Observations of Water and other molecules in Protoplanetary Disk Atmospheres

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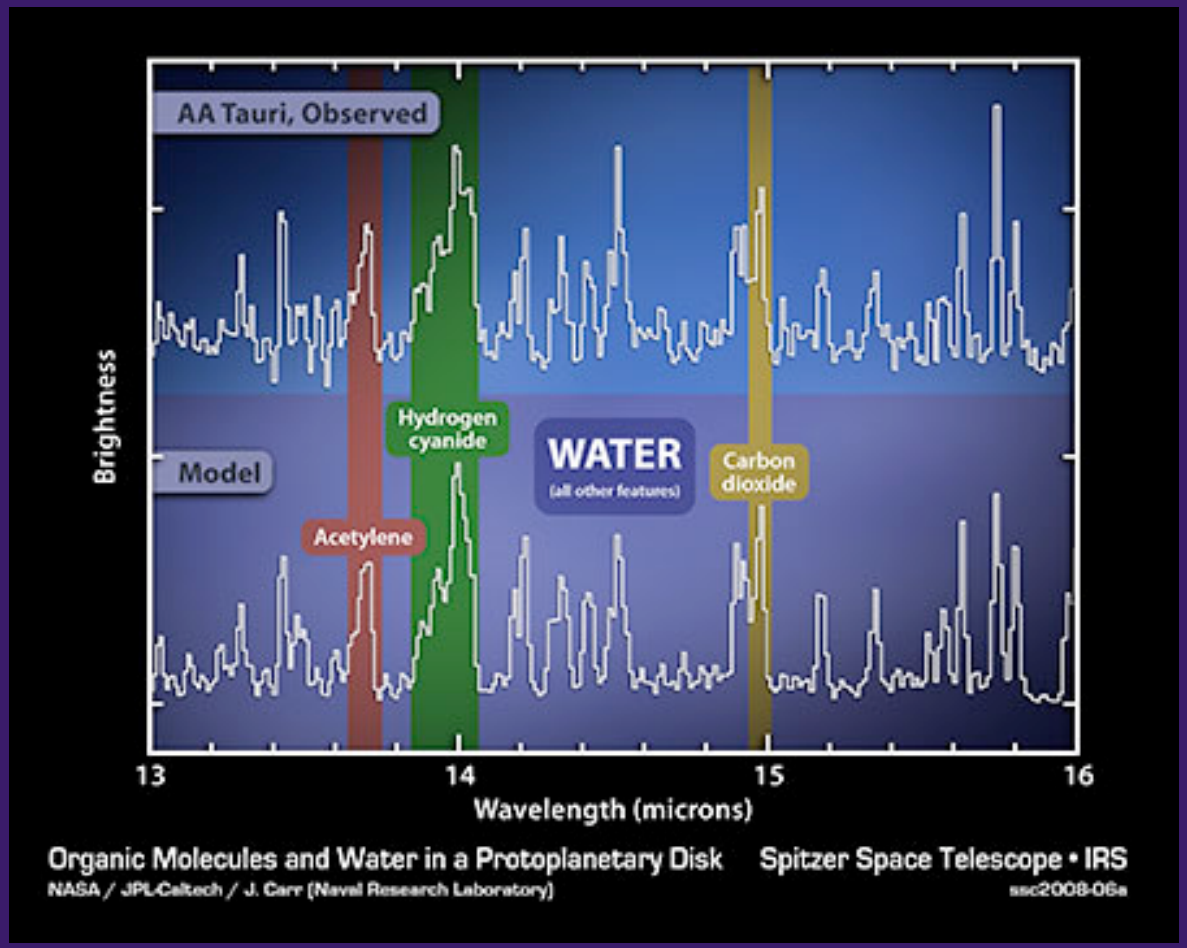
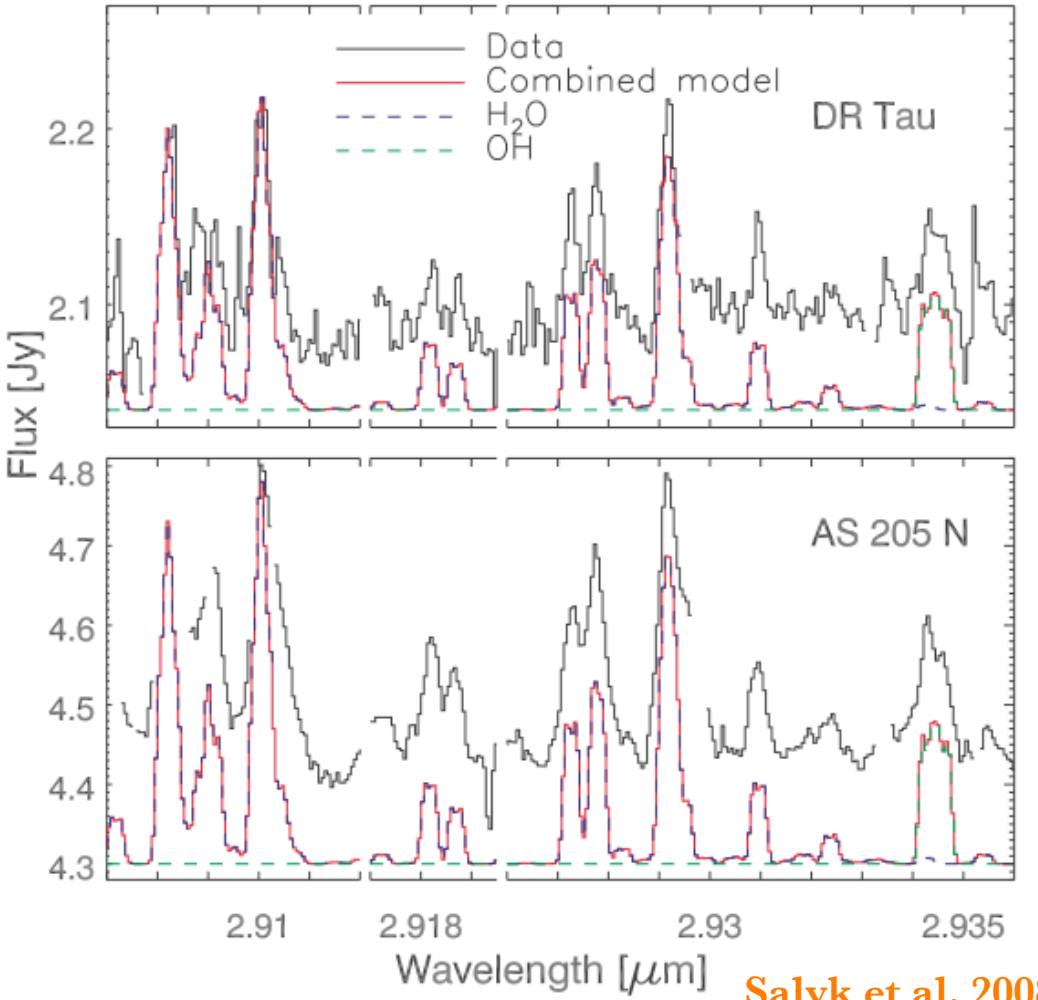
Water vapor and organics detected with Spitzer-IRS



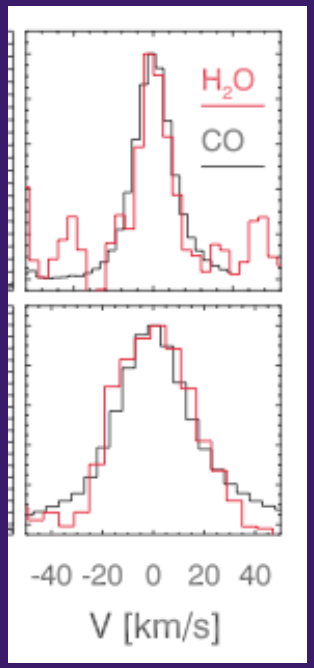
Carr & Najita 2008; Salyk et al. 2008

T~500-1000 K

Ground-based follow-up confirms origin in planet-forming regions of disks (NIRSPEC/CRIRES)



Salyk et al. 2008



Line widths consistent with ~1 AU emitting radii

What processes might this emission probe?

