WASP-43 b dayside: a case study with MSG + *syntos*

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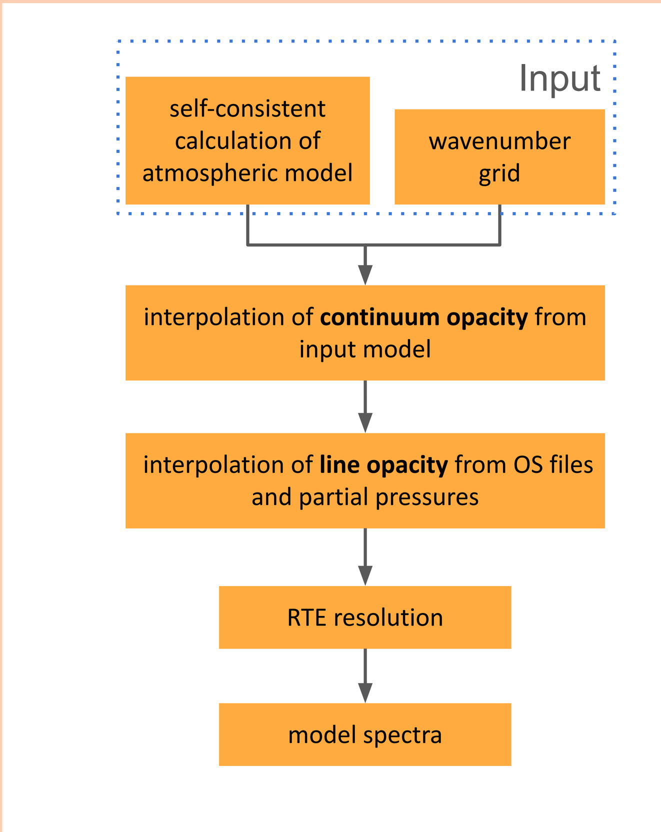
The model

We use the MSG model atmospheres from *Jørgensen et al. 2024 (arXiv 2407.093972, A&A in press)*, in combination with *syntos*, a simple, reliable code to calculate high resolution synthetic spectra, that we introduce here for the first time.



Our assumptions:

- Irradiation treatment as in Vaz. L & Nordlund A., 1985
- No clouds

Opacity sources

Continuum opacity sources:
H_{I} (bound-free, free-free and collision induced absorption), H^- (bound-free, free-free), H_2^-, H_2^+, He_{I}, He^-, C_{I}, Mg_{I}, Al_{I}, Si_{I}, Ca_{I}, e^- scattering, Rayleigh scattering. For more details see Tab.1 in Juncher, D. et al. 2017, A&A, 608, A70.

Line opacity sources:
AlCl, AlF, AlH, AlO, BeH, C_2, CaF, CaH, CH, CH_4, CN, CO, CO_2, CP, CrH, CS, FeH, H_2, H_2CO, H_2O, HCl, HCN, HS, KCl, KF, LiCl, LiF, LiH, MgF, MgH, NaCl, NaF, NaH, NH, NH_3, NO, OH, PH_3, PN, PO, PS, SiH, SiO, SiS, SN, SO_2, TiH, TiO, VO, ZrO. **Source**: Exomol database.

