Flares and Flat Lines: A First Look at TRAPPIST-1 f with JWST NIRISS SOSS

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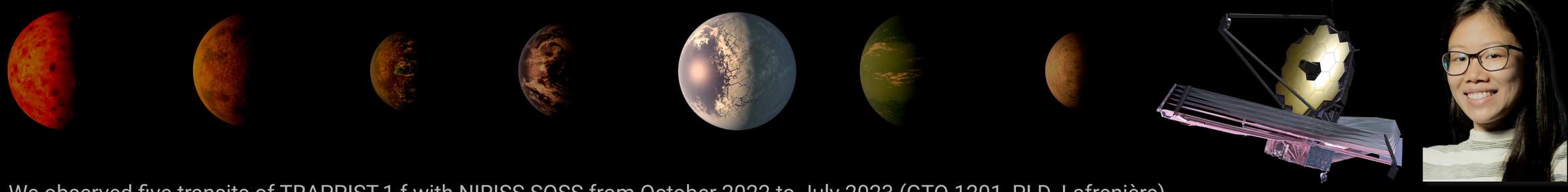
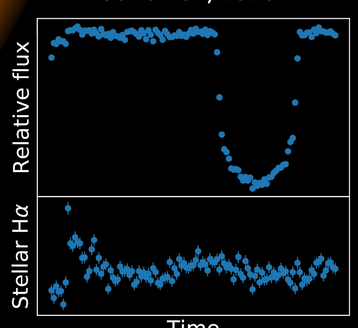
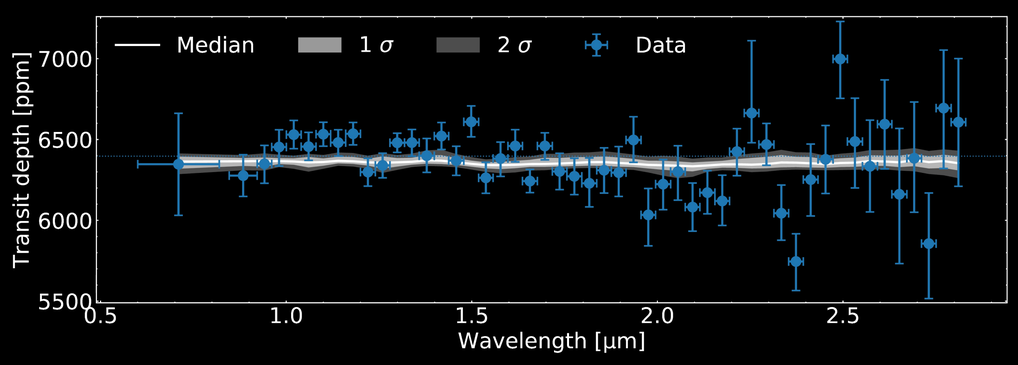


We observed five transits of TRAPPIST-1 f with NIRISS SOSS from October 2022 to July 2023 (GTO 1201, PI D. Lafrenière).
In this poster, we classify the five visits according to their level of contamination due to stellar flares.

