

@EGonzales788



egonzales@sfsu.edu

# Atmospheric Informer: Unlocking Metal-Poor Brown Dwarf Atmospheres

Eileen Gonzales<sup>1</sup>, Efrain Alvarado<sup>1</sup>, Ember Vosmek-Park<sup>1</sup>, Adam Burgasser<sup>2</sup>, Nicolas Lodieu<sup>3</sup>, Stan Metchev<sup>4</sup>, Zenghua Zhang<sup>5</sup>, Christian Aganze<sup>6</sup>, Dan Caselden<sup>7</sup>, Michael Cushing<sup>8</sup>, Jackie Faherty<sup>7</sup>, Roman Gerasimov<sup>9</sup>, Chih-Chun Hsu<sup>10</sup>, Aaron Meisner<sup>11</sup>, Adam Schneider<sup>12</sup>, Genaro Suarez<sup>7</sup>, and Chris Theissen<sup>2</sup>

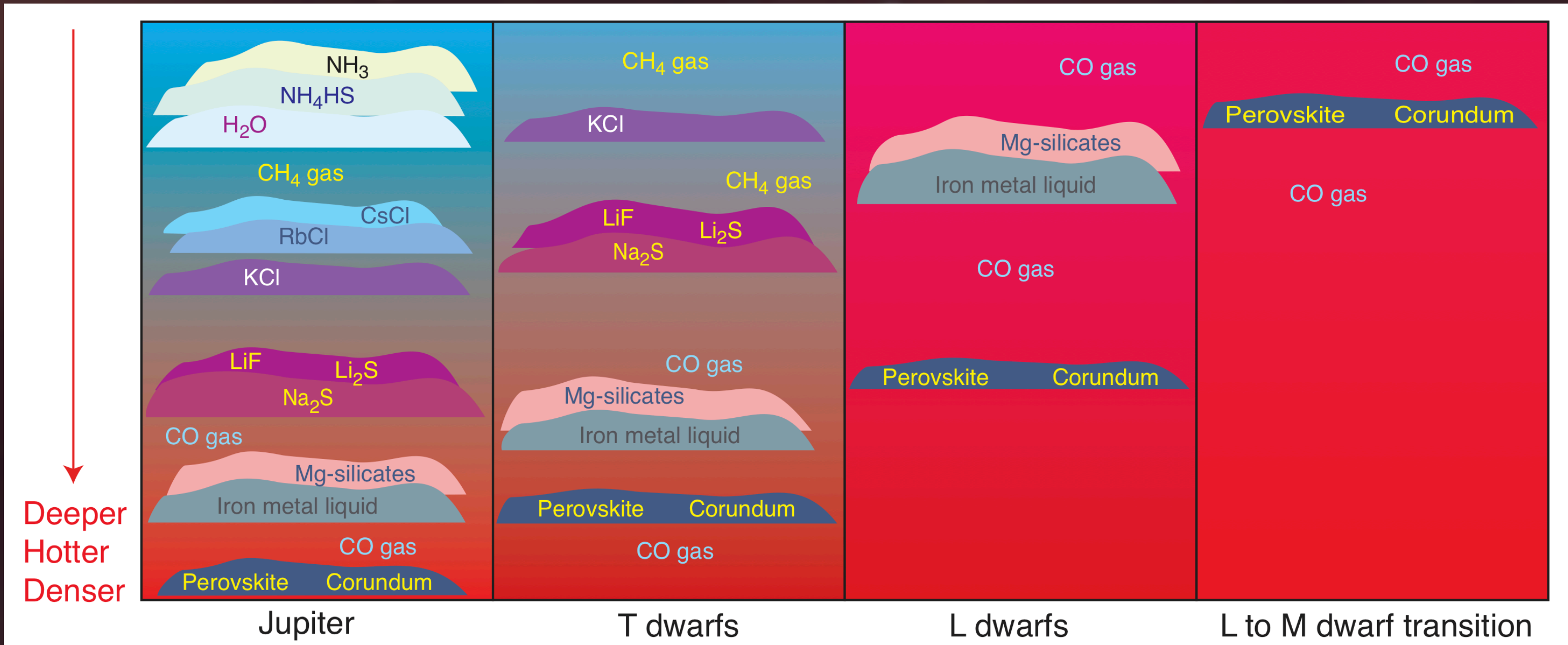
1. San Francisco State University, 2. University of California, San Diego, 3. Instituto de Astrofísica de Canarias, 4. The University of Western Ontario, 5. Nanjing University, 6. Stanford, 7. American Museum of Natural History, 8. University of Toledo, 9. Notre Dame, 10. Northwestern University, 11. NOIRLab, 12. USNO Flagstaff



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## Metallicity drives atmospheric composition



Metallicity is a key parameter in the formation, evolution and atmospheric composition of brown dwarfs.

