JWST Observations of a Feature-Rich Sub-Neptune Atmosphere

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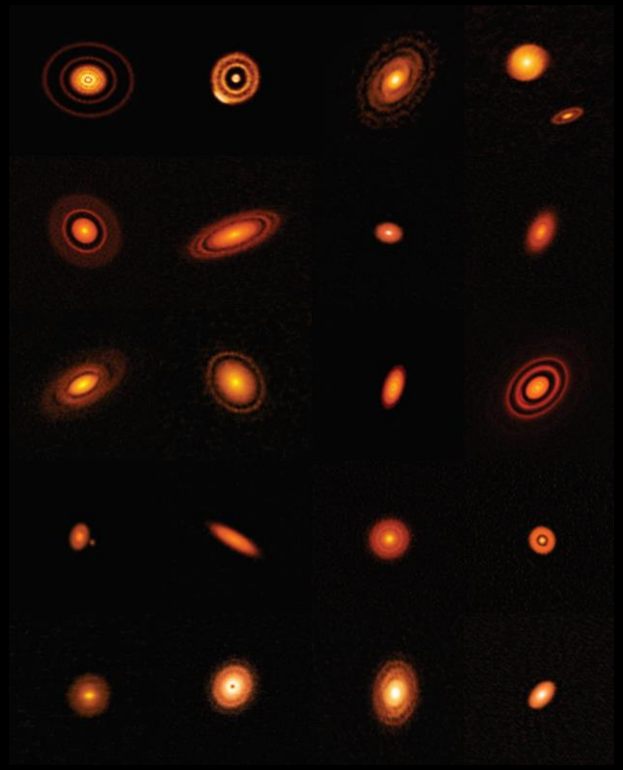
We want to measure the compositions of exoplanet atmospheres to understand planet formation

How do we go from protoplanetary disks?



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To planets?

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How do we go from protoplanetary disks?

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What's the recipe?

To planets?

To figure out the recipe for planet formation, we need to understand planet compositions – the ingredients

