Uranus in the Herschel Time Frame
(Focus on continuum measurements by HIFI)

Mark Hofstadter (JPL/Caltech), Glenn Orton (JPL/Caltech),
Mark Gurwell (SAO), Bryan Butler (NRAO)

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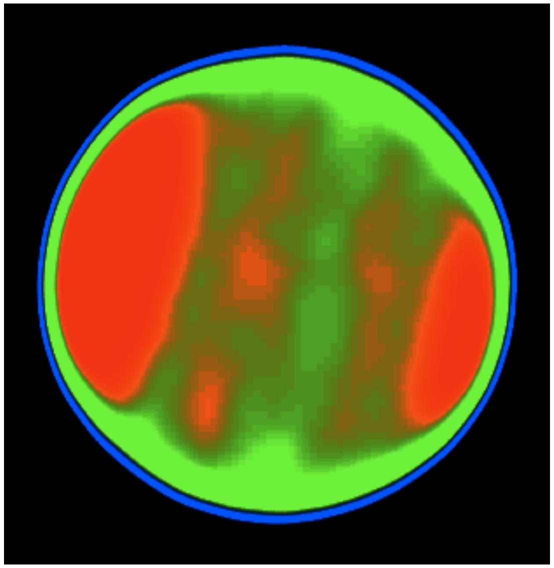

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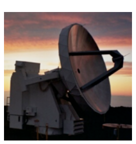
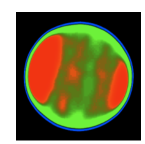
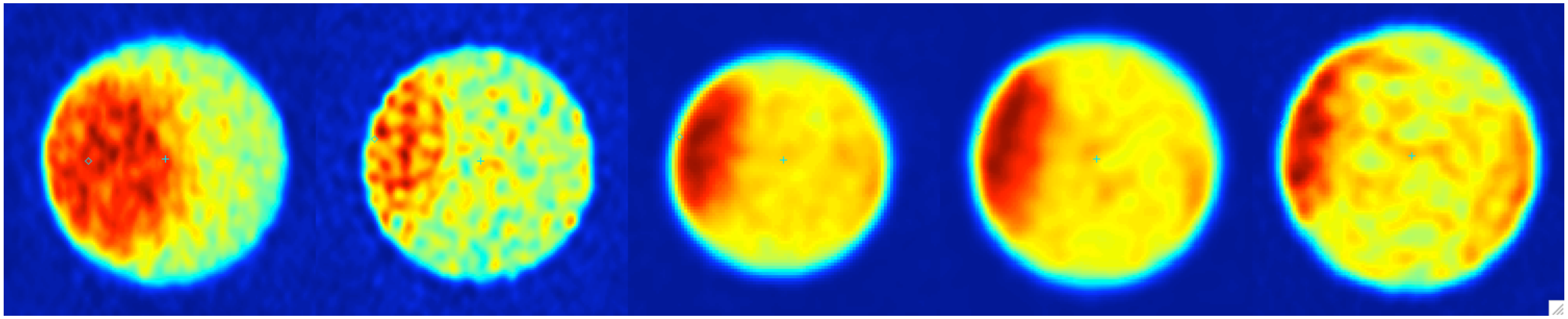




What Does Uranus Look Like?

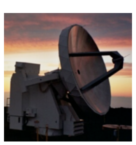


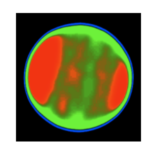
1994 2002 2003 2004 2006

• At wavelengths from the visible to decimeters, Uranus shows strong brightness variations. For example, in the above 2 cm data, we clearly see that the South Pole is bright.

