

Spitzer Spectroscopy of Low-Mass Stars and Brown Dwarfs

Michael Cushing, SETI Institute/NASA Ames

Collaborators:

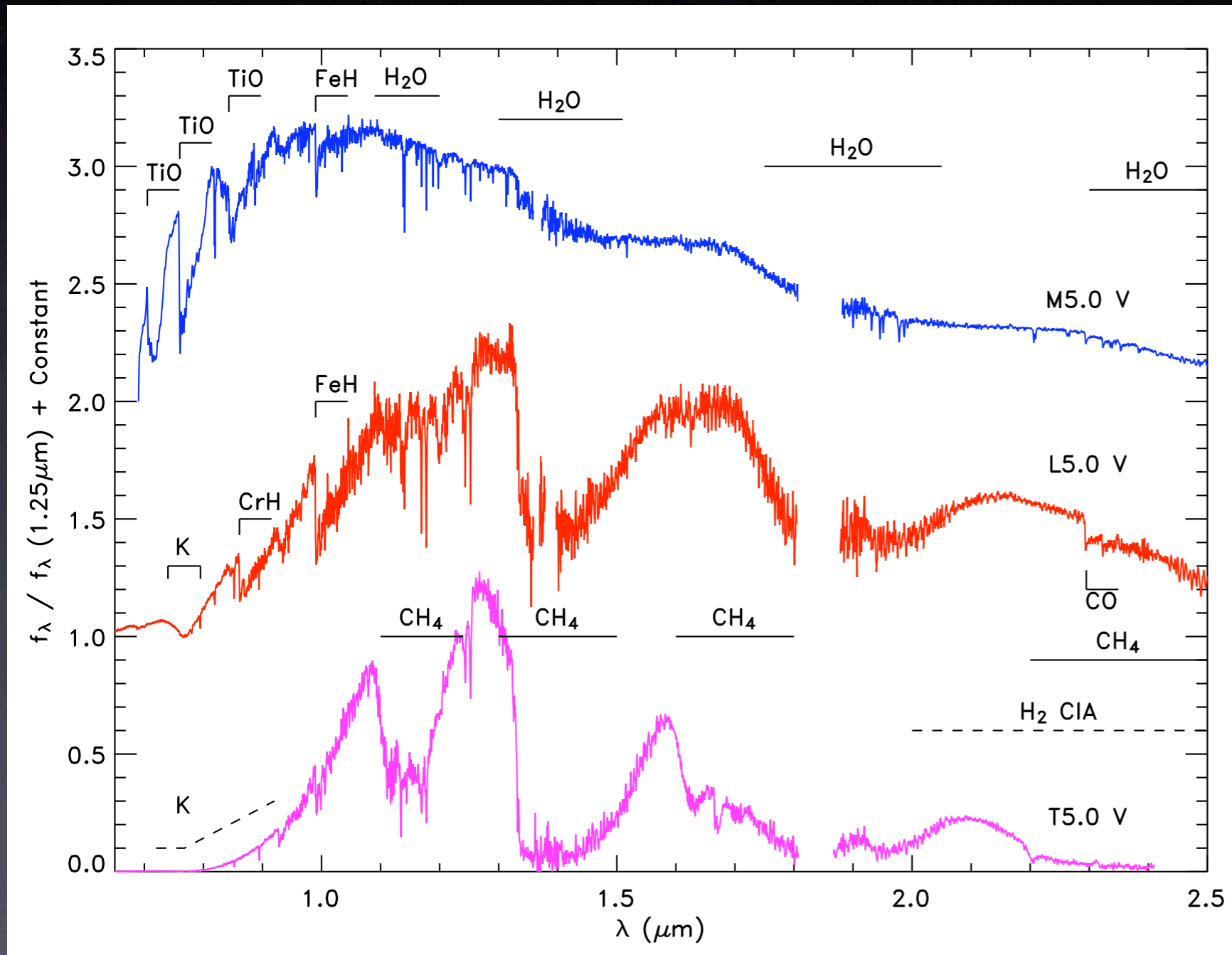
Tom Roellig, Jeff Van Cleve, Greg Sloan, John Wilson,
Mark Marley, Didier Saumon, Sandy Leggett, Davy
Kirkpatrick, Amy Mainzer and Jim Houck