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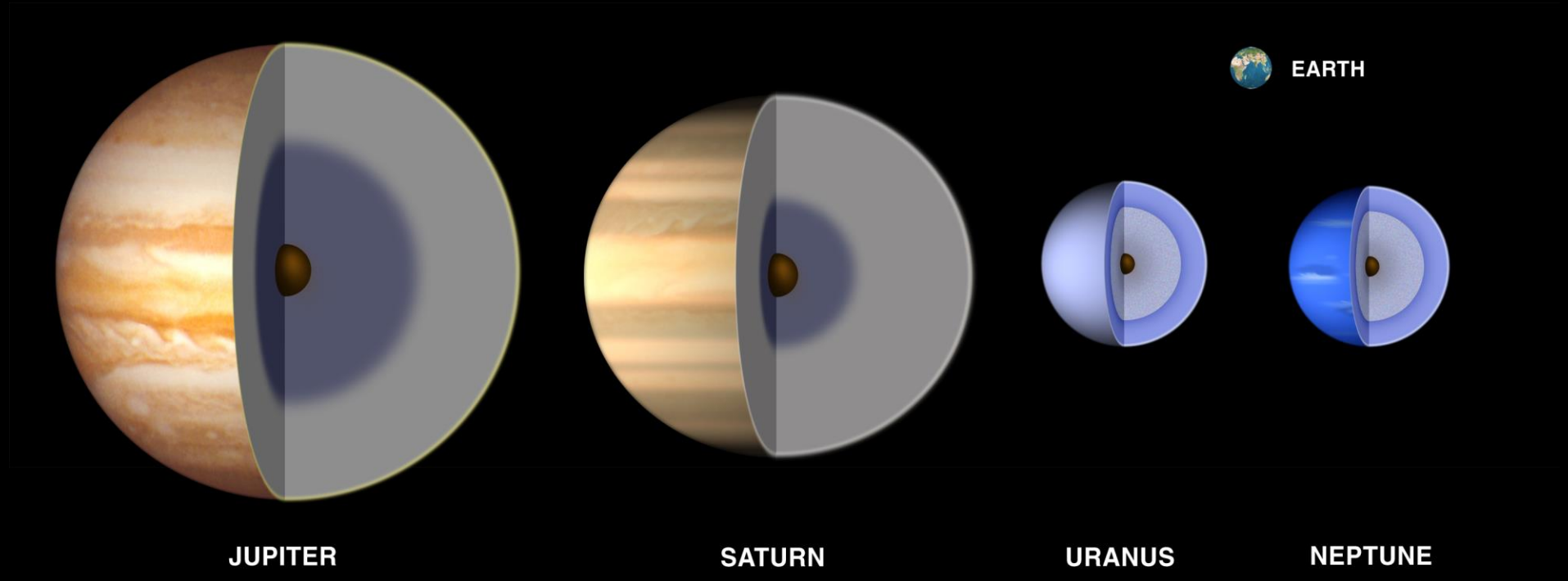
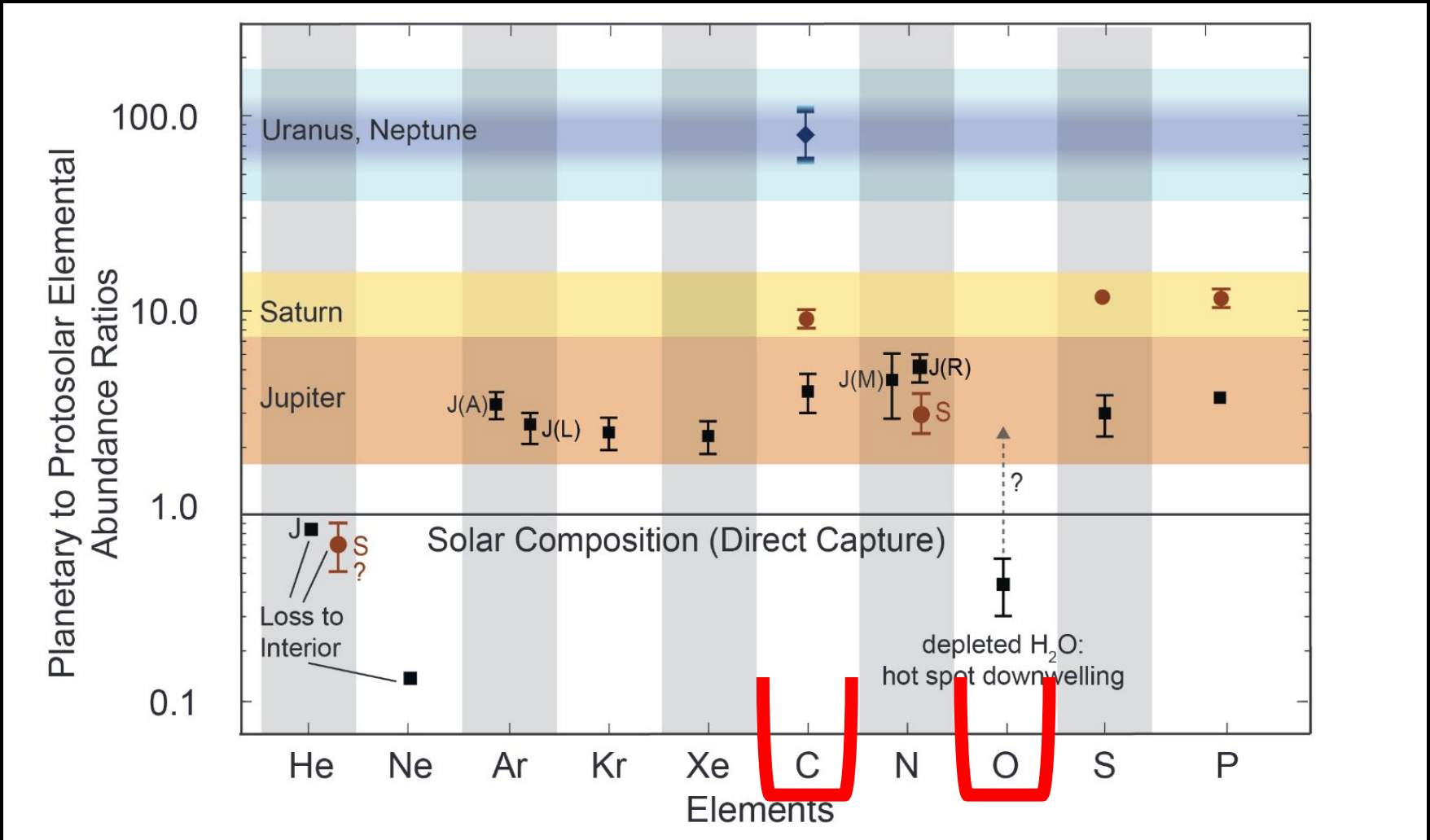
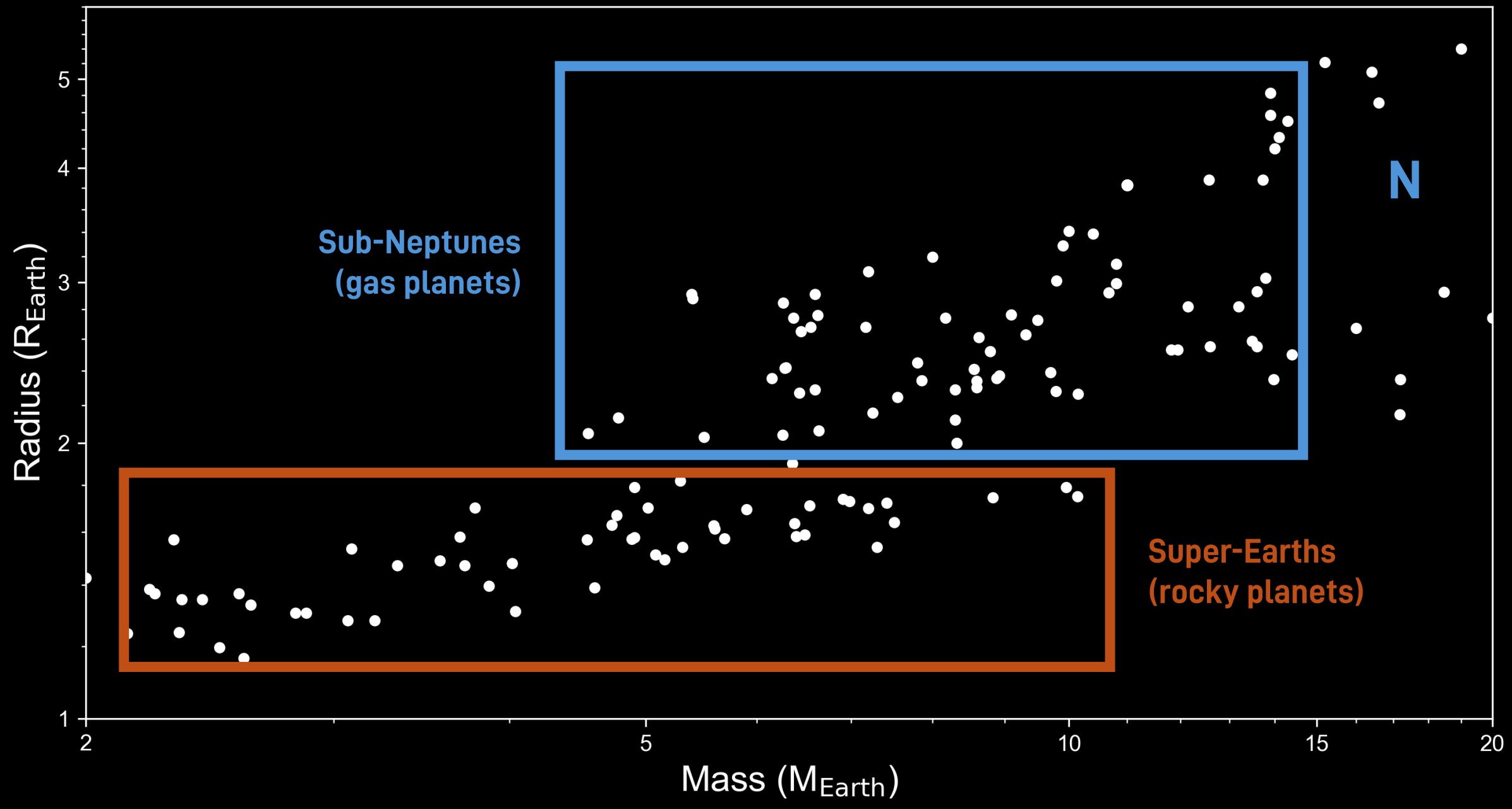


For the last decade, the two main "ingredients" astronomers have looked for are carbon and oxygen

