

Modelling, interpretation, and preparation of JWST observations of the temperate super-Earth LHS 1140 b

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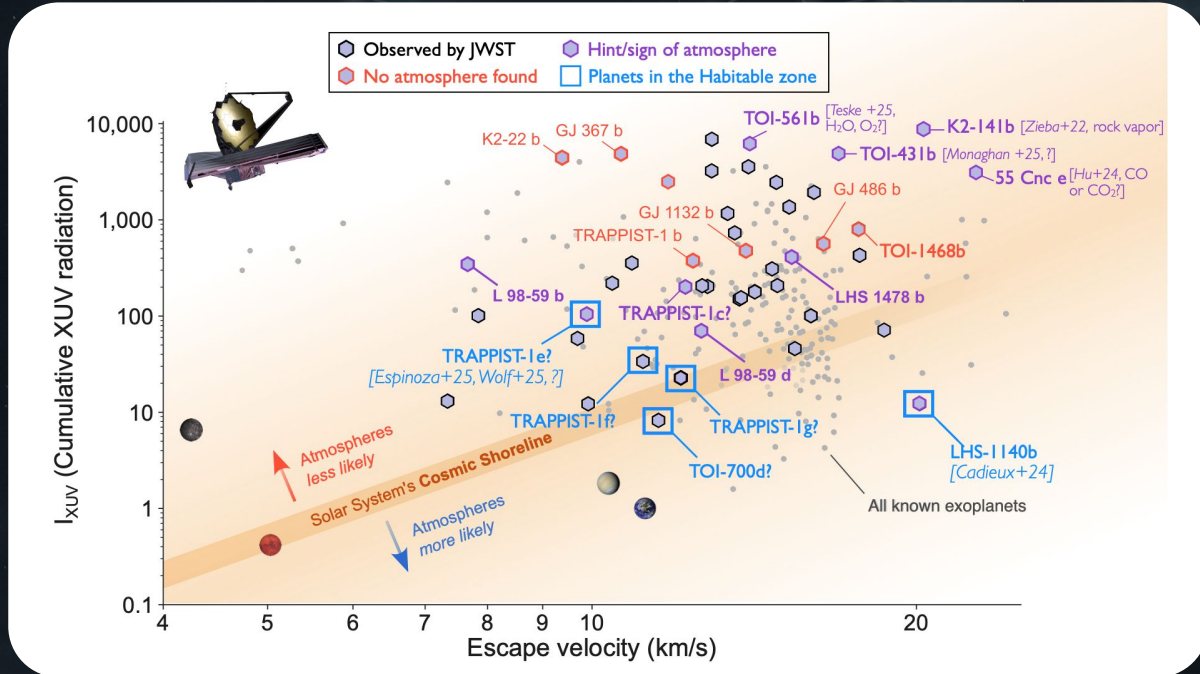


Tell me whyyyyyy ?

(me too Backstreet Boys, me too)

A bit of context...

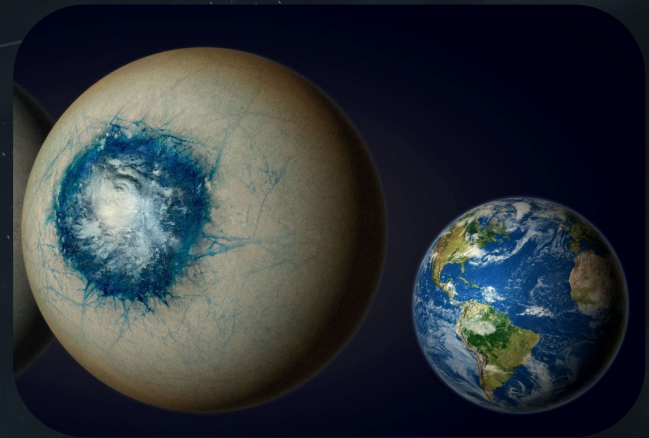
Atmospheres around rocky planets



The best planet

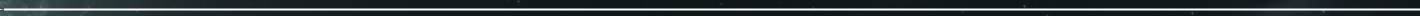
LHS 1140 b

- **Distance to Earth** : 49 light-years
- **Size** : $1.730 R_{\oplus}$
- **Mass** : $5.60 M_{\oplus}$ → Low density
- **Period** : 24.737 days
- **Mean temperature** : 226 K
- In the **habitable zone**



Artist's impression © B. Gougeon, UdeM

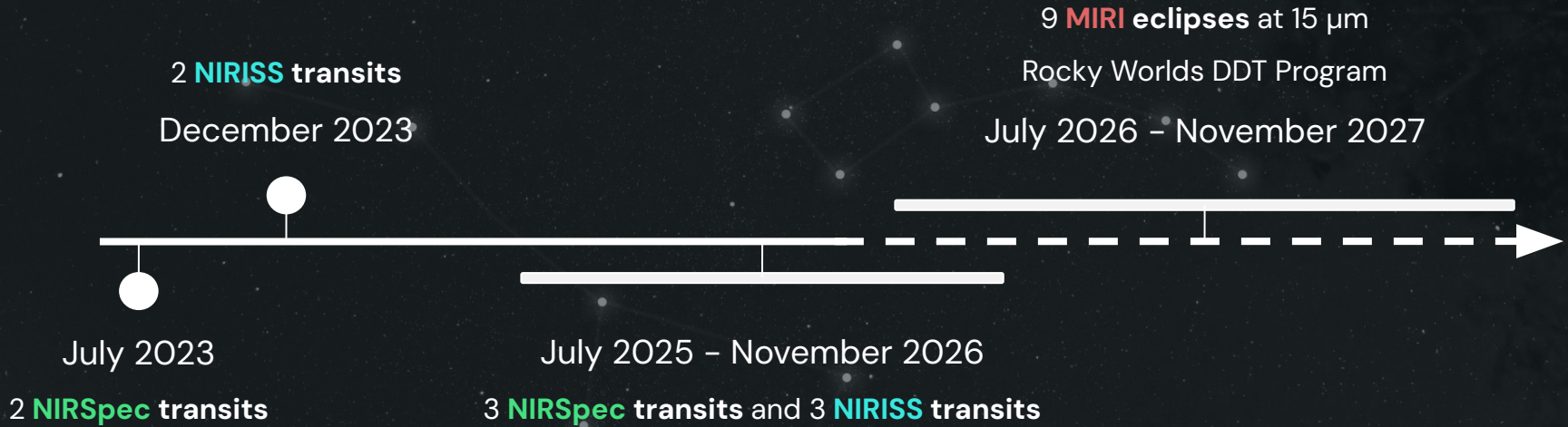
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JWST observations

(insert funny joke)

Timeline



In total : 184 hours of observations !