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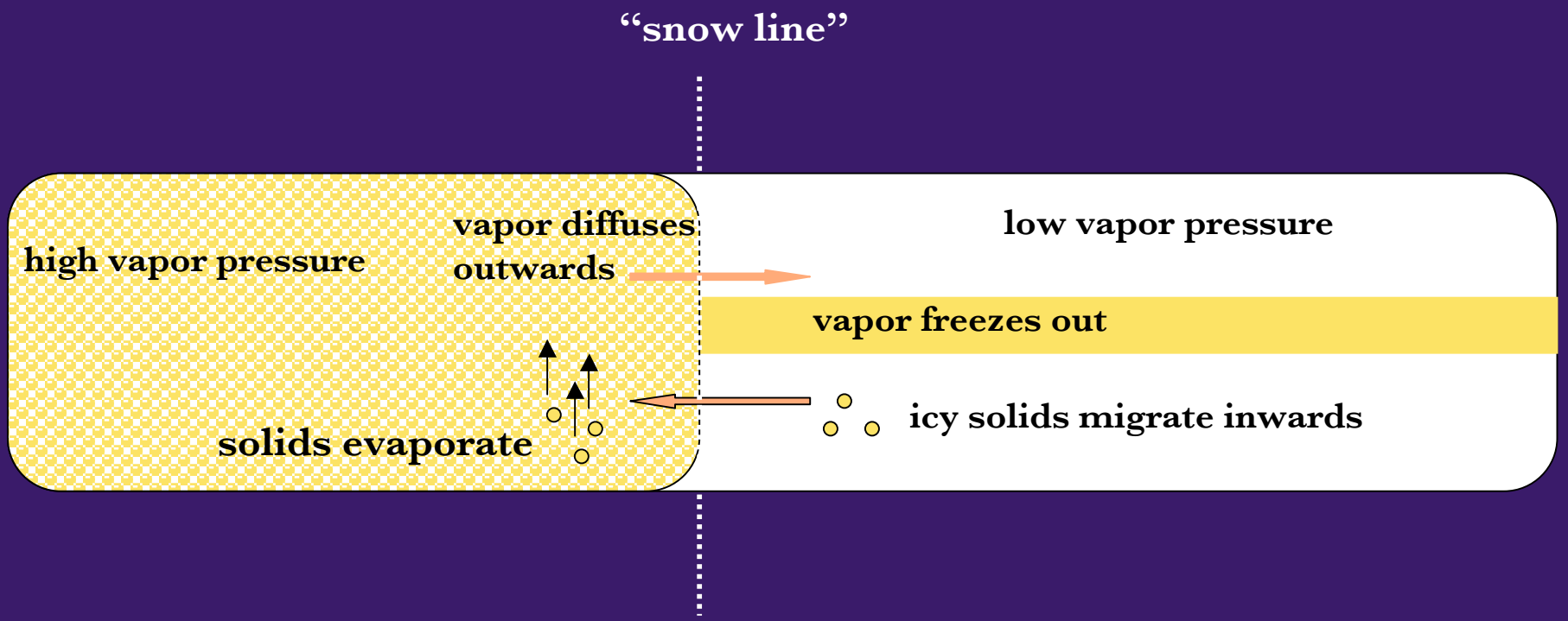
Radial transport of water via diffusion (out) and icy-body migration (in)



e.g. Stevenson & Lunine 1988; Ciesla & Cuzzi 2006

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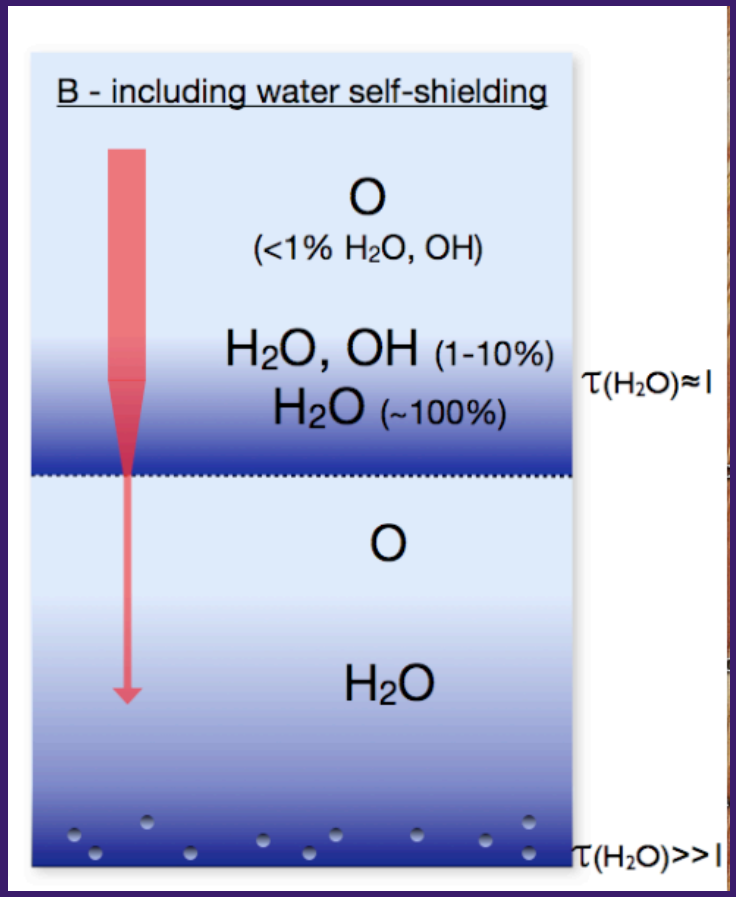
Water self-shielding



Bethell & Bergin, in press

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Disk chemistry

Radiative processes

Condensation fronts

Dust grain growth/settling

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Clearly a challenge to disentangle multiple effects

GO5 program: Water in Disks (PI: J. Carr)