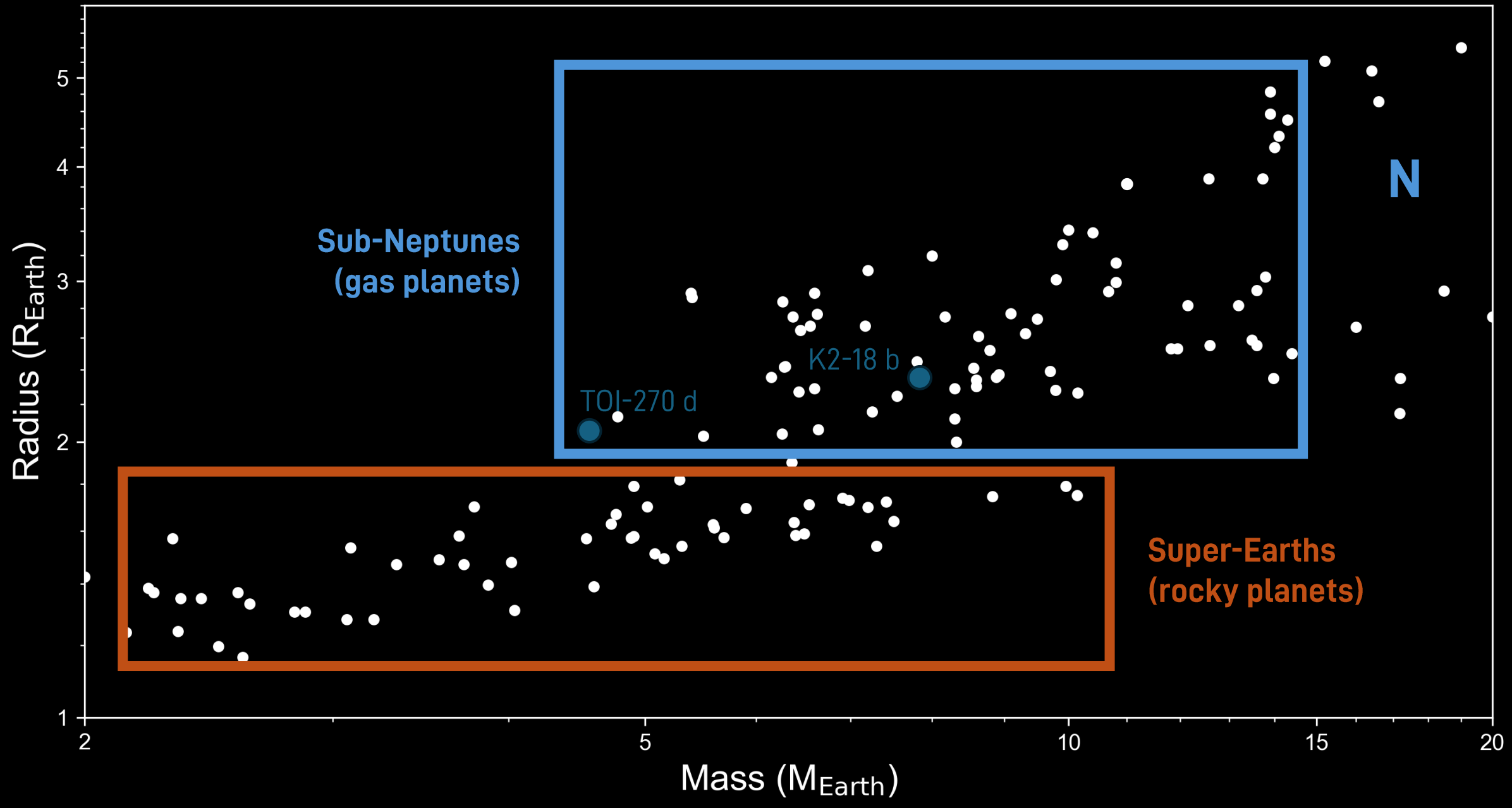


Atreya et al. (2016)

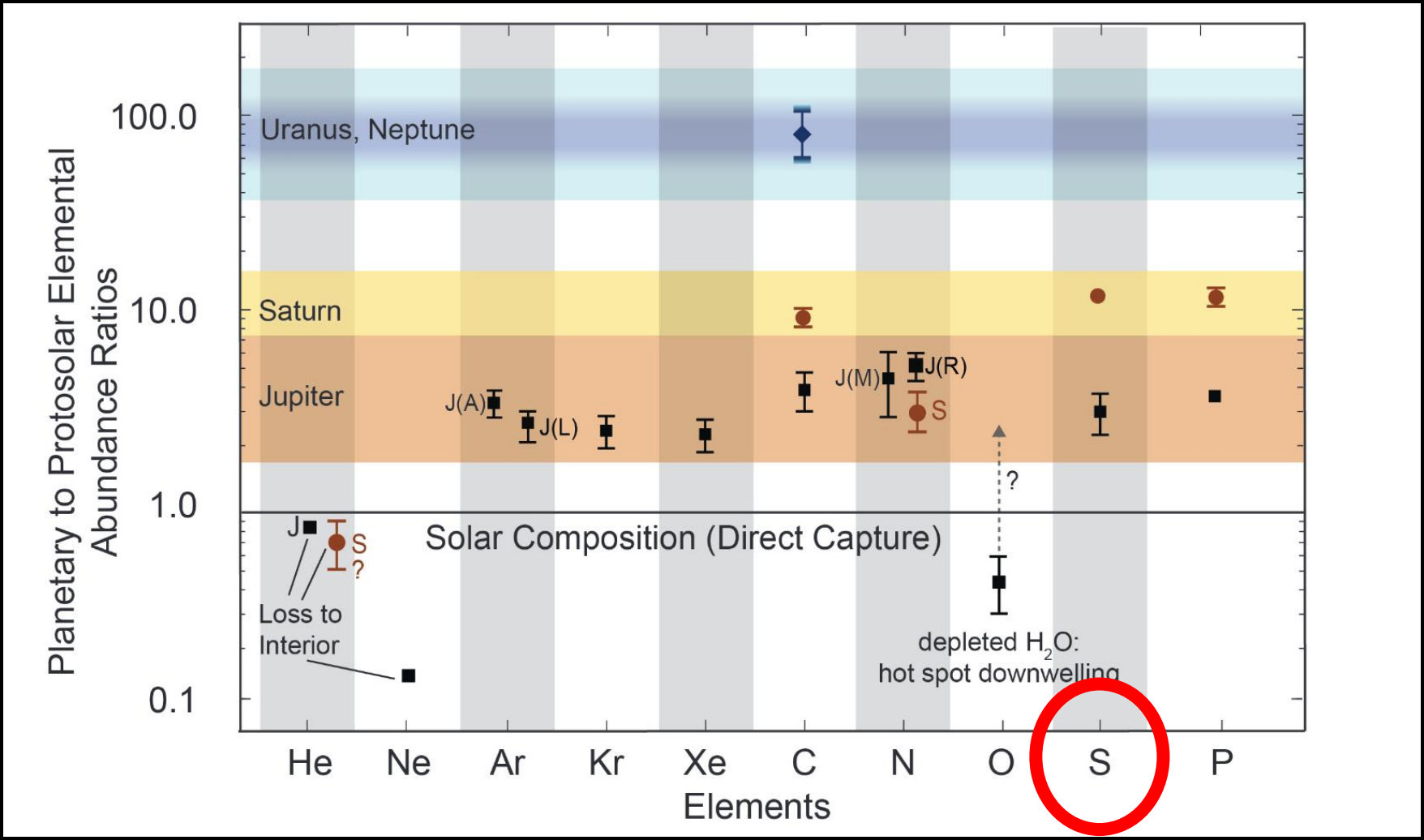
The most common exoplanets are sub-Neptunes