Timeline

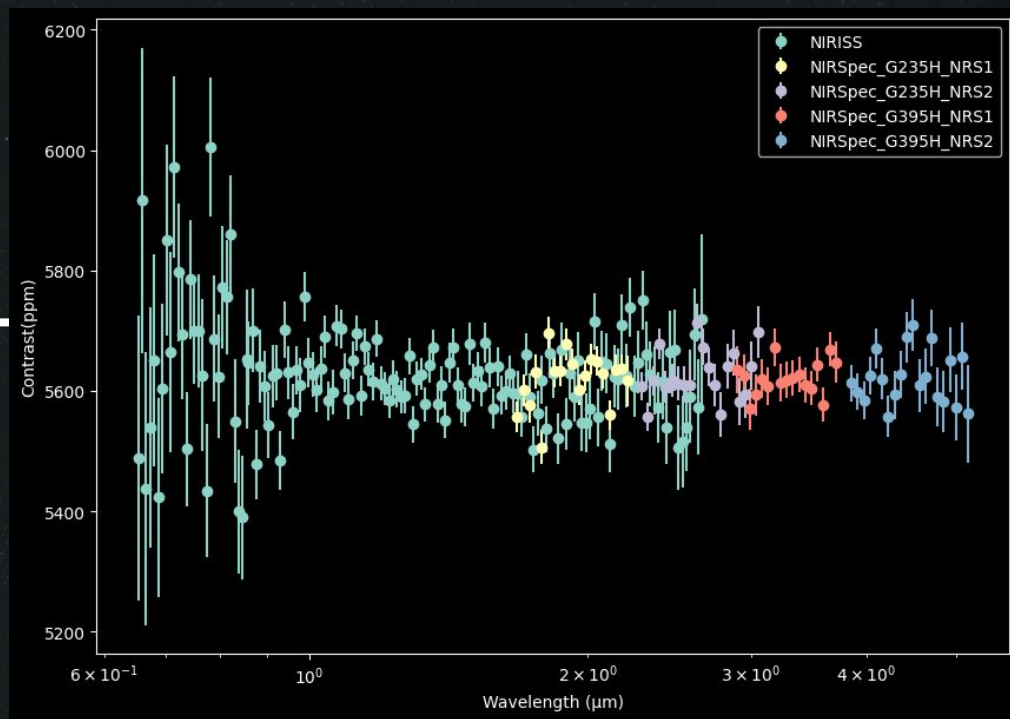
2 **NIRISS** transits

December 2023



July 2023

2 **NIRSpec** transits



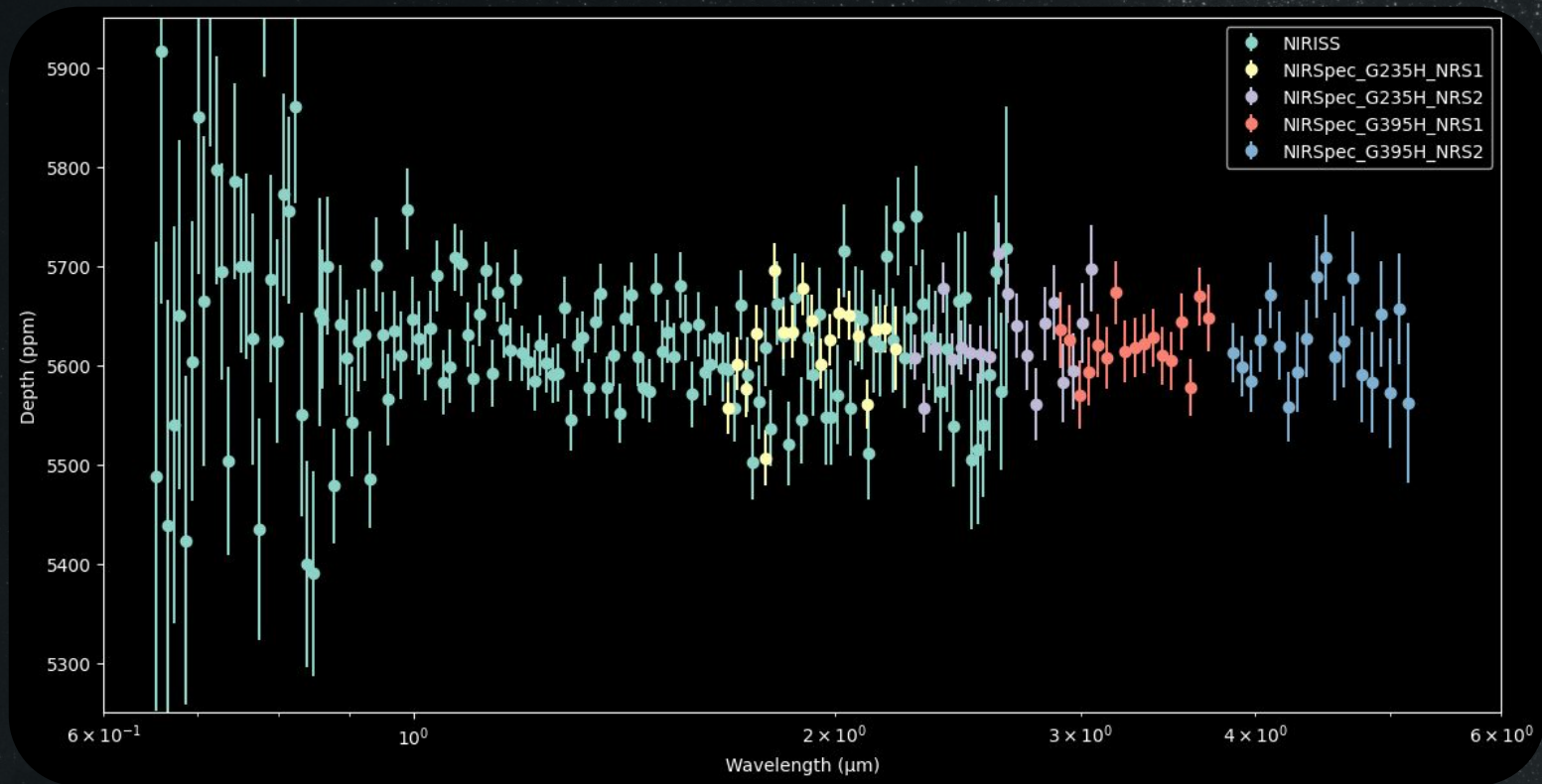
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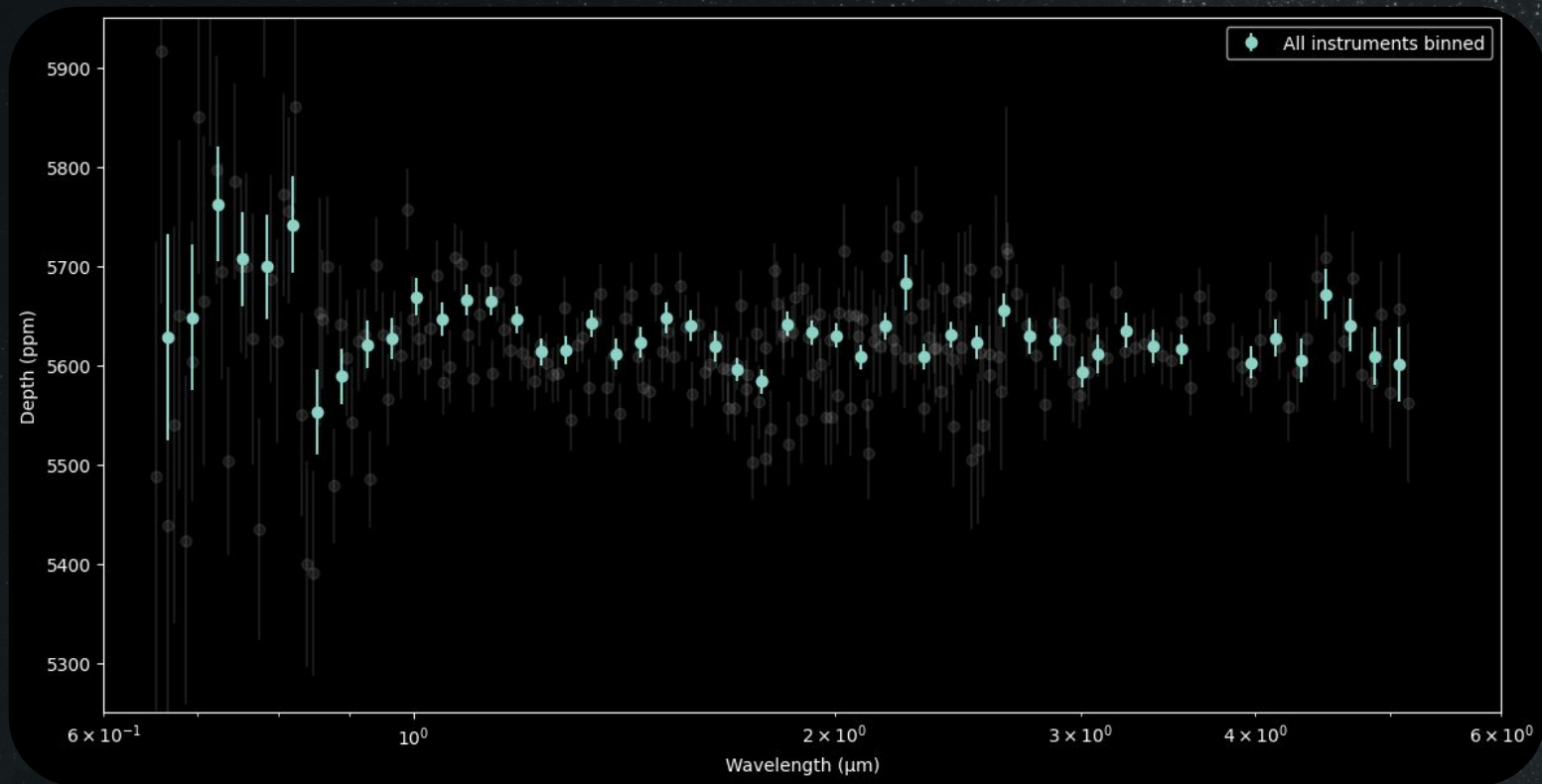
Methods

(me and my many problems)

Aggregating JWST data



Aggregating JWST data



3D modelling : Generic PCM

Why 3D modelling ?

- Presence of clouds in the atmosphere
- Possibility for emission spectra



Generic Planetary Climate Model

Credit: A. Gauvain

2 test simulations :

- 5 bar CO₂
- 1 bar N₂ 400 ppm CO₂ (Earth-like)

3D modelling : Generic PCM

Why 3D modelling ?

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(cool preliminary new logo)

**Generic Planetary
Climate Model**

Credit: A. Gauvain

2 test simulations :

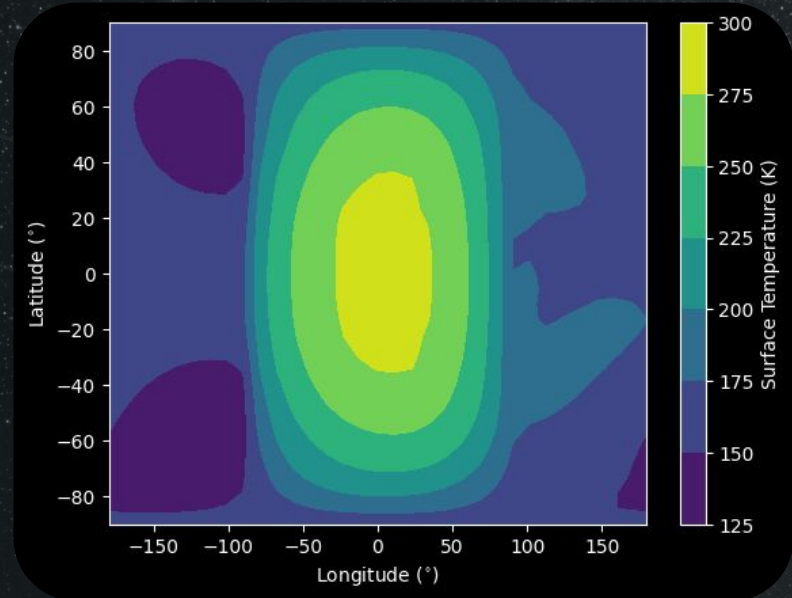
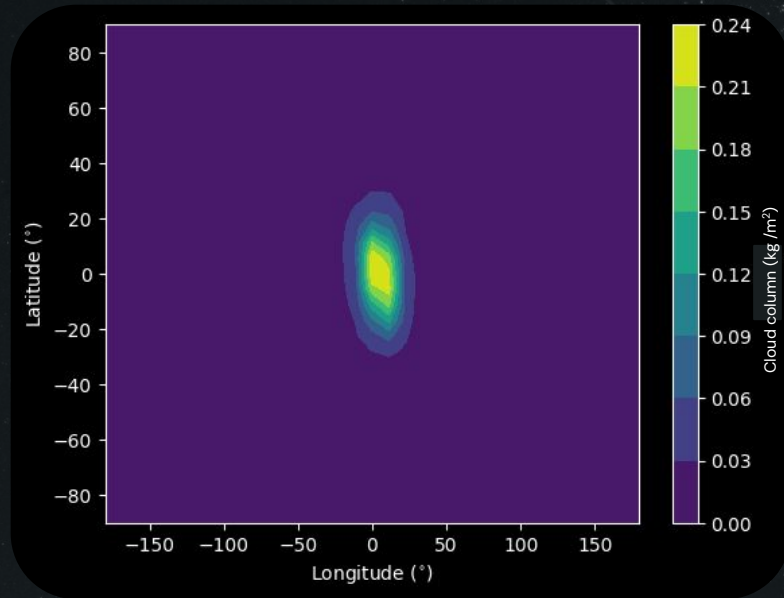
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3D modelling : Generic PCM