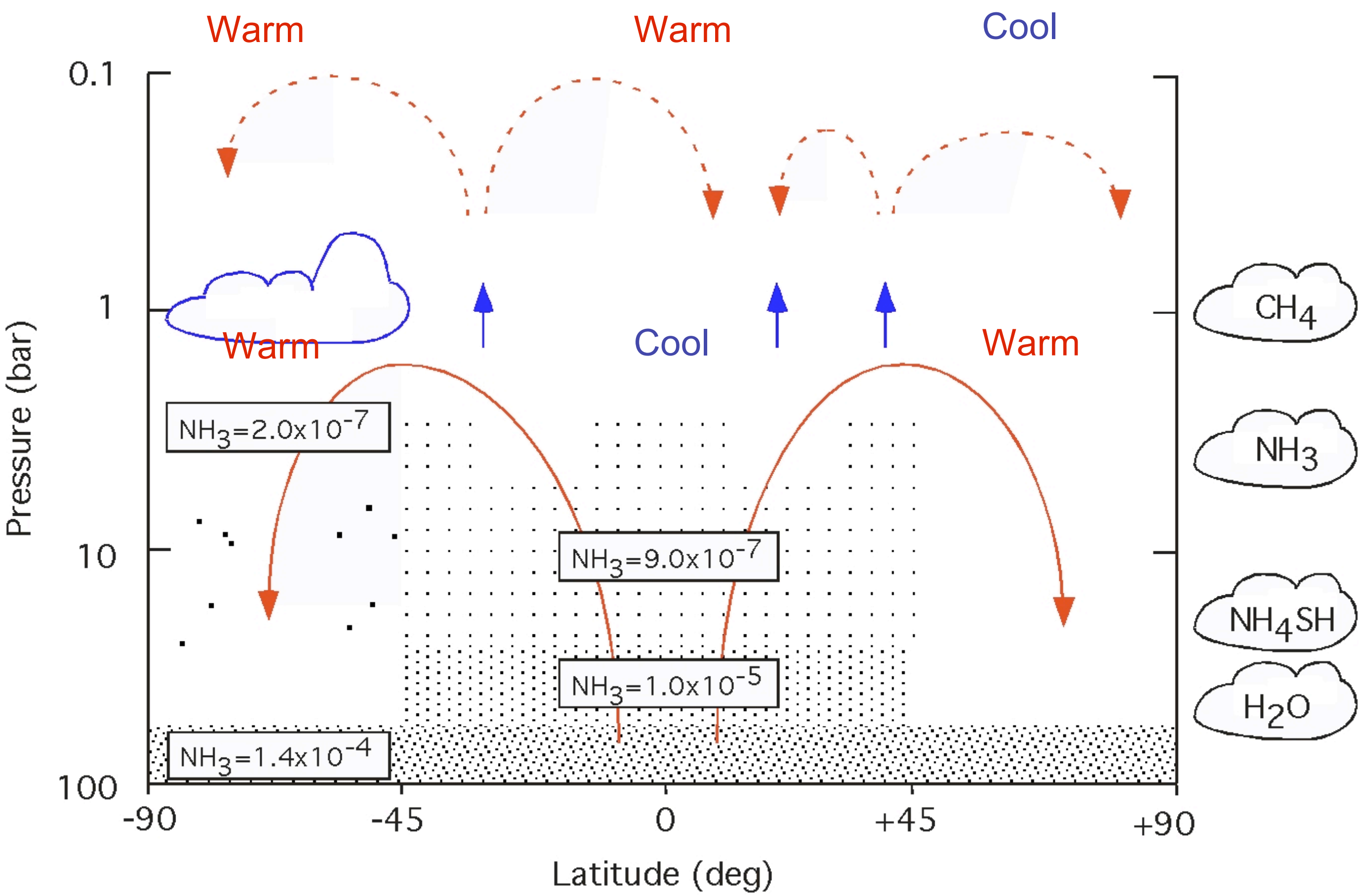
• With a period of 21 years, we alternate between seeing a pole (the South in 1985), and the equator (2007). This means that, even in the absence of true seasonal change on the planet, the average brightness as seen from the Earth will vary. I refer to this variation as a geometry variation.

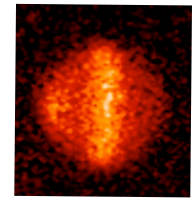
• In addition to viewing geometry effects, at some wavelengths true seasonal changes are seen.