For two of these planets, we have good carbon and oxygen detections

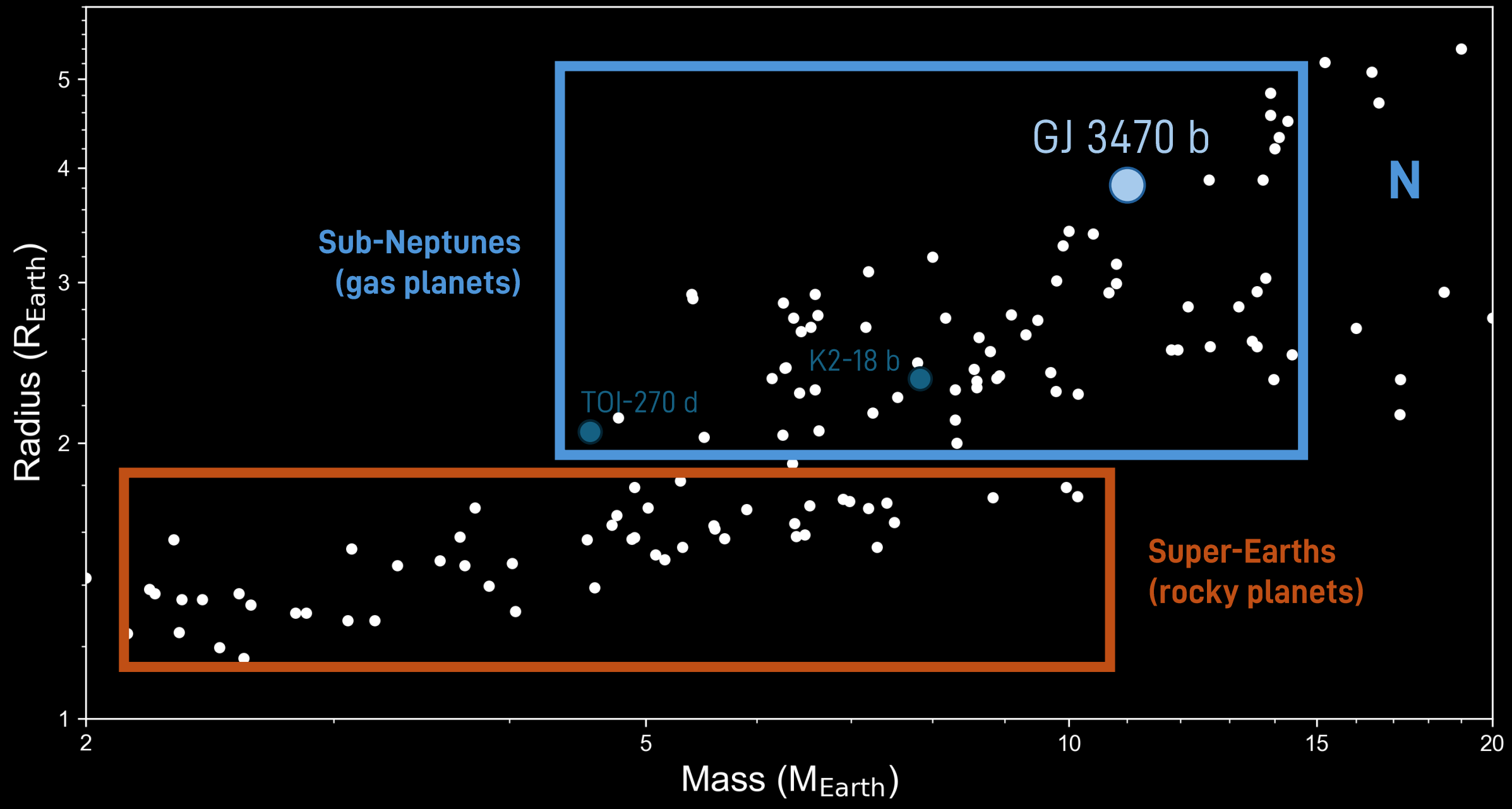


But there are many other possible ingredients to look for!

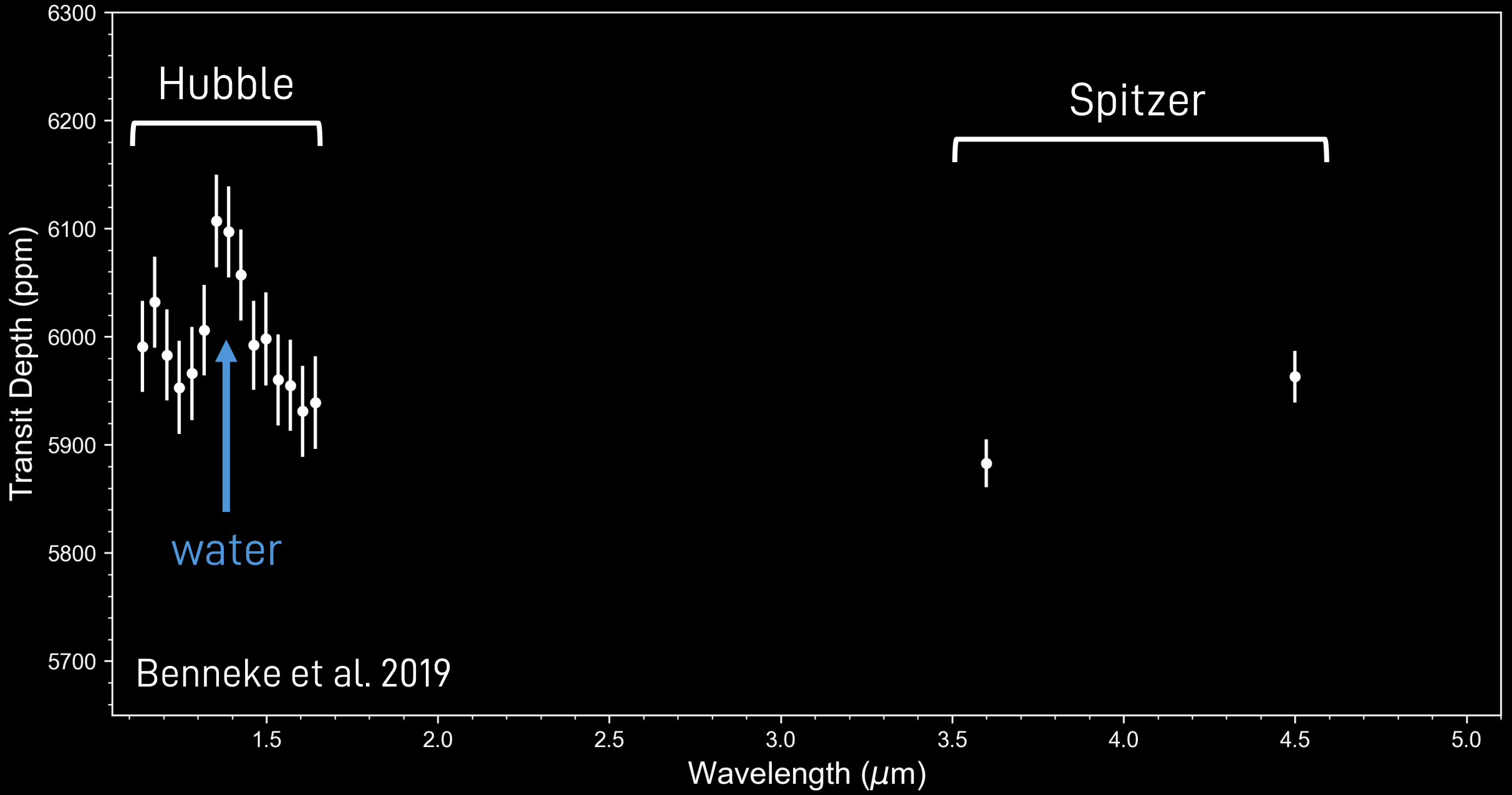


Atreya et al. (2016)

