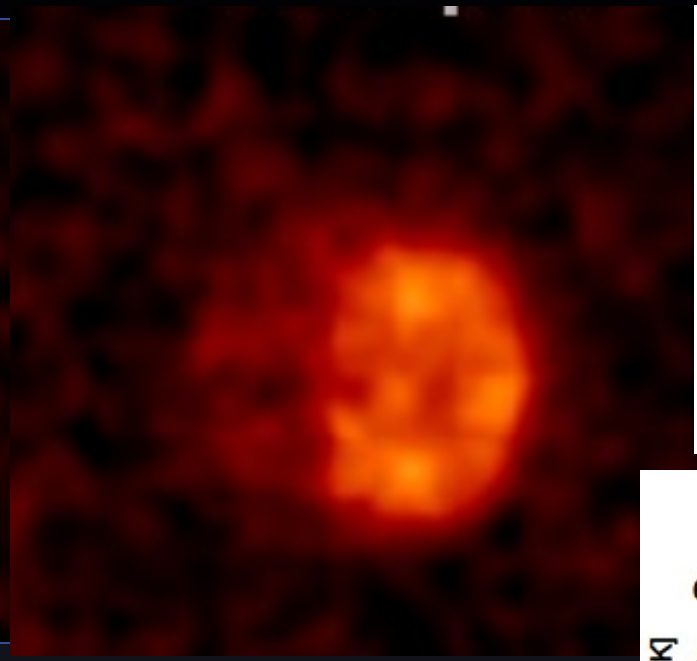
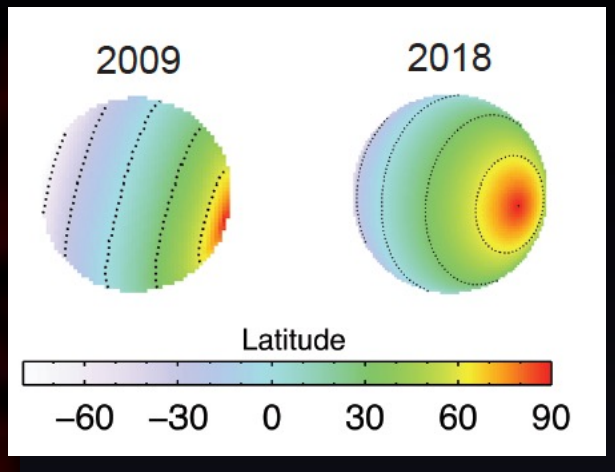
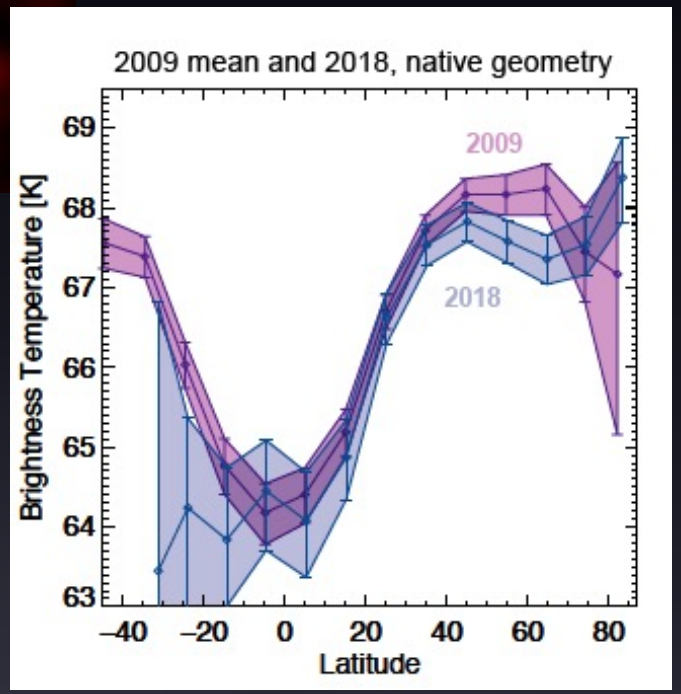
URANUS – Temporal variability of the stratosphere (with 2 data points)?











Change over 9 years appears insignificant within uncertainties.

- Mostly steady, in both troposphere *and* stratosphere
- Only ½ a season. Longer baseline of observations needed

Is the pattern seen due to temperatures or chemical gradients?