Brown dwarfs retain their initial chemical signature, those with subsolar metallicities can be used as tracers to study the chemical evolution history of the Milky Way.

## JWST GO 4668: Arcana of the Ancients

A 0.6-14 micron spectroscopy survey of 32 L and T dwarfs and subdwarfs. Data includes NIRSpec Prism, G395H, and MIRI LRS

### Program Goals

1. Distinguish diagnostics of temperature and metallicity for  $T_{\text{eff}} = 600\text{--}2500\text{K}$
2. Explore abundance effects on molecular chemistry and condensation to guide development go low-temp atmosphere and evolutionary models
3. Anchor infrared surveys that will identify large samples of metal-poor UCDS in the thick disk, halo, and globular clusters.

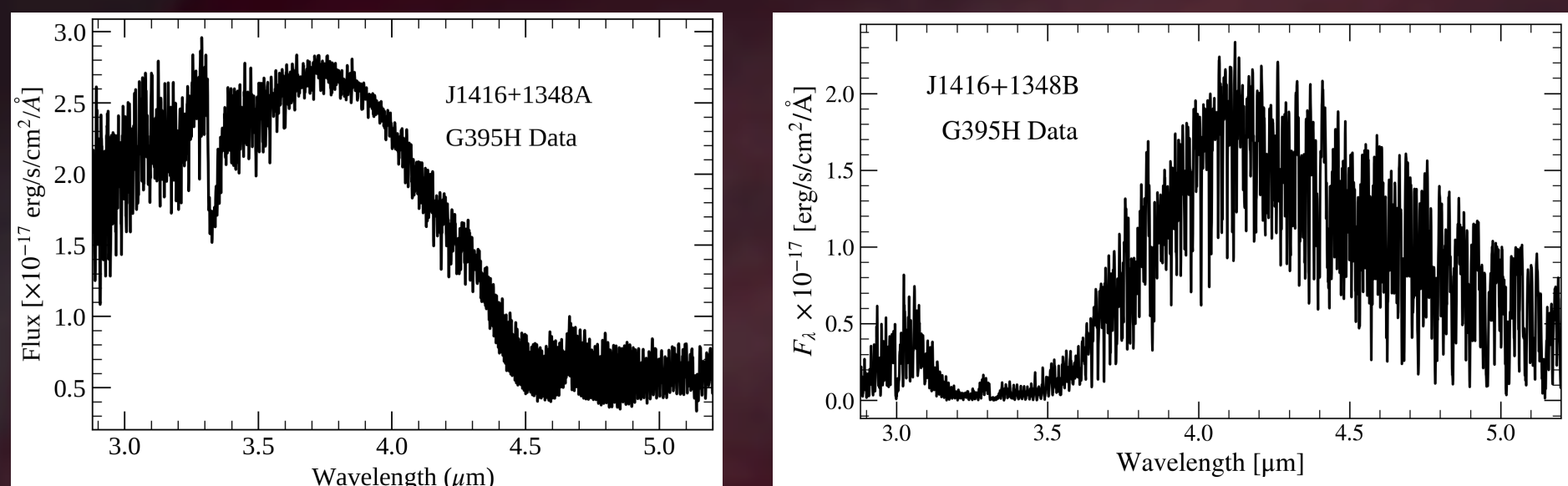
### Our Team's subset

| Group | L dwarfs                        |                                |                                 |
|-------|---------------------------------|--------------------------------|---------------------------------|
|       | Early-type                      | Mid-type                       | Late-type                       |
| dL    | HD 89744B<br>L0.5 [M/H] = +0.17 | G200-28B<br>L4.5 [M/H] = +0.05 | Gliese 584C<br>L8 [M/H] = +0.01 |
| d/sdL | J0829-1309<br>d/sdL2            | J1126-5003<br>d/sdL5           | J1416+1348A<br>d/sdL7           |
| sdL   | J1256-6202<br>sdL3              | J1412+1216<br>sdL5             | J0645-6646<br>sdL8              |
| esdL  | J1444-2019<br>esdL1             | J0616-6407<br>esdL6            | J0532+8246<br>esdL8             |
| usdL  | J0104+1535<br>usdL1.5           | J1256-0224<br>usdL3            | J1626+3925<br>usdL4             |