Atmospheric structure at varying metallicity

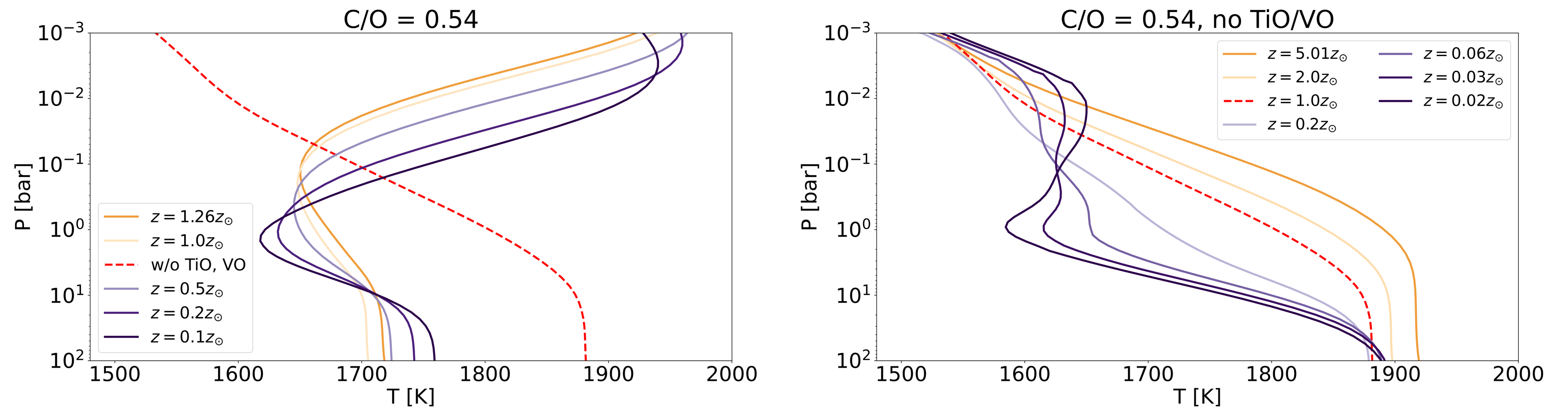


Figure: PT profile of the model atmosphere at fixed C/O = 0.54 and varying metallicities. The models in the right panel are calculated excluding TiO and VO from the opacity calculation. The red dashed line is, in both panels, the model at solar C/O ratio, solar metallicity, without TiO and VO.

Atmospheric structure at varying C/O ratio

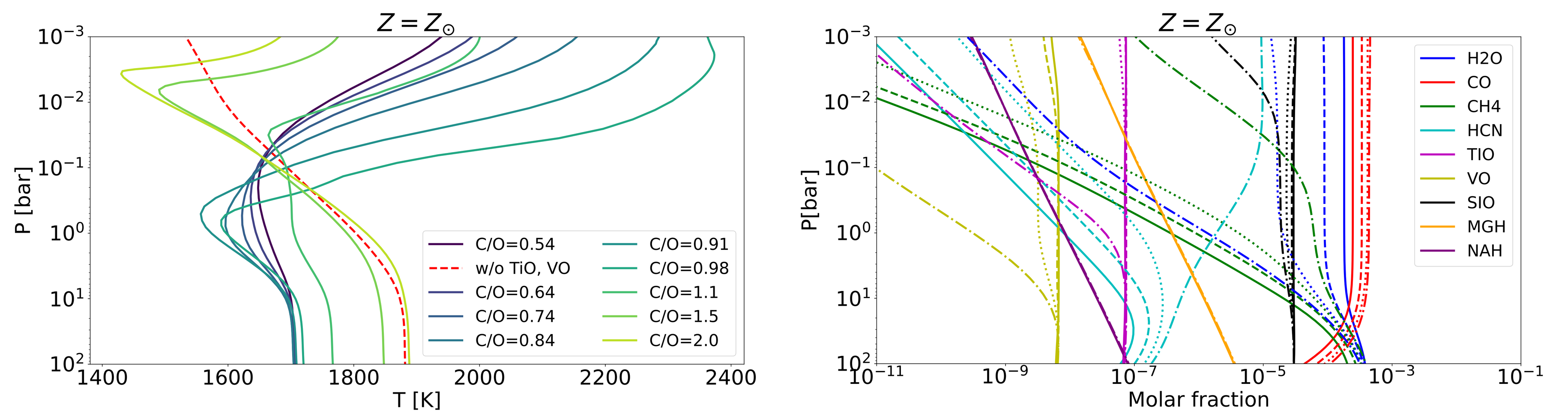


Figure: Left panel: PT profile of the model atmosphere at varying C/O ratio values. The red dashed line is calculated excluding TiO and VO from the opacity calculation. Right panel: Molar fraction at solar C/O ratio and solar metallicity as function of pressure for relevant species at C/O = 0.54 (solid line), 0.74 (dashed), 0.91 (dotted), 1.1 (dot-dashed).

