Investigating Ammonia Gas in the Jovian Atmosphere Using Centimeter Wavelength Total Flux

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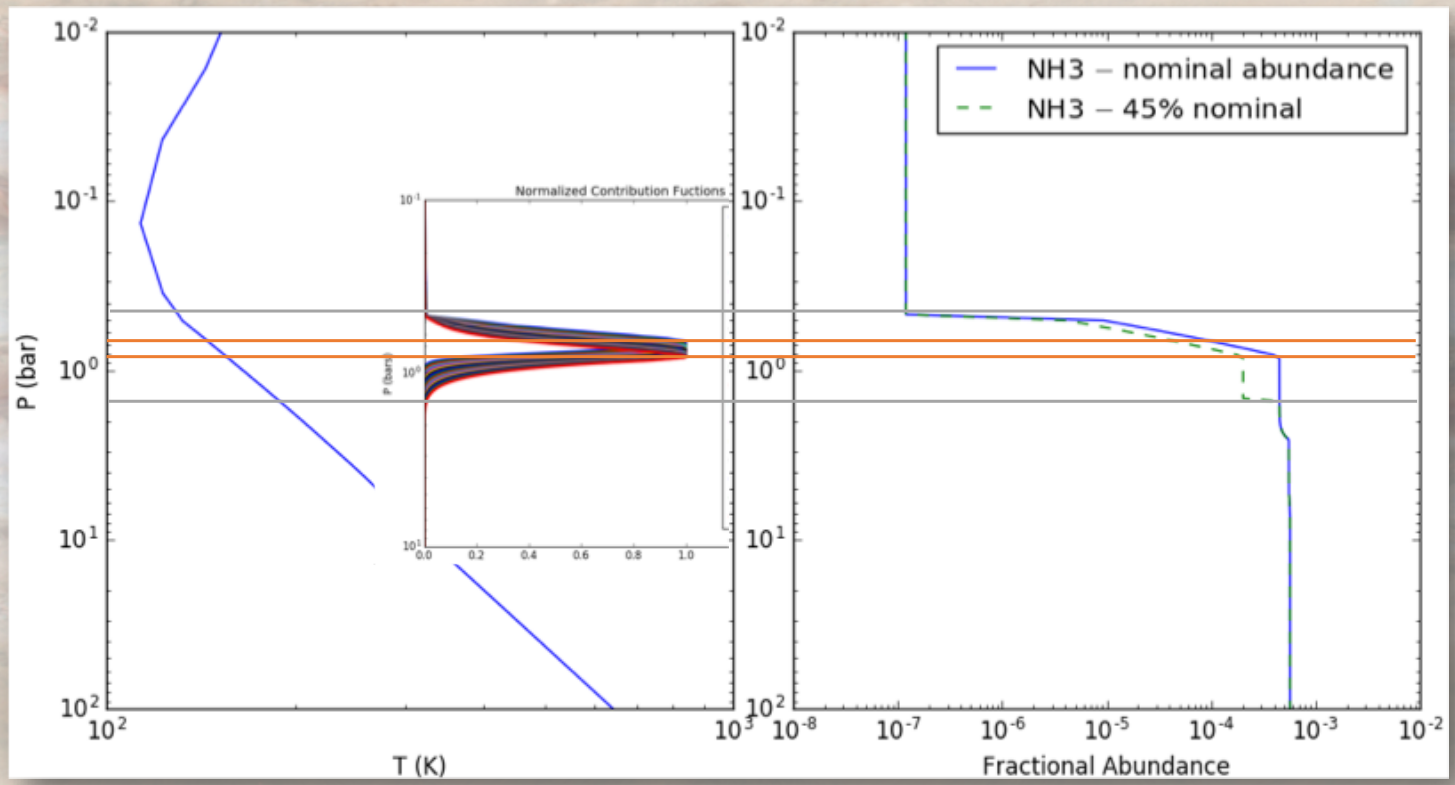
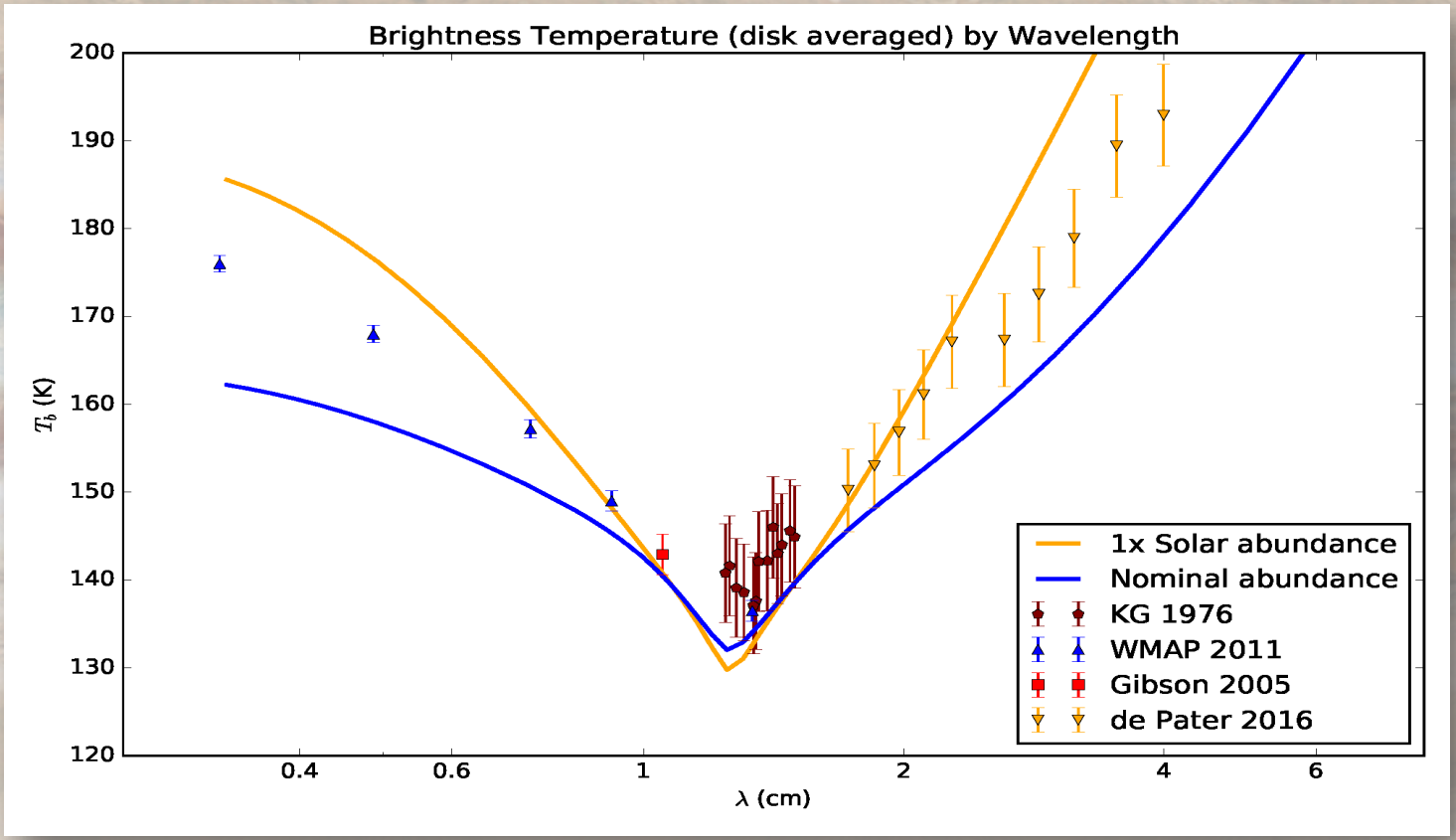
Background: Ammonia (NH3) on Jupiter