-41 class II disks in multiple star-forming regions – high S/N

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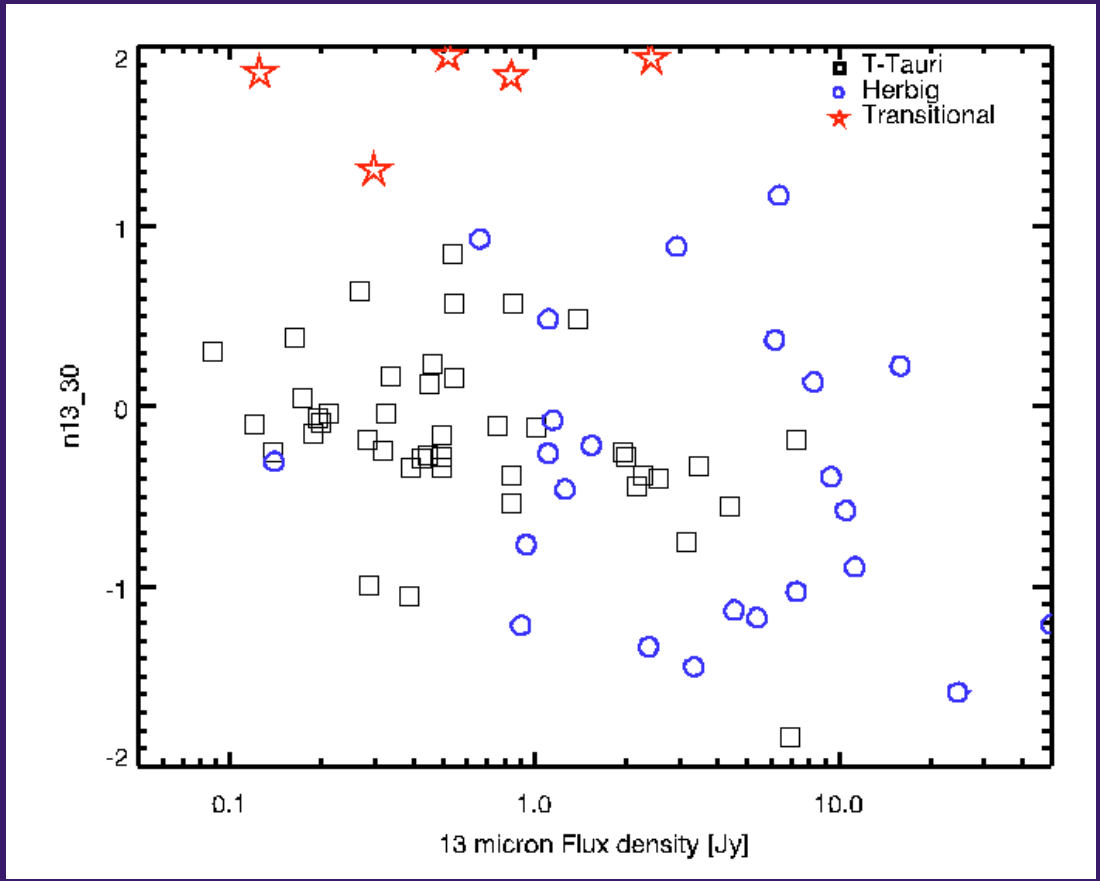
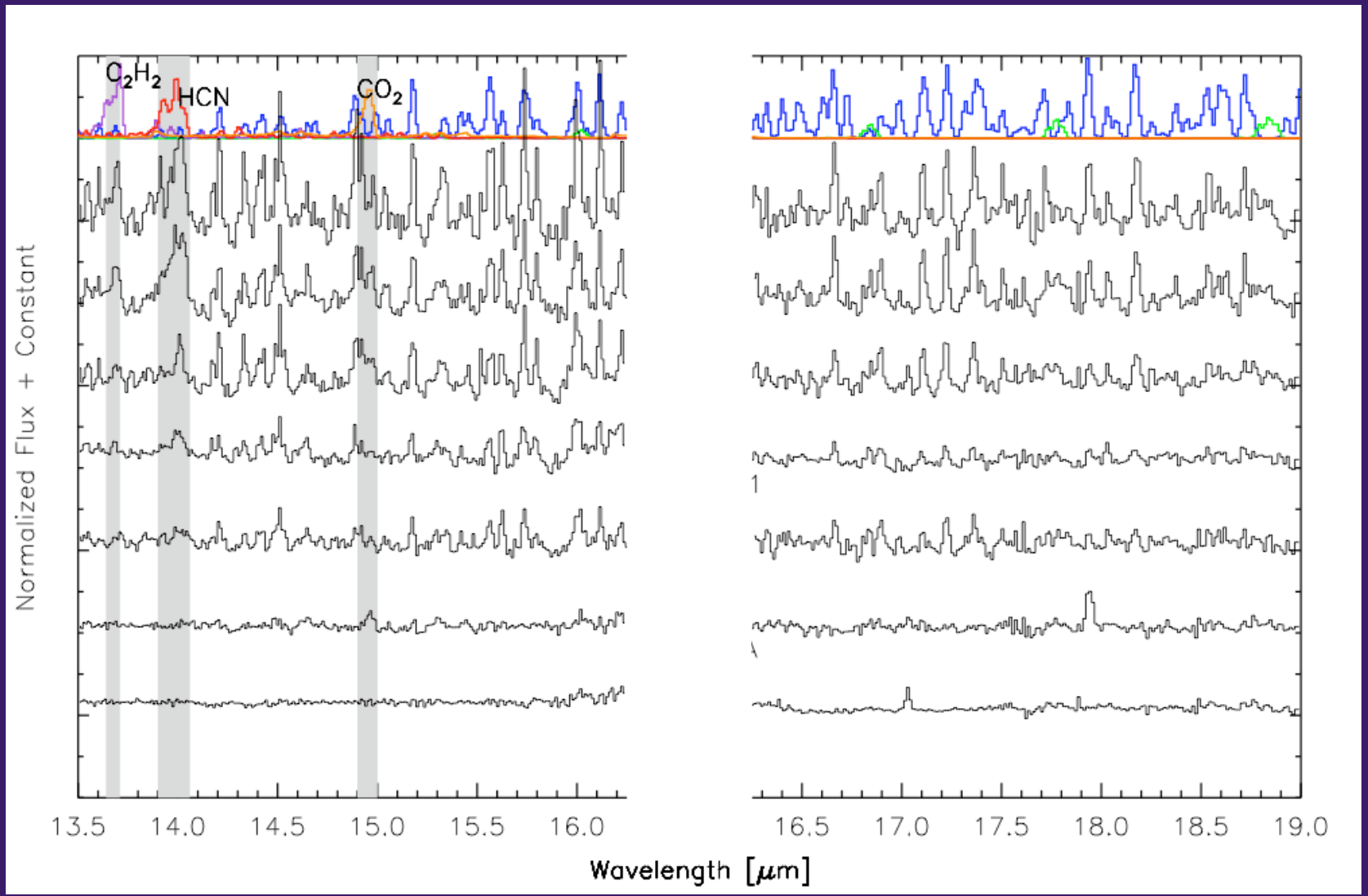
-Shown here: subset of GO5 sample + c2d + Bouwman et al.

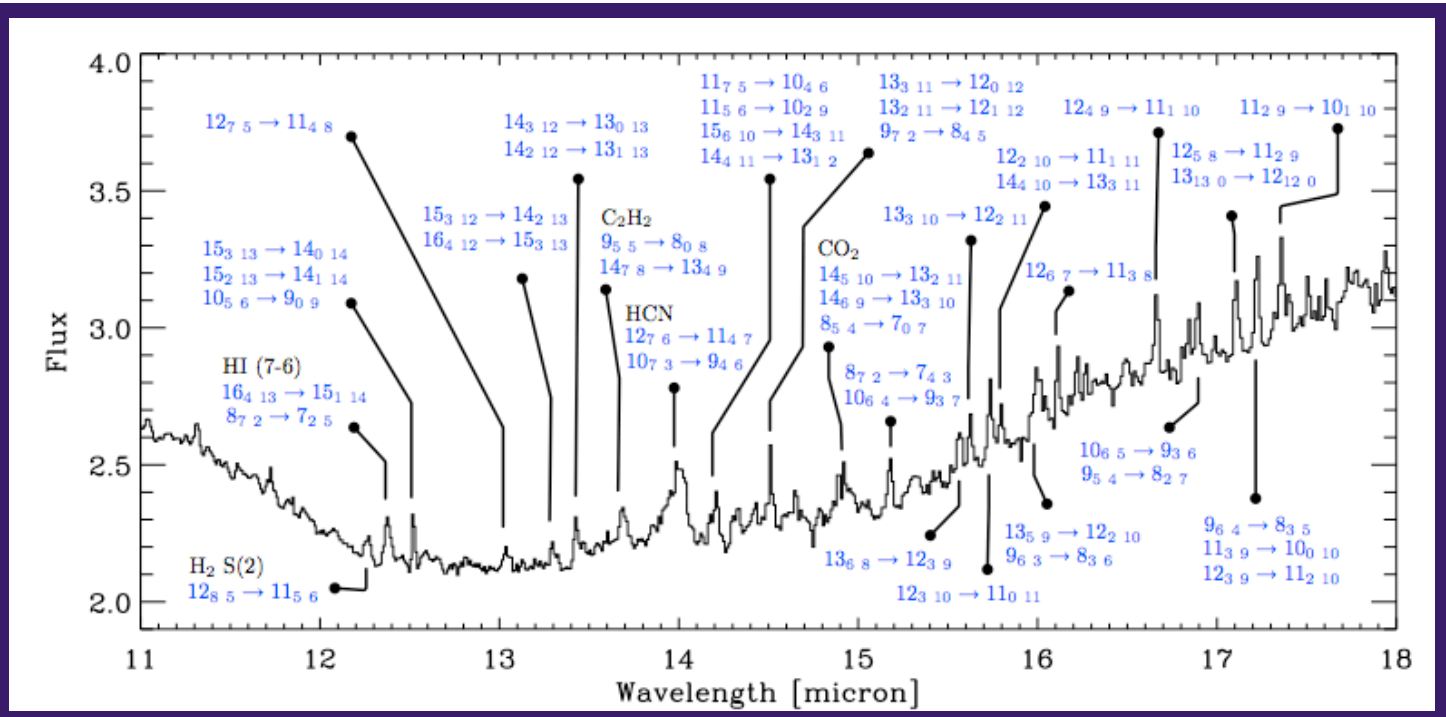
-(Focused look at Taurus subsample by J. Carr, J. Najita)

