

An Homogeneous Retrieval of Exoplanet Atmospheres

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Collaborators:

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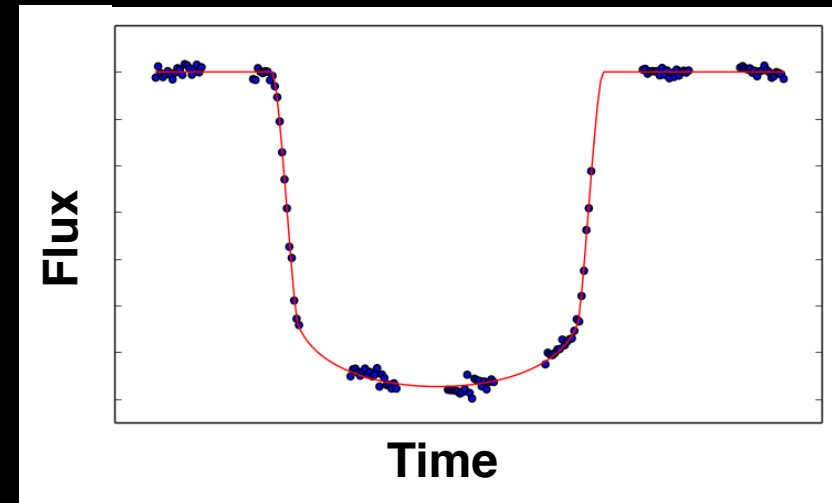
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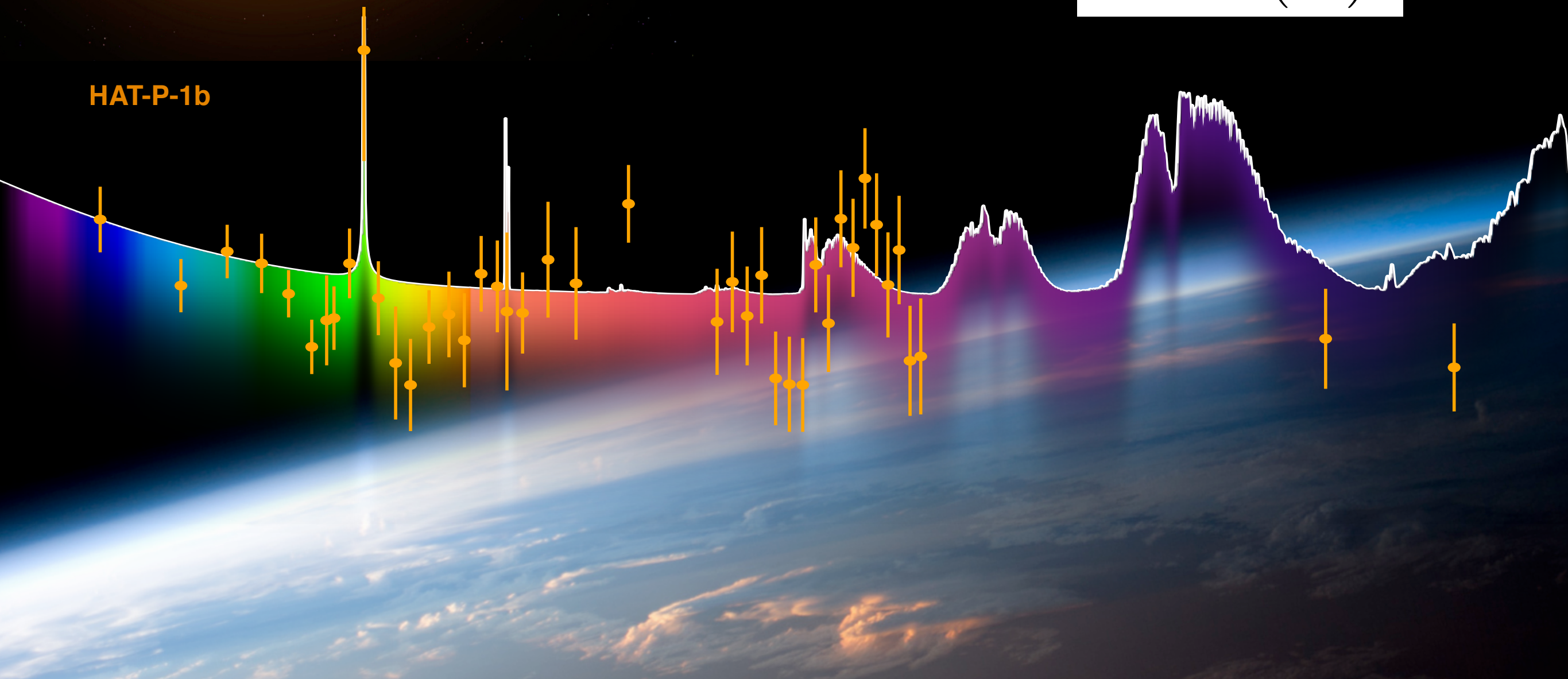
Spectroscopy of Exoplanets
08-11.07.2018

Motivation



$$\text{depth} \propto \left(\frac{R_p}{R_s} \right)^2$$

HAT-P-1b



The Pyrat Bay Package (Cubillos et al., in prep.)

(Python Radiative-transfer in a Bayesian framework)

- Atmospheric models
- Radiative transfer
- MCMC

Open-source code:

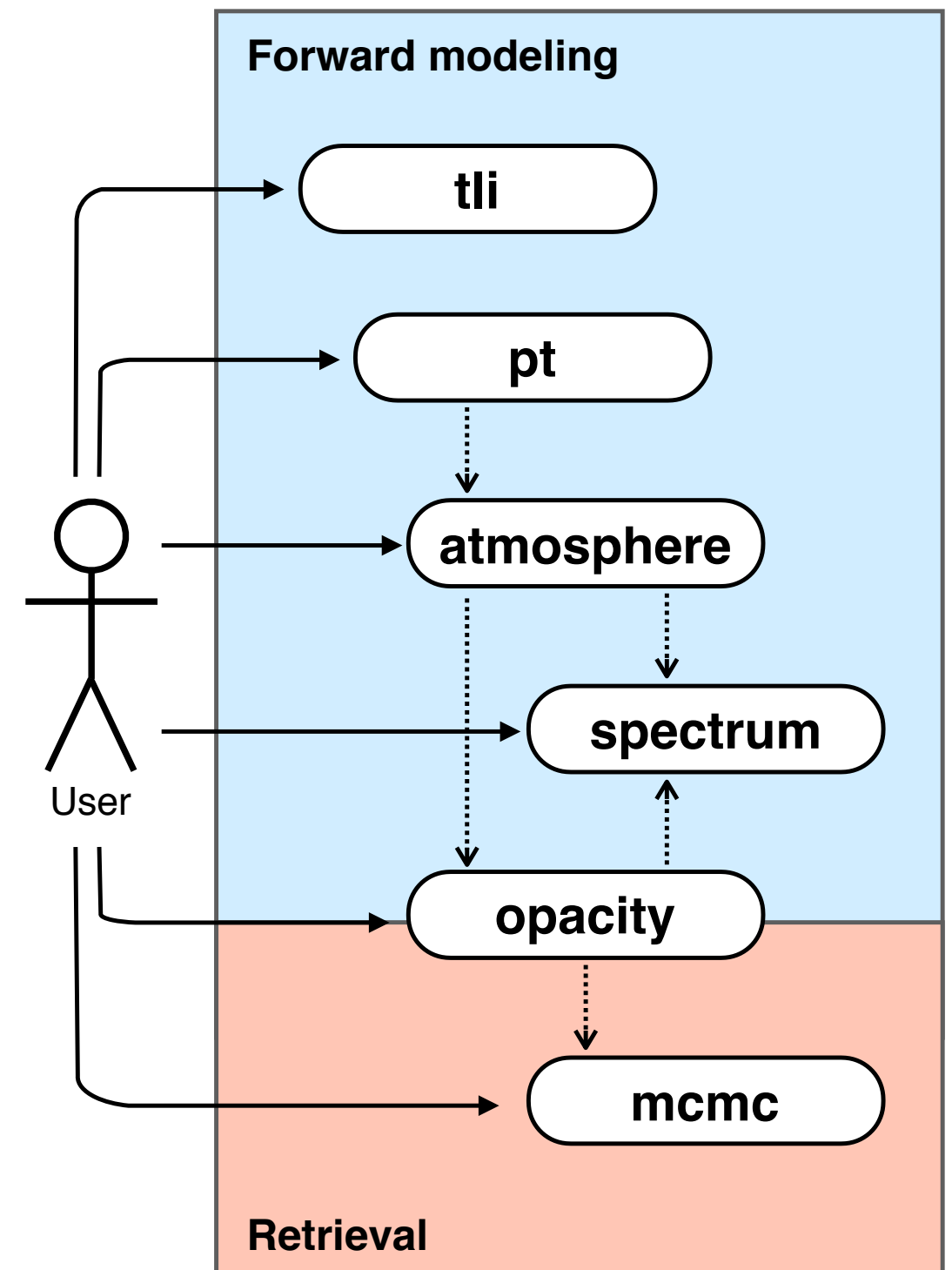
<http://pcubillos.github.io/pyratbay/>

Publications:

- Lammer+ (2016)
- Blečić+ (2017)
- Blumenthal+ (2017)
- Cubillos+ (2017)
- Cubillos (2017)
- Fossati+ (2017)
- Juvan+ (2017)
- Kubyshkina+ (2017)
- Lendl+ (2017)
- Kilpatrick+ (2018)

In preparation:

- Blečić+ a,b
- Cubillos+ a,b,c
- Harrington+
- Khalafinejad+
- Kubyshkina+
- Lendl+
- Venot+



‘Repack’ Line Compression (Cubillos 2017)

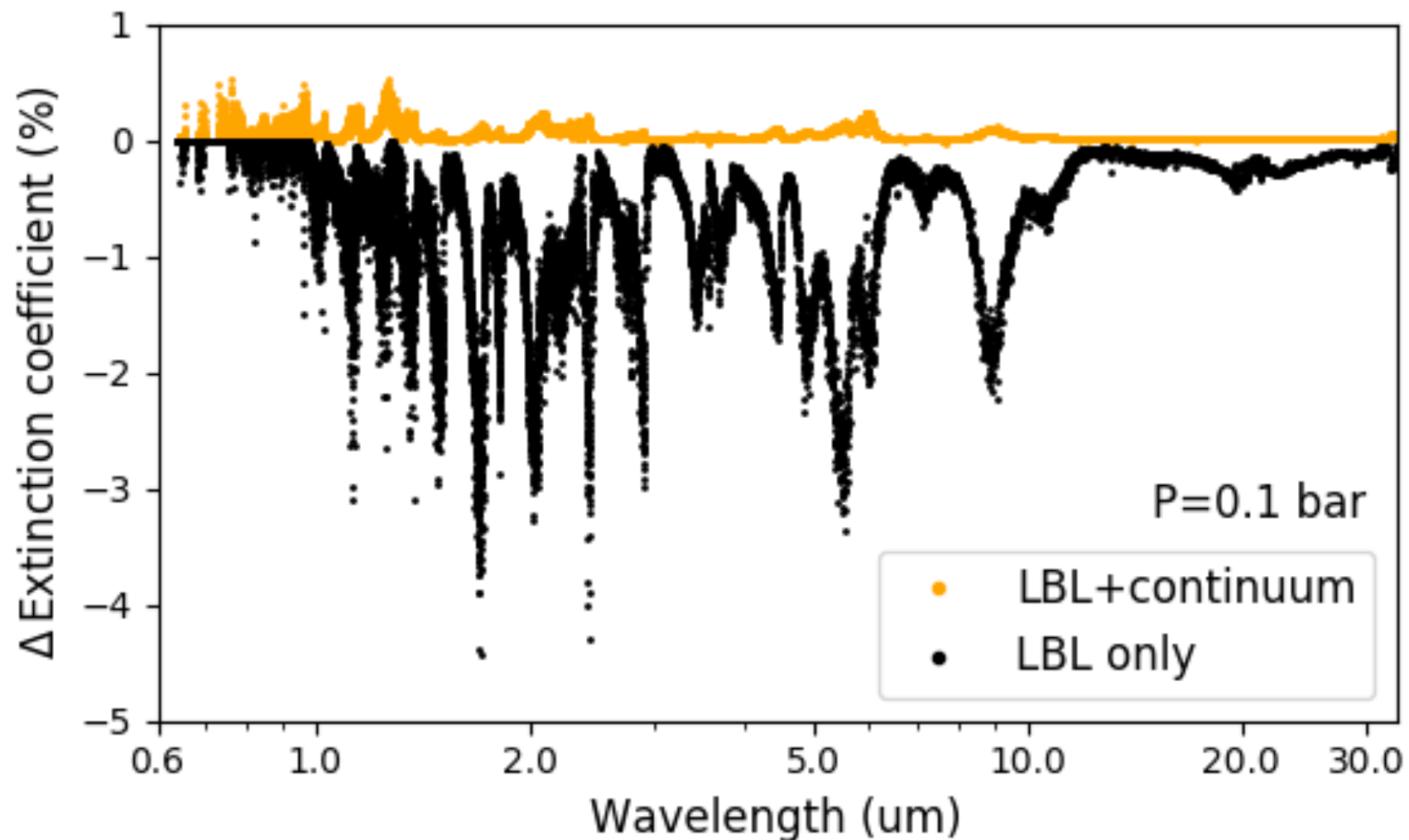
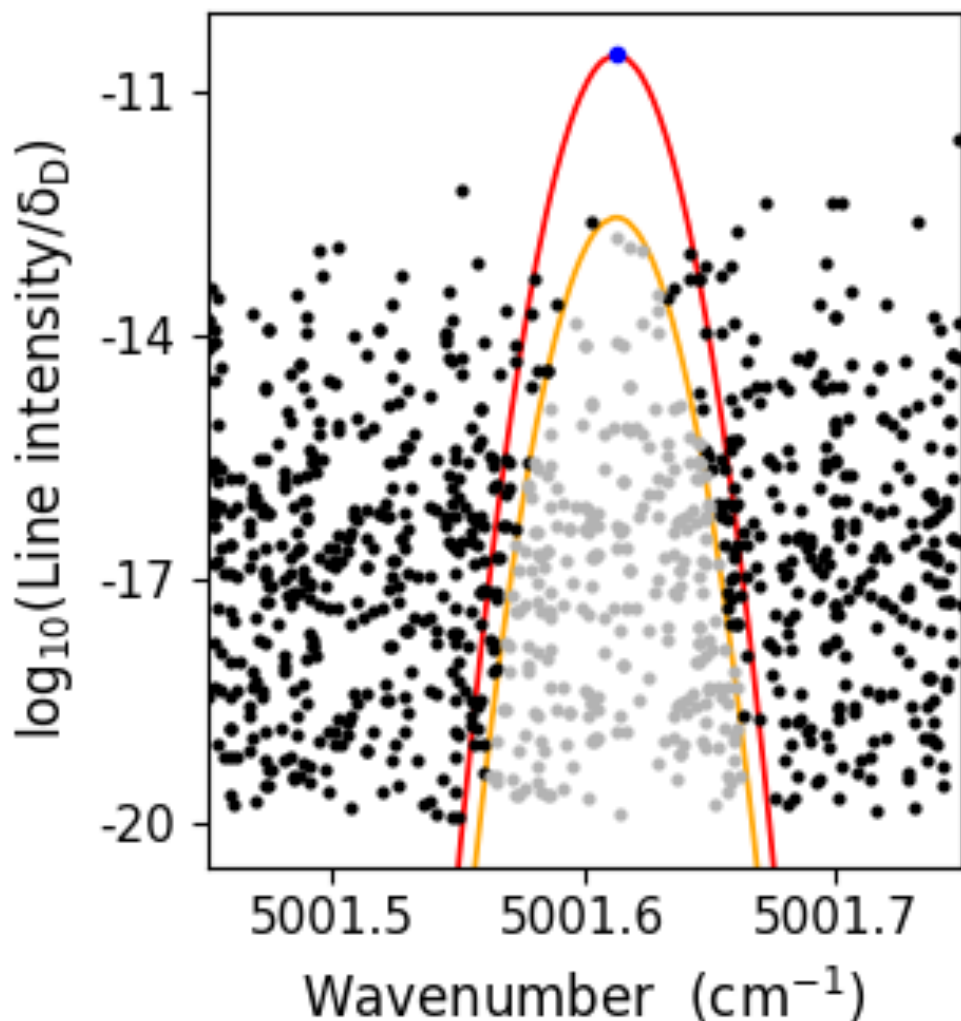
Open-source code:

<http://github.com/pcubillos/repack>

Strong lines → Keep LBL info

Weak lines → Compress into continuum

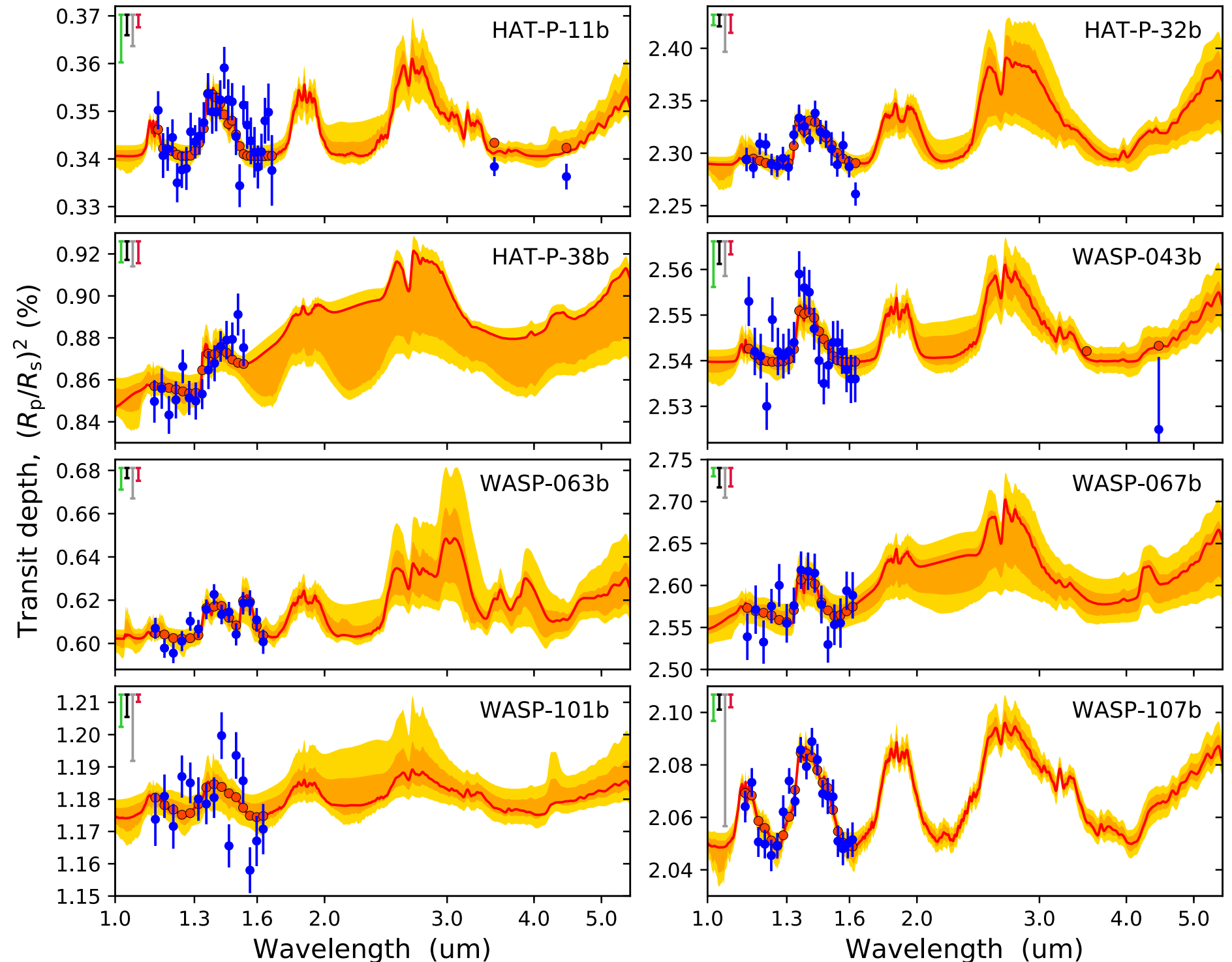
- A few billion lines → a few million
- Preserves ~99% of information
- Temperature dependent



An Homogeneous Retrieval Sample

(Cubillos et al., in prep.)

- Goals:**
1. Sample of standardized transmission retrievals
 2. Comparison with literature



An Homogeneous Retrieval Sample

(Cubillos et al., in prep.)