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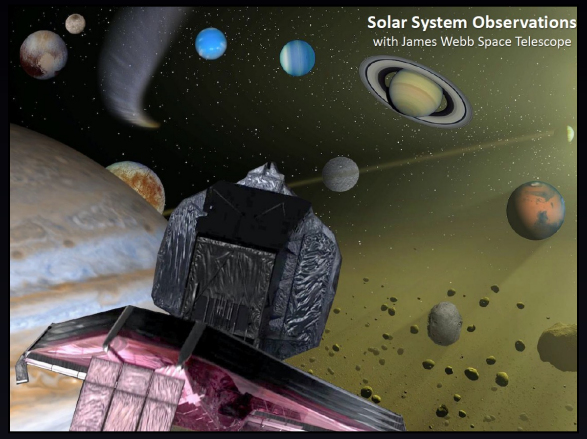
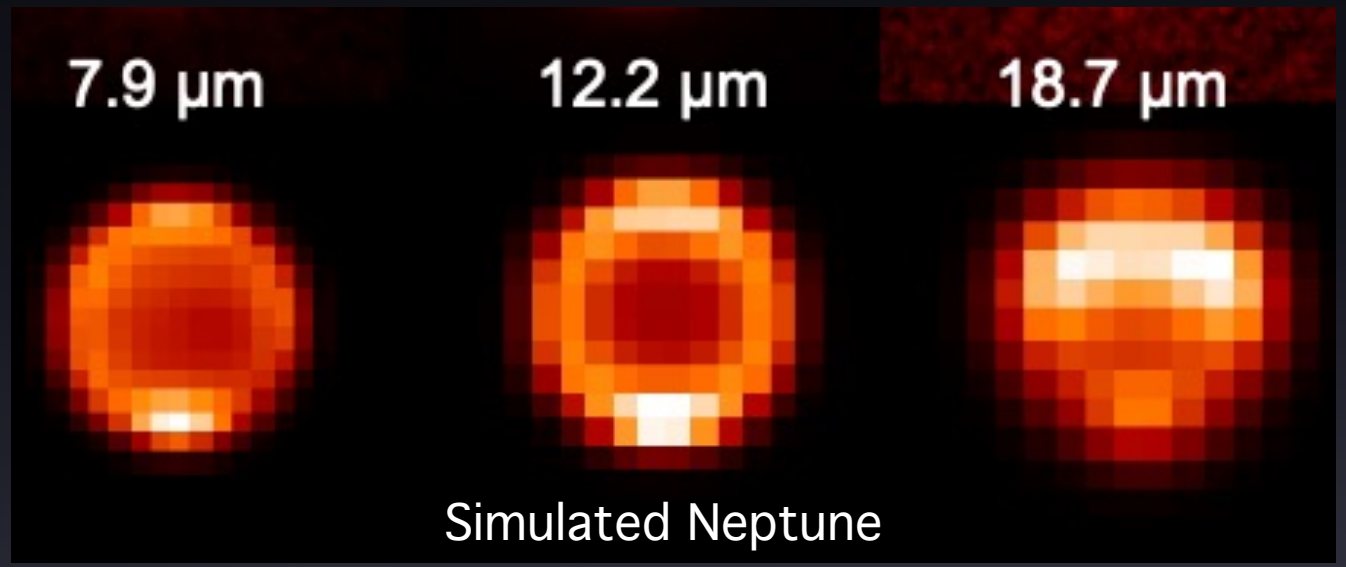
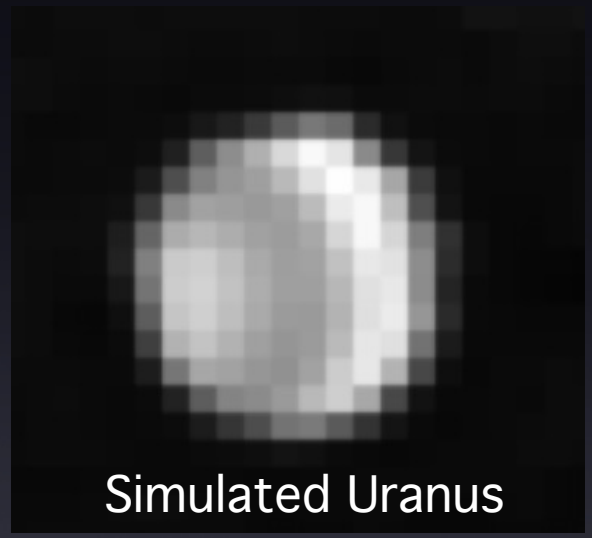
Finally, The James Webb Space Telescope (JWST) MIRI will provide spatially resolved spectra with unprecedented sensitivity between 5-30 μm