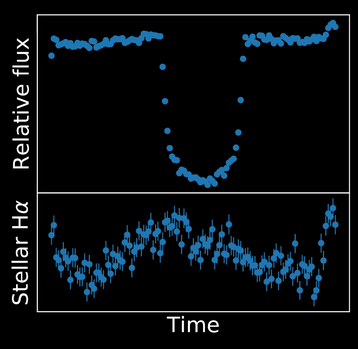
Top-tier visits: No big flares

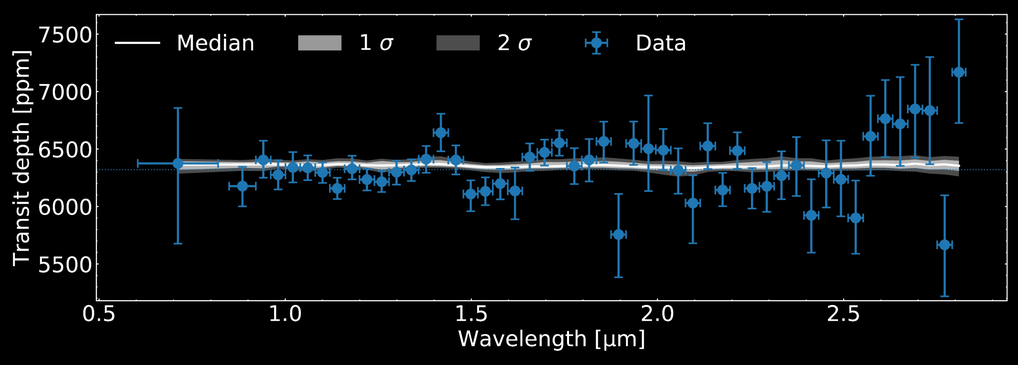
June 15th, 2023





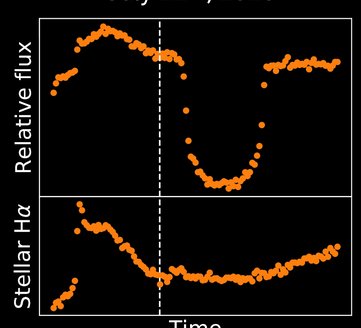
June 24th, 2023



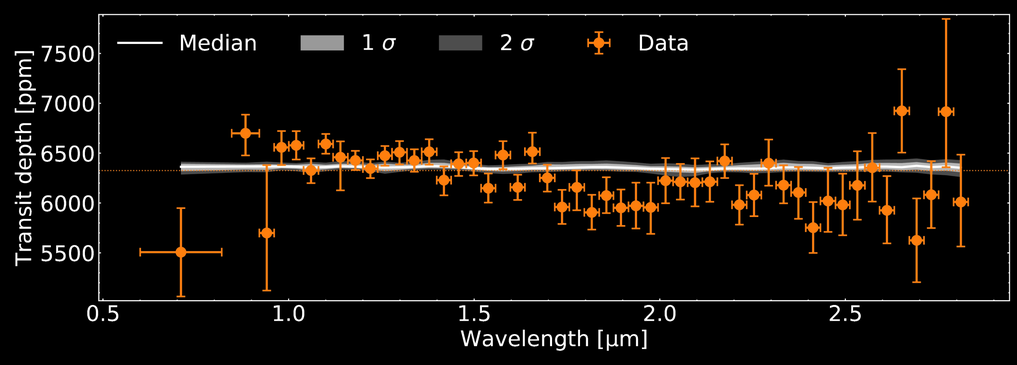


Second-tier visit: Big flare, but early enough to leave a usable transit

July 22nd, 2023



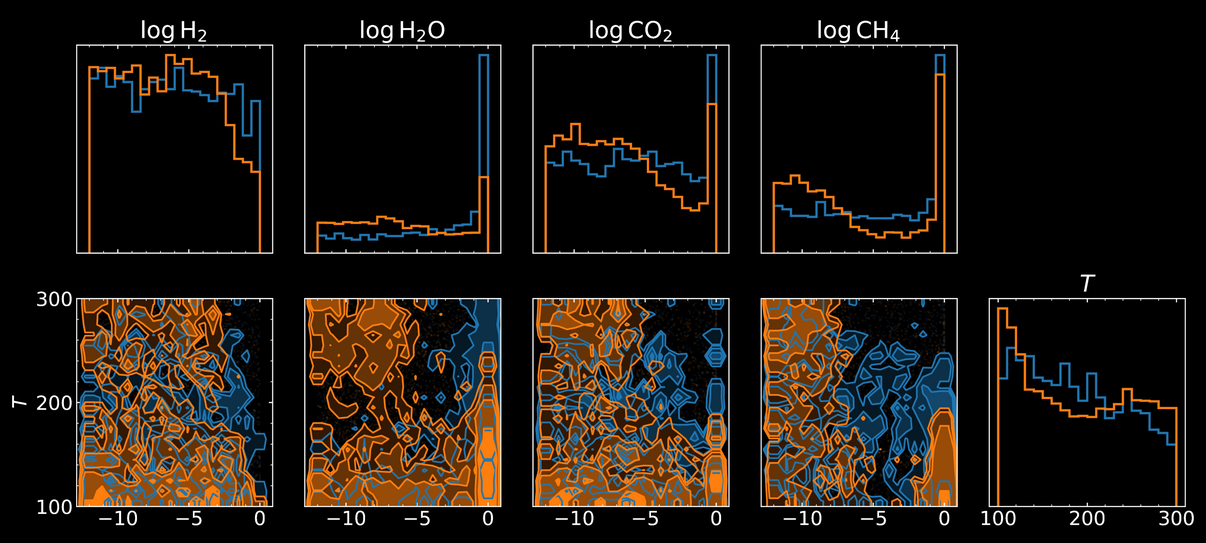
⬅ To fit the light curves, we mask out all integrations before the vertical dashed line, and we model out any remaining stellar signal by detrending against the Hα timeseries (bottom panel) and by adding a Gaussian process to the transit model.