Background

- Wide field surveys (2MASS, SDSS, and DENIS) have uncovered hundreds of very low-mass stars and brown dwarfs (BDs)
- Intensely studied, both observationally and theoretically, in the optical and near-infrared

⇒ L and T dwarfs

Background



- **M dwarfs:**
3800 K $> T_{\text{eff}} >$ 2200 K
Stars
No Condensates
- **L dwarfs:**
2200 K $> T_{\text{eff}} >$ 1400 K
Stars and BDs
Condensates
- **T dwarfs:**
1400 K $> T_{\text{eff}} >$ 800 K
BDs
Condensates cleared

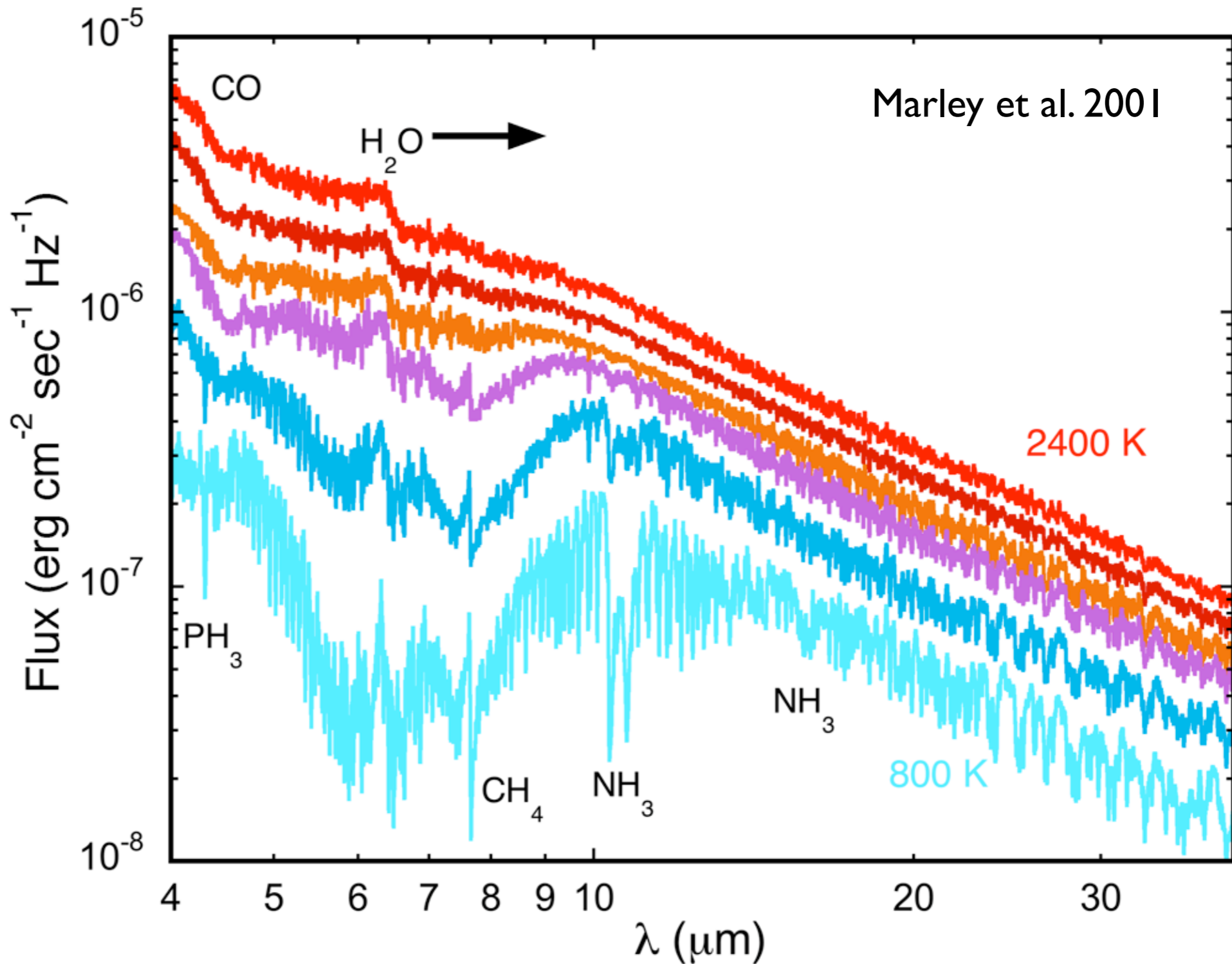
Motivation

- 3.3 and 7.8 μm CH_4 , 4.7 μm CO , 10.5 μm NH_3
- ~ 10 μm silicate cloud feature?
- Improved L_{bol} estimates
- CO , CH_4 , NH_3 non-equilibrium chemistry