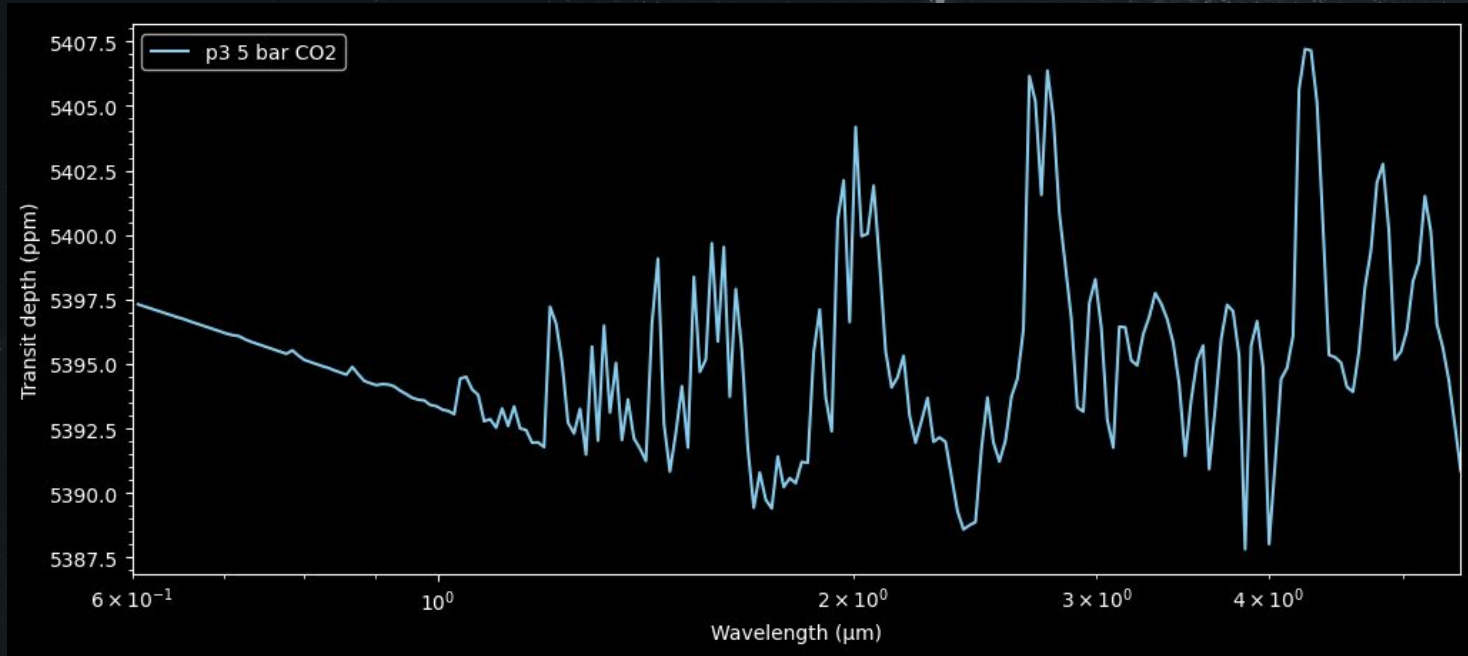
Example of an Earth-like atmosphere

Clouds

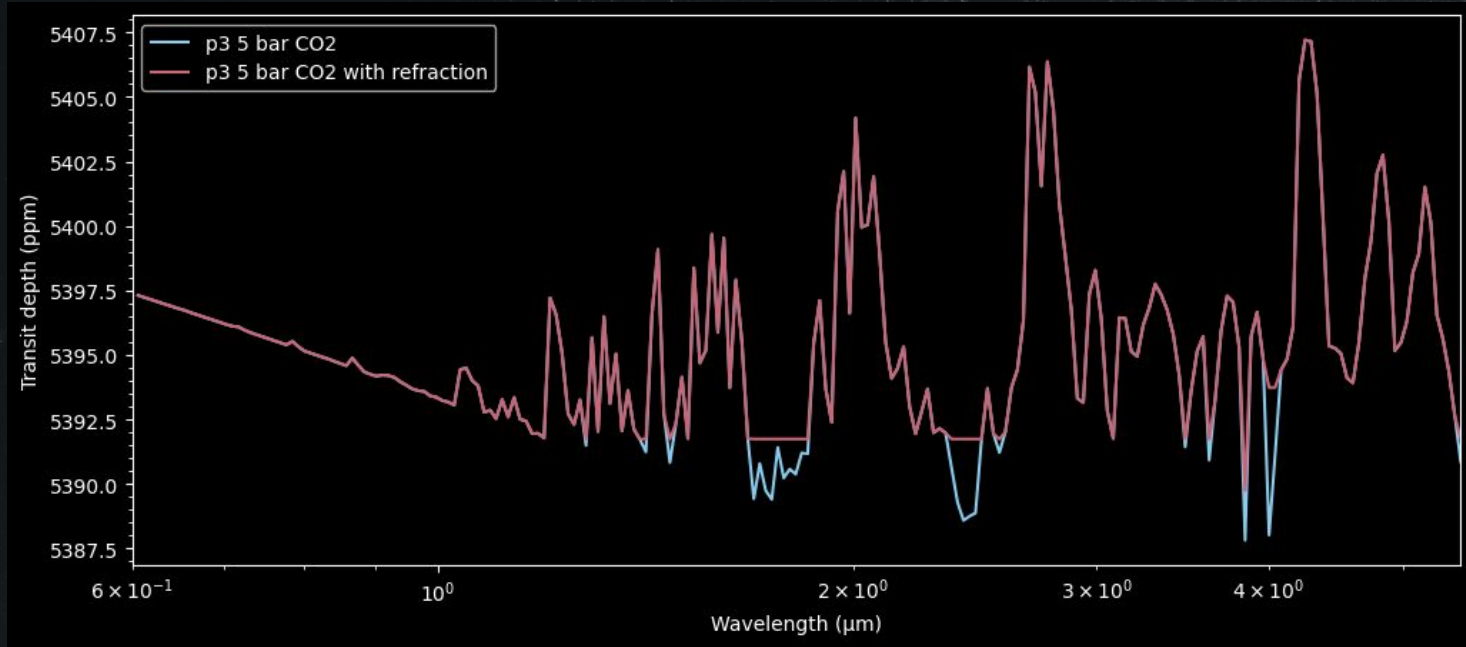
Heat map



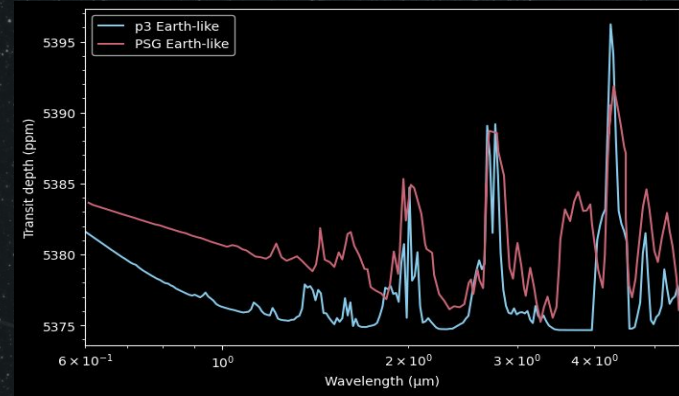
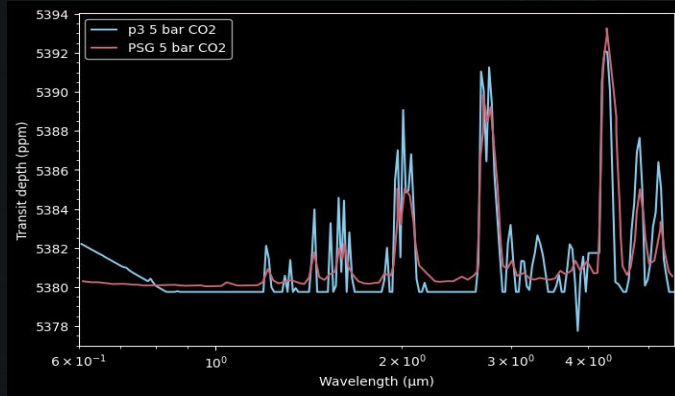
Pytmosph3R : refraction