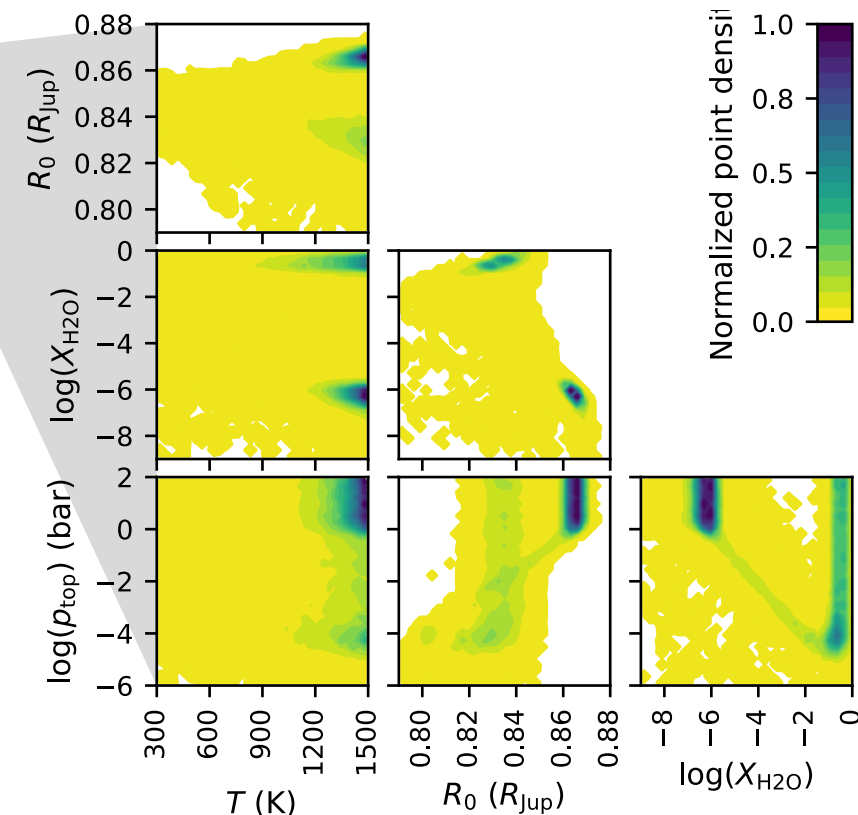
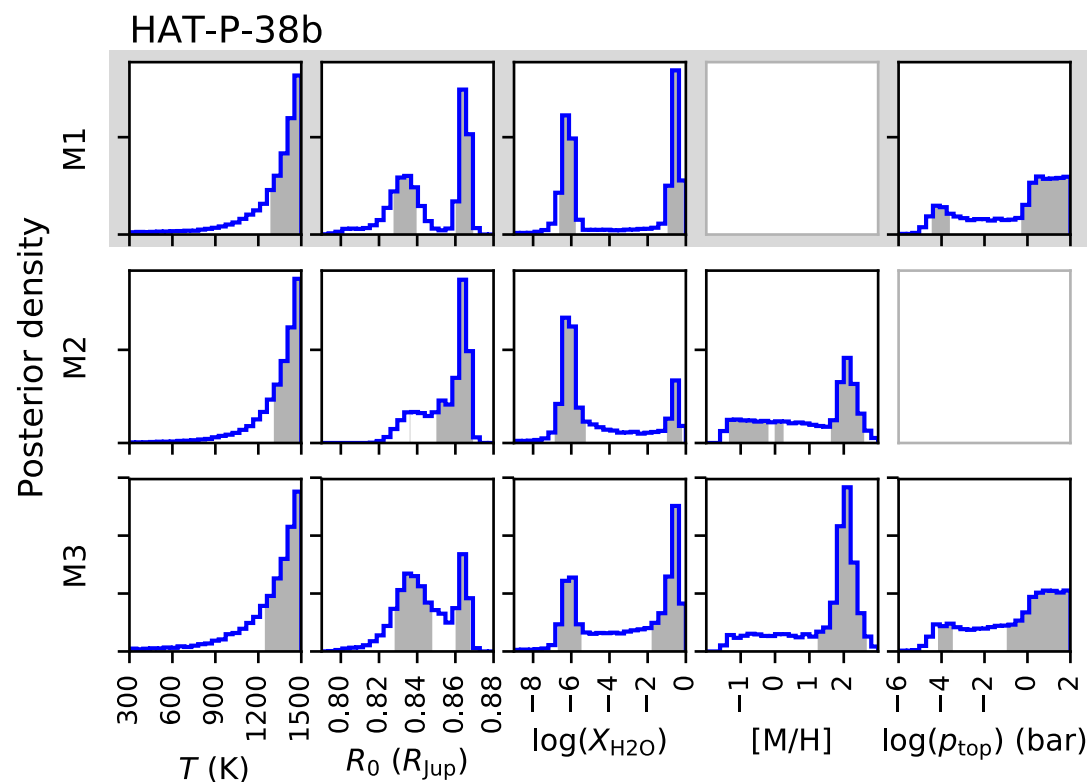
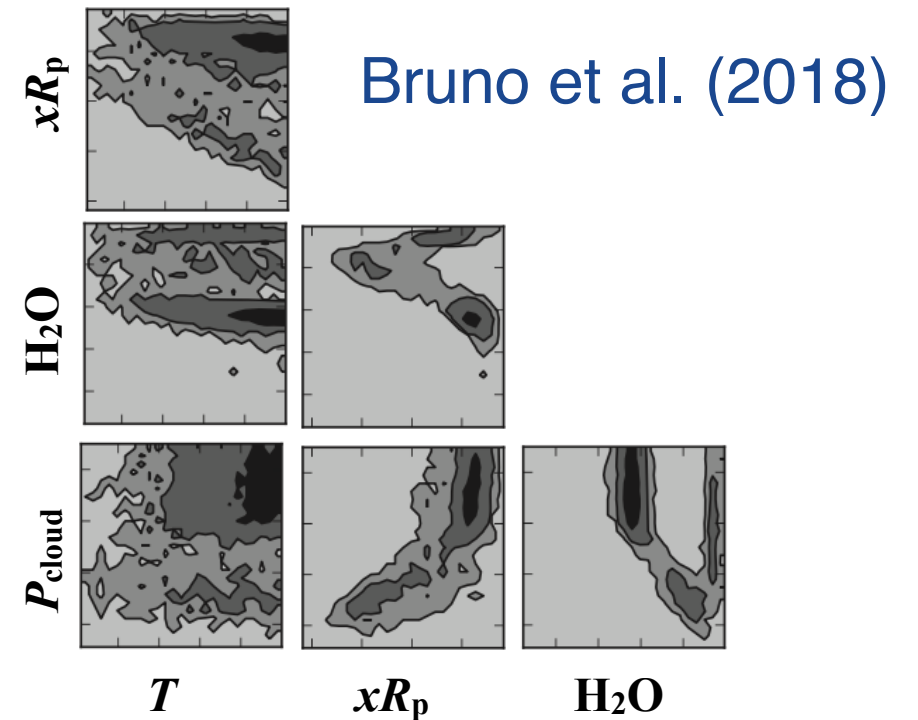
For each target:

- Multiple standard retrievals
- BIC comparison

Table 5. HAT-P-38b model comparison.

ID	Free parameters	N_{free}	ΔBIC	χ^2_{red}
M1	$T, R_0, \text{H}_2\text{O}, p_{\text{top}}$	4	0.0	1.52 ± 0.43
M2	$T, R_0, \text{H}_2\text{O}, [\text{M}/\text{H}]$	4	0.0	1.53 ± 0.43
M3	$T, R_0, \text{H}_2\text{O}, [\text{M}/\text{H}], p_{\text{top}}$	5	2.8	1.68 ± 0.45
M0	Flat fit	1	10.8	2.55 ± 0.38