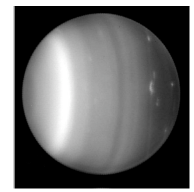


The Emerging Picture

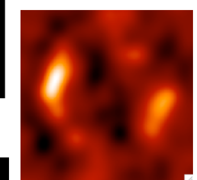




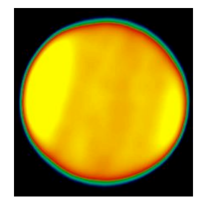
Orton et al. (thermal IR)



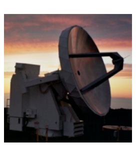
Hammel et al. (Near-IR)

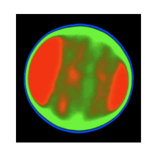


Hofstadter and Gurwell (millimeter)

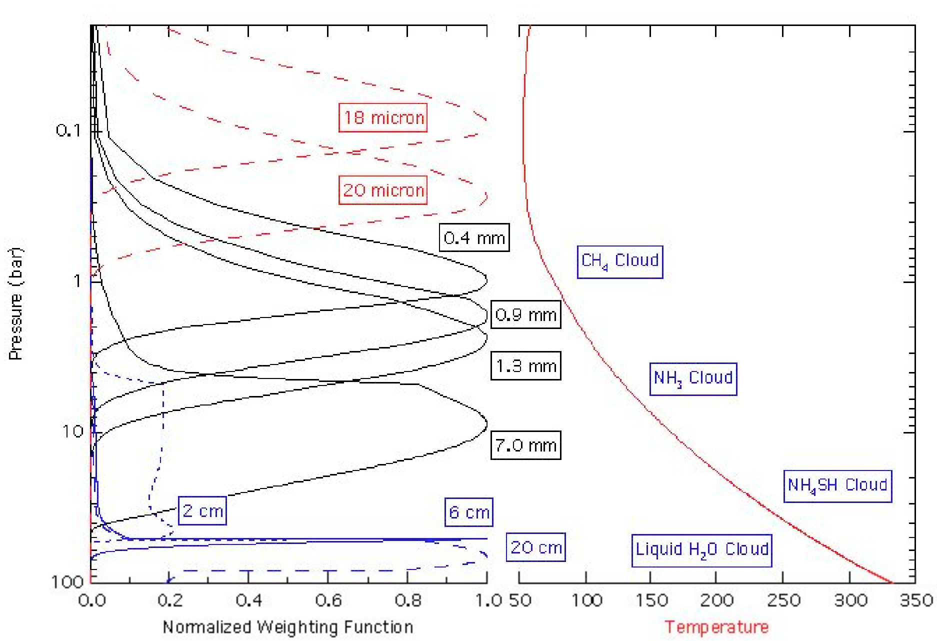


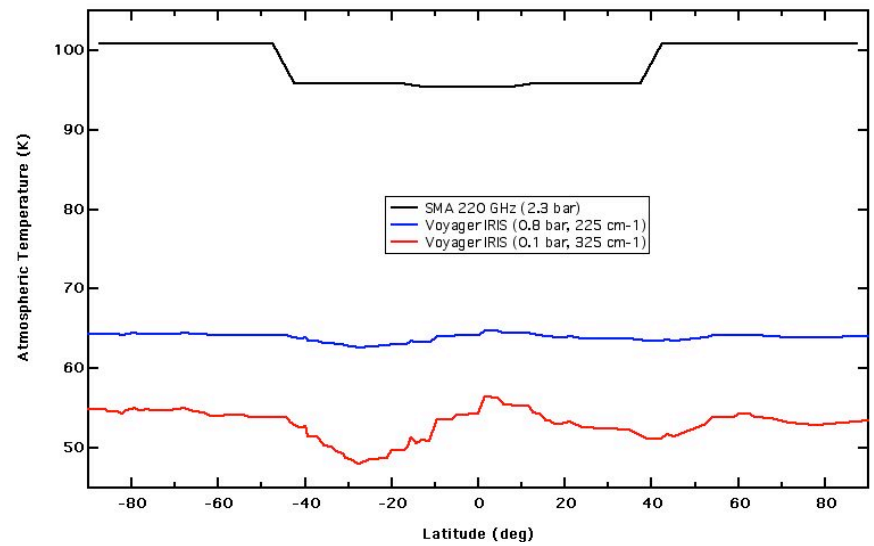
Hofstadter and Butler (centimeter)