Plus: Wolf 1130C (sdT8) and SDSS J1416+1348B (d/sdT7)

## Atmospheric Retrievals with *Brewster*

Input Spectra: G395H & NIRSpec Prism+ MIRI LRS



### Assumed Gases

J1416A: H<sub>2</sub>O, CH<sub>4</sub>, CO, CO<sub>2</sub>, TiO, VO, CrH, FeH, Na+K

J1416B: H<sub>2</sub>O, CH<sub>4</sub>, CO, CO<sub>2</sub>, NH<sub>3</sub>, PH<sub>3</sub>, H<sub>2</sub>S

### Underlying Assumptions

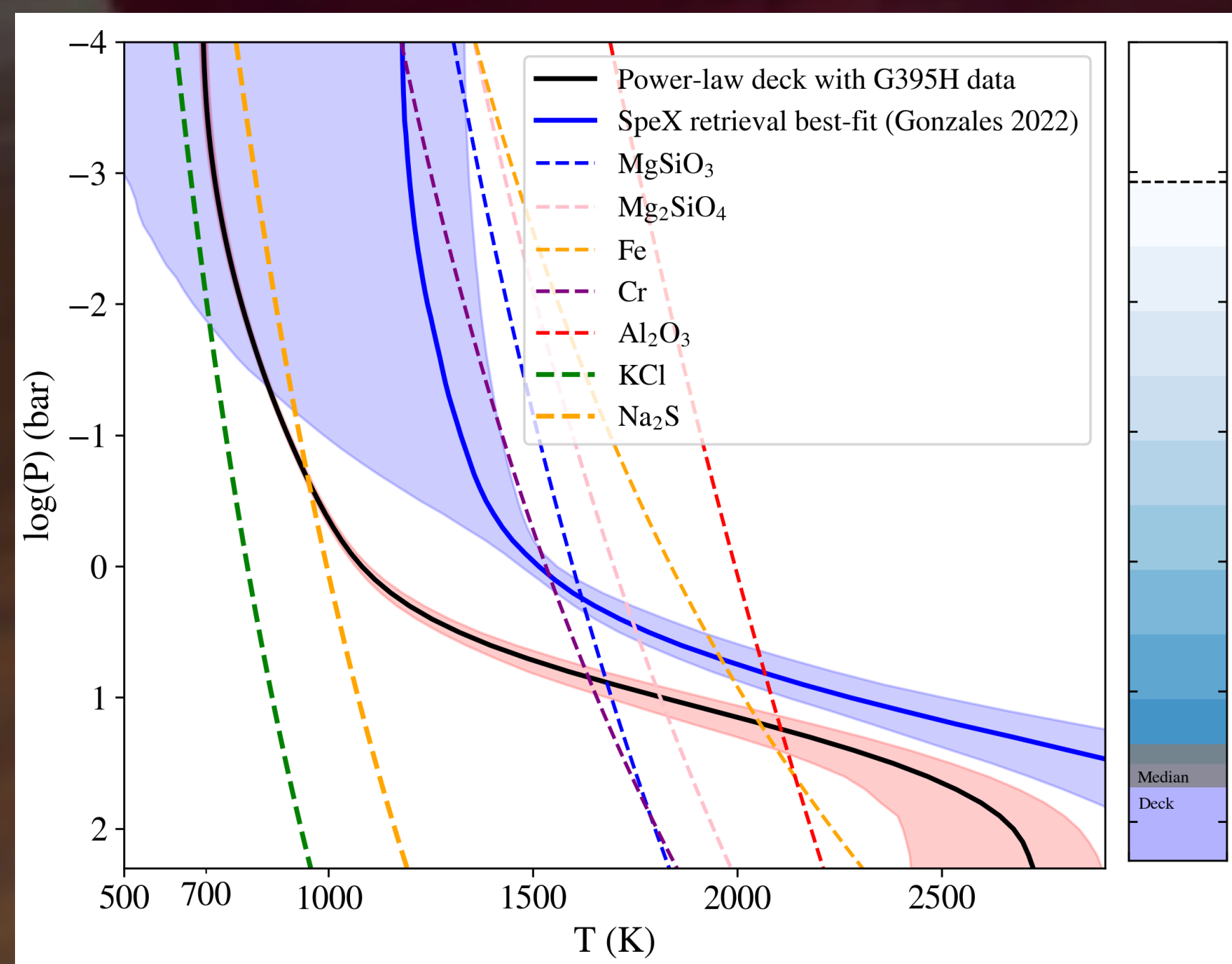
- Radiative transfer treatment
- Gas opacities (i.e. Line Lists)