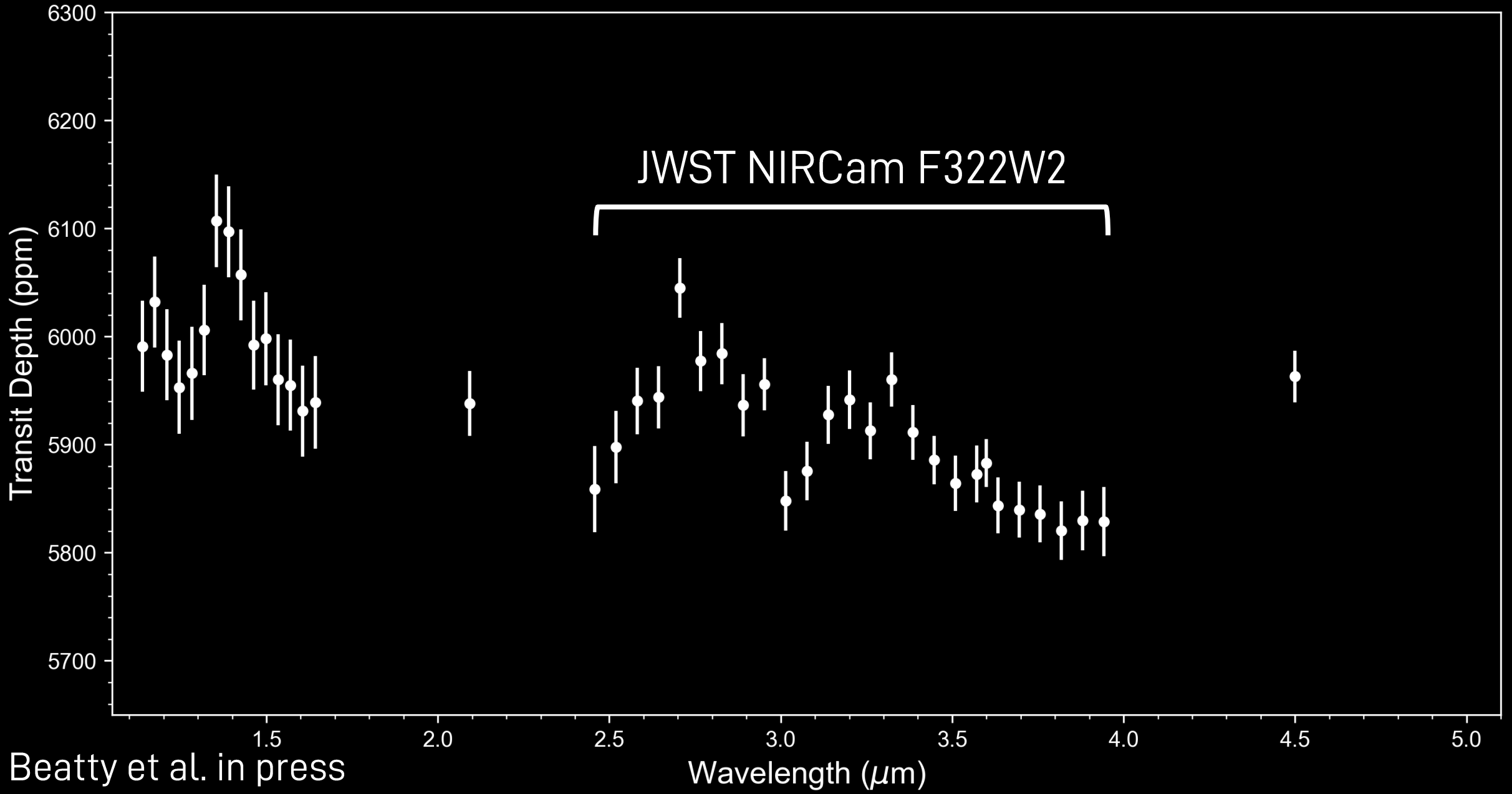
We looked at the sub-Neptune GJ 3470b using JWST