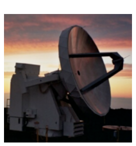


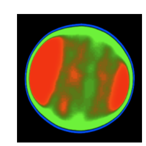
Recent Modeling





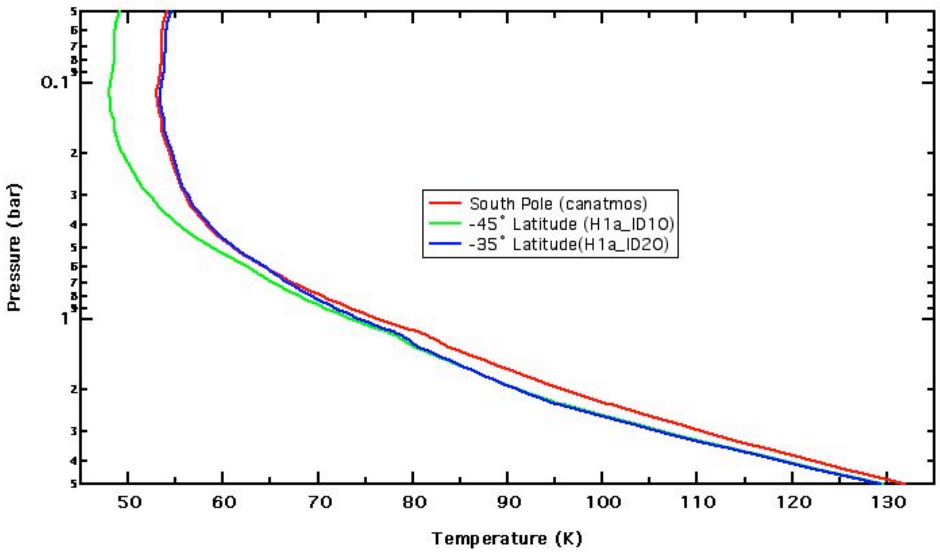
- At HIFI's wavelengths, the brightness of Uranus is controlled by atmospheric temperatures in the ~0.1 to ~2 bar region.
- Ground-based submillimeter and thermal IR measurements determine the current atmospheric structure above and below this region.
- Voyager observations (1986) help characterize seasonal variability.

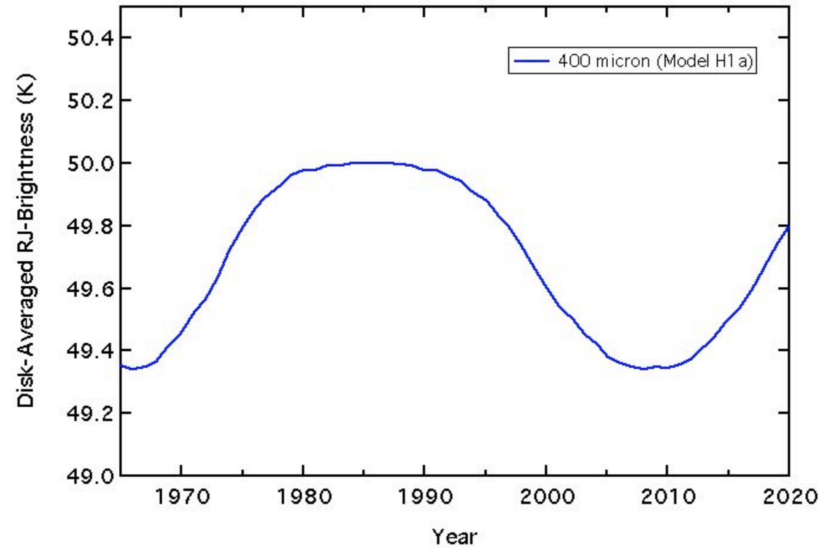




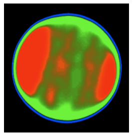
Recent Modeling: Atmospheric Temperatures

Plots show results with no seasonal change, only viewing geometry varies.