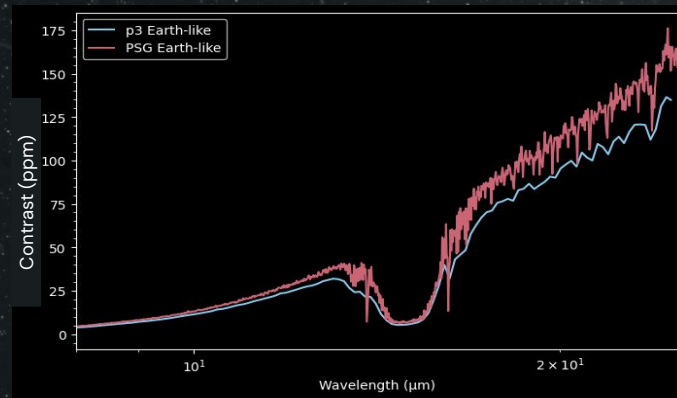
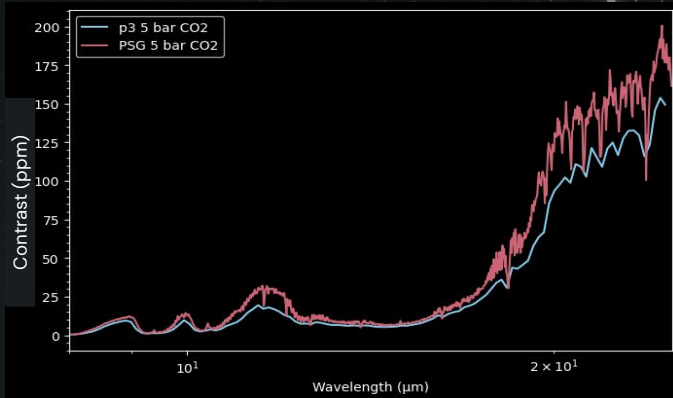
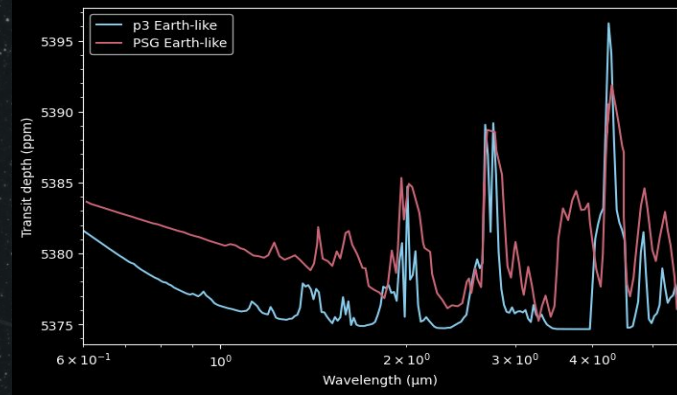
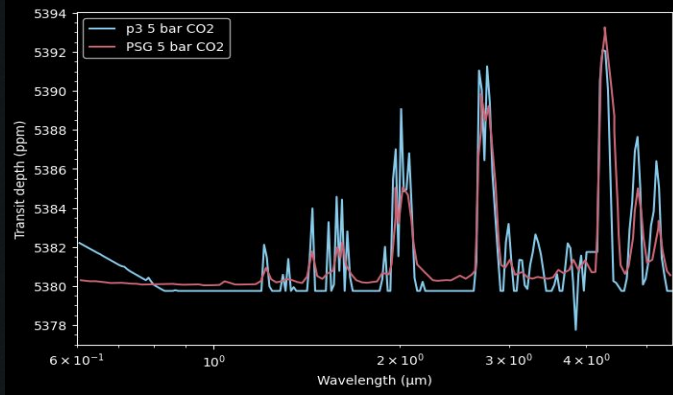
Pytmosph3R : refraction



Benchmarking : Pytmosph3R vs PSG



Benchmarking : Pytmosph3R vs PSG



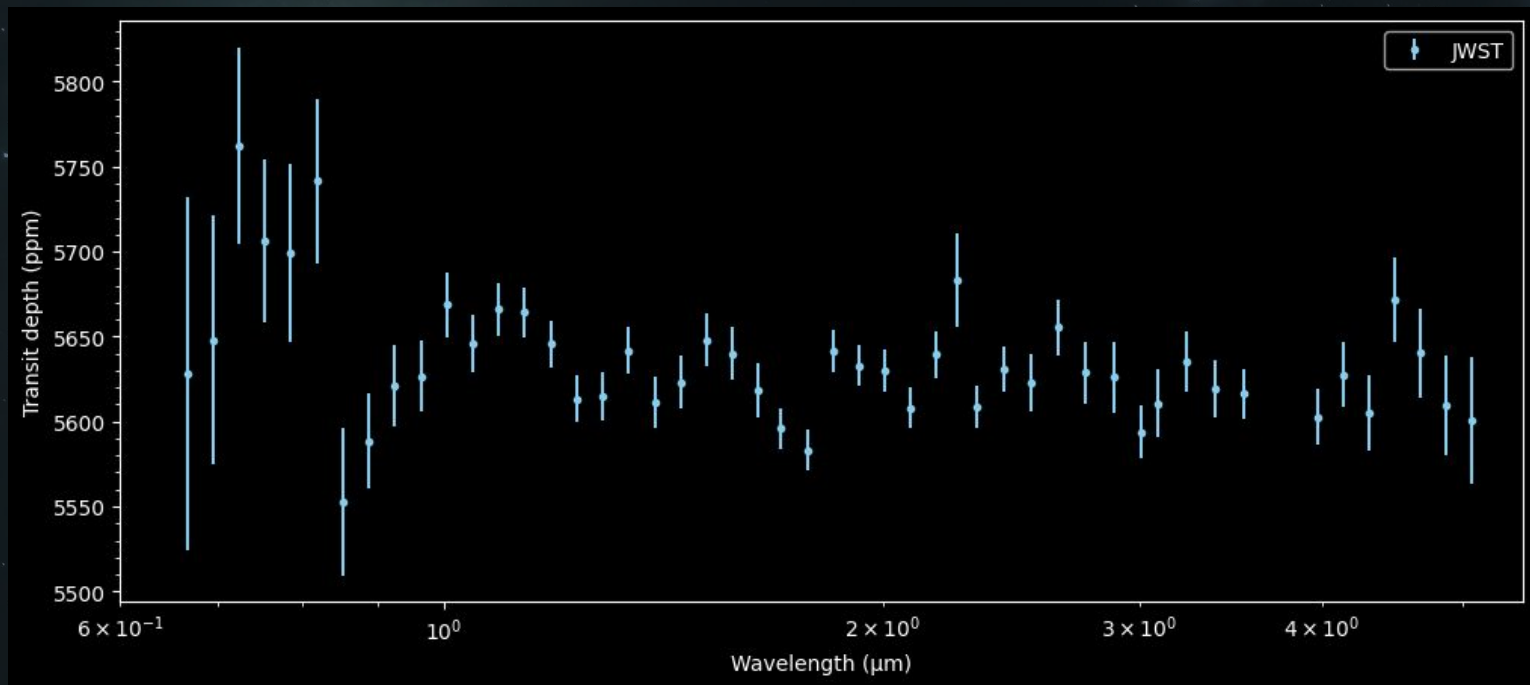
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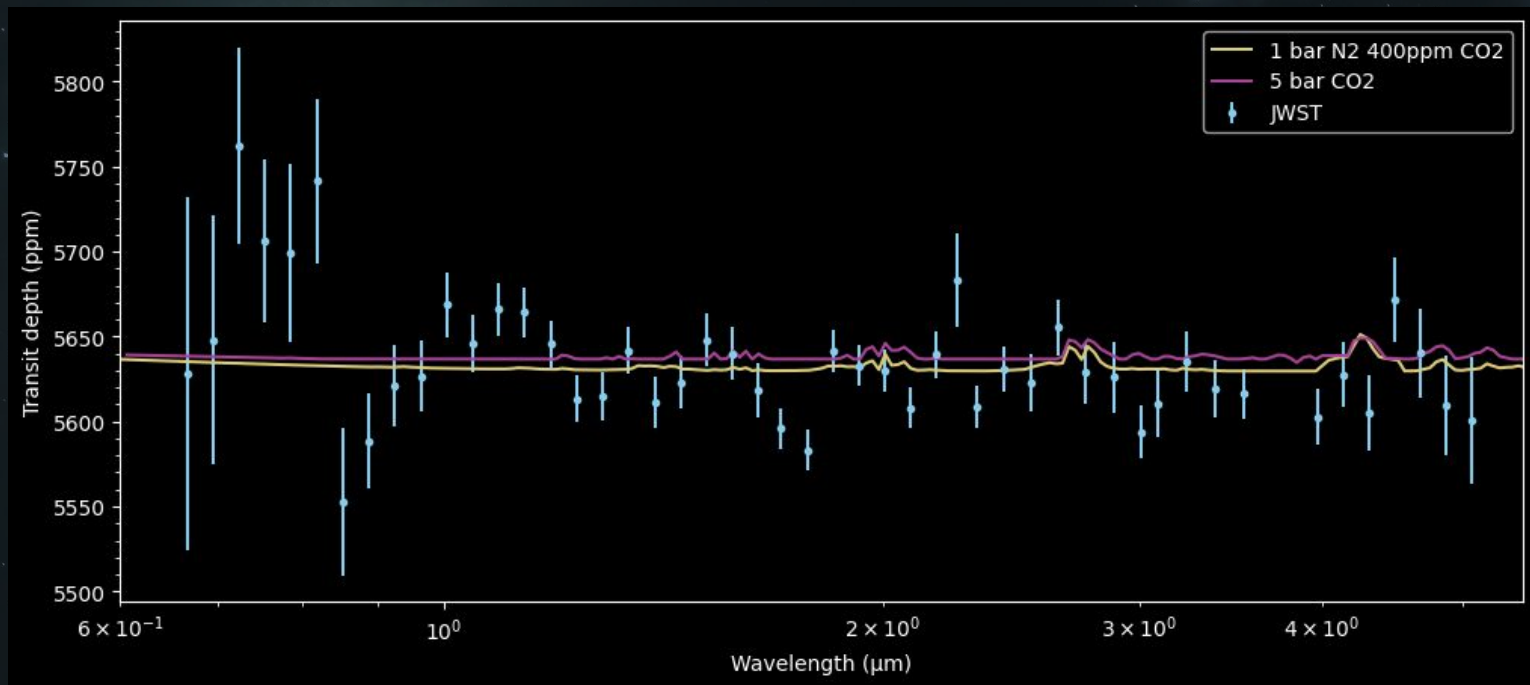
Preliminary results