- Different frequencies probe different depths
- Spectral features of atmospheric constituents affect observed depth, which affects feature shape
- Characterize feature shape: characterize constituent abundance



Jupiter at ~1 cm

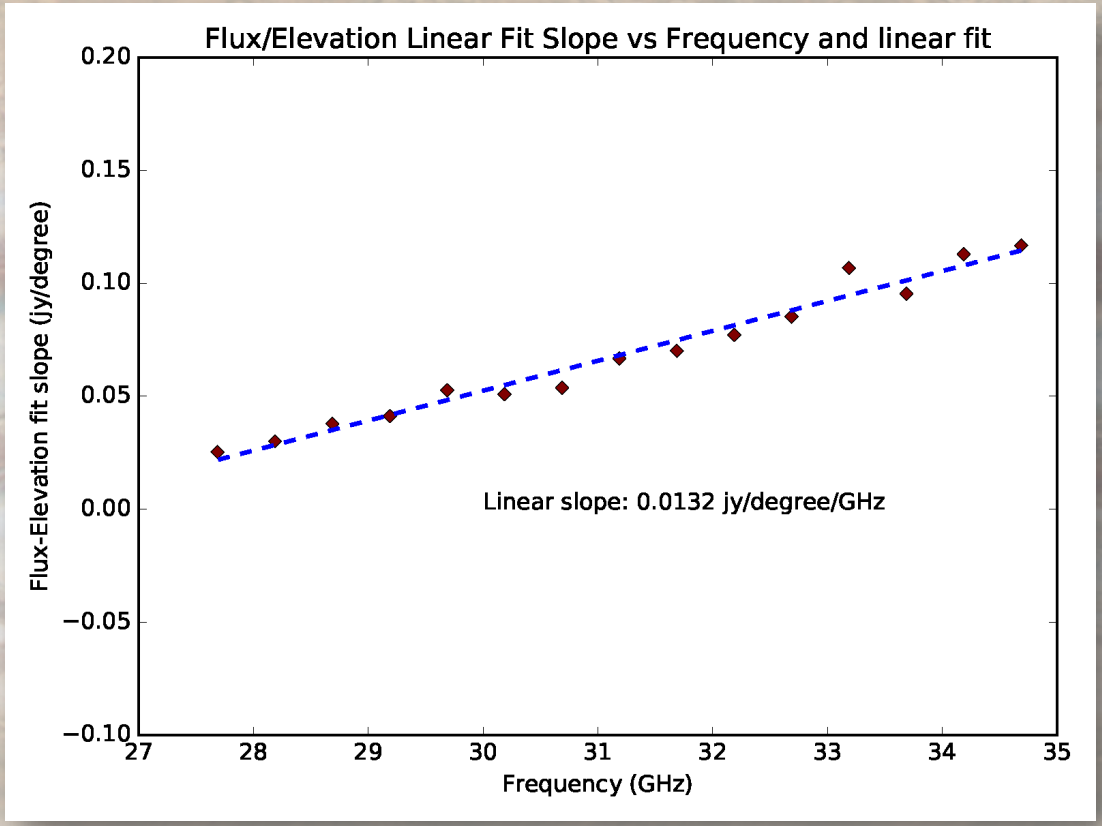


CARMA & COPSS

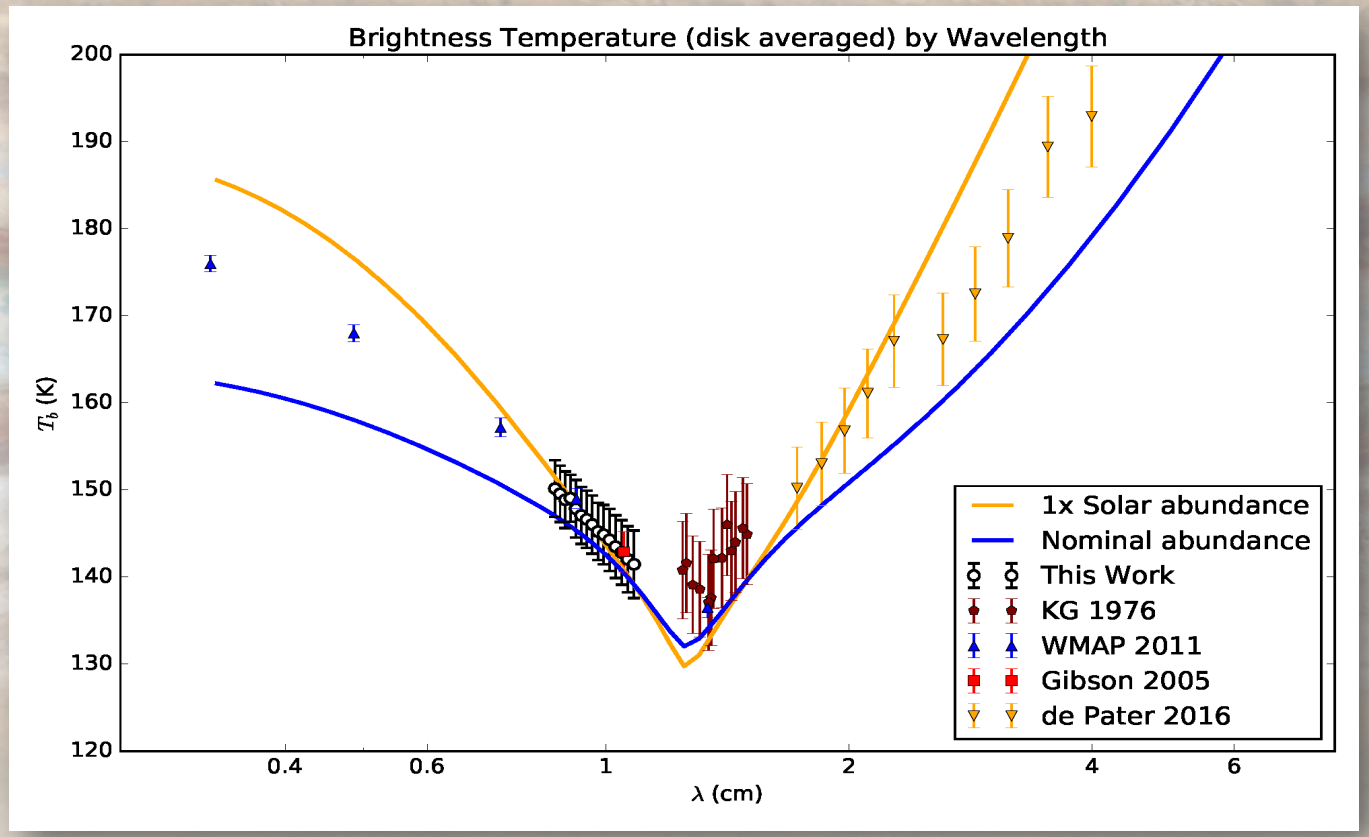
- CO Power Spectrum Survey (COPSS) using the Sunyaev-Zel'dovich Array (SZA) subset of the Combined Array for Research in Millimeter-wave Astronomy (CARMA) at Owens Valley in California (Keating et al. 2016)
- Secondary calibration scans of Jupiter at 15 channels between 27-35 GHz

Processing

- Corrected for systematic errors: Jupiter's distance, air mass calibration error, synchrotron contribution (Gibson et al. 2005)
- Jackknife testing to isolate systematics
- Time-averaged
  - Systematic uncertainty ~2%
  - Relative uncertainty ~0.005%