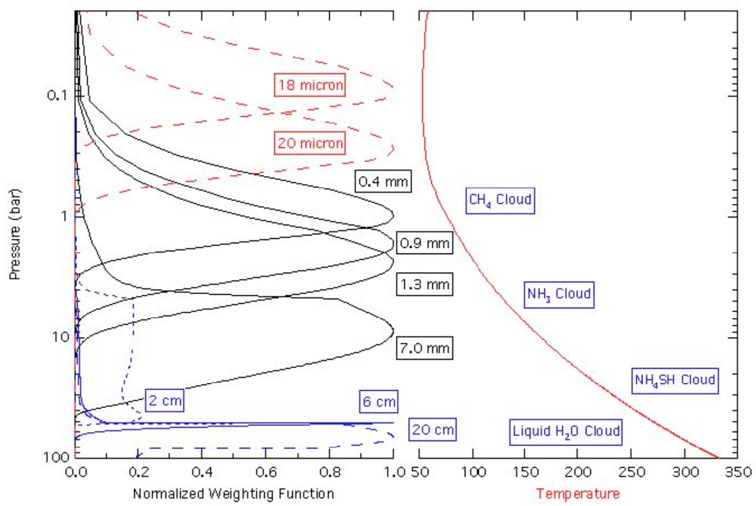


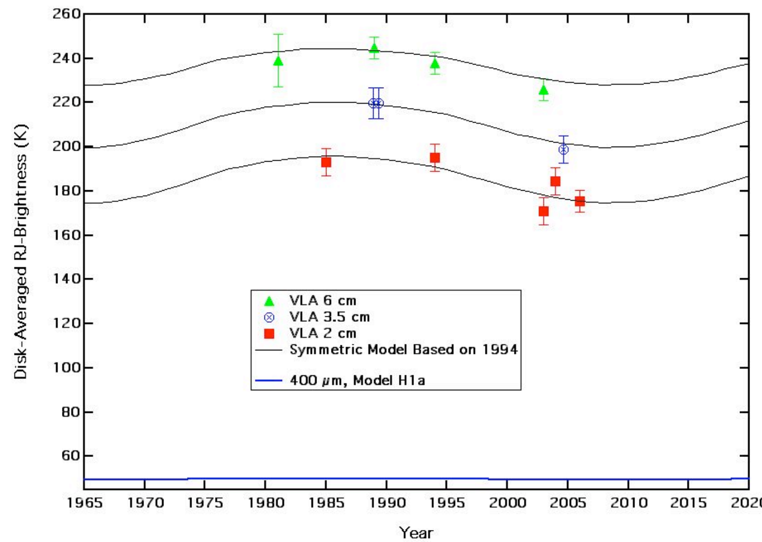


- At a given altitude (observed by a particular HIFI frequency), physical temperatures vary with location by up to 10%.
- Voyager (summer solstice) to recent VLT (equinox) differences at thermal IR wavelengths suggest seasonal variations are also up to 10%.



Recent Modeling: Uncertainties





•Abundance of trace species: <1%.

Partial mitigation with radiative/dynamical modeling, and observations.

• Vertical lapse rates in the 0.1 to 2-bar region: <5%.

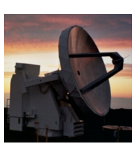
Mitigate with radiative/dynamical modeling, additional observations.

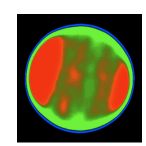
• Absolute brightness: 5% at millimeter wavelengths, 10% at IR.

Mitigation? Improve on SMA or Spitzer calibration?

• Possible rapid seasonal change: <10%.

Mitigate with ground-based observations during Herschel mission.





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