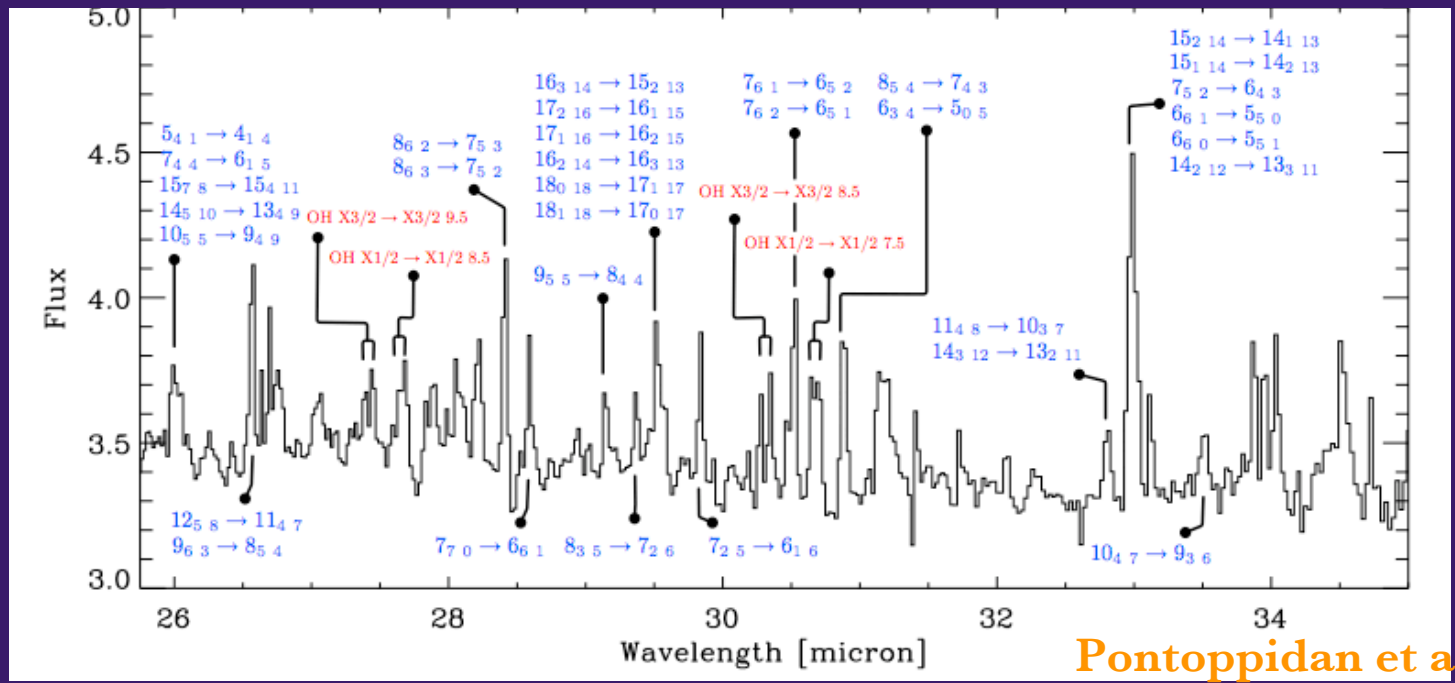


Sampled disks show significant diversity

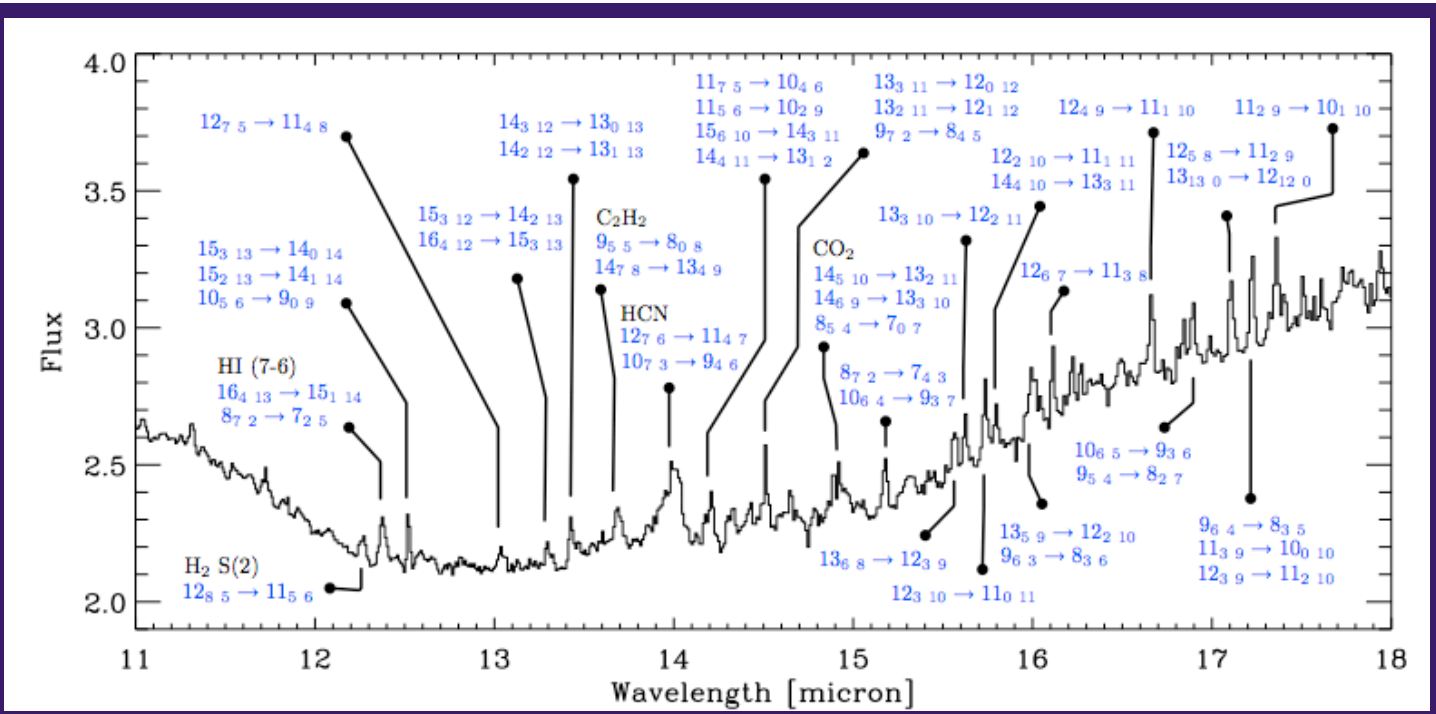


Salyk et al., in prep





Pontoppidan et al., in prep

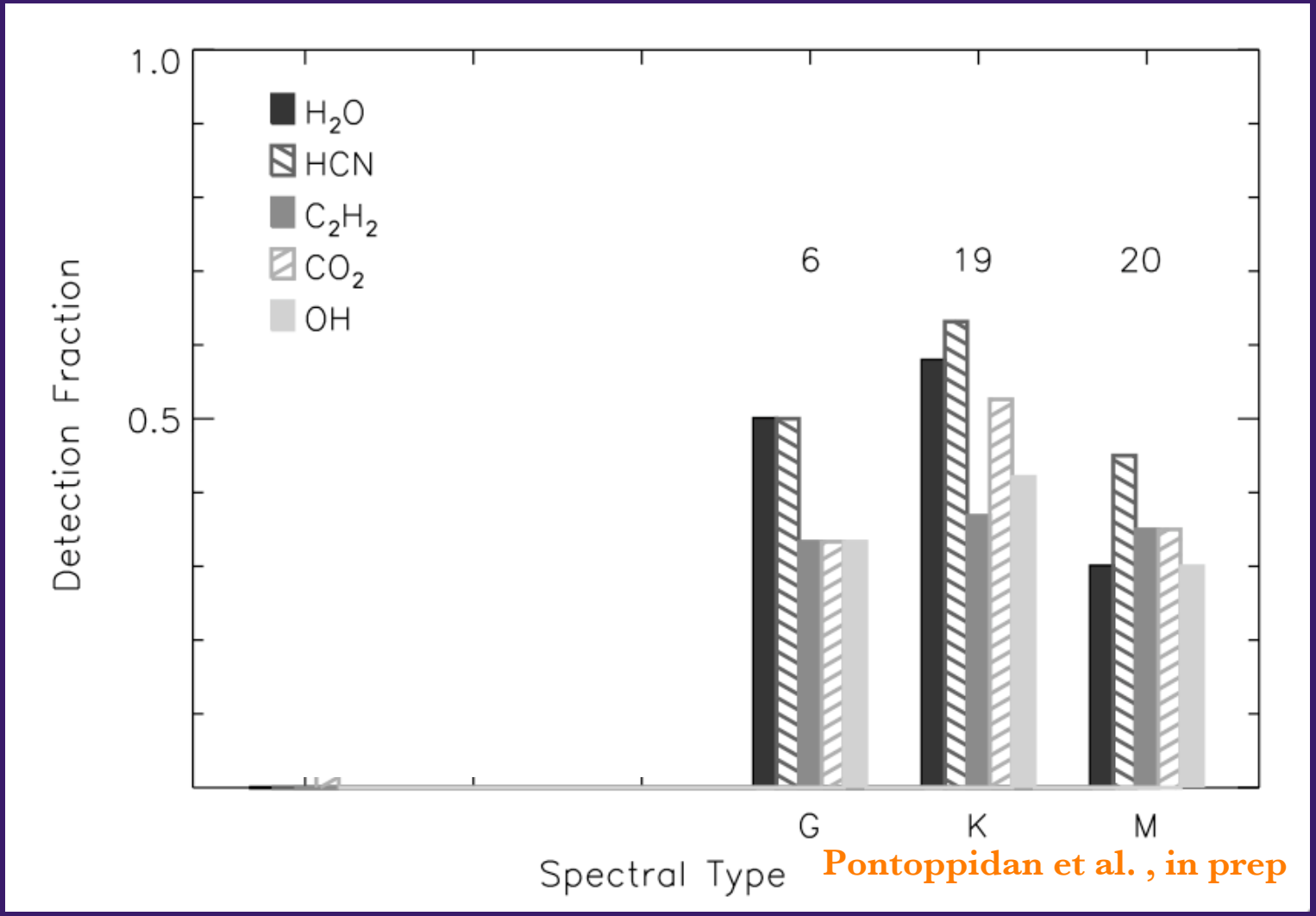