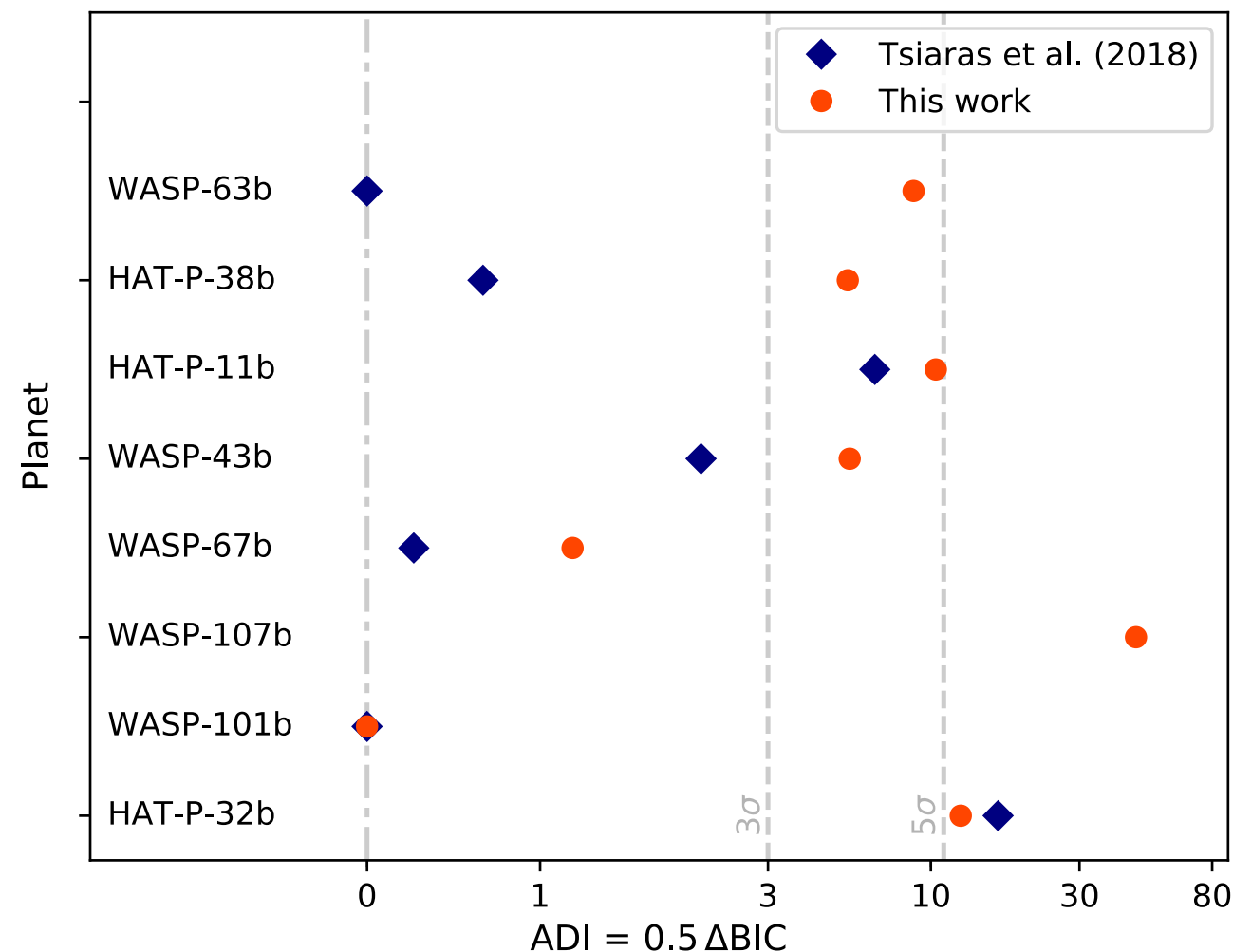
- Literature comparison



An Homogeneous Retrieval Sample

(Cubillos et al., in prep.)

More dispersion when datasets differ



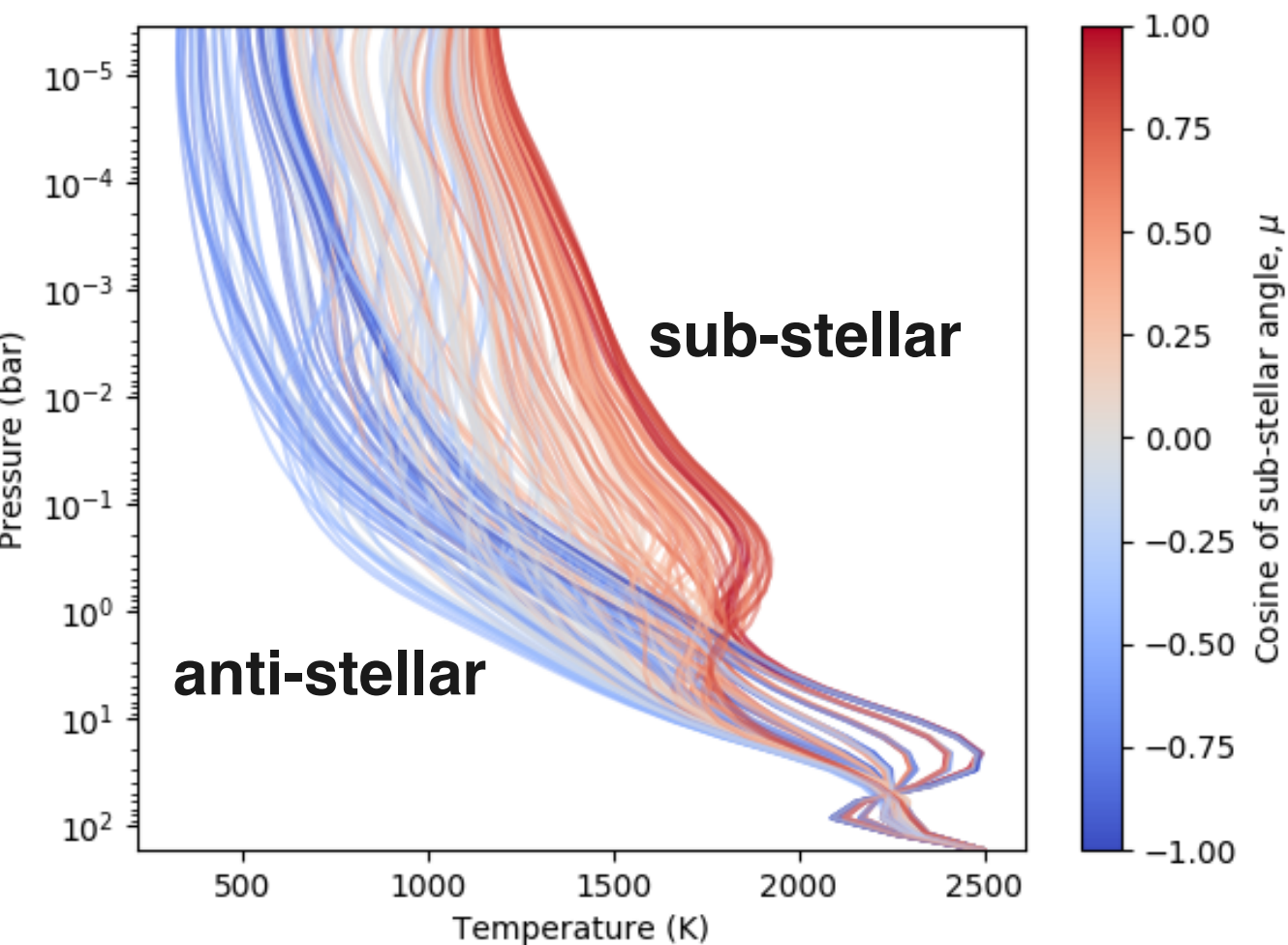
Conclusions:

- Independent retrievals agree if:
 1. Same dataset
 2. Same setup
- Posteriors plagued with degeneracies:
 - abundances
 - clouds
 - mean molecular weight
 - temperature
 - reference radius