Here we present retrievals using the JWST G395H and NIRSpec Prism+ MIRI LRS spectra. We use a similar setup for all targets as that presented in Burgasser et al. (2025) for our G395H runs. For J1416B we test models with and without phosphine.

## A First look at SDSS J1416+1348AB: A widely separated L+T subdwarf binary

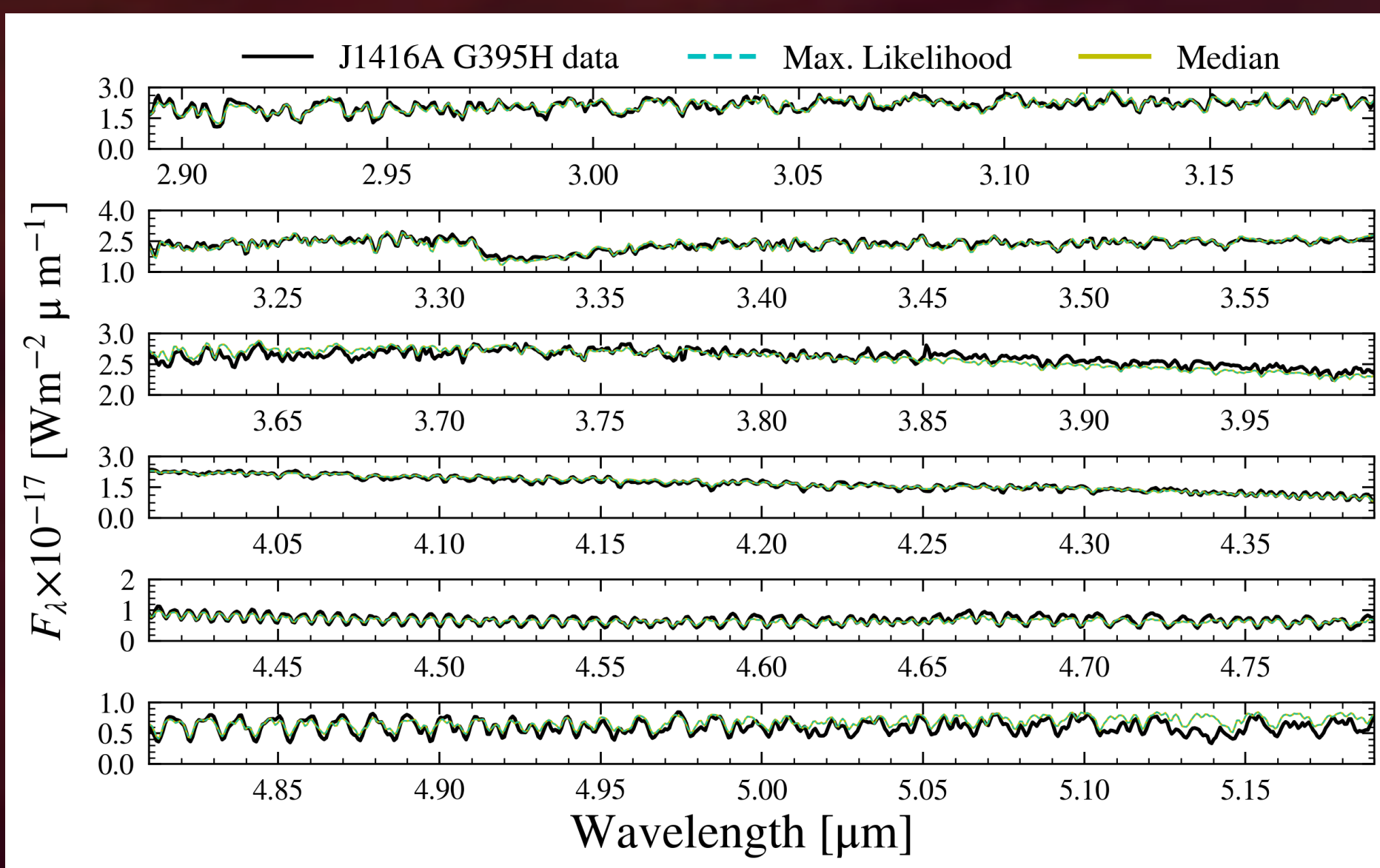
J1416+1348A: Initial results for G395H differ from Gonzales et al. (2022) but may not be reliable