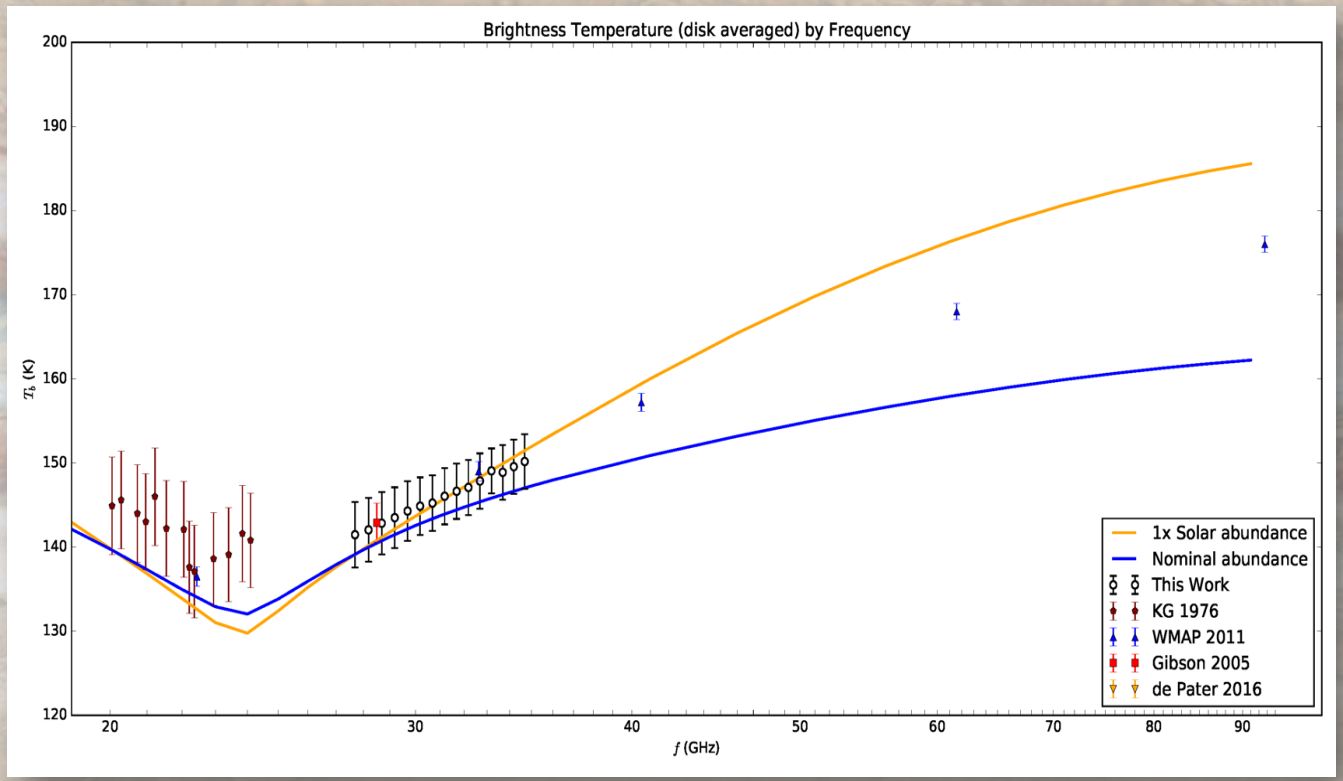


Measurements



Model

- Atmospheric radiative transfer modeling software (de Pater et al. 2016)
- Fit data to 2-parameter grid:
  - Saturation coefficient
  - Pressure cutoff for saturation adjustment
- Subsaturation of ammonia gas by some coefficient above some depth and below NH3 cloud at 0.5-0.6 bar