-Lines not only spectrally uresolved – most are blends (at the Spitzer-IRS resolution)

-Lines probe a large range of excitation temperatures

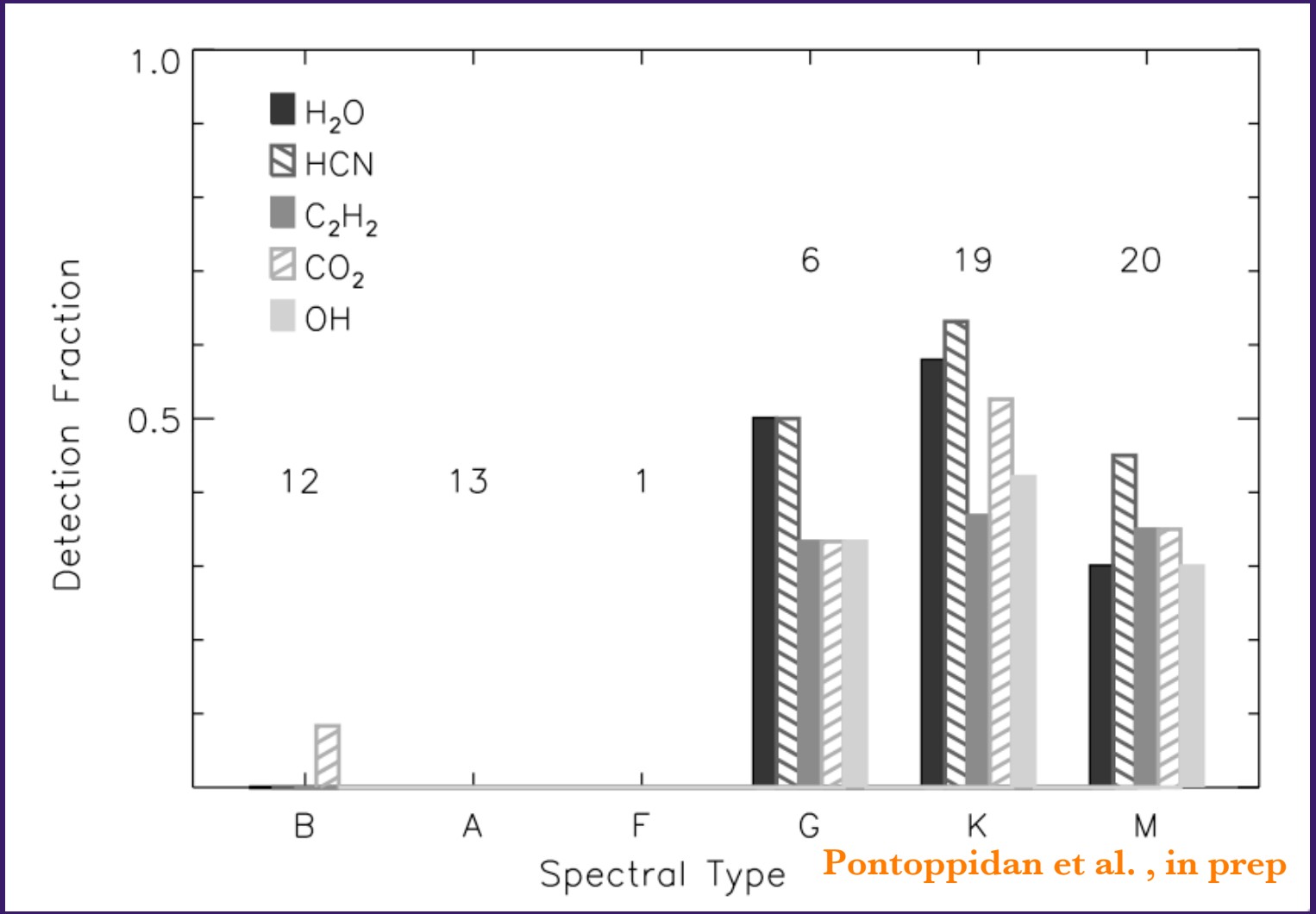
-Higher spectral resolution would provide higher line/continuum ratios and emitting location