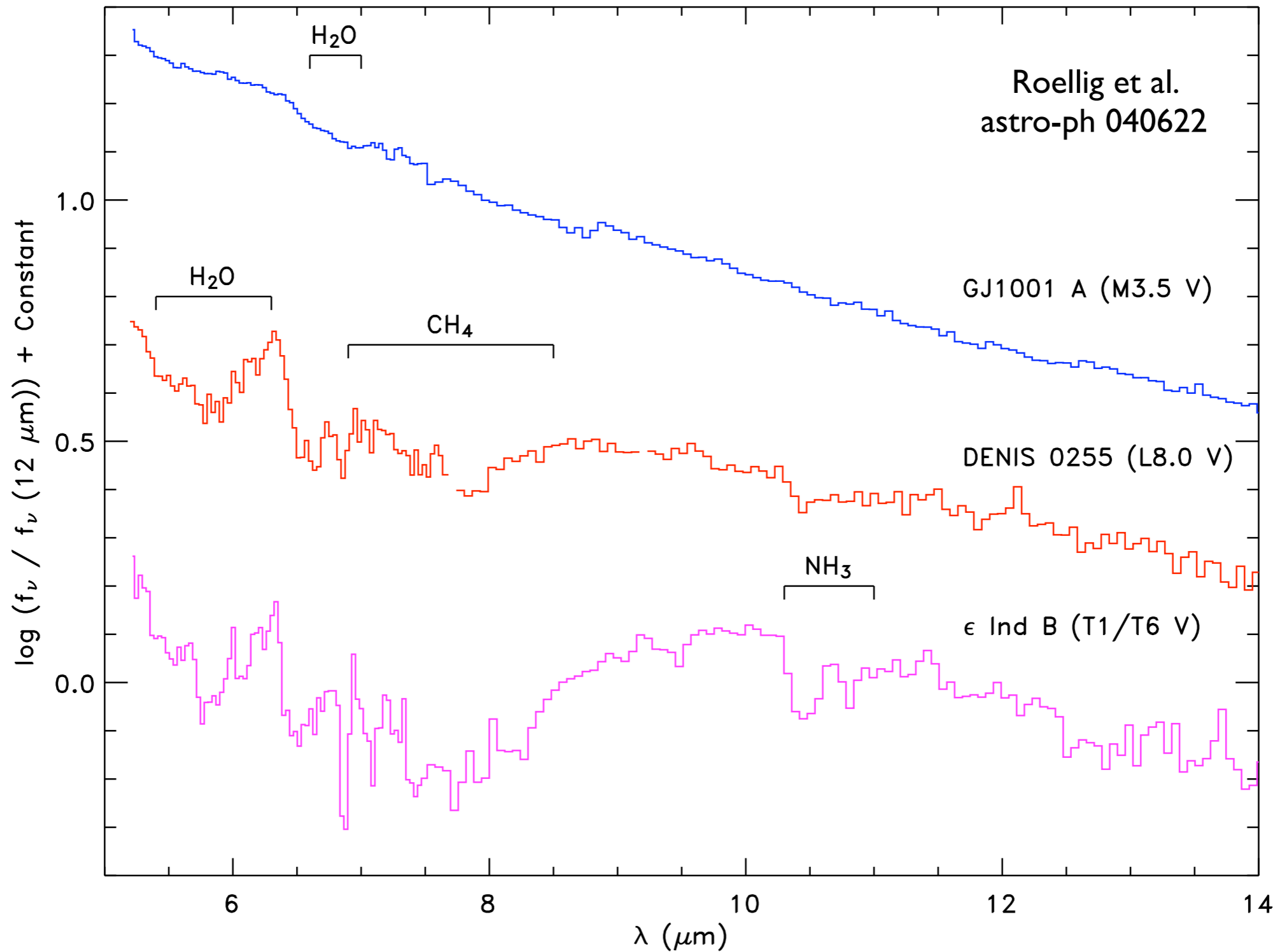
“Dim Suns” Survey

- Science team of the Infrared Spectrograph (IRS) created the “Dim Suns” GTO program
- Observe ~20 M, ~30 L, and ~10 T dwarfs with the IRS
- Focus on Short-Low module:
 - 5.2 -14.5 μm at $R \approx 100$
- Limited observations with other modules