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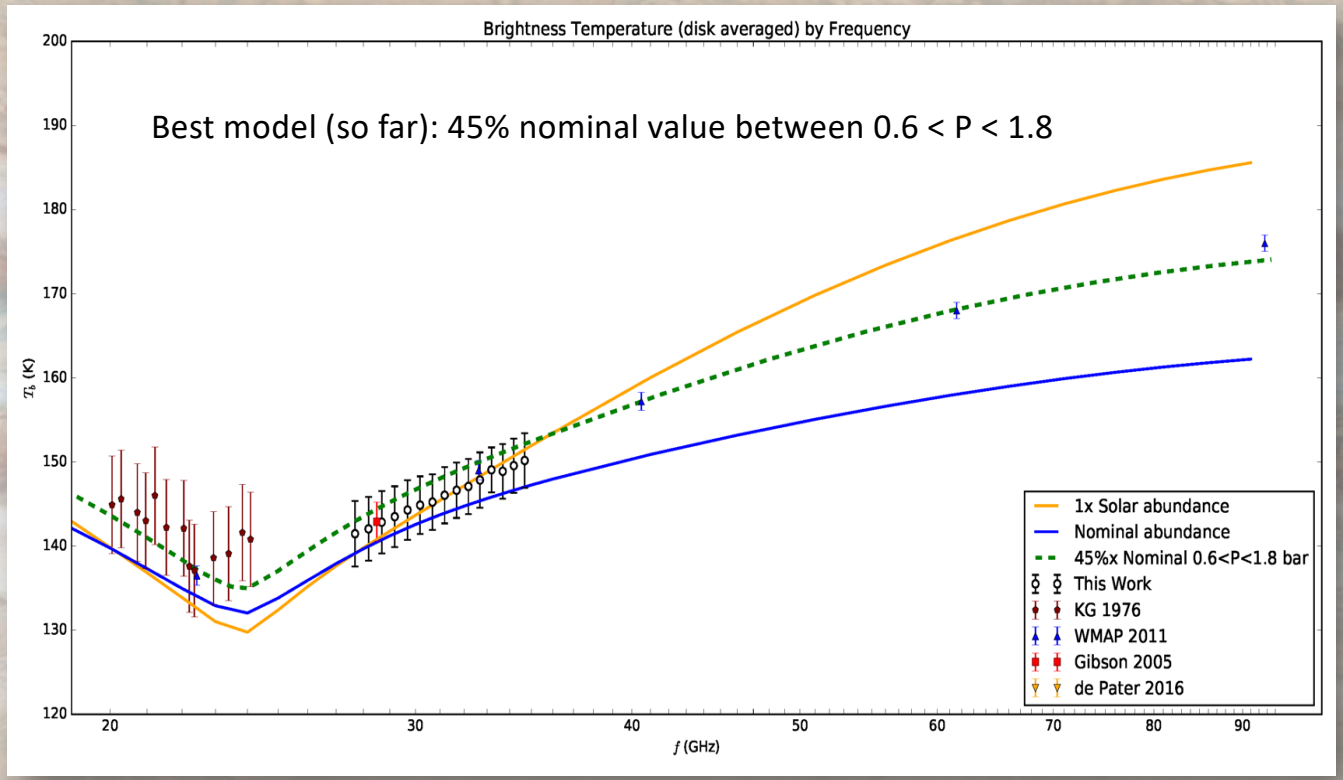