Water vapor and organic emission is common around low-mass young stars

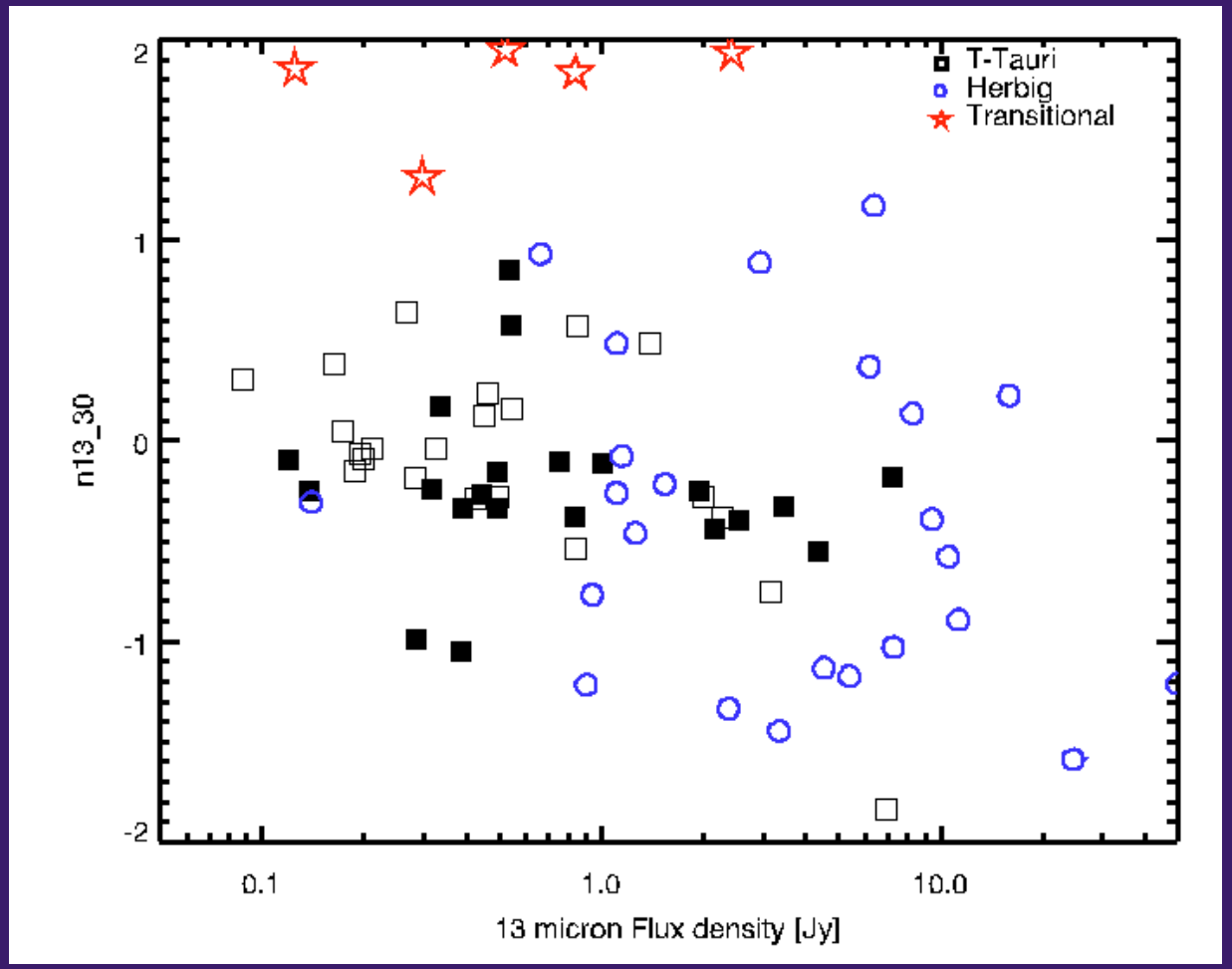


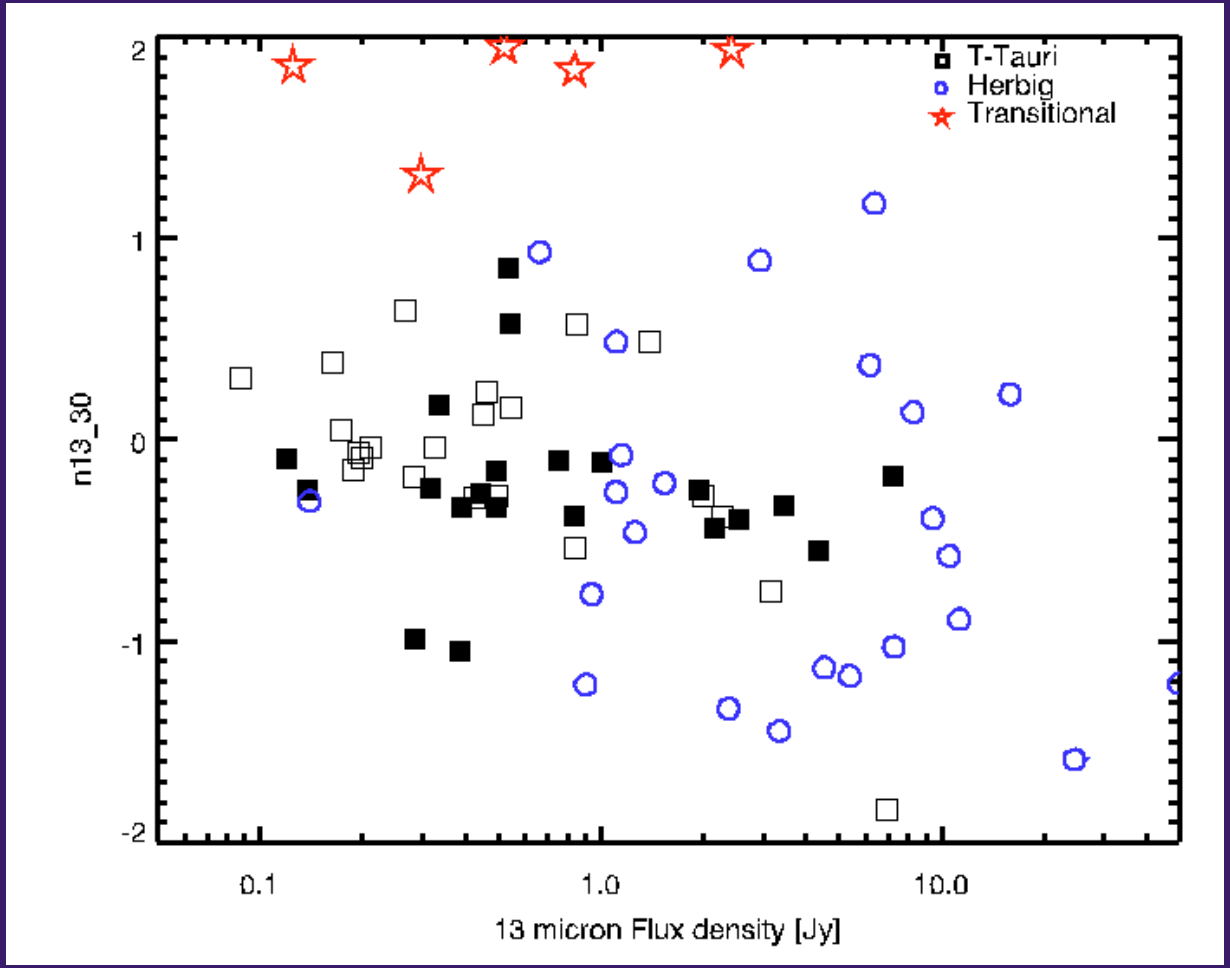
Pontoppidan et al. , in prep

Detection rates drop precipitously for SpT<G



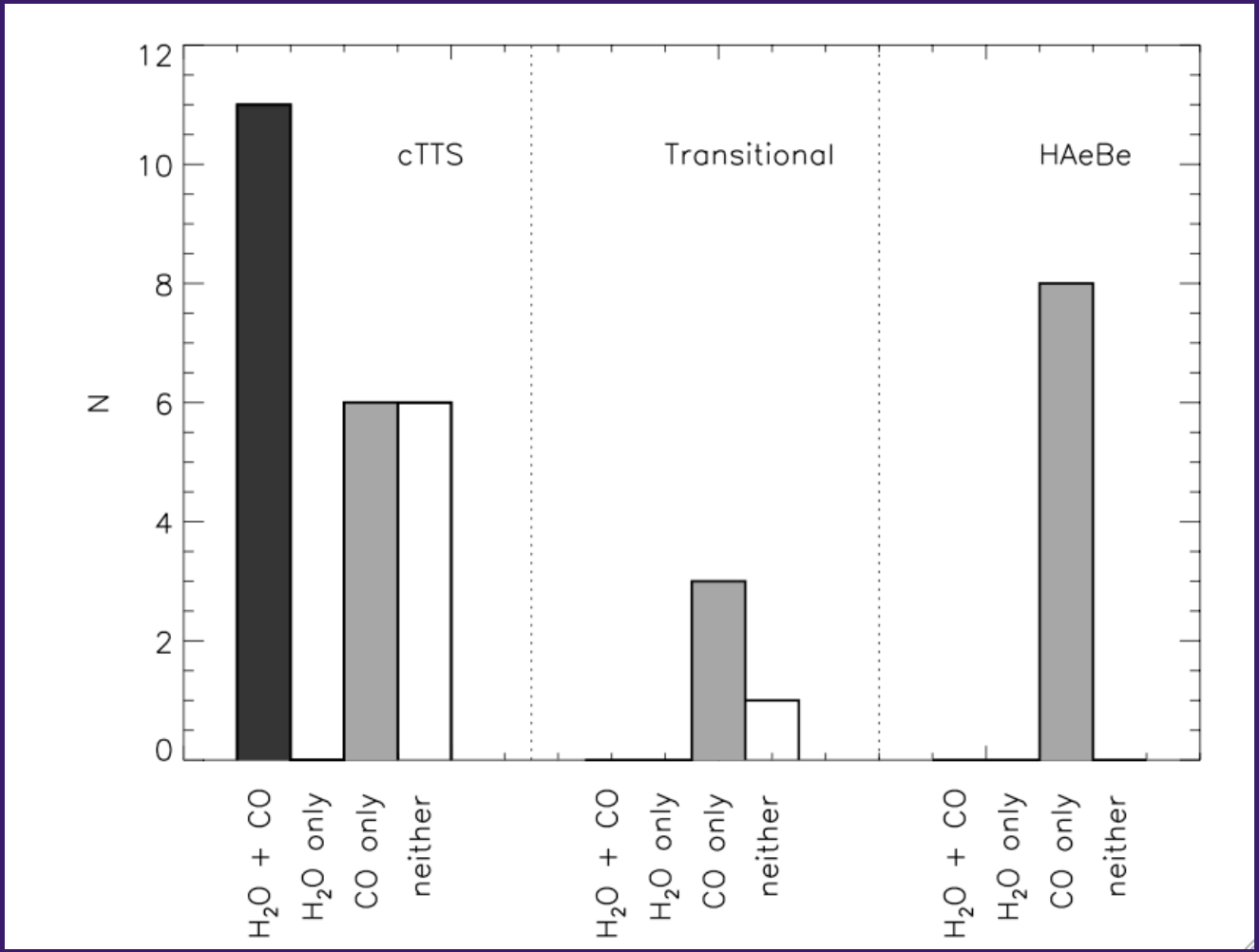
Pontoppidan et al. , in prep


T-Tauri
Herbig
Transitional
n13_30
2
1
0
-1
-2
0.1
1.0
10.0
13 micron Flux density [Jy]

