COMPARING ATMOSPHERIC CLOUD MODELS OF JUPITER

CAN WE REDUCE THE DEGENERACY OF THIS PROBLEM?

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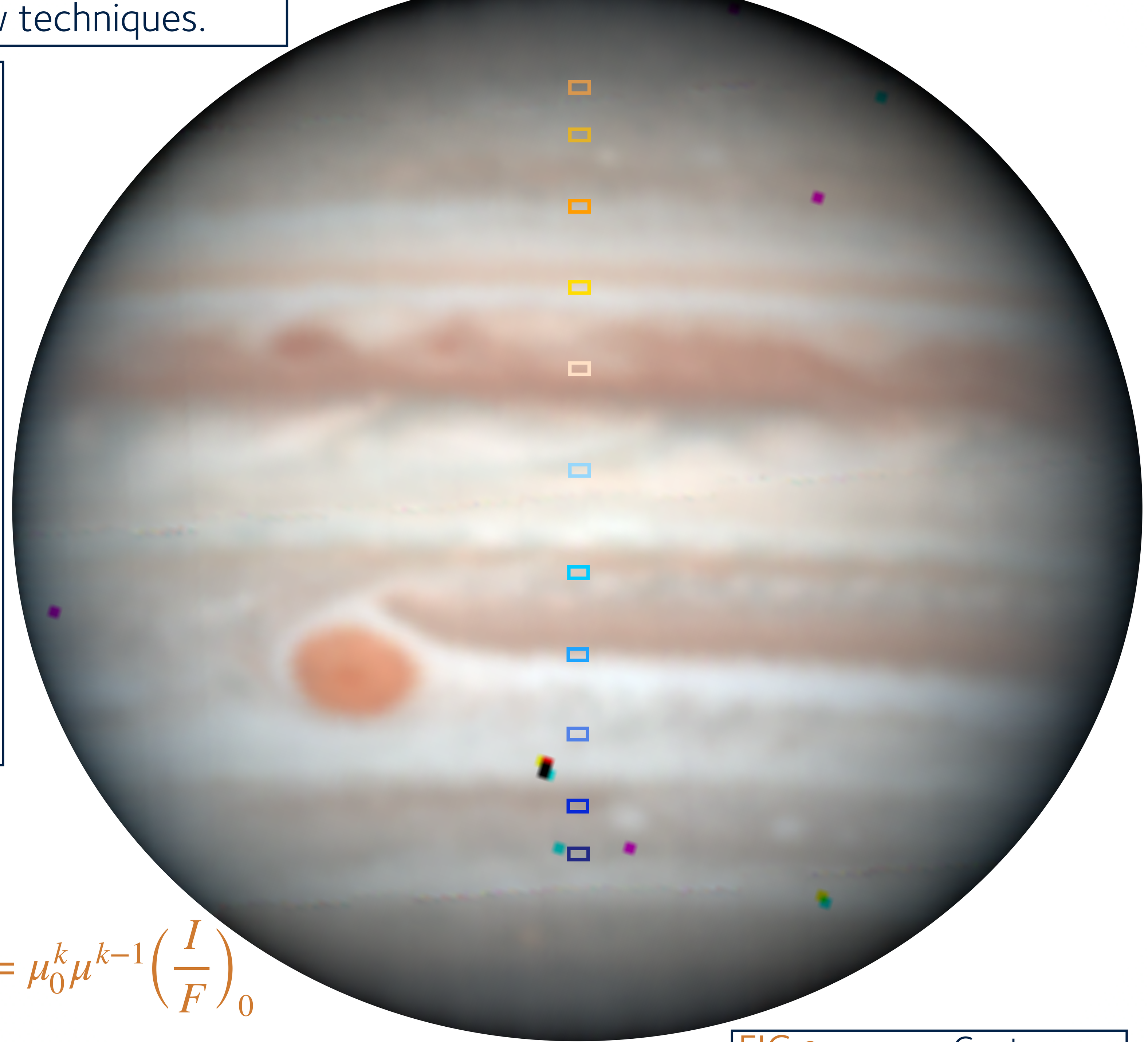
INTRODUCTION

- Jupiter has a banded structure to its atmosphere, which is coloured with many shades from white to red.
- Models of the cloud structure currently have a large number of parameters which vary in order to reproduce observations of all regions over time, leading to large changes to fit each observation.
- This work details how we are simplifying the cloud structure through the application of new techniques.

FIG 1 RGB image of VLT/MUSE observation from 9/04/18. Boxes where the nadir spectra have been extracted are marked (colours correspond to latitude as in Fig 3).



CURRENT MODELS AND DEGENERACY

- Many previous works [1-4] have been able to successfully reproduce observations of Jupiter using 3-cloud models, which include a single chromophore (colour causing compound) layer, alongside a main cloud layer in the troposphere and a stratospheric haze.
- The complexity of these models leads to many varying parameters which can be altered in order to fit deviations between observations. However this leads to large differences for the atmospheric structure between these observations.