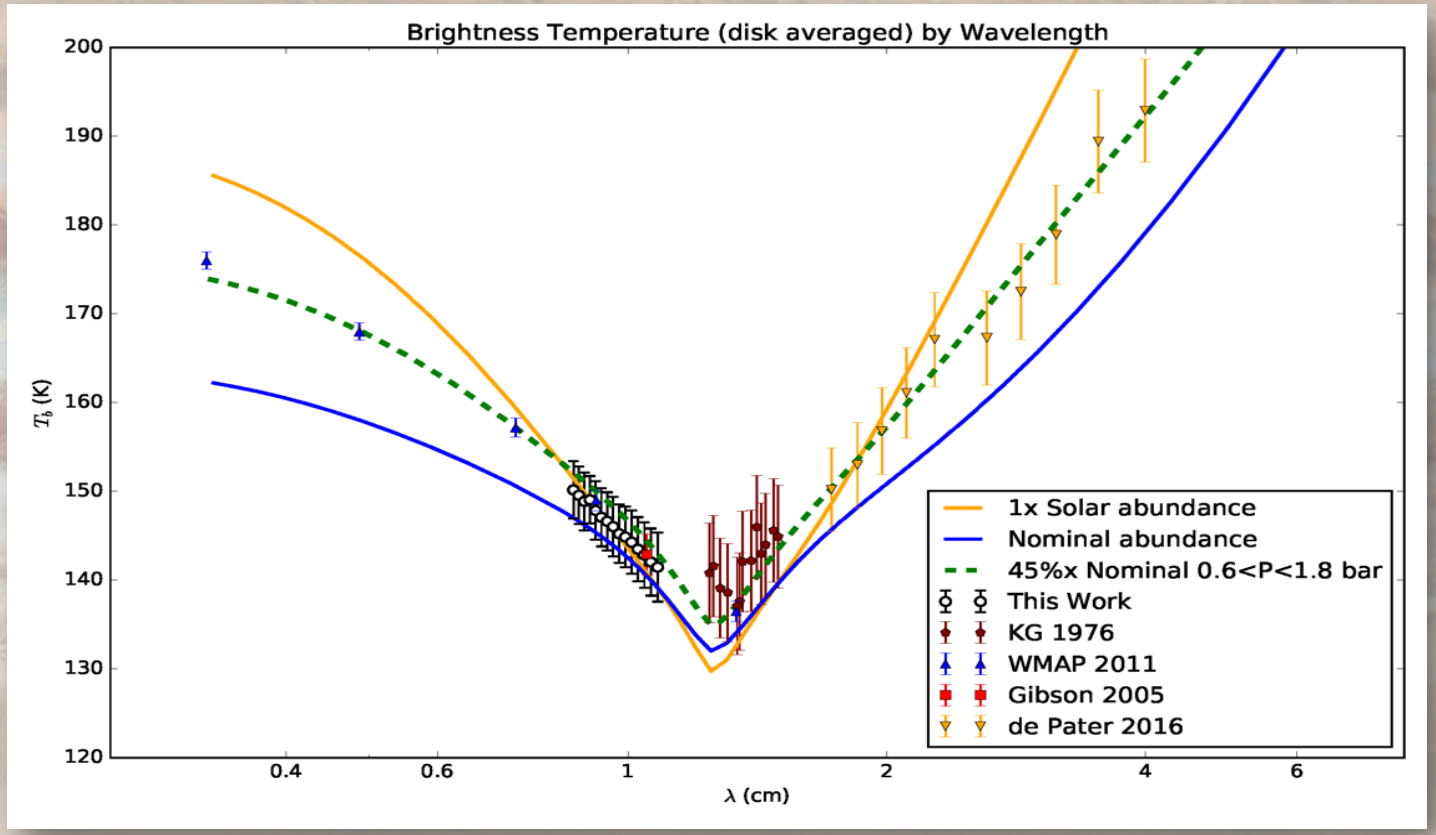
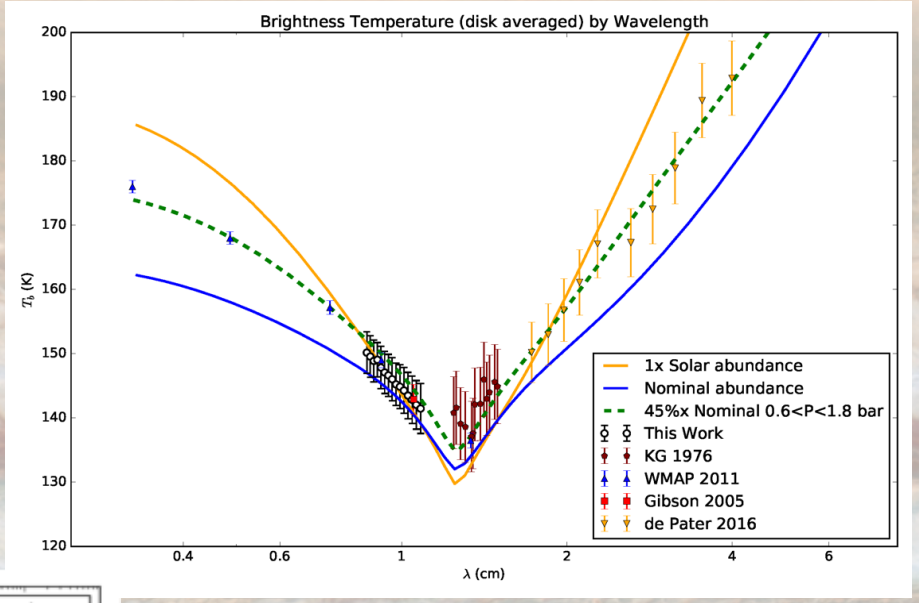