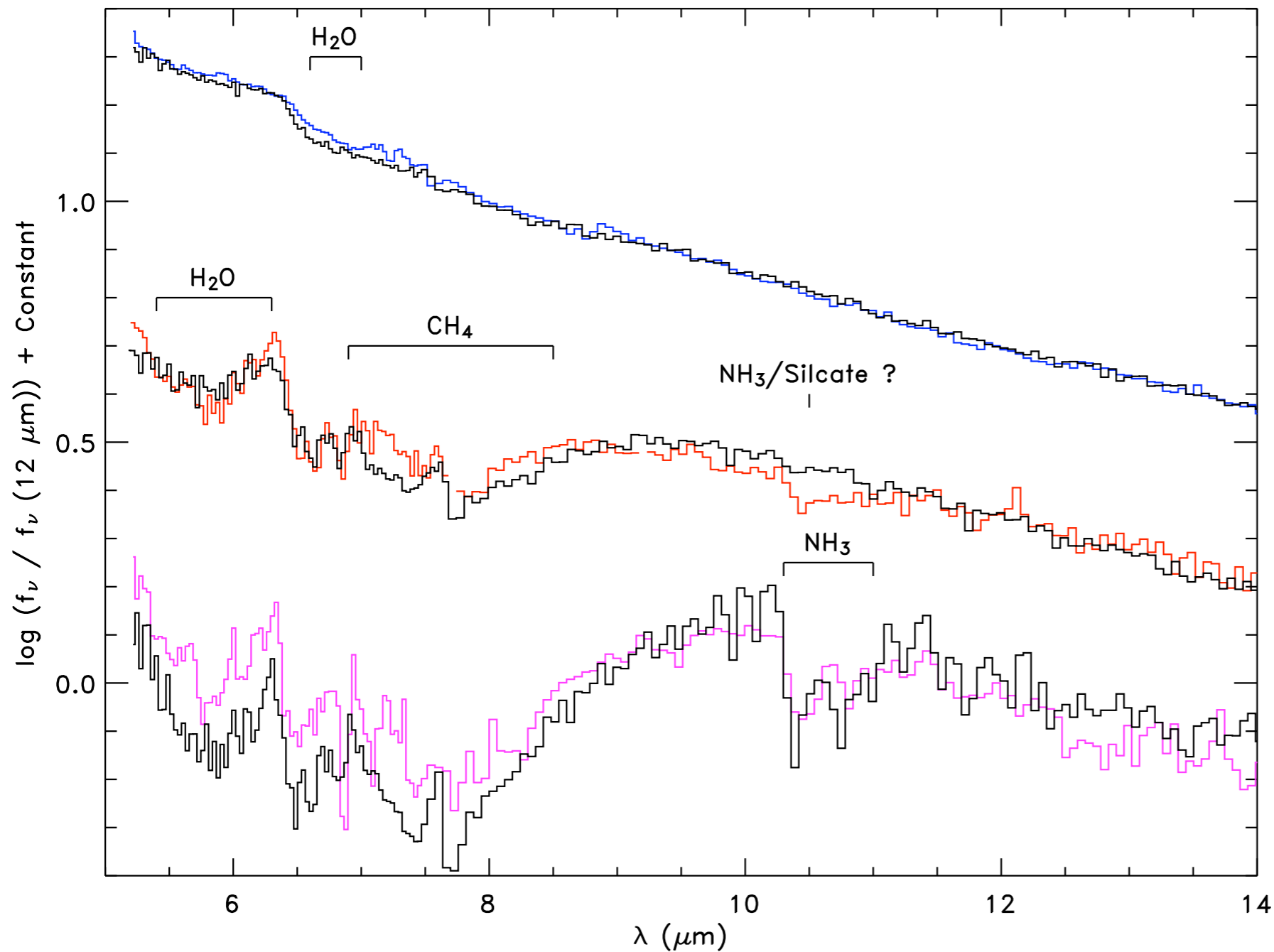
Expectations



First Results

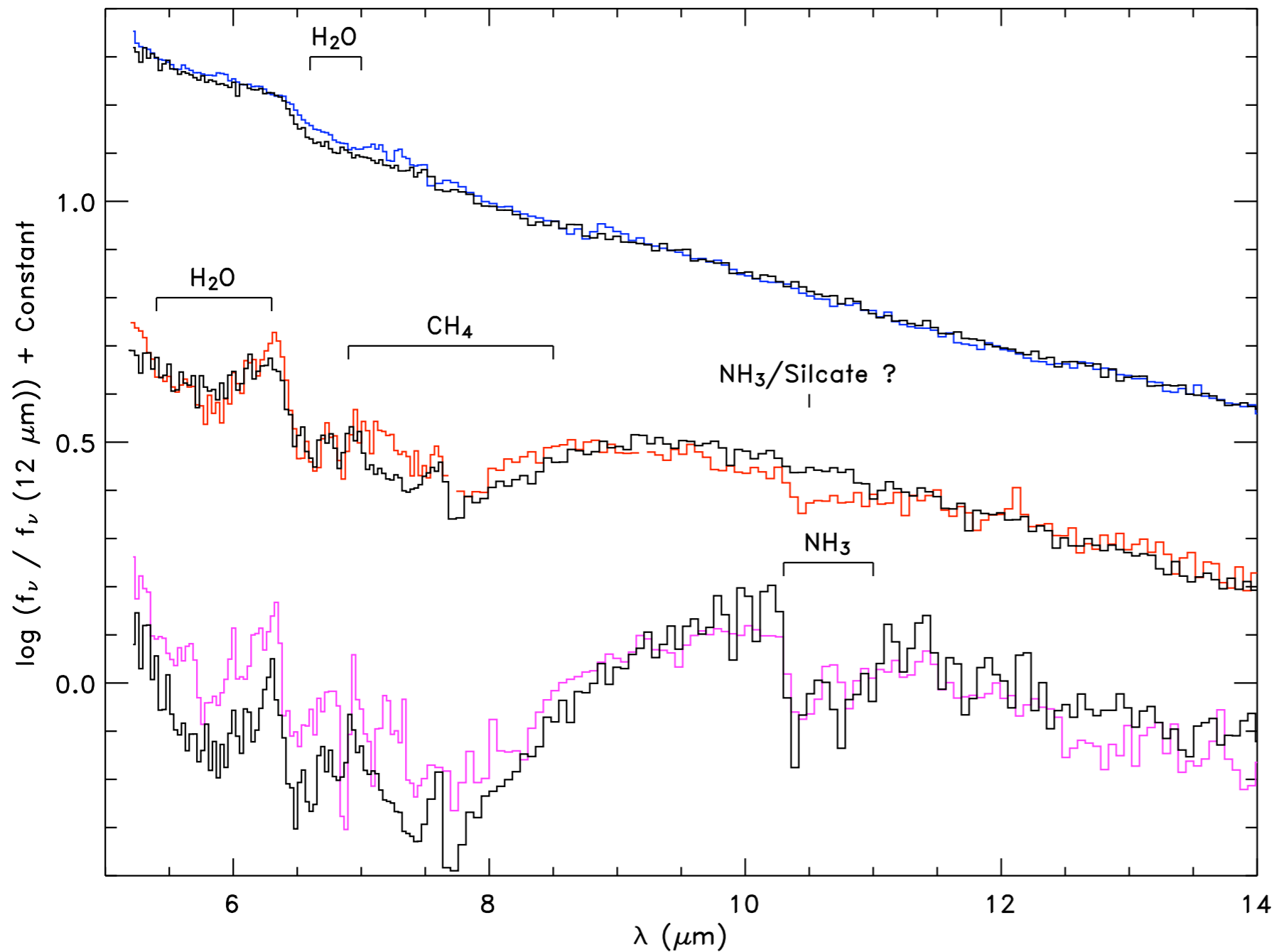