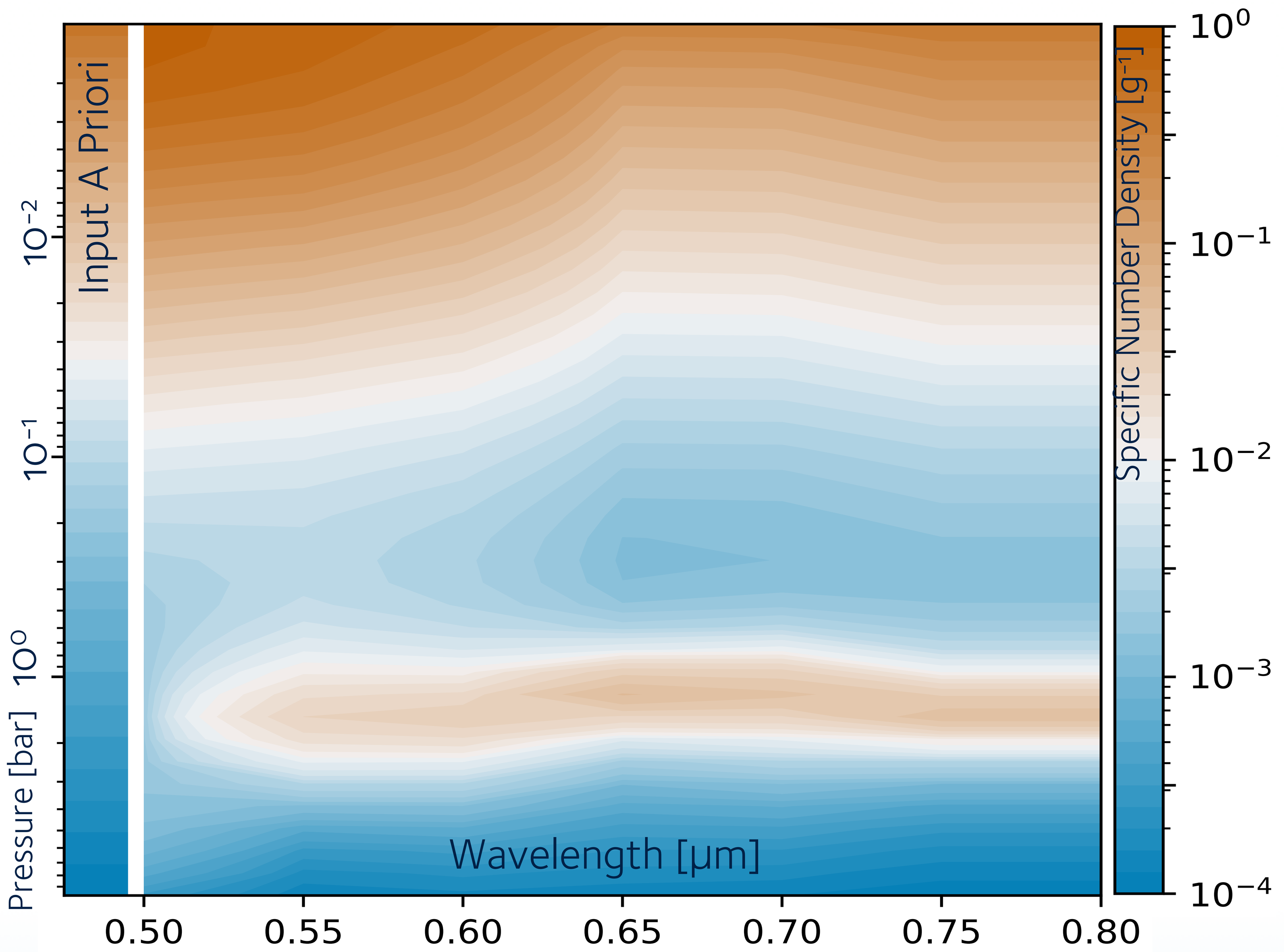
PRESSURE LEVEL - RADIUS - REFRACTIVE INDEX - OPTICAL DEPTH - DENSITY

- These parameters are highly degenerate, multiple combinations of different values can all reproduce the same observations equally well, thus identifying the true set up is difficult.
- Therefore, by undertaking retrievals with more of these values fixed, it will reduce some of the degeneracy within the problem, hopefully finding a more realistic solution which varies less with each region and/or observation.