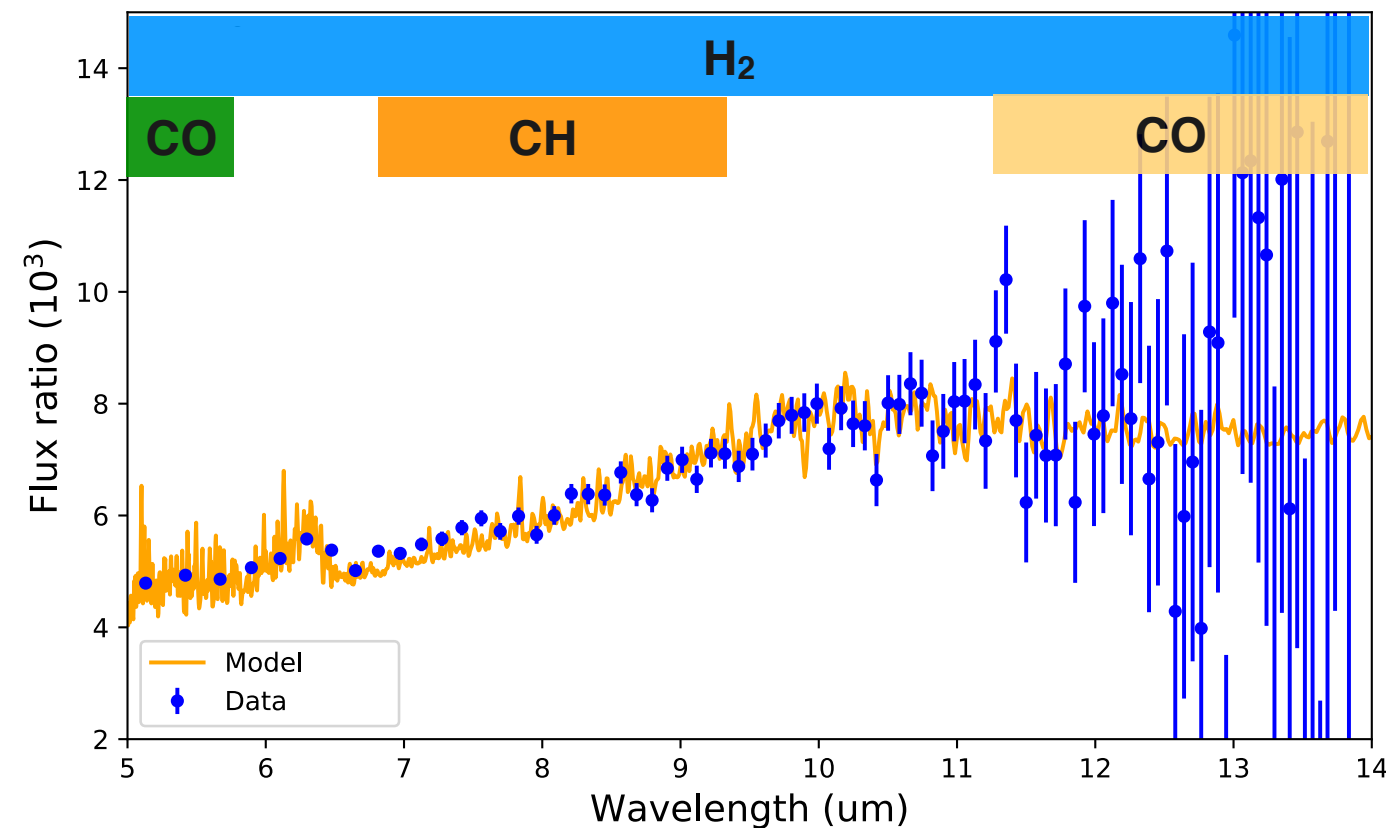
WASP-43b JWST Simulation (Venot et al., in prep.)

JWST/MIRI-LRS phase-curve simulations for WASP-43b:

- Thermo-, photo-, kinetics chemistry models
- 3D GCM
- Pandexo simulations



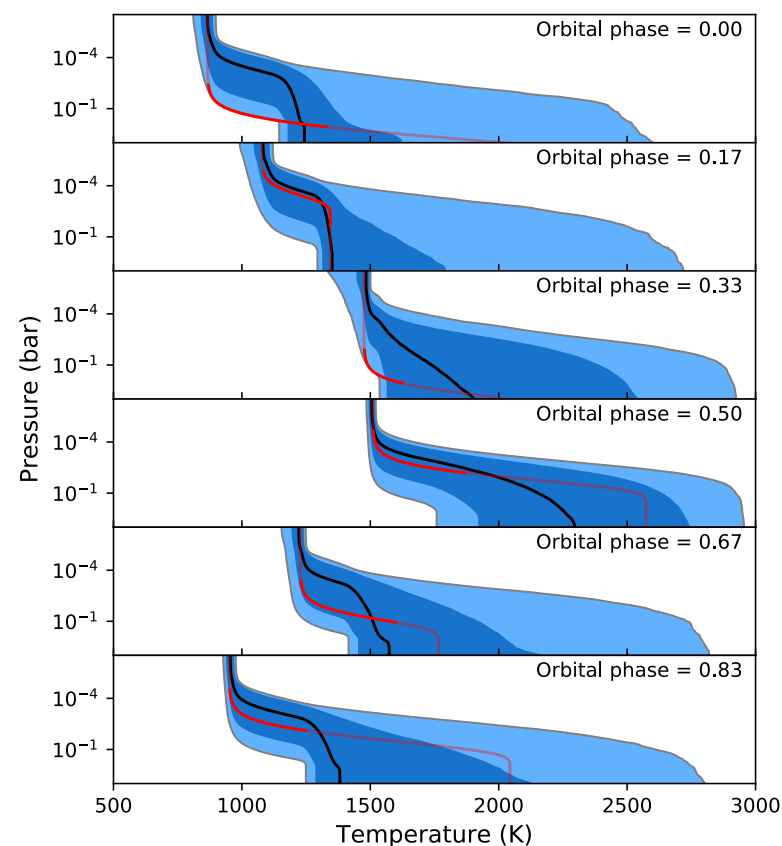
MIRI emission spectrum



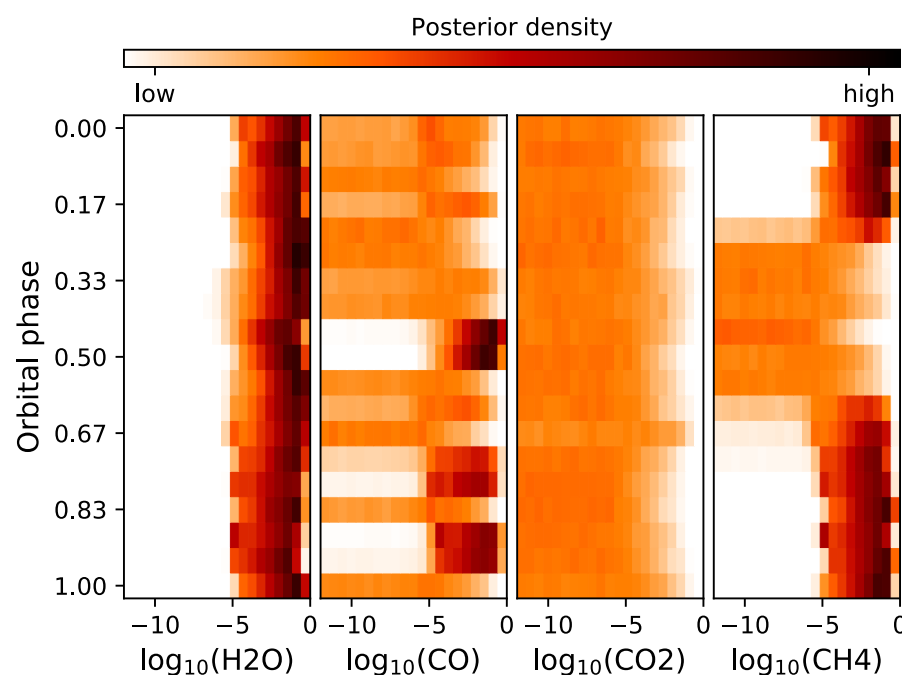
WASP-43b JWST Simulation (Venot et al., in prep.)