Spectra

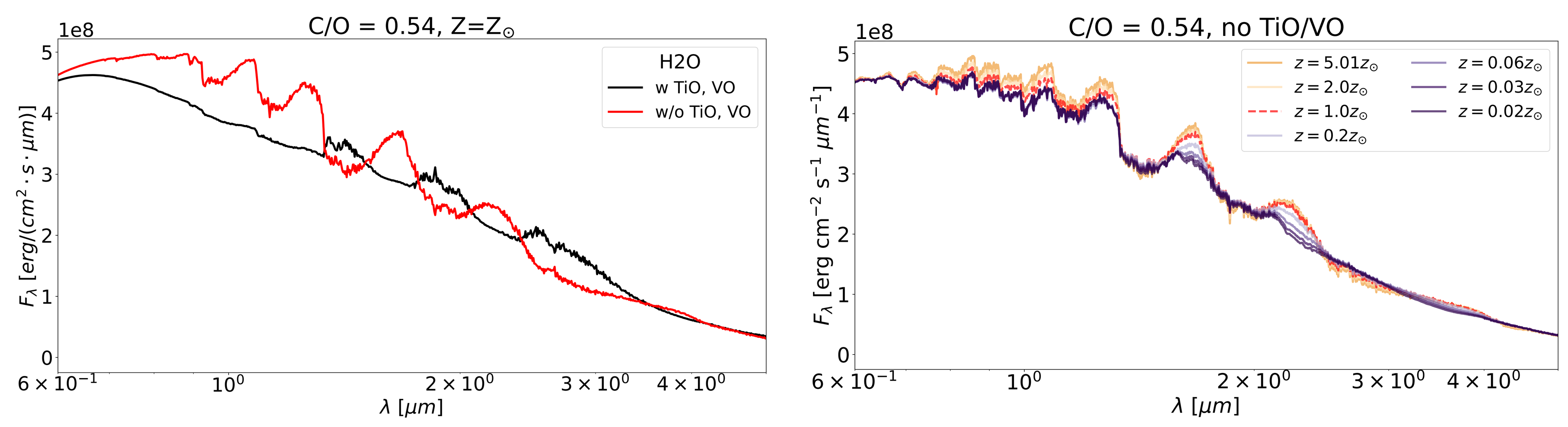


Figure: Left panel: spectrum contribution of H2O in two models at solar C/O ratio and solar metallicity with (black) and without (red) TiO and VO. Right panel: spectrum of models without TiO and VO at solar C/O ratio and varying metallicity.