Previous Hubble and Spitzer data have seen water



We observed GJ 3470 b twice, using the NIRCam instrument



Beatty et al. in press

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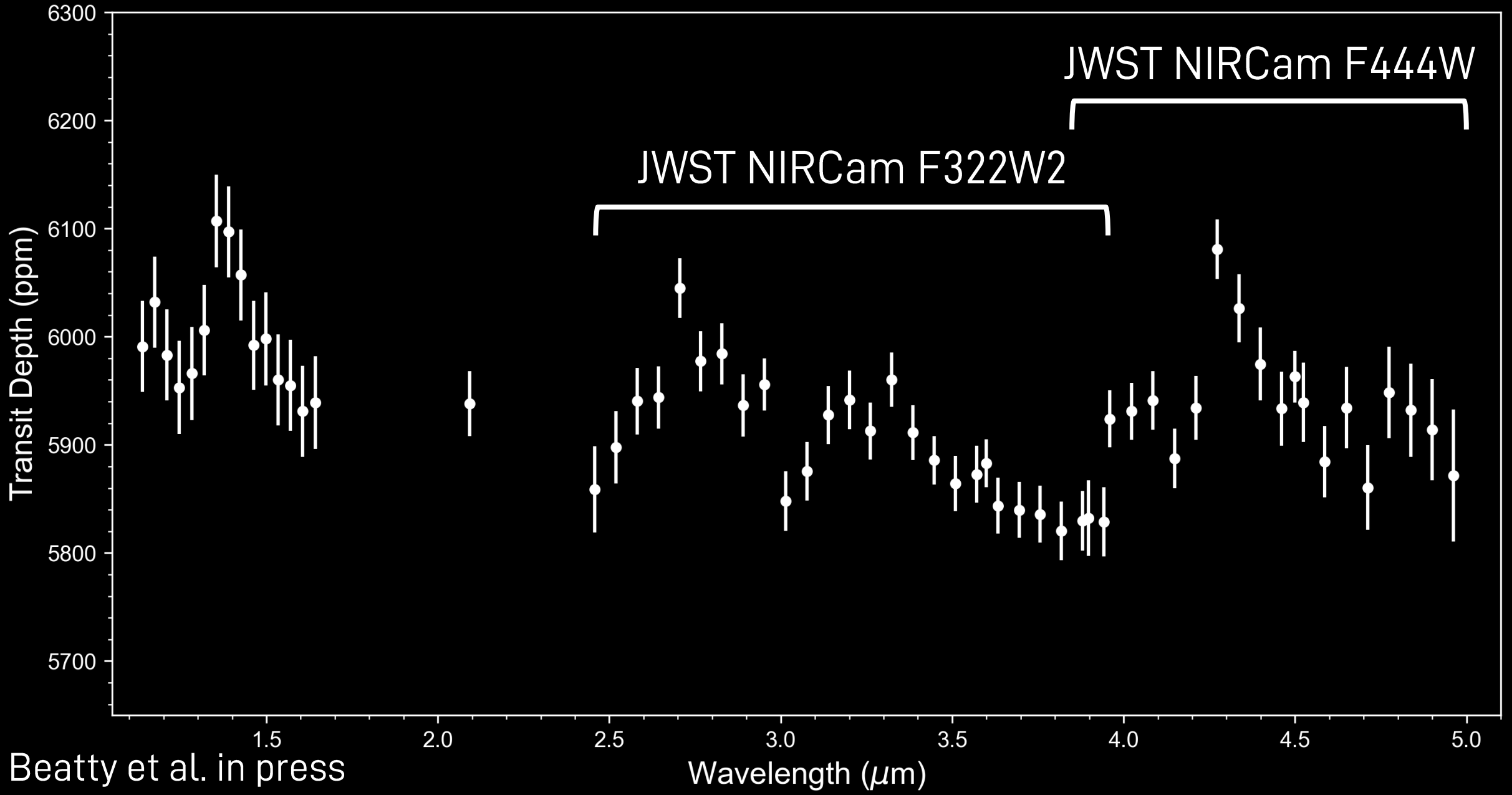
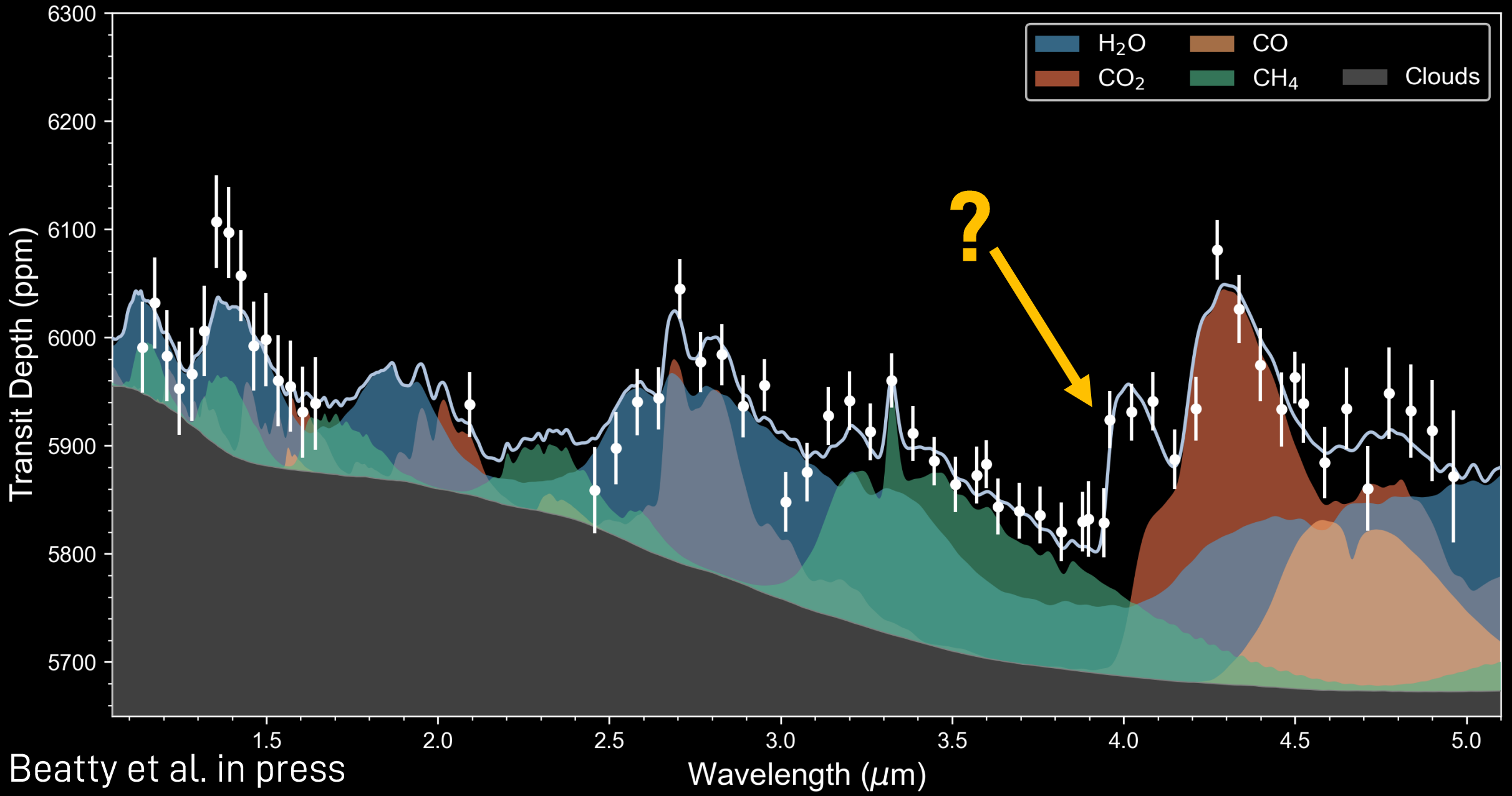