Retrieval results

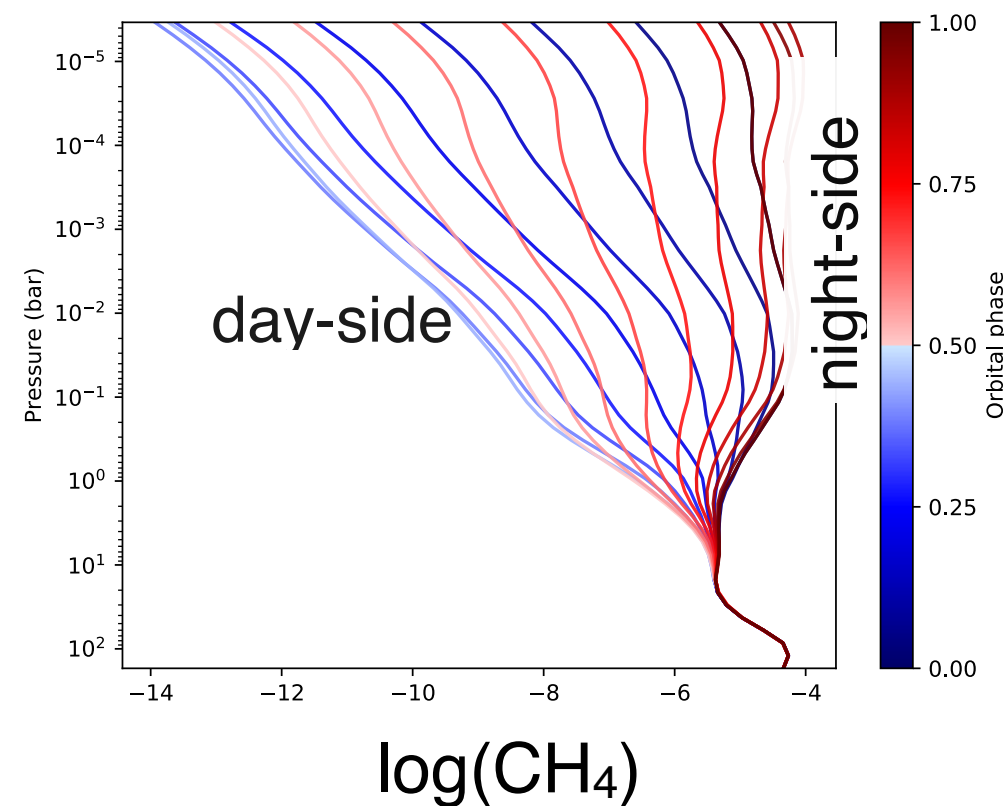
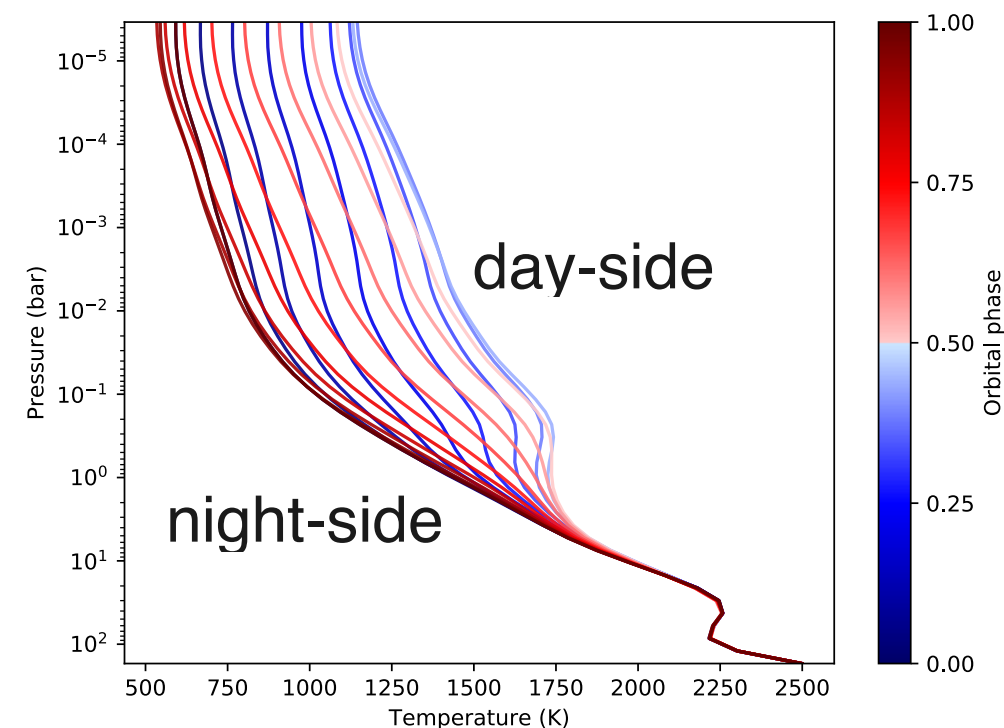
Temperature:



Abundances:



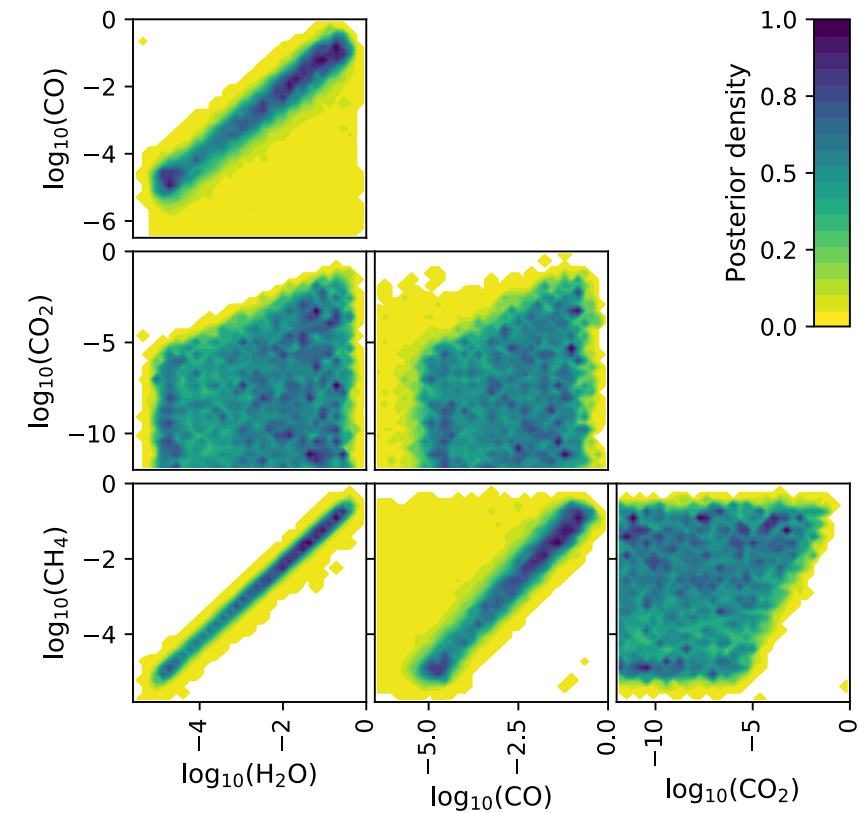
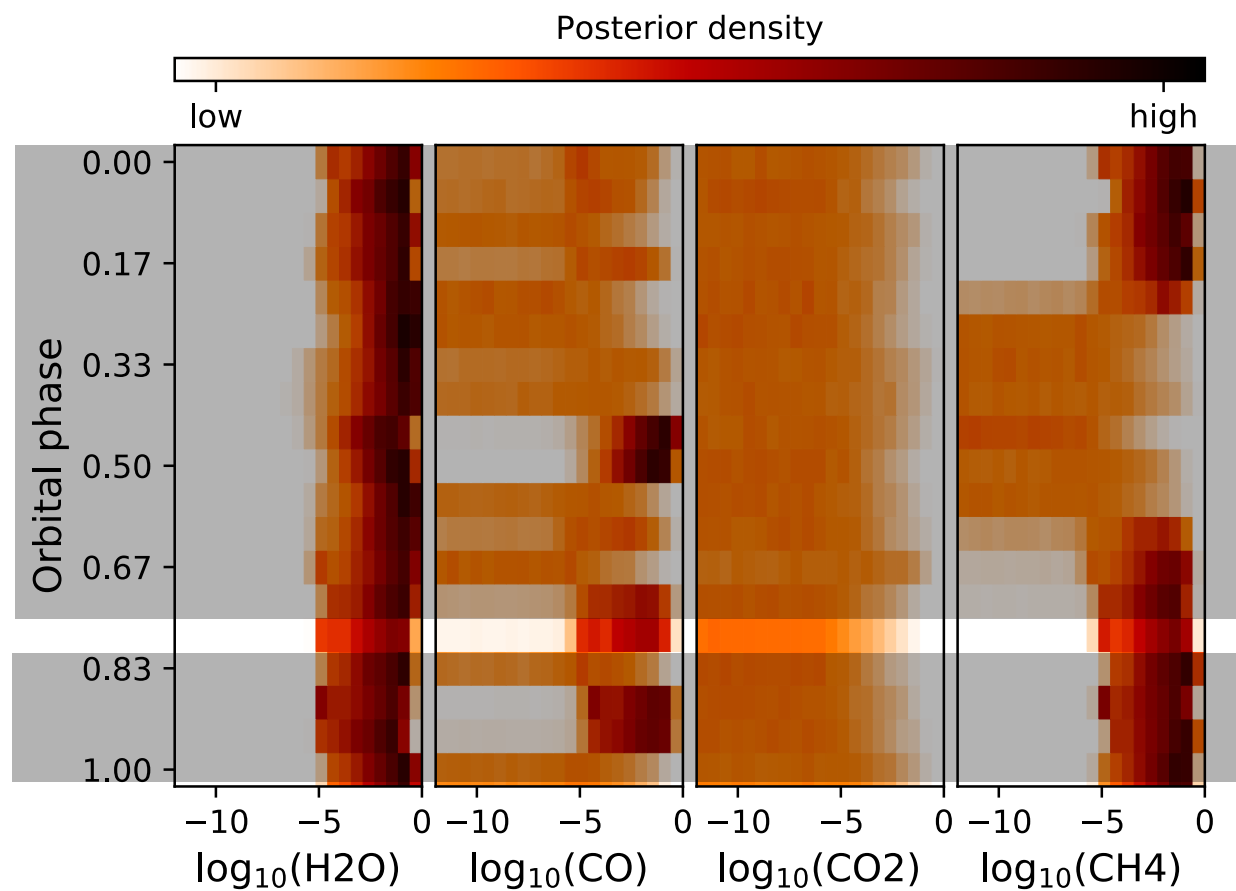
Averaged inputs