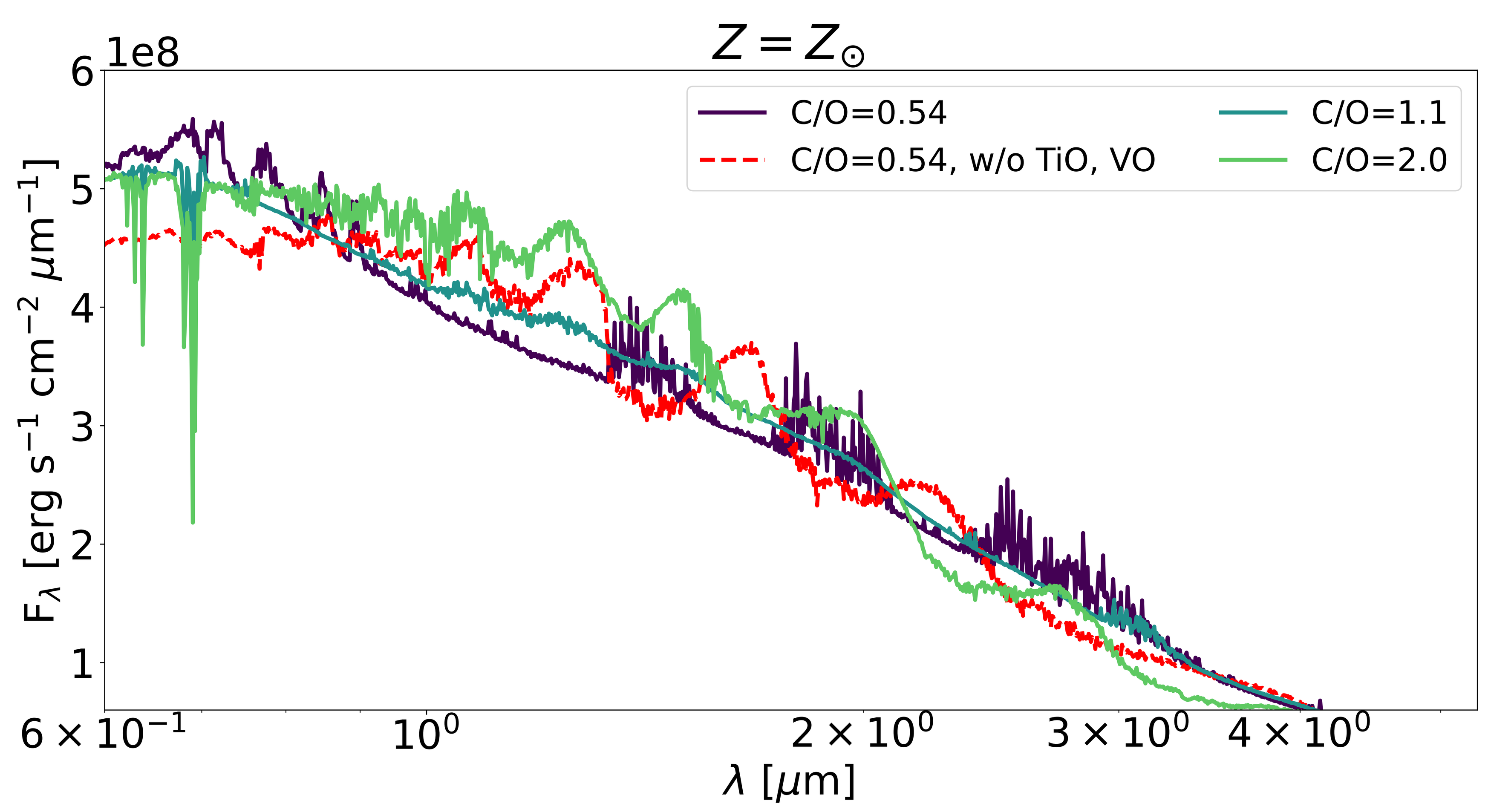


Figure: Spectra of models at solar metallicity and varying C/O ratio. All models include TiO and VO except for the red line.

Methods

We expand the work of Jørgensen et al. 2024 on irradiated models through a case study. We model the dayside emergent spectrum of a hot Jupiter with the same global properties as those of WASP-43 b: $T_{star} = 4250$K, $R_{star} = 0.667 R_\odot$ for the star, $a = 0.015$ AU for the semimajor axis, $T_{int} = 100$K for the internal temperature of the planet. We assume homogeneous redistribution of the heat on the dayside. We explored:

- Effects of TiO/VO
- Effects of metallicity
- Effects of C/O ratio

Results

- Assuming equilibrium chemistry, solar metallicity, C/O = 0.54 and including all the opacity sources in the "**Line opacity**" list (left column of the poster), the model will show a temperature inversion at $10^{-2} < P <$ 1bar. For the same conditions, removing TiO and VO from the opacity sources results in a non inverted PT profile.
- A model without TiO and VO opacity will present an inversion if the metallicity is decreased down to $Z \leq 0.01 Z_\odot$.
- Increasing the C/O ratio up to C/O = 1 will accentuate the temperature inversion caused by TiO and VO . For C/O >1 TiO and VO will be strongly depleted, but we still see a temperature inversion at lower pressures, $10^{-3} < P < 10^{-2}$bar, caused by different molecules.

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