(very preliminary)

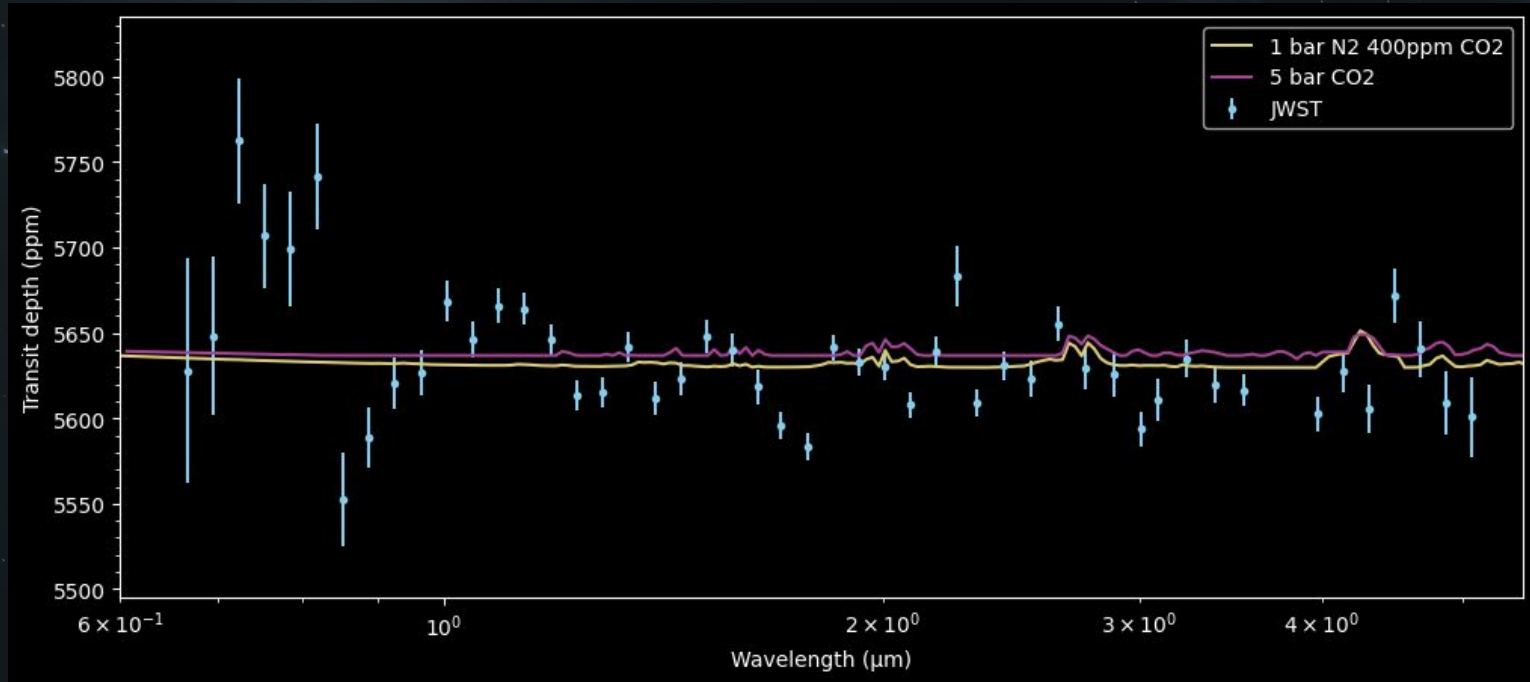
Transits



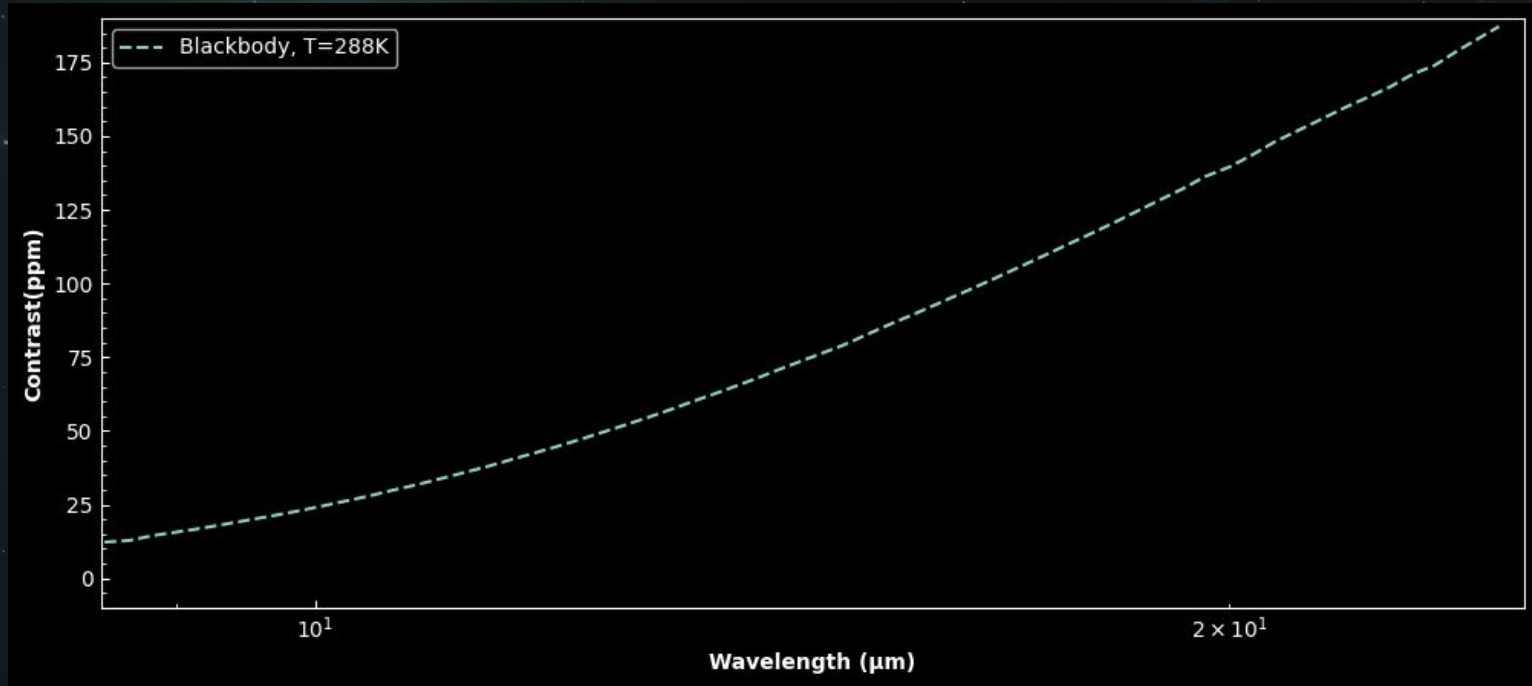
Transits



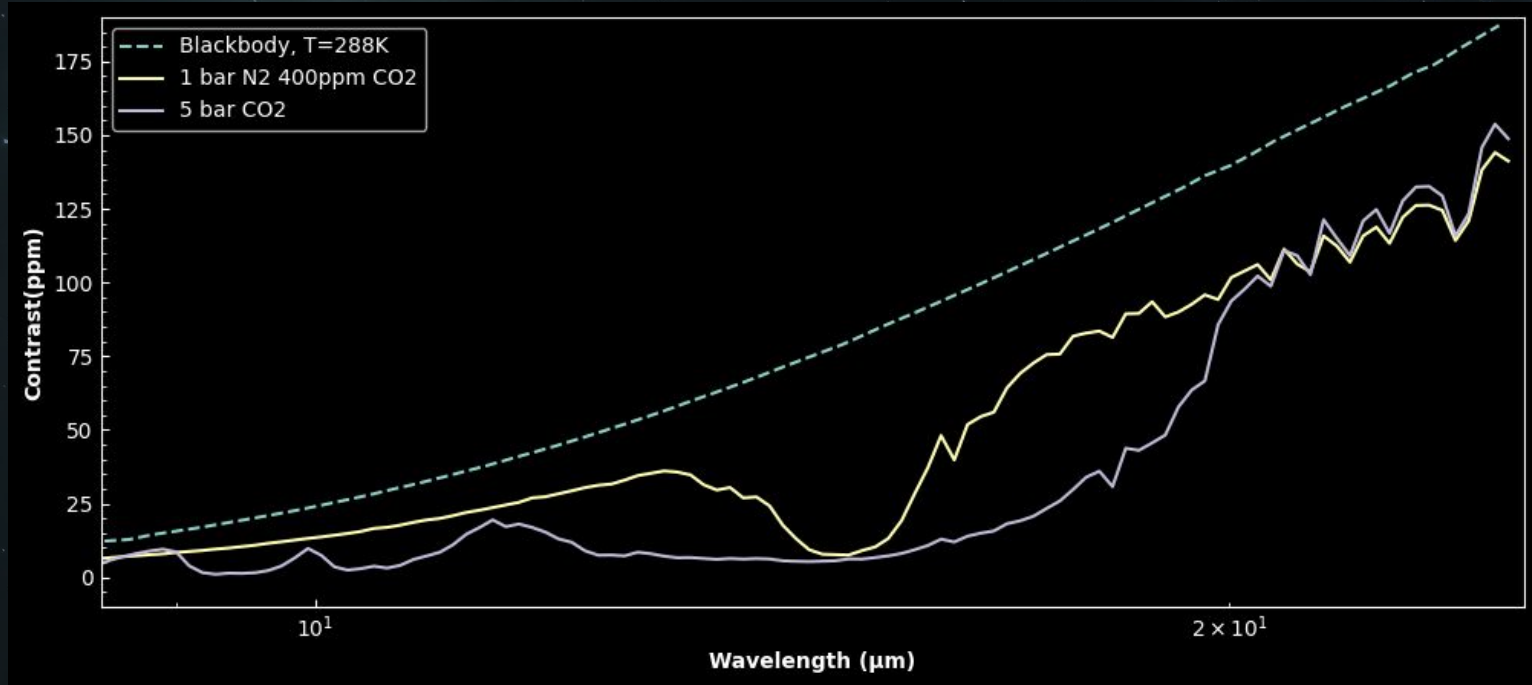
Transits



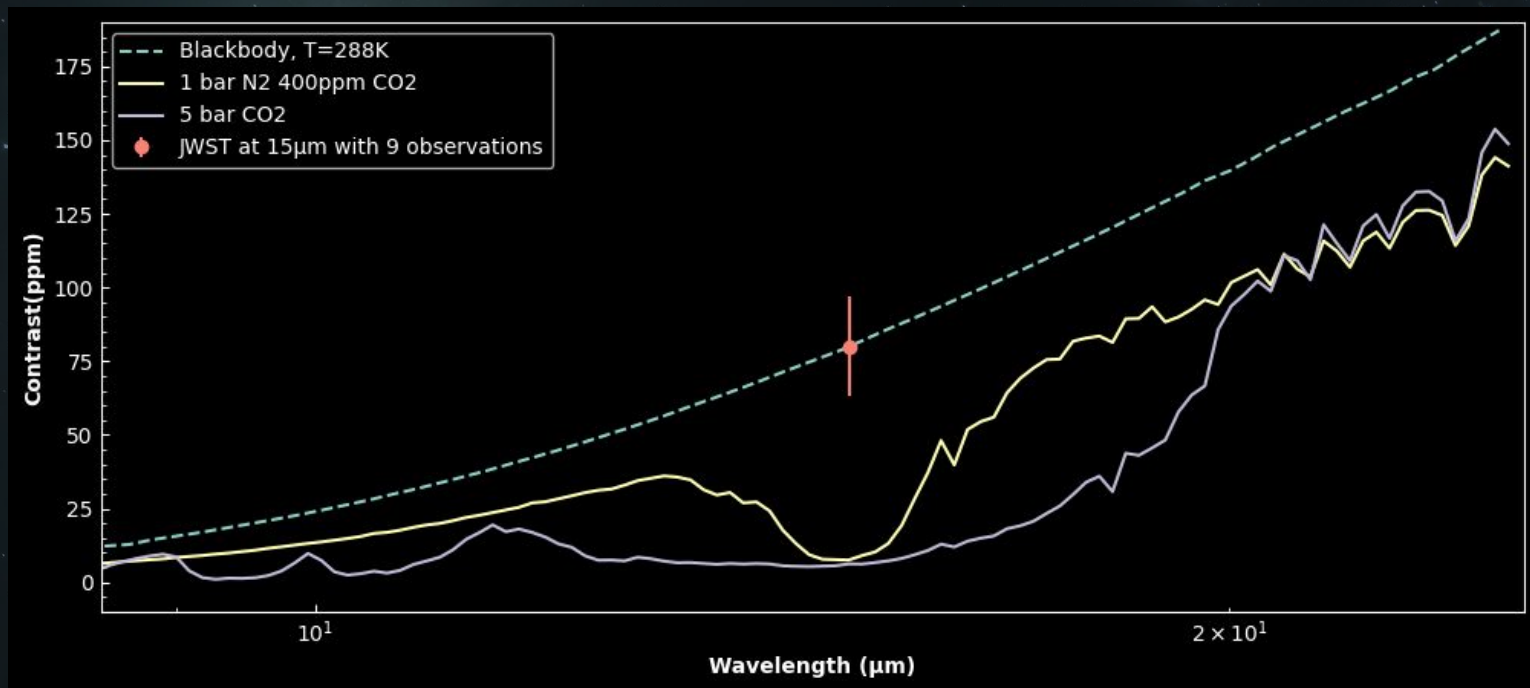
Eclipses



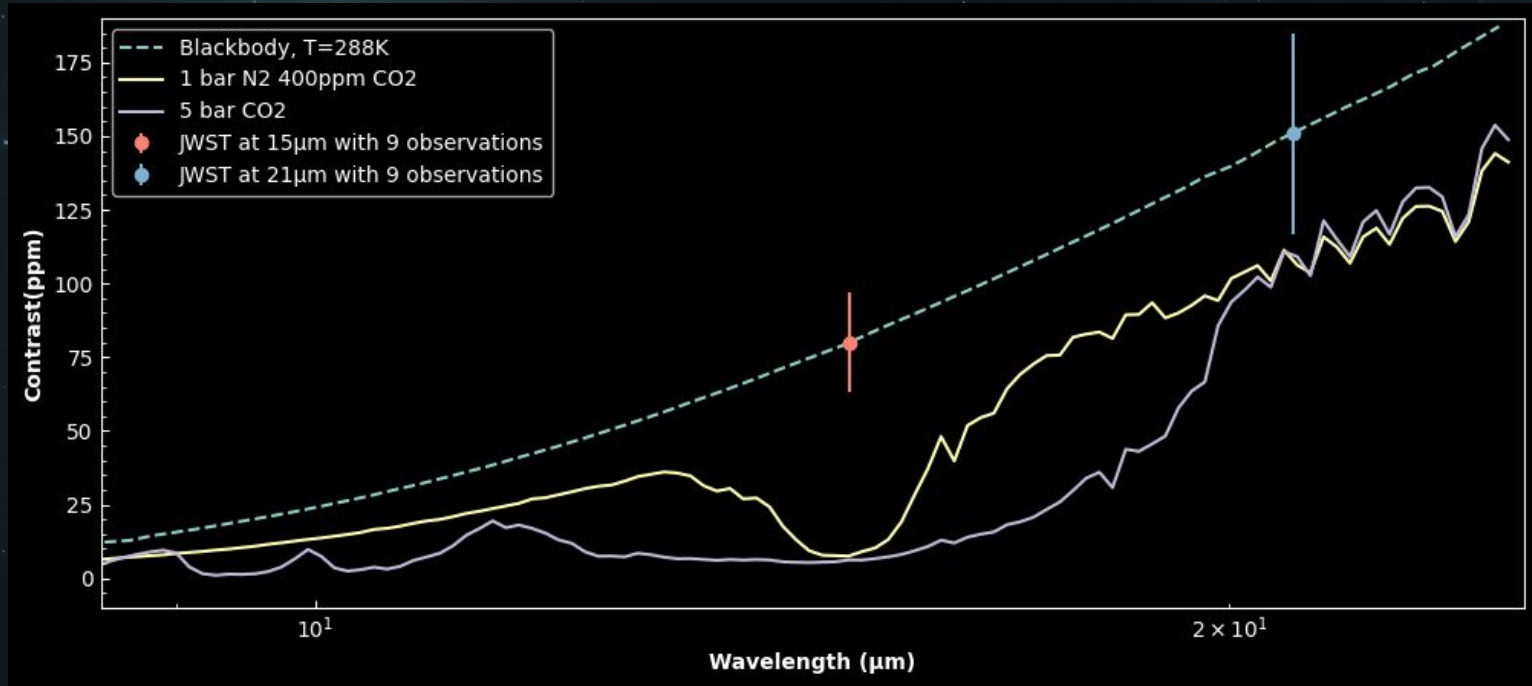
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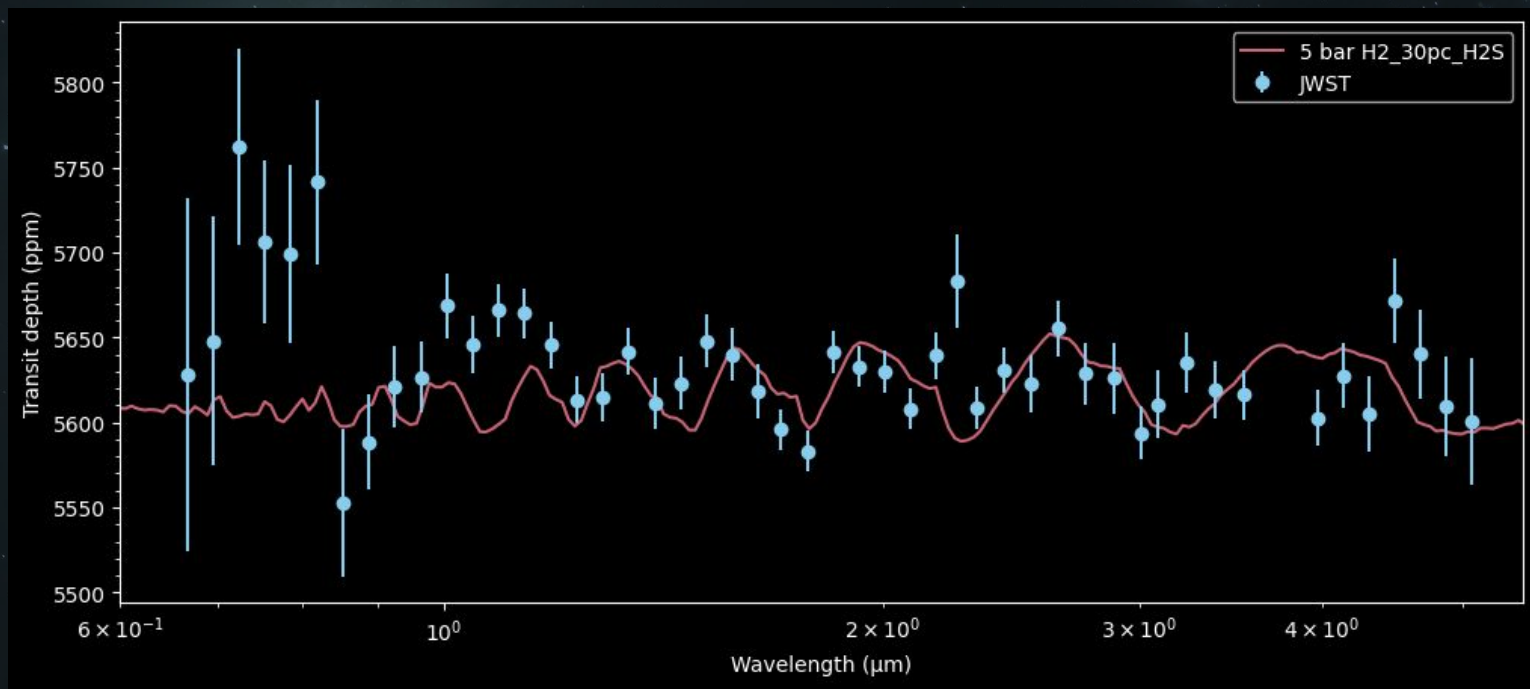
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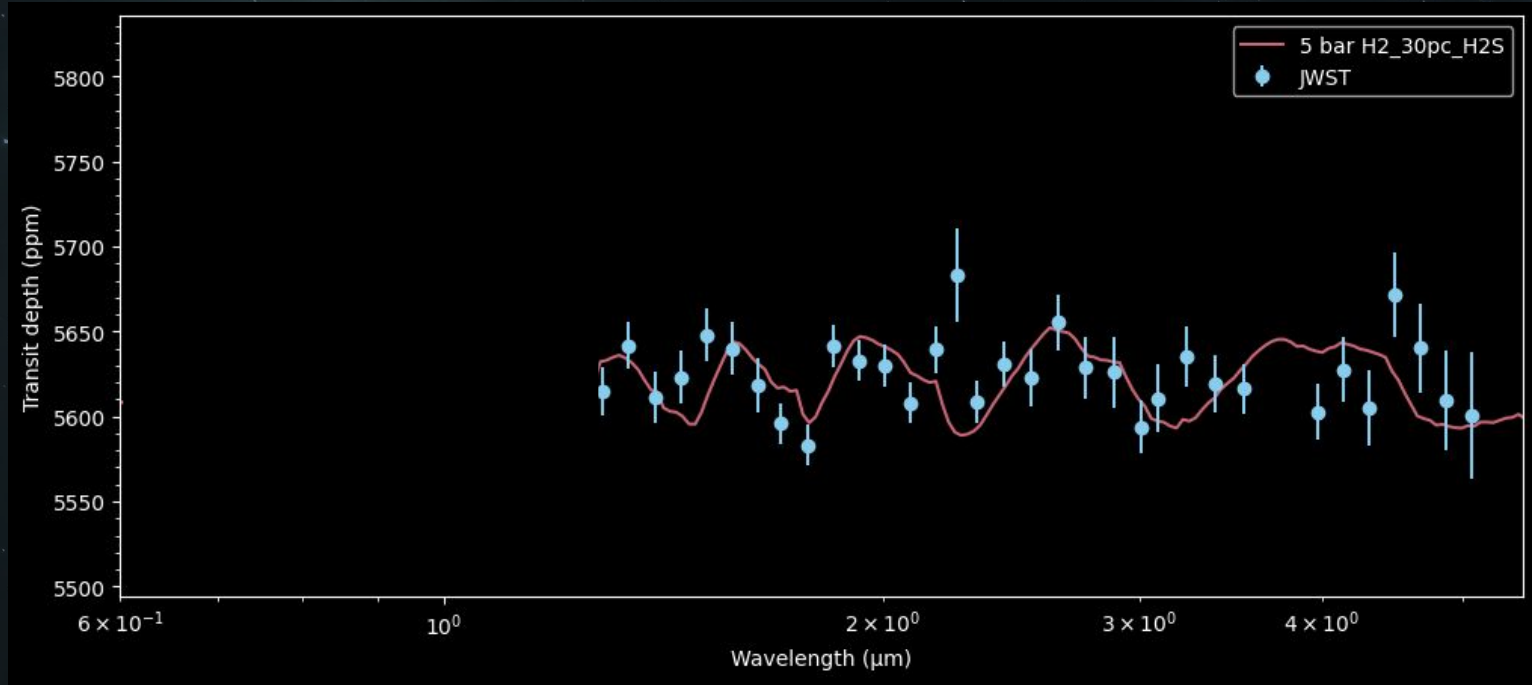
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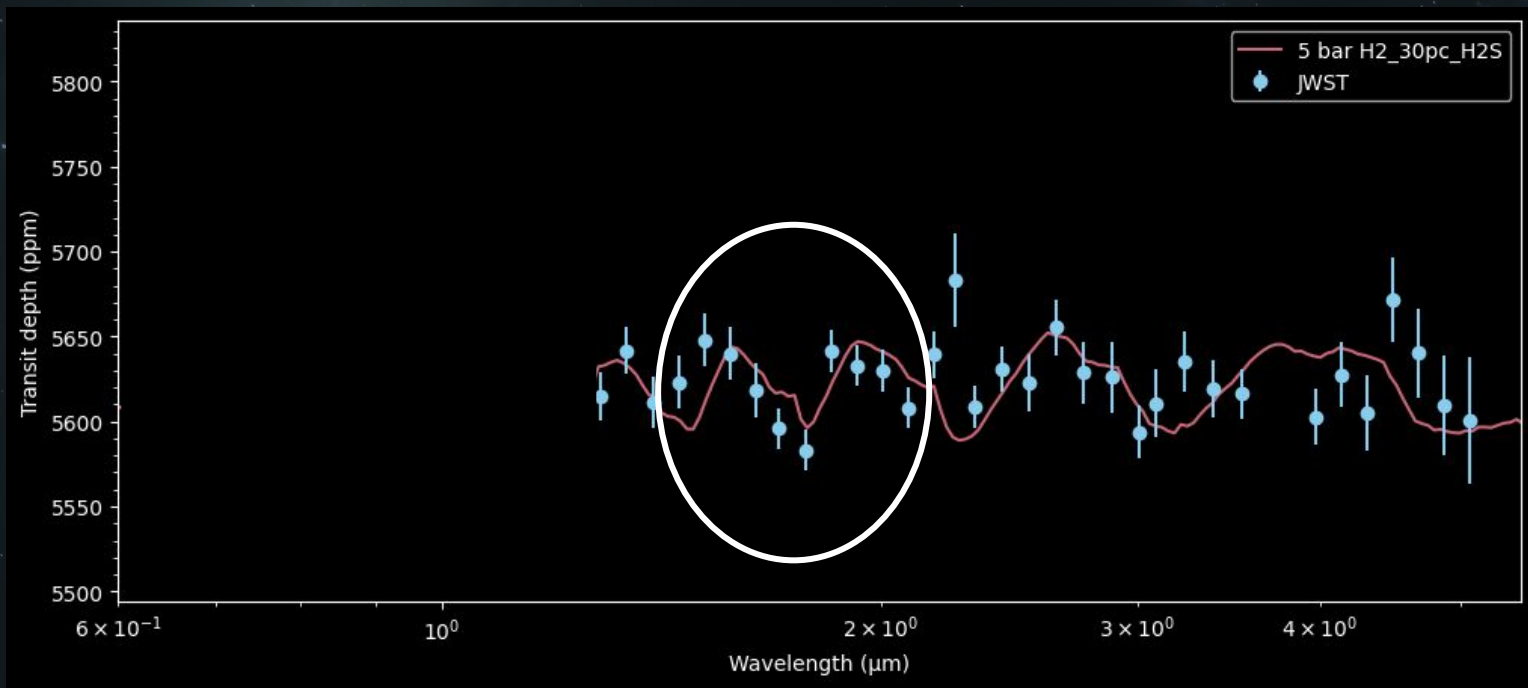