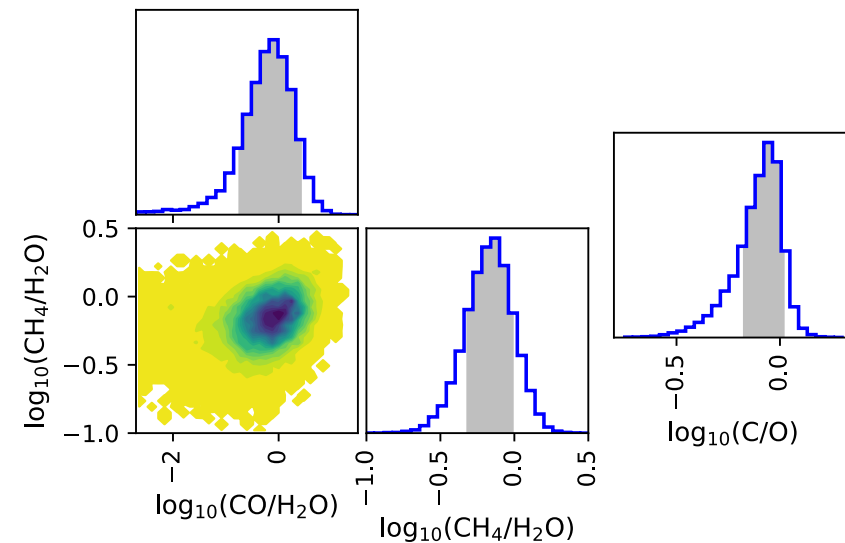
WASP-43b JWST Simulation (Venot et al., in prep.)

Free retrievals: abundance constraints

1. Poor absolute constraints



2. But, better ratio constraints



Summary

Pyrat Bay package:

- Forward/retrieval atmospheric modeling
- Open source:
<http://pcubillos.github.io/pyratbay/>

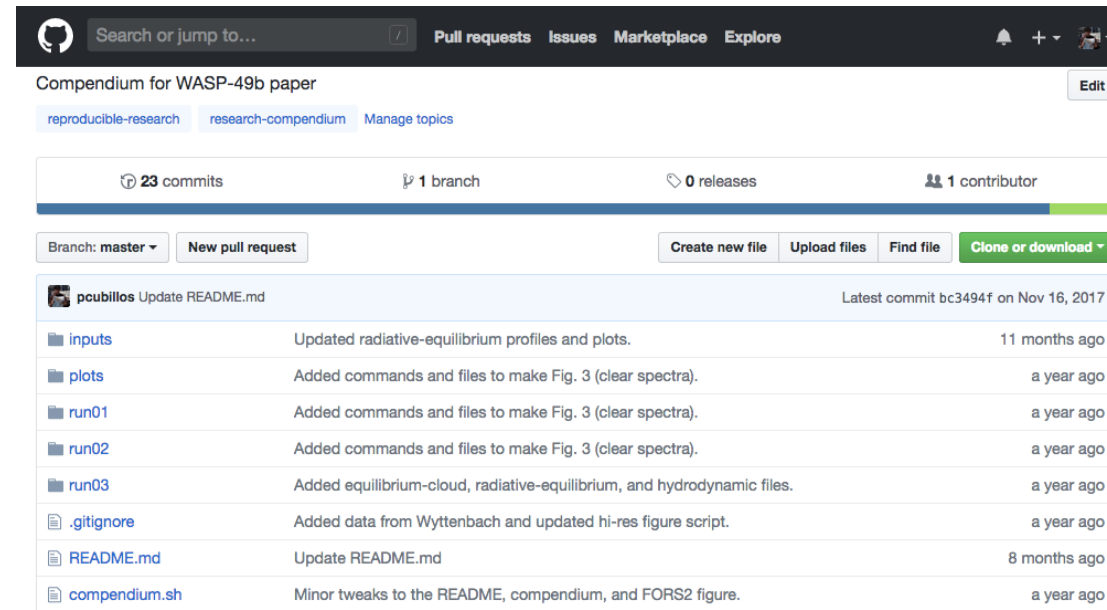
Atmospheric Retrieval:

- Muted but significant H₂O absorptions
- Cloudy / high-metallicity not statistically distinguishable
- Degenerate solutions
- Independent retrievals are consistent*

Ongoing development:

- Thermochemical-consistent retrievals (as in [Line+; Heng & Tsai 2016](#))
- Thermal-stability cloud model (as in [Ackerman & Marley 2001; Benneke 2015](#))
- Thermo/radiative-equilibrium profiles (as in [Malik+ 2017](#))

Reproducible



Compendium for WASP-49b paper

reproducible-research research-compendium Manage topics

23 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

File	Description	Time
inputs	Updated radiative-equilibrium profiles and plots.	11 months ago
plots	Added commands and files to make Fig. 3 (clear spectra).	a year ago
run01	Added commands and files to make Fig. 3 (clear spectra).	a year ago
run02	Added commands and files to make Fig. 3 (clear spectra).	a year ago
run03	Added equilibrium-cloud, radiative-equilibrium, and hydrodynamic files.	a year ago
.gitignore	Added data from Wyttenbach and updated hi-res figure script.	a year ago
README.md	Update README.md	8 months ago
compendium.sh	Minor tweaks to the README, compendium, and FORS2 figure.	a year ago