### Pressure-Temperature profile



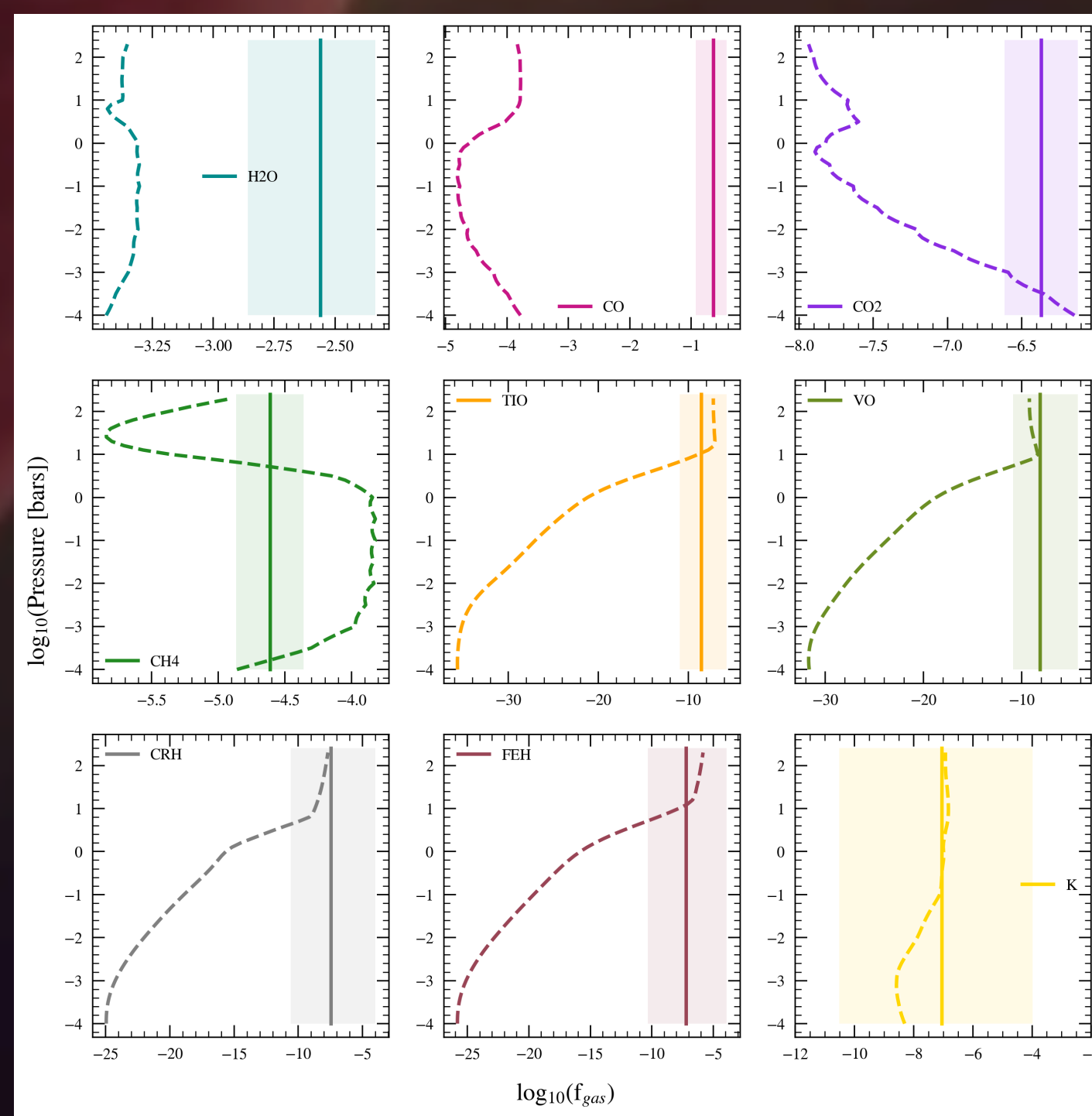
Profile is cooler than literature profile at all pressures. Deeper cloud top, suggesting weak impact of cloud in 3-5  $\mu\text{m}$  region.