Model Fits



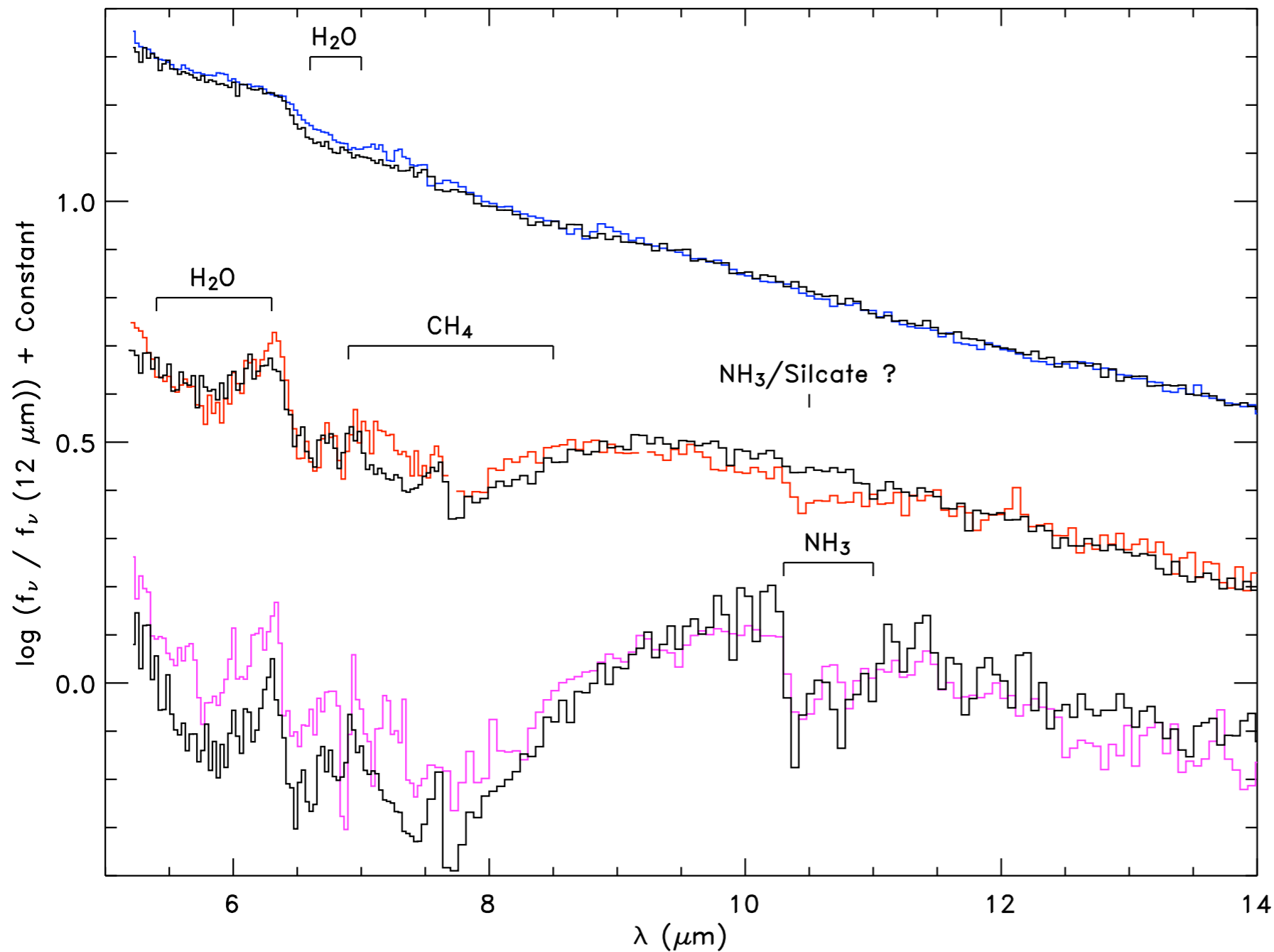
- Ames-DUSTY (Allard et al. 2001)
- $T_{\text{eff}} = 3200 \text{ K}$, $\log g = 5.0$
- Parameters from near-IR analysis (Leggett et al. 2001)