Spoilers : maybe H₂S ?



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Spoilers : maybe H₂S ?



Summary

- LHS 1140 b is currently the **most likely** rocky exoplanet around an M dwarf to have an atmosphere
 - If there is none, atmospheres on rocky planets might be extremely rare
- The next JWST observations should allow us to determine if there is an atmosphere, and in conjunction with GPCM models constrain its atmospheric composition



Thank you for listening !

Questions ? Remarks ? Concerns ?

TRAPPIST-1 Timeline



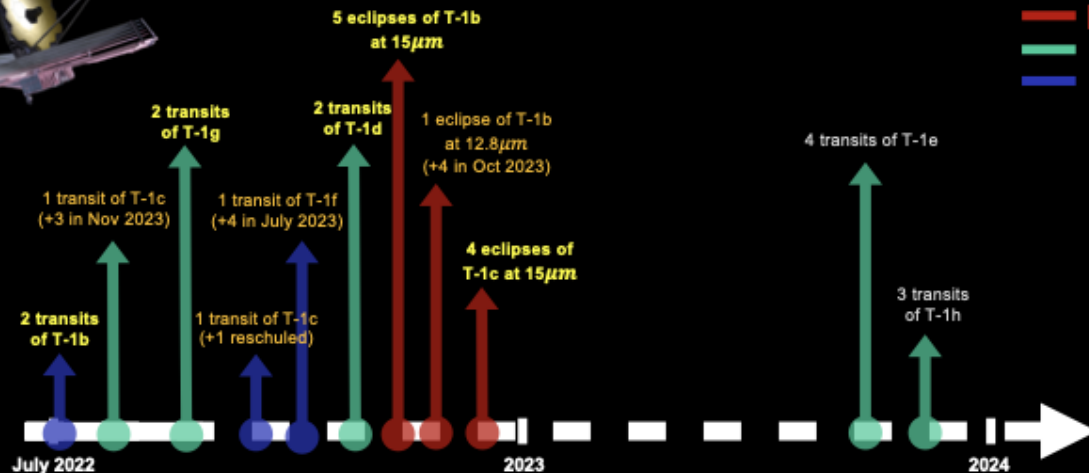
Multi-wavelength transit observations (LR and HR): De Wit et al. 2018, 2020, Burdanov et al. 2019, Hirano et al. 2020, Gn

Stellar properties: Burgasser et al. 2017, B al. 2019, Davenport et al. 2019, Gonzalez et

Atmospheric modeling: Wolf 2017, 2018, Turbet et al. 2018, Yang et al. 2019, Rushby et al. 2020, Barth et al. 2021, Serge

Observability with JWST: Morley et al. 20 2019, Malik et al. 2019, Pidhorodetska et al.