Bayesian model comparison with POSEIDON (MacDonald & Madhusudhan, 2017; MacDonald, 2023) reveals **no evidence for a planetary atmosphere or for stellar contamination** from unocculted spots/faculae: a flat line can fit the transit spectra as well as (or marginally better than) models with an atmosphere and/or contamination.

To put upper limits on molecular abundances, we fit the transit spectra with a cloud-free planetary atmosphere model:

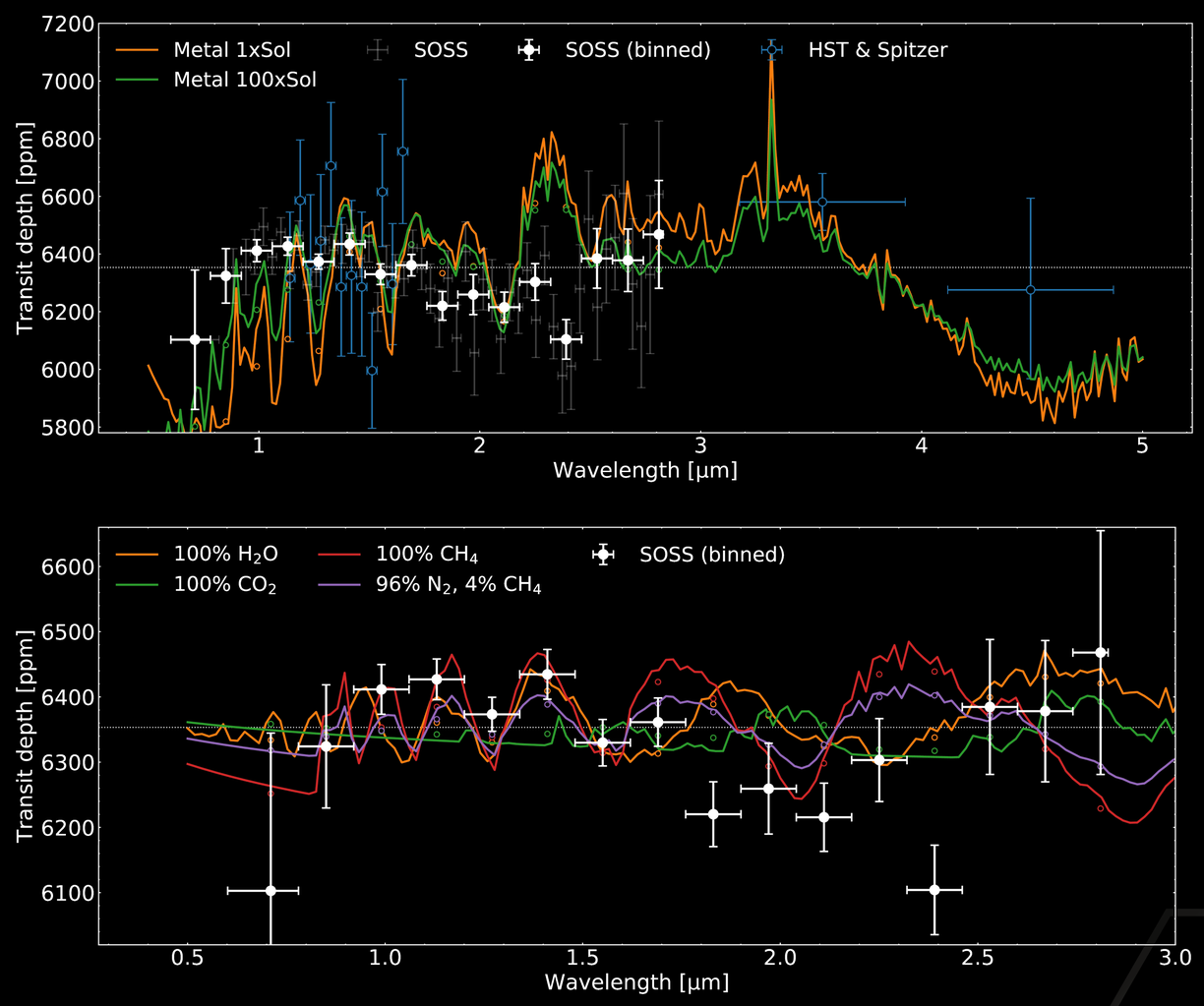
- We fit **top**-tier visits, then add the **second**-tier visit to see how constraints change.
- Retrieved spectra from the top- and second-tier fit are shown in white above.
- Posterior distributions are shown below for a subset of atmospheric parameters.