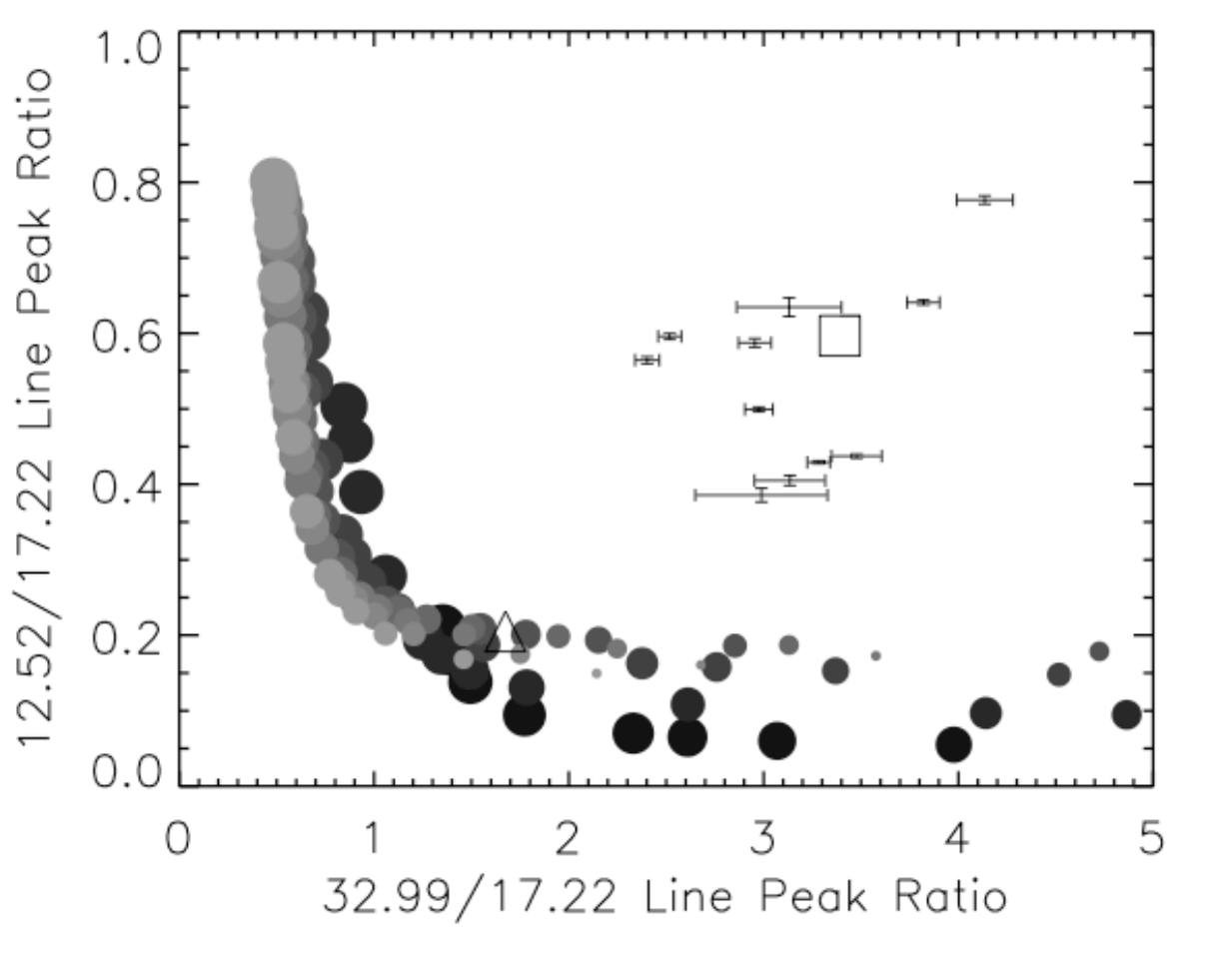


Transitional disks also do not show mid-IR emission

CO vibrational emission observed even when water is not

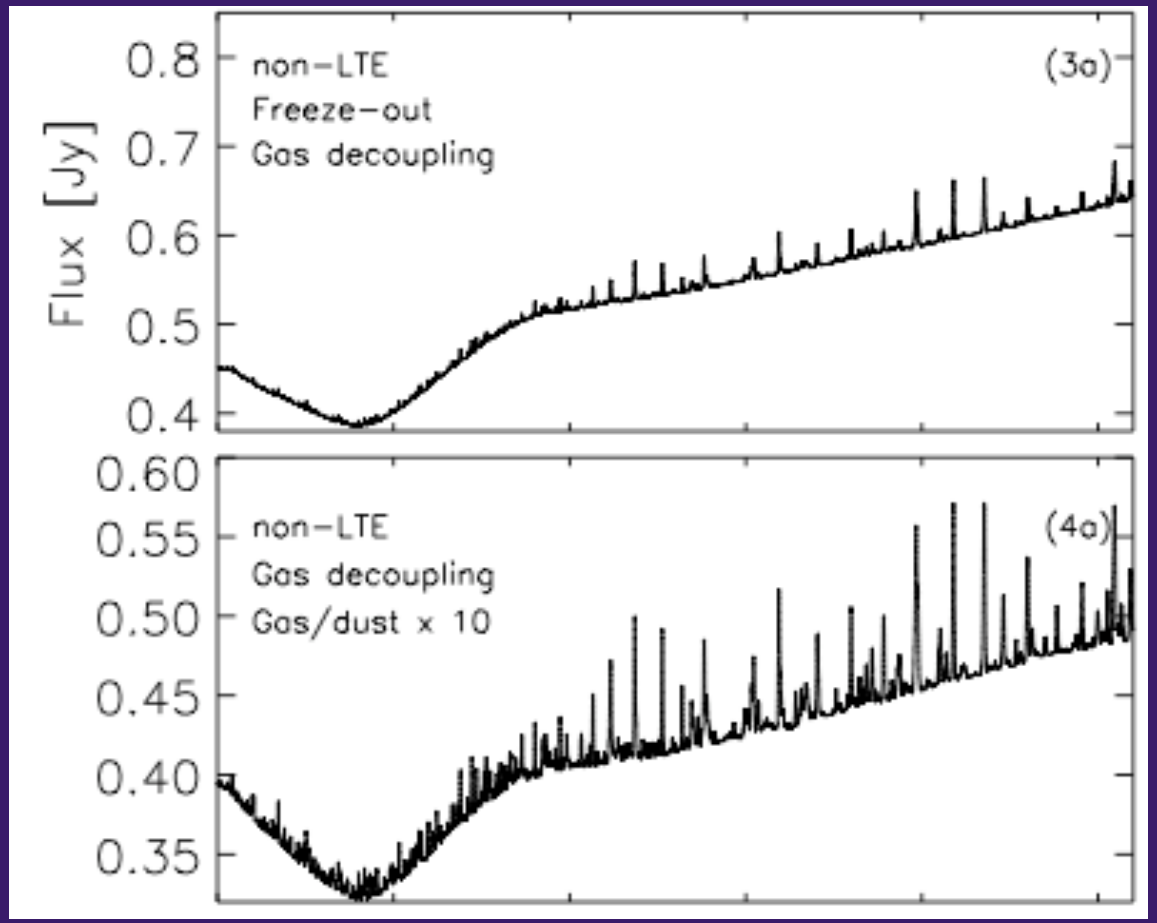


Simple models are helpful, but have serious limitations…



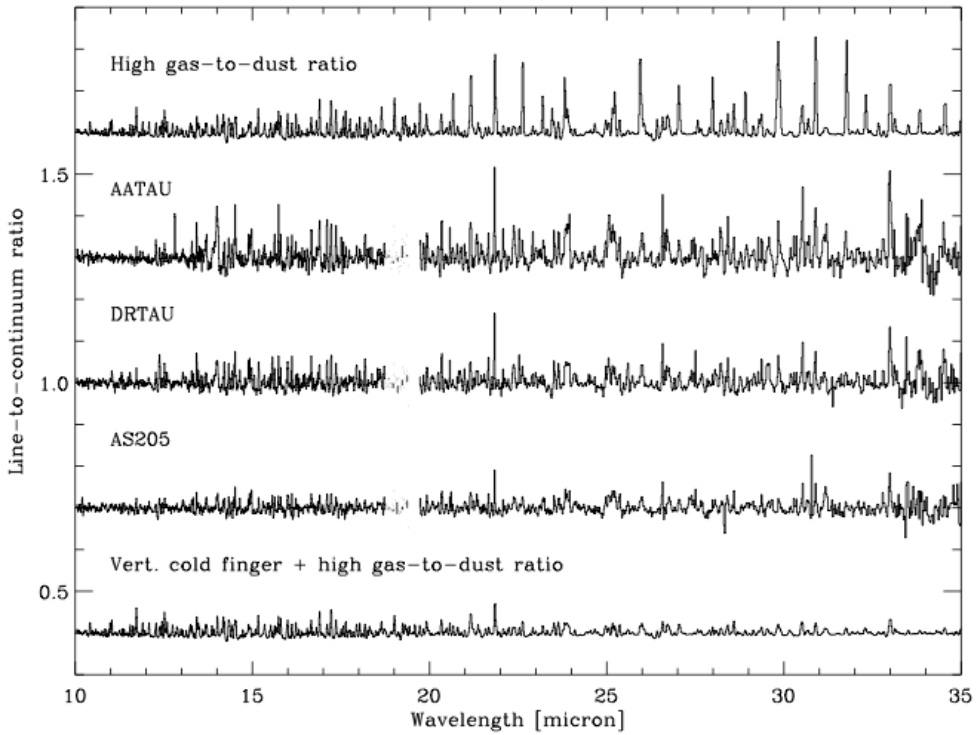
Both simple and more realistic models are being pursued

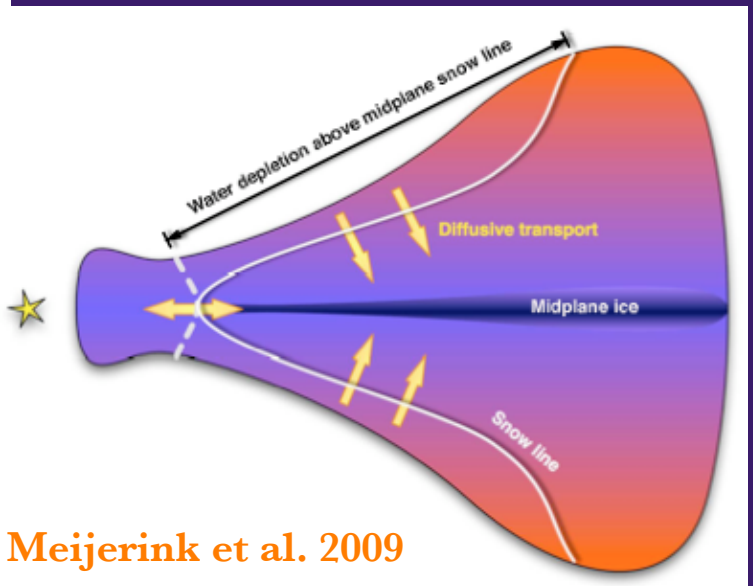
Reduction of small dust required to produce sufficient line fluxes.



Meijerink et al. 2009

Relative strengths of water emission lines require depletion of water well inside the canonical ‘snow-line’.





Meijerink et al. 2009

In Conclusion…

Mid-IR emission from water, OH, HCN, C_2H_2 and CO_2 is common around low-mass stars, though not ubiquitous

Emission consistent with high T (500-1000 K) and small radii (~1 AU)

Emission not seen from Herbig Ae/Be stars and transitional disks, perhaps due to the radiation environment

Water models suggest high gas/dust ratios and depletion at ~few AU radii

Source-to-source variation still being investigated

Ground-based follow-up with high spectral resolution instruments (NIRSPEC, CRIRES, MICHELLE, TEXES) is actively being pursued