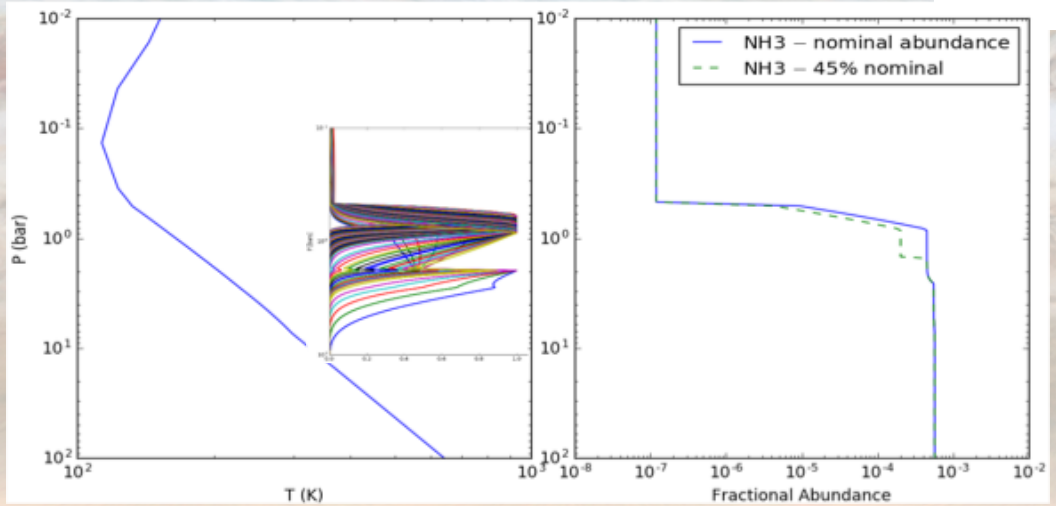
Model


Brightness Temperature (disk averaged) by Wavelength
200
190
180
170
160
150
140
130
120
T_b (K)
0.4
0.6
1
2
4
6
λ (cm)
1x Solar abundance
Nominal abundance
45%x Nominal 0.6<P<1.8 bar
This Work
KG 1976
WMAP 2011
Gibson 2005
de Pater 2016

Conclusion

- Jupiter's thermal emission measured at 15 channels between 27-35 GHz (~0.9-1.1 cm)
- Modeled ammonia content using this data set, relying primarily on slope
- Found ~45% of nominal value between 0.6 < P < 1.8 bar





- Surrounding measurements probe different depths and will help make the model more accurate

References

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2. Gibson, J.L., 2003. An accurate measurement of the brightness temperature of Jupiter at 28.5 GHz. PhD dissertation. University of California, Berkeley.
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4. Keating, G.K., Marrone, D.P., Bower, G.C., Leitch, E., Carlstrom, J.E., DeBoer, D.R., 2016. COPSS II: the molecular gas content of ten million cubic megaparsecs at redshift z~3. ApJ, accepted for publication.
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Background image: Astronomy Picture of the Day 10/24/2015: NASA, ESA, Amy Simon (GSFC), Michael Wong (UC Berkeley), Glenn Orton (JPL-Caltech)