Model Fits



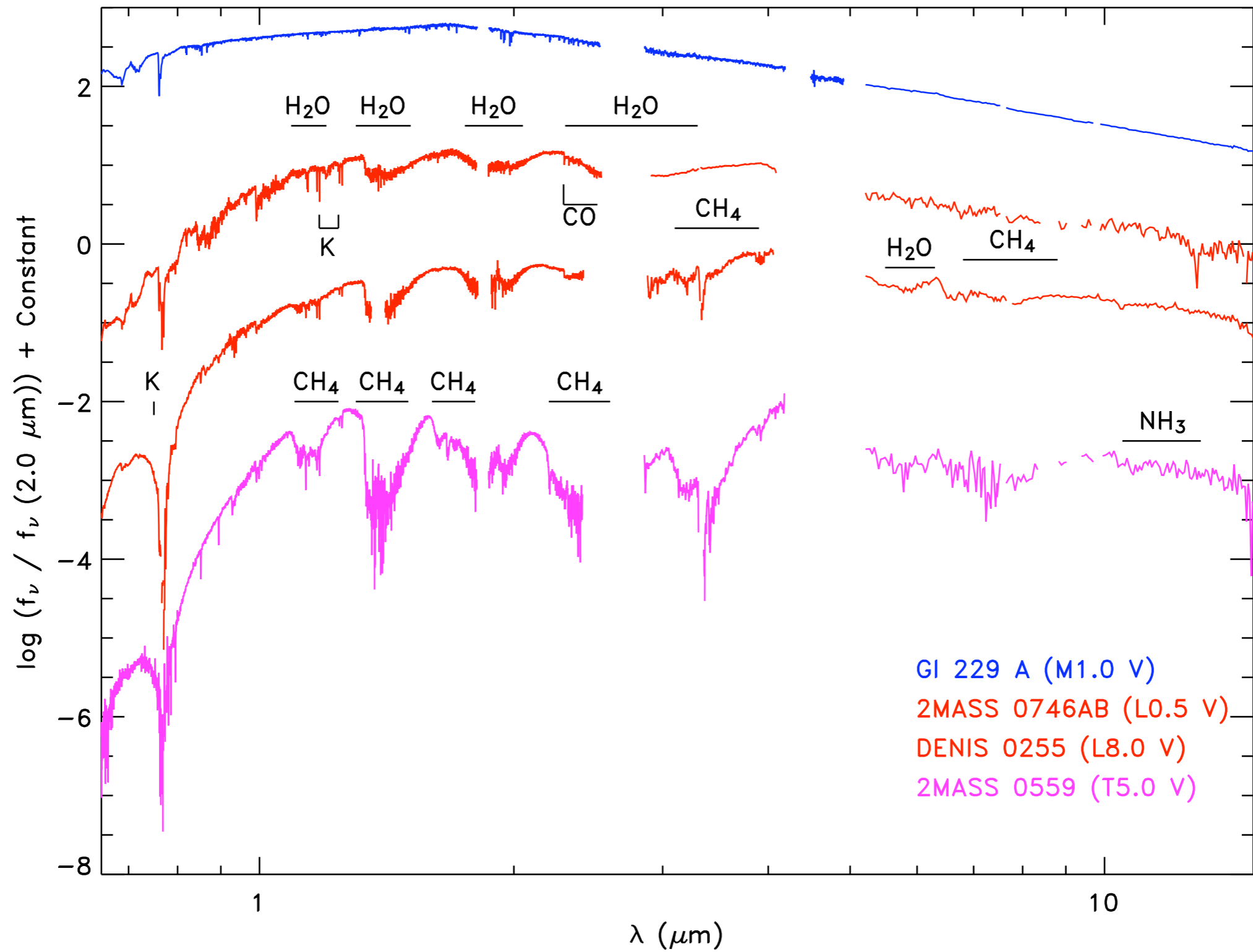
- CLOUDY (Marley et al. 2001)
- $T_{\text{eff}} = 1400 \text{ K}$, $\log g = 4.5$
- Silicate feature or NH_3 at $\sim 10 \mu\text{m}$?

Model Fits



- Composite CLEAR model (Marley et al. 2001)
- Determined (T_{eff} , $\log g$) from (L_{bol} , age) estimates of McCaughrean et al. 2004

SEDs



Bolometric Luminosities

- L_{bol} s are used to determine T_{eff}
- Typically use optical and near-IR spectra, L- and M-band photometry, and correction based on models for $\lambda > 5 \mu\text{m}$ (e.g. Golimowski et al. 2004, see poster)
- L_{bol} estimates using IRS spectra agree with previous results of Golimowski et al. (2004) within errors

Summary

- Present the first mid-infrared spectra of M, L, and T dwarfs obtained with IRS onboard Spitzer
- First detection of the 7.8 μm CH_4 band and 10.5 μm NH_3 band
- Model spectra fit the data well
- L_{bol} s agree with previous estimates