TRAPPIST-1 Timeline in the JWST era



9 transits with NIRISS, 15 transits with NIRSpec, 14 eclipses with MIRI

~210 hours of observations for the TRAPPIST-1 system

Liste programmes sélectionnés : (à sauvegarder qq part, ce sera utile pour ton rapport/article)

- 2 transits NIRSpec (programme GO 2334), pour 14h d'observation au total ; dates : 5 et 30 Juillet 2023
- 2 transits NIRISS (programme DDT 6543), pour 15h d'observation au total ; dates : 1 au 26 Décembre 2023
- 3 transits NIRSpec et 3 transits NIRISS (programme GO 7073), pour 42h d'observation au total ; dates : 16 Juillet 2025 au 21 Novembre 2026
- 9 éclipses avec MIRI à 15 microns (programme DDT 12498), pour 113 heures d'observation. Éclipses réparties entre le 10 Juillet 2026 et le 17 Novembre 2027.

Au total : 184 heures d'observation pour LHS1140b !

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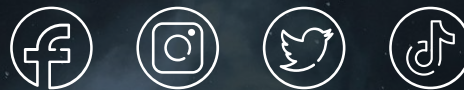
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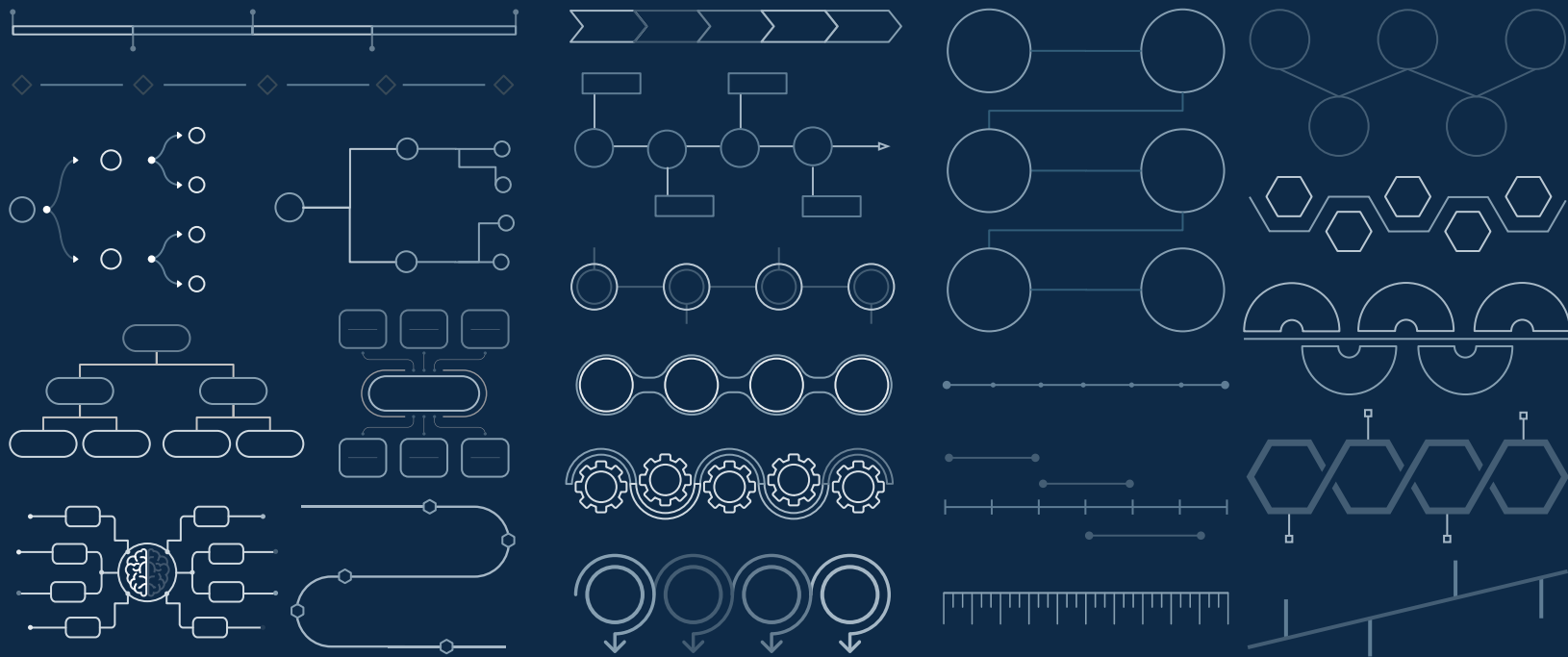
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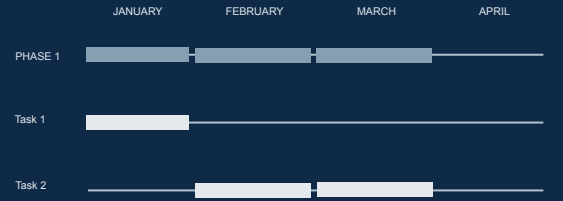
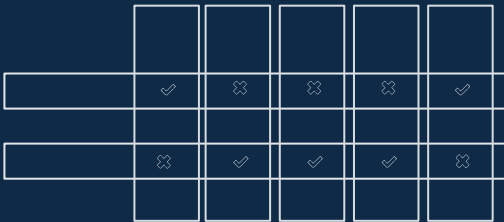
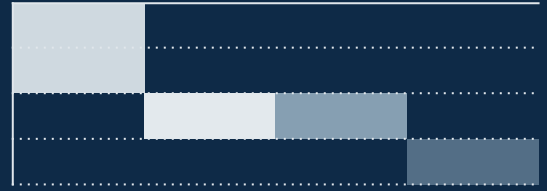
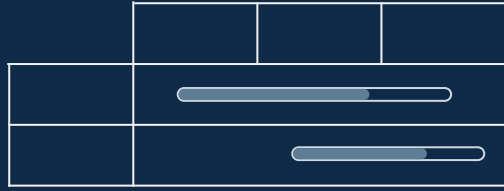
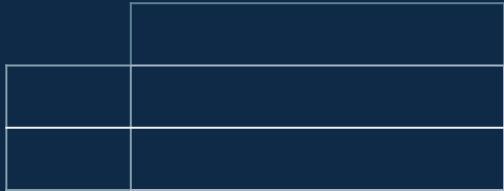
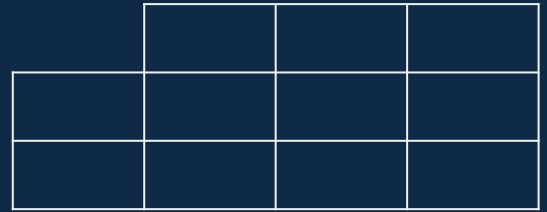
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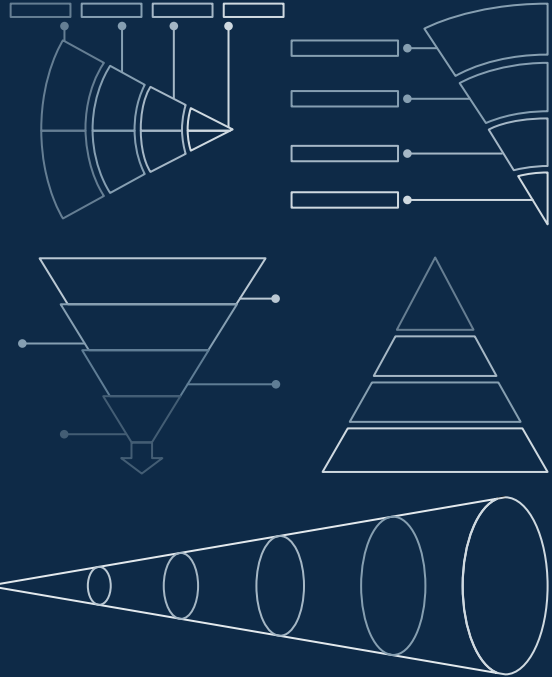
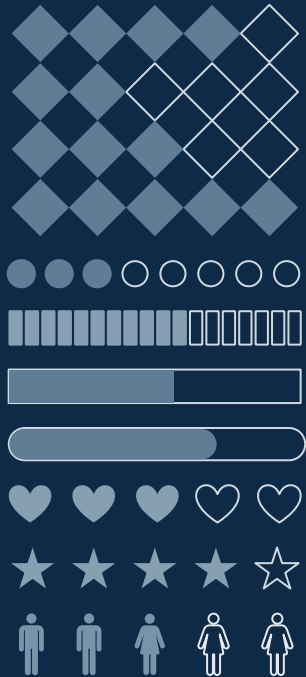
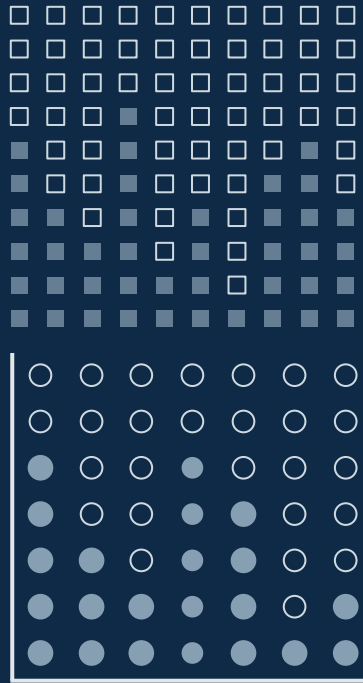












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