### Retrieved model spectrum



Poor fit to data beyond 5  $\mu\text{m}$ . Potentially missing an opacity source.

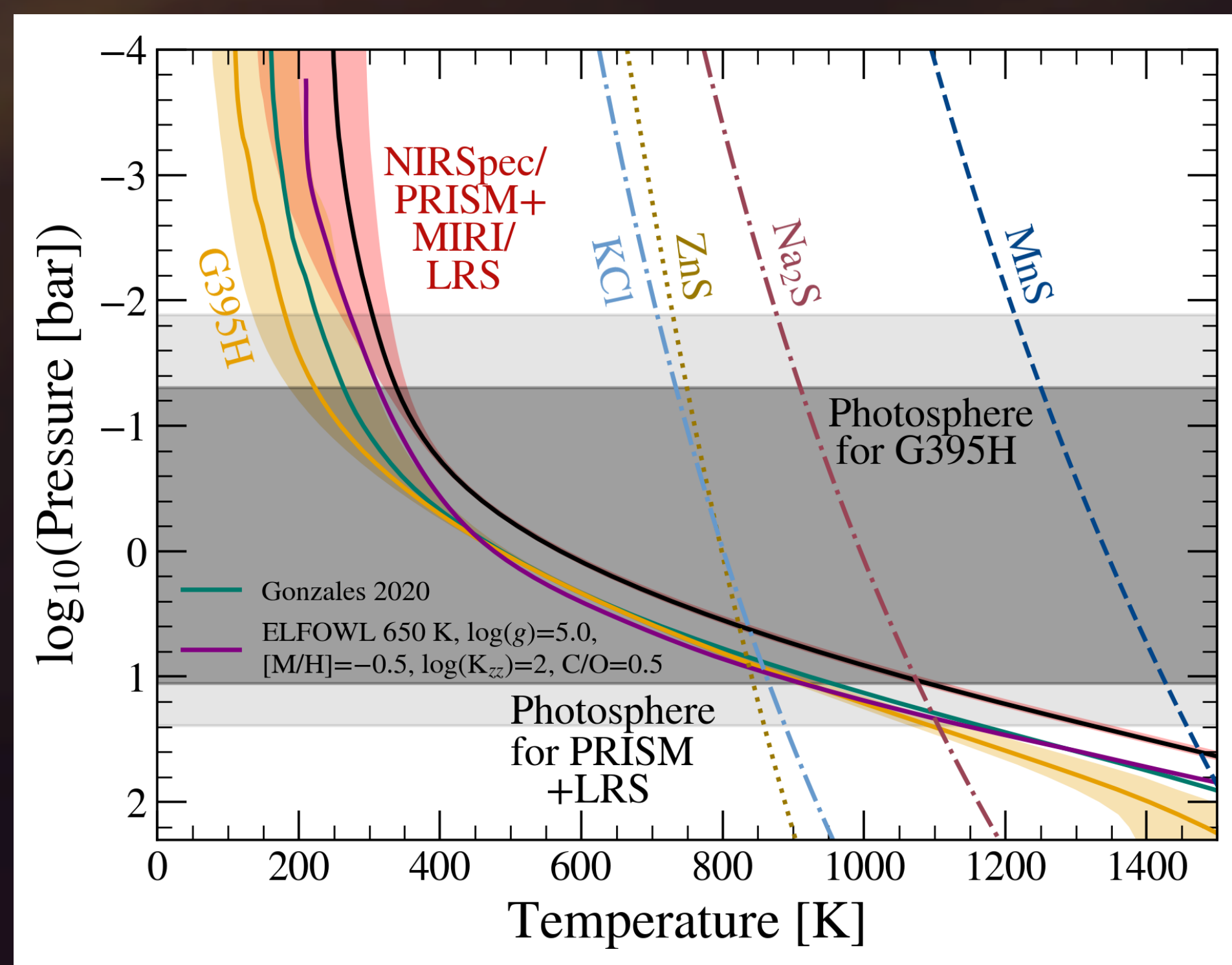
### Gas Abundances



Water and CO abundances too high, indicating issue with current model setup

## J1416+1348B: G395H data paints a picture matching Gonzales et al. (2020), while Prism+LRS differs!

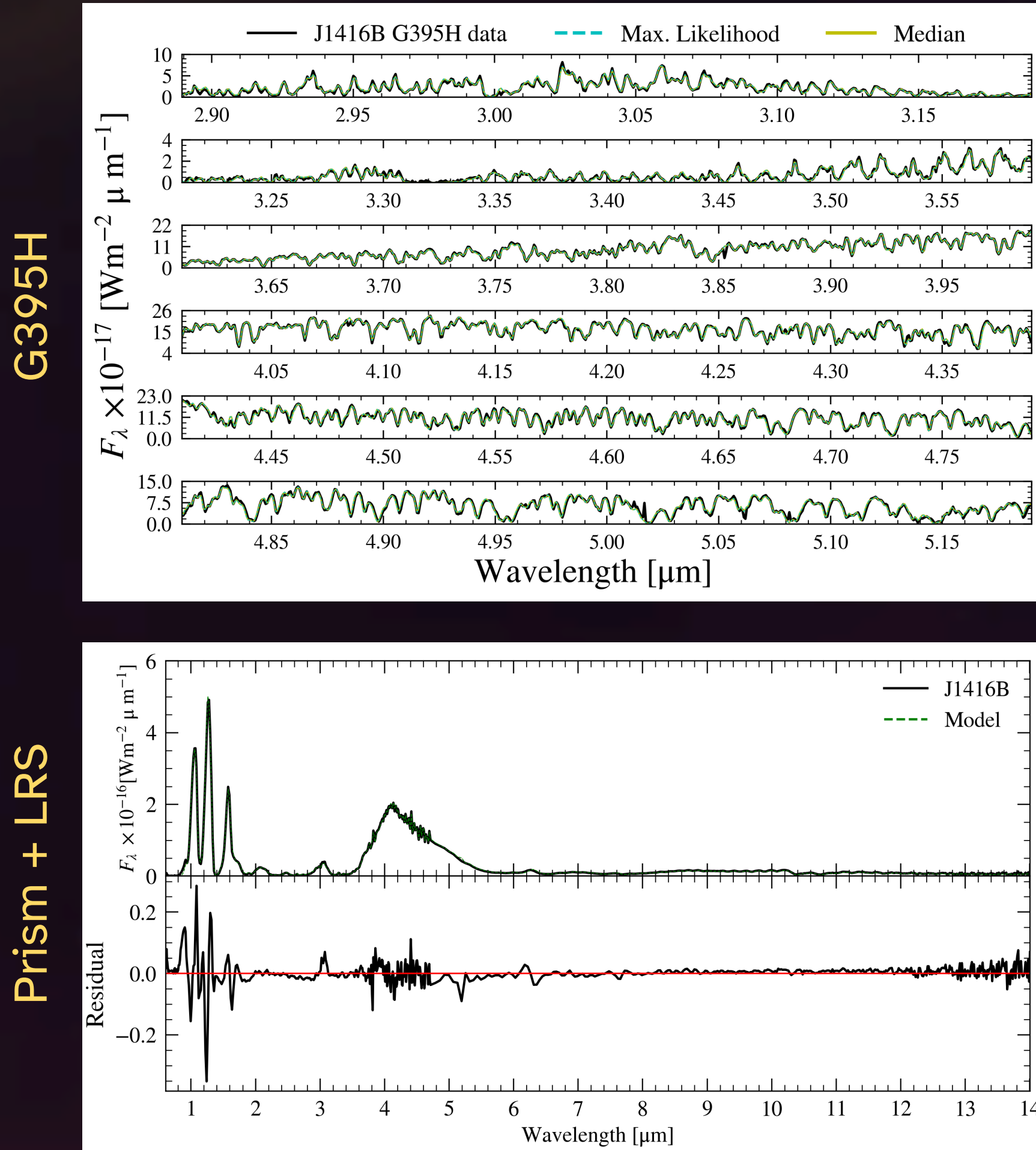