- Guaranteed time observations (GTO)
  - Uranus window: Aug 6, 2022 - Sep 25, 2022
  - Neptune window: Jun 13, 2023 - Jun 26, 2023 (+GO in late 2023, PI Orton)
- Huge advancement in our understanding of the chemical and temperature structure of both Neptune and particularly Uranus



Simulated Neptune


Simulated Uranus

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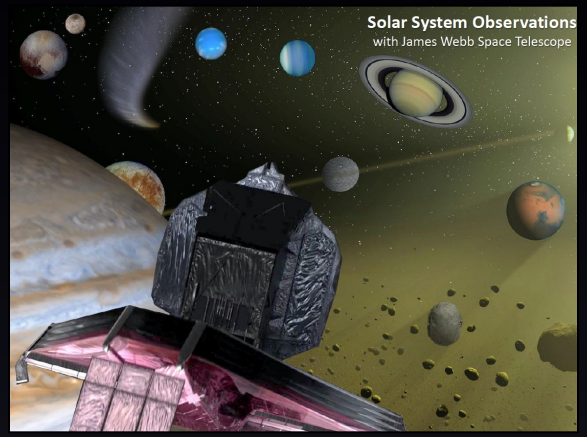
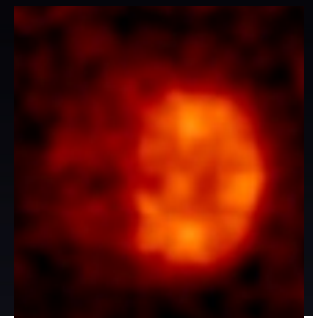
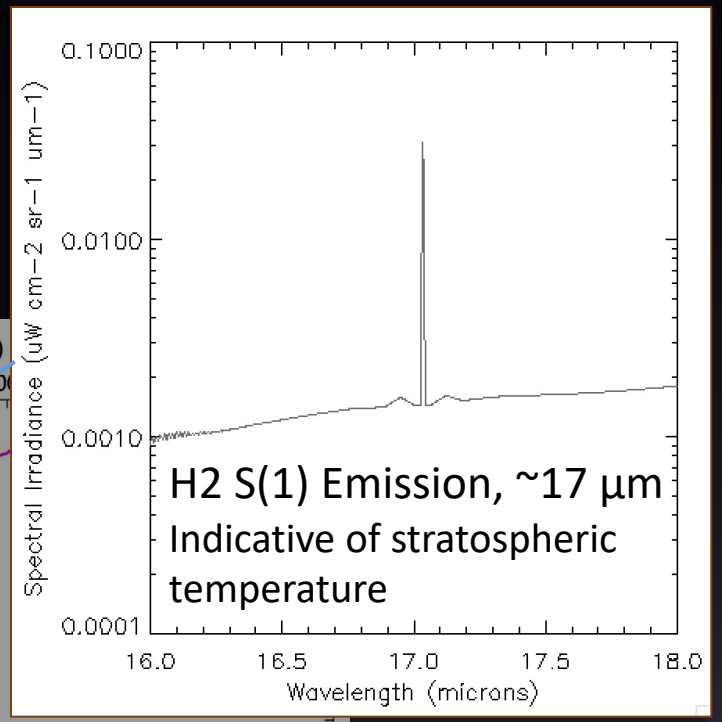
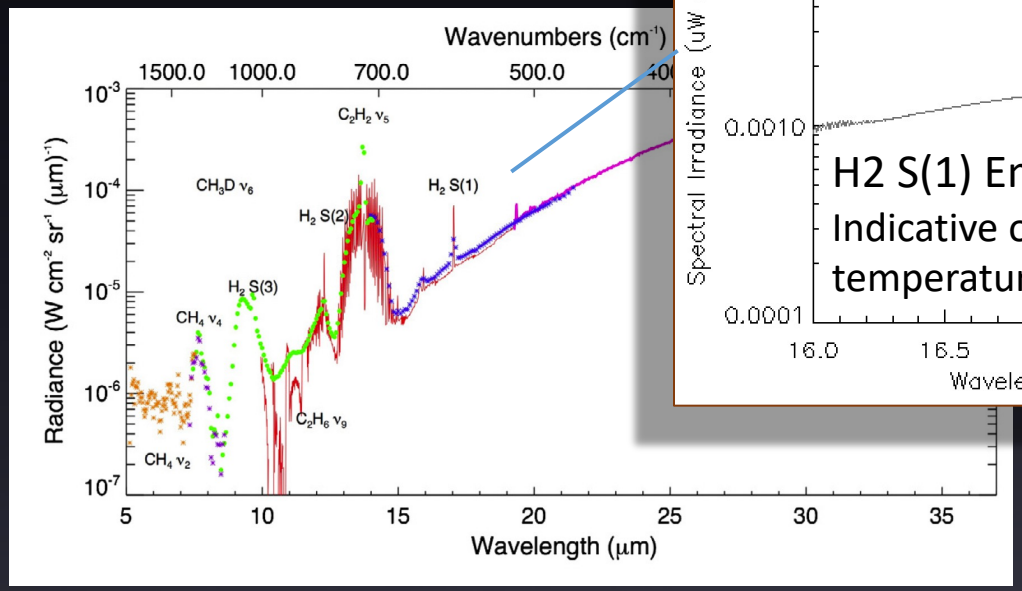
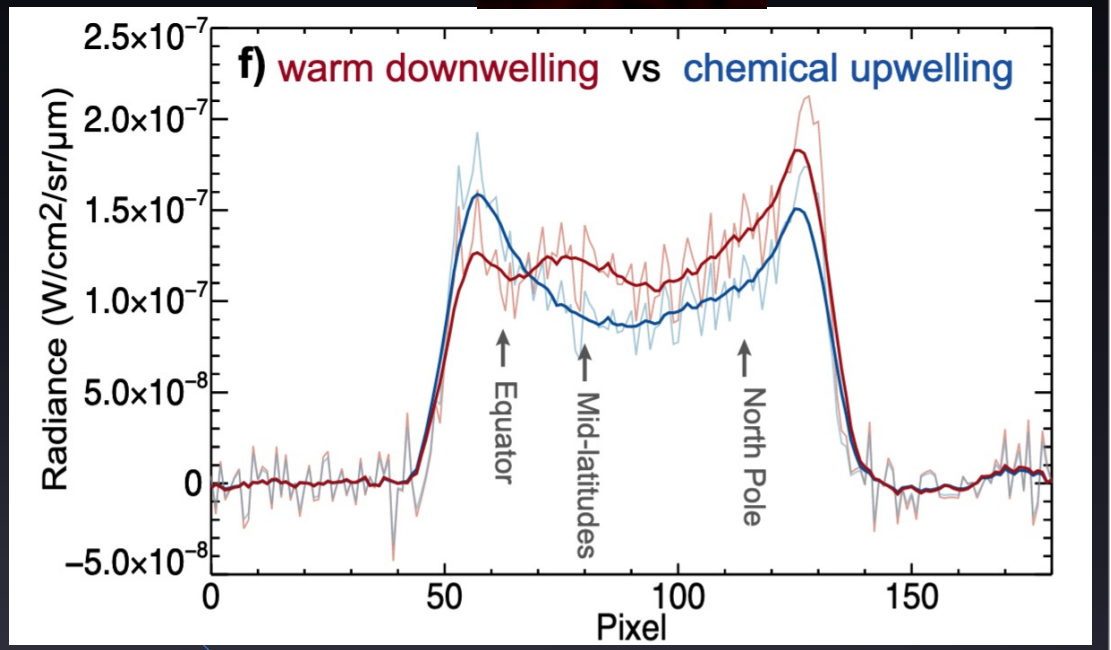


- Example: Resolving the Uranus stratospheric structure question—temperature or chemistry?









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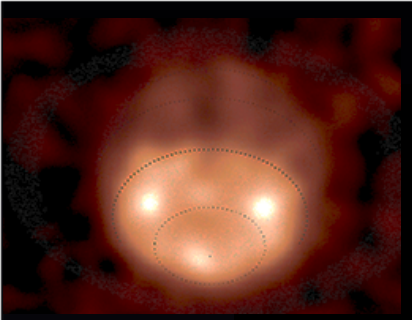

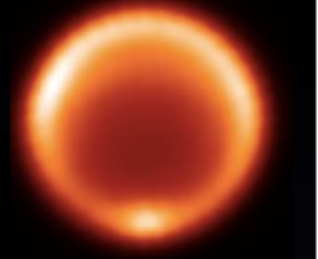

Takeaway messages:

- Neptune's stratosphere can vary considerably in time at mid-infrared wavelengths, particular at the pole. No strong evidence yet of changes on Uranus. The tropospheres of both planets appear nearly invariant so far.

- Additional observations are needed to establish trends and nature of the variability, from the ground, from space, and eventually from orbiting spacecraft. JWST will answer open questions in the years ahead.

Thank you for listening!

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