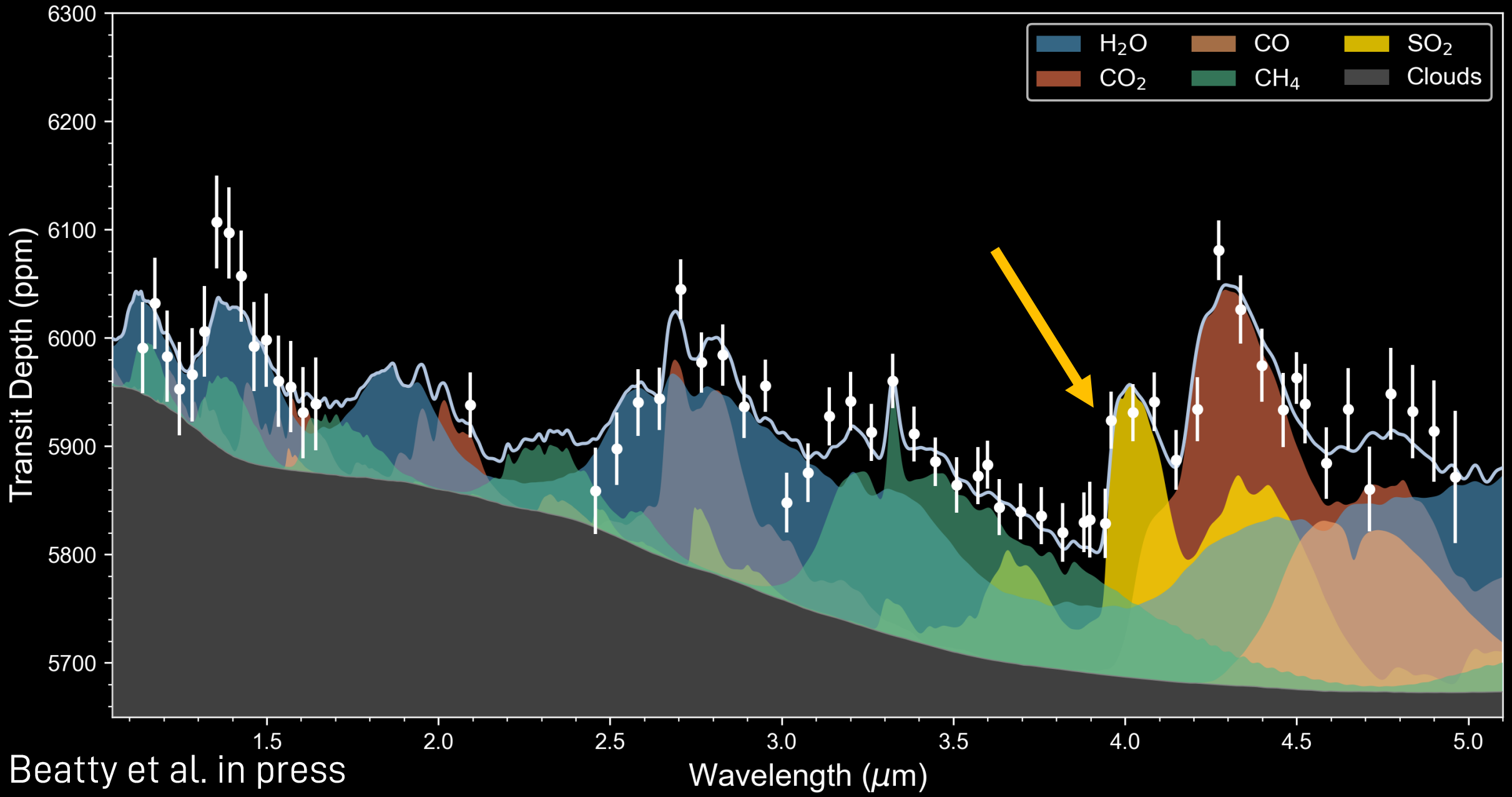
Beatty et al. in press

We see water, methane, and carbon dioxide/monoxide – and one more surprise



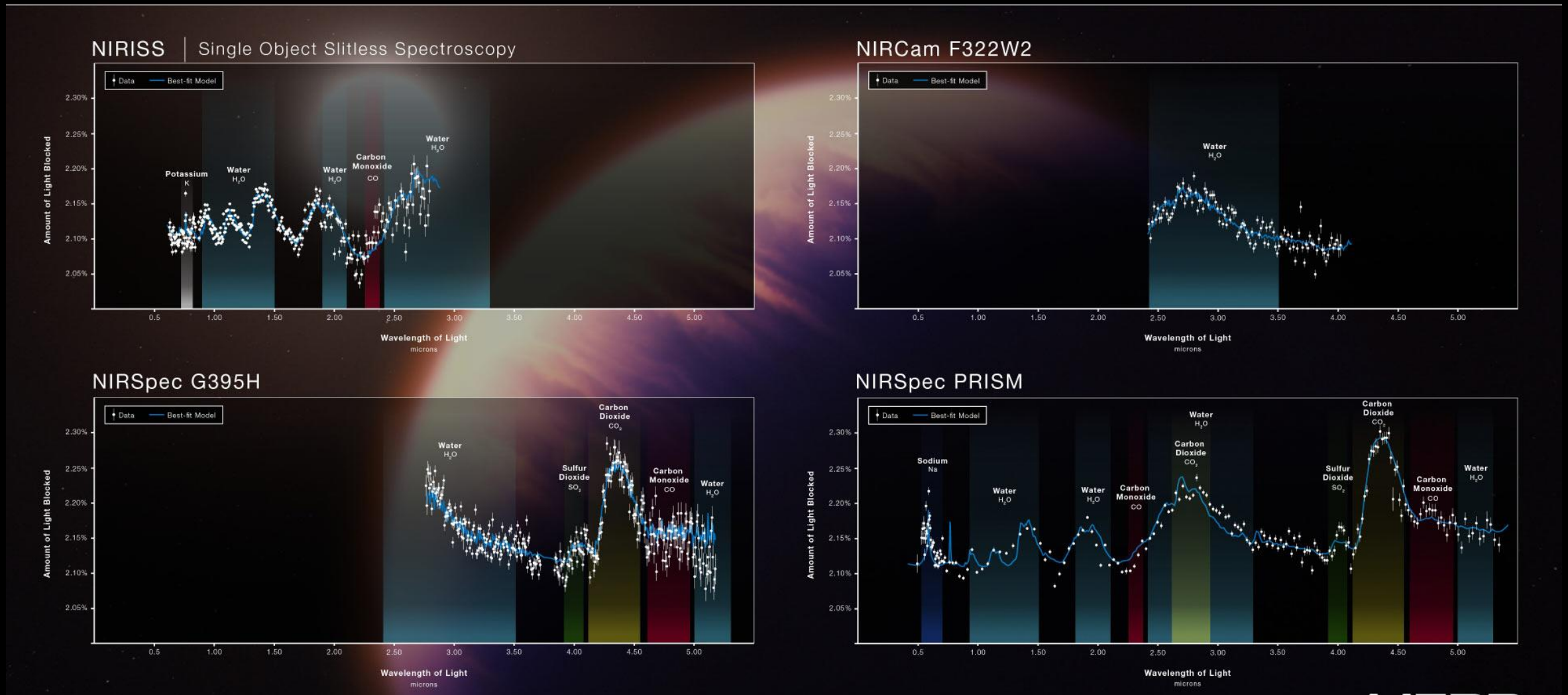
Beatty et al. in press

For the first time in an exoplanet this small and cool, we see sulfur dioxide



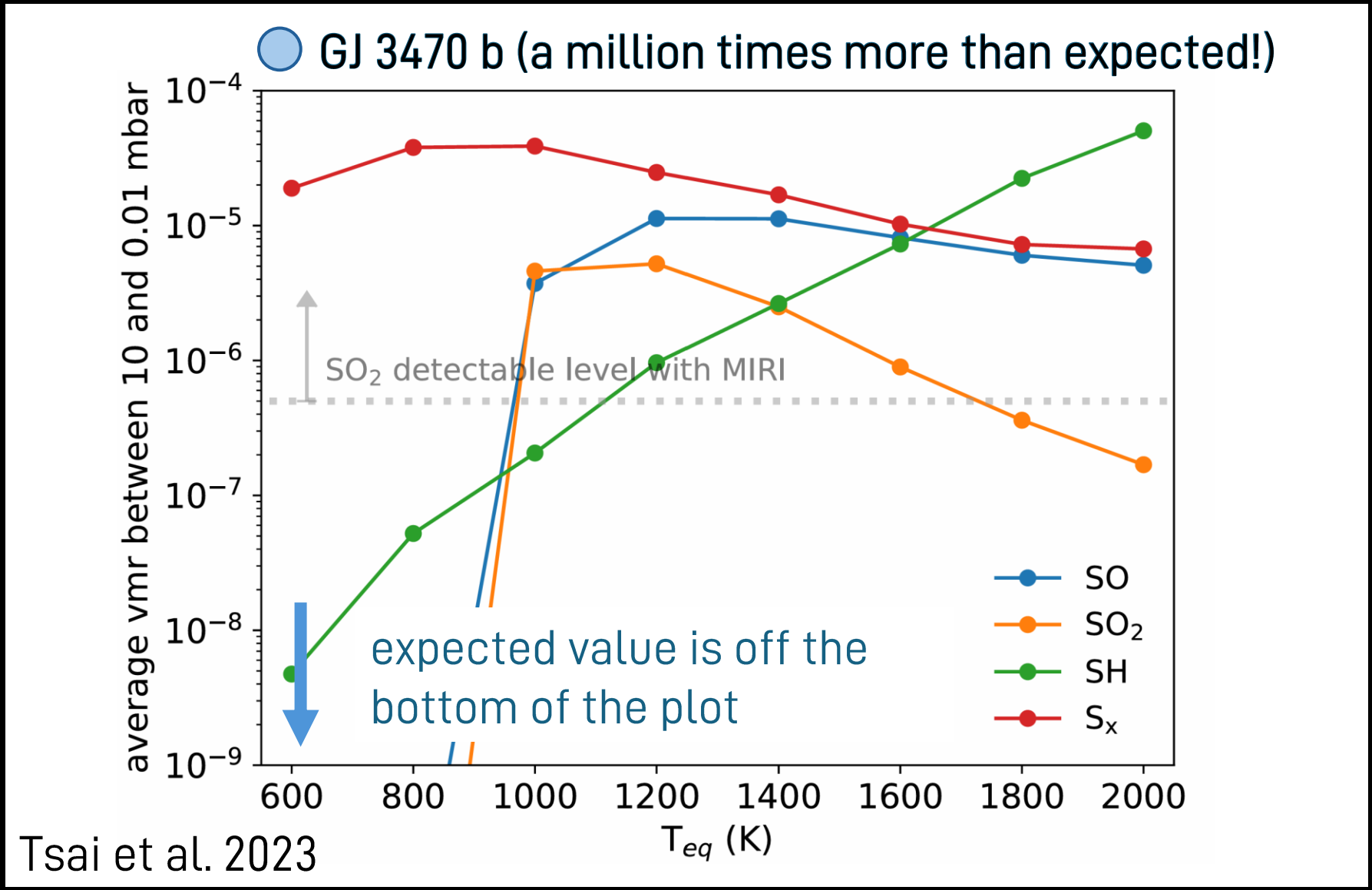
Beatty et al. in press

Sulfur dioxide has been seen before in the hot Jupiter WASP-39b, a planet 2x hotter and 100x more massive than GJ 3470 b



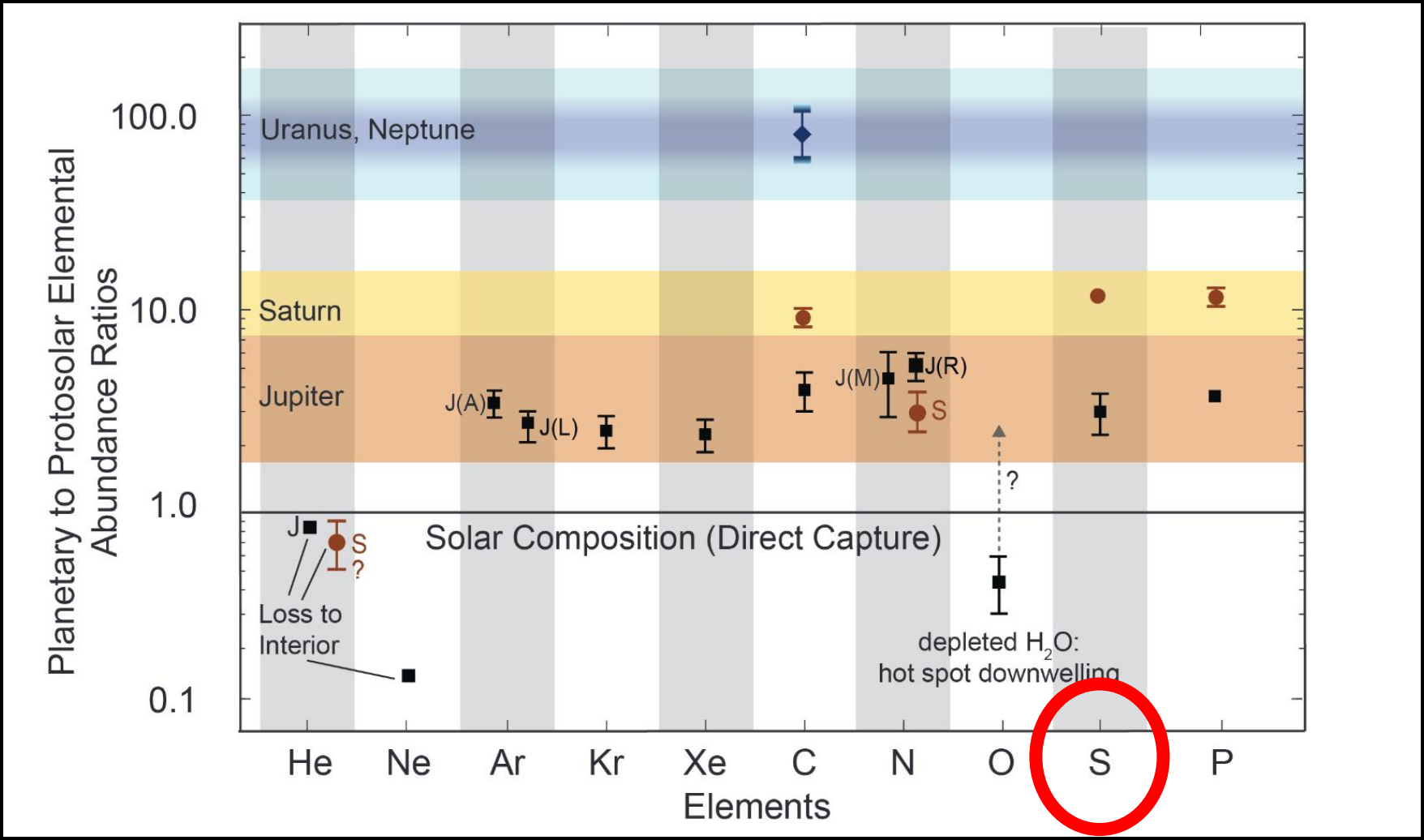
WEBB SPACE TELESCOPE

Sulfur dioxide was not expected in a planet this cool (Teq = 600 K)



Tsai et al. 2023

This gives us a new major ingredient to trace planet formation in these small sub-Neptunes



Atreya et al. (2016)

This gives us a new major ingredient to trace planet formation in these small sub-Neptunes

- For the first time we have identified sulfur dioxide in the atmosphere of a small, cool, exoplanet using JWST.
- Sulfur dioxide has only other been seen in WASP-39b, which is twice as hot and a hundred times more massive than GJ 3470 b.
- This was unexpected! We see about a million times more sulfur dioxide than we thought we would see.
- This is exciting because it gives us a new ingredient with which to figure out the recipe for planet formation. We have our foot in the door for using JWST to understand these small planets!

Sulfur Dioxide and Other Molecular Species in the Atmosphere of the Sub-Neptune GJ 3470 b

Beatty, et al., ApJL, in press https://arxiv.org/abs/**2406.04450**