### Pressure-Temperature profiles



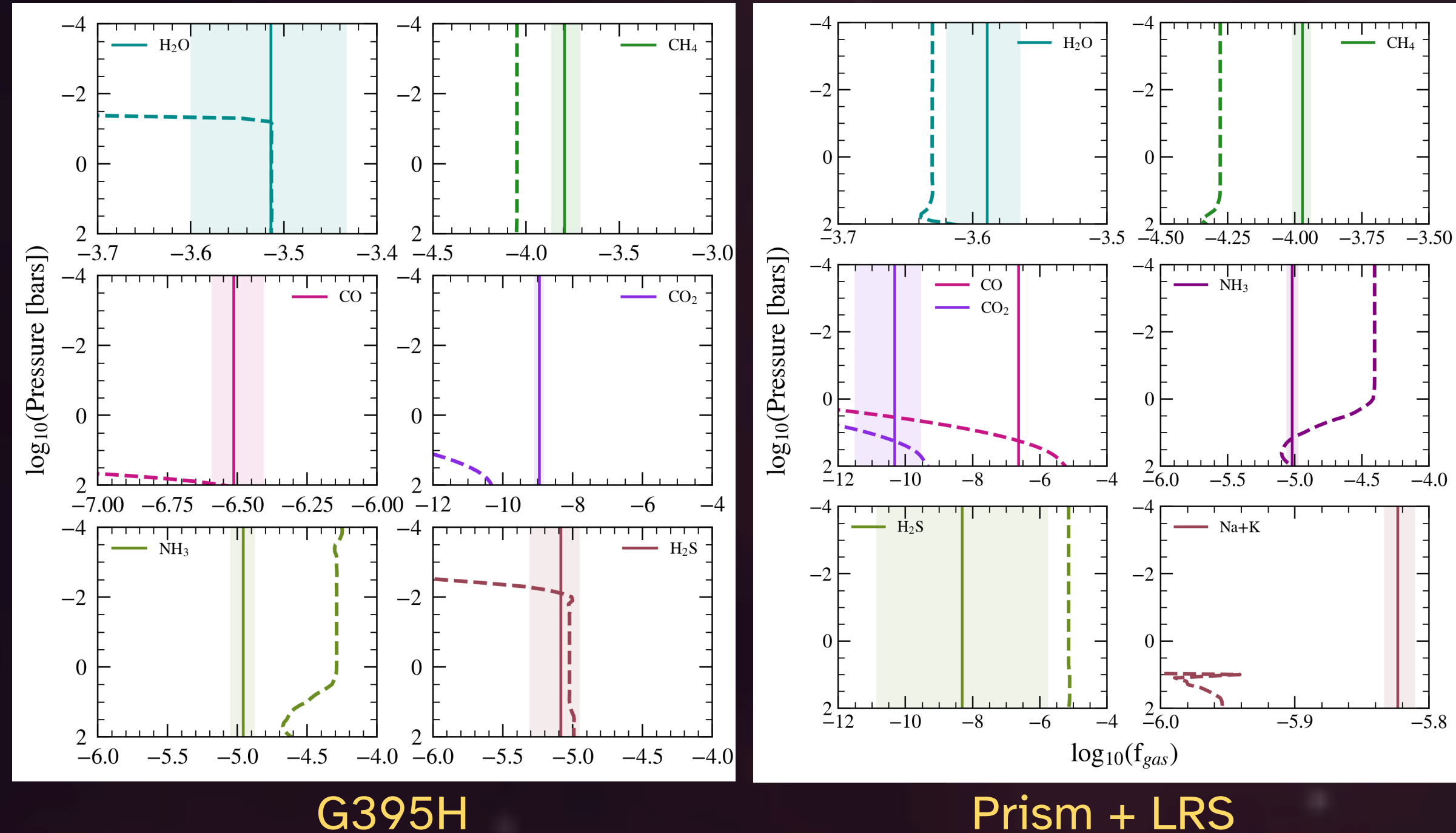
G395H profile agrees with past retrieval and Elf-Owl 650K, subsolar metallicity model.

Deeper than ~0.1 bar, G395H profile is cooler at the same pressure.

### Retrieved model spectra



### Gas Abundances



Retrieved abundances and fundamental parameters agree with Gonzales et al. (2020)

Retrieved gas abundances differ  $>1\sigma$  from G395H.

$M_{Jup} \approx 8^{+1.9}_{-1.7}$  vs  $M_{Jup} \approx 23^{+5.51}_{-6.03}$ , driven by lower surface gravity.

This research was supported by STScI Grant # JWST-GO-04668.016-A

## WAVELENGTH COVERAGE IMPACTS RETRIEVED PARAMETERS AND DRIVING MAJOR DIFFERENCES IN FUNDAMENTAL PARAMETERS