We find **upper limits on the H_2 abundance** in the planetary atmosphere, but no definitive constraints on any other species.

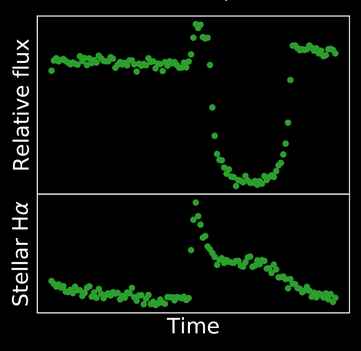
TRAPPIST-1 f has either no atmosphere, a cloudy atmosphere, a cold (T < 200K) atmosphere with unconstrained abundances, or a "warm" (T > 200K) atmosphere with little CH_4, CO_2, and likely little H_2O

The combined (3-visit) transit spectrum is shown in white below, compared to H-rich models (top) and higher mean molecular mass models (bottom). ⬇

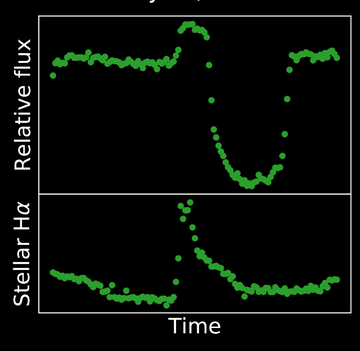


Third-tier visits: Big flare right before ingress

October 28th, 2022



July 3rd, 2023



Flares produce a **signal that varies with time and with wavelength**, and they do so in a way that is **difficult to model with the accuracy required to extract ppm-level atmospheric signatures**.

We tried to correct for the flares in these two visits by subtracting a temporally cooling blackbody from the spectral time series, but even after this correction, a ~1500-ppm slope remained in the transit spectra, which is unlikely to be explained by stellar contamination or a planetary atmosphere.