MODELLING TWO VIEWING ANGLES

- In order to gain more vertical sensitivity whilst additionally assessing limb darkening, two viewing angles are fitted simultaneously. One at nadir and another at 61.45° (Fig.1) using reconstructed spectra produced with the Minnaert relation (right) as done in [4].

$$\frac{I}{F} = \mu_0^k \mu^{k-1} \left(\frac{I}{F}\right)_0$$



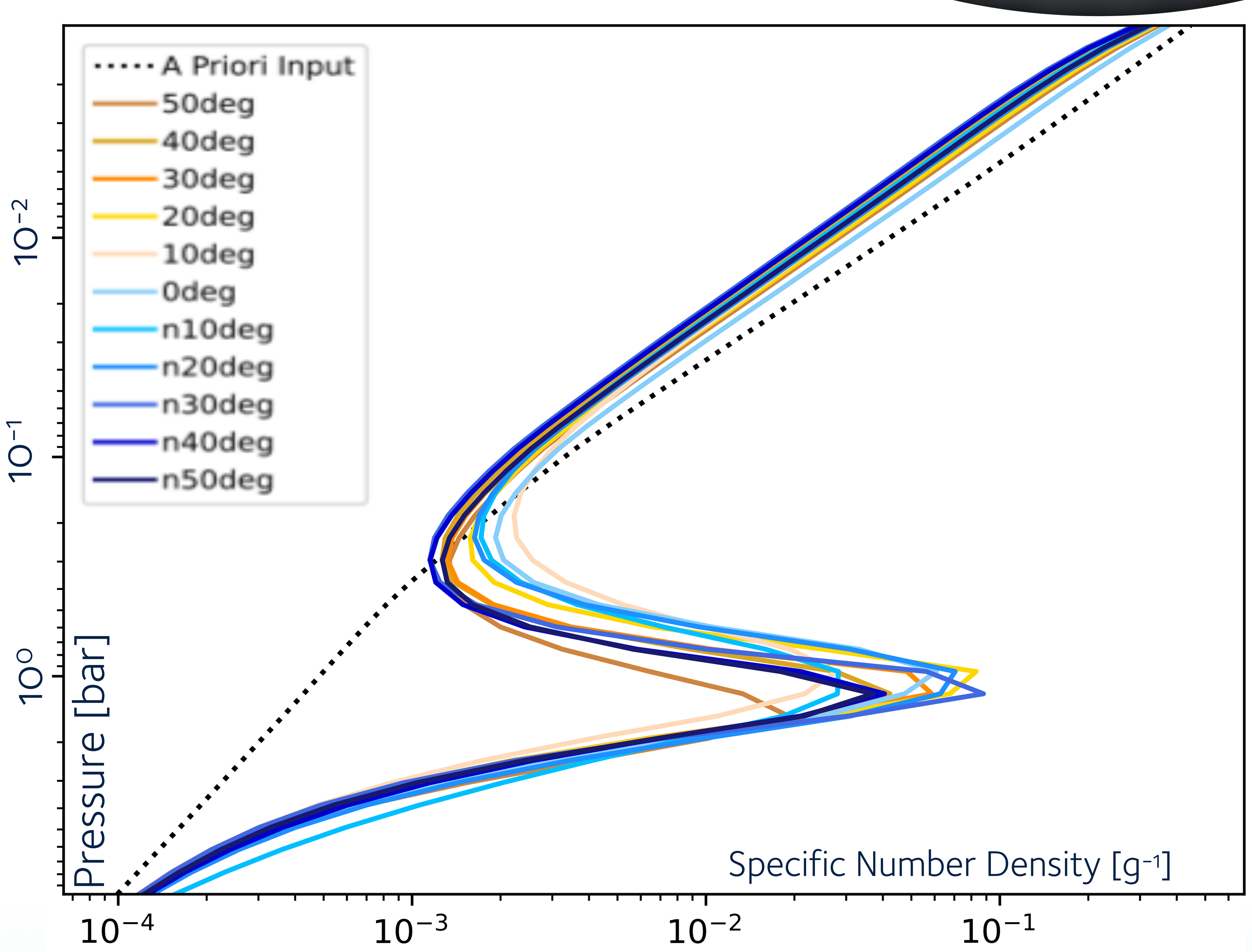


FIG 2 (FAR LEFT) Contour plot showing the retrieved cloud level and density for aerosol within the atmosphere for multiple snippet retrievals. Revealing a main cloud pressure level of ~1.4 bar. Spectra extract at 40°N fitting 0° and 61.45° viewing angles simultaneously.

FIG 3 (LEFT) Profiles of aerosol density within the atmosphere for a bracket retrieval (0.70-0.80μm). Retrievals move away from the a priori input at the latitude levels where there is sensitivity to cloud, peaking around 1.4 bars for all latitudes.

DERIVING MAIN CLOUD LOCATION

- "Snippet" retrievals, as in [5], were undertaken to infer the aerosol structure in the atmosphere. Small wavelength sections (0.1μm) are fitted with only the aerosol profile varying, which identifies the pressure level(s) of the cloud(s) (Fig. 2). It was found to retrieve a single cloud at 1.4 bar, for all wavelength bins.
- This was then done systematically for all latitudes, 50°N to 50°S (Fig. 3), it was found for all latitudes that a single tropospheric cloud layer was present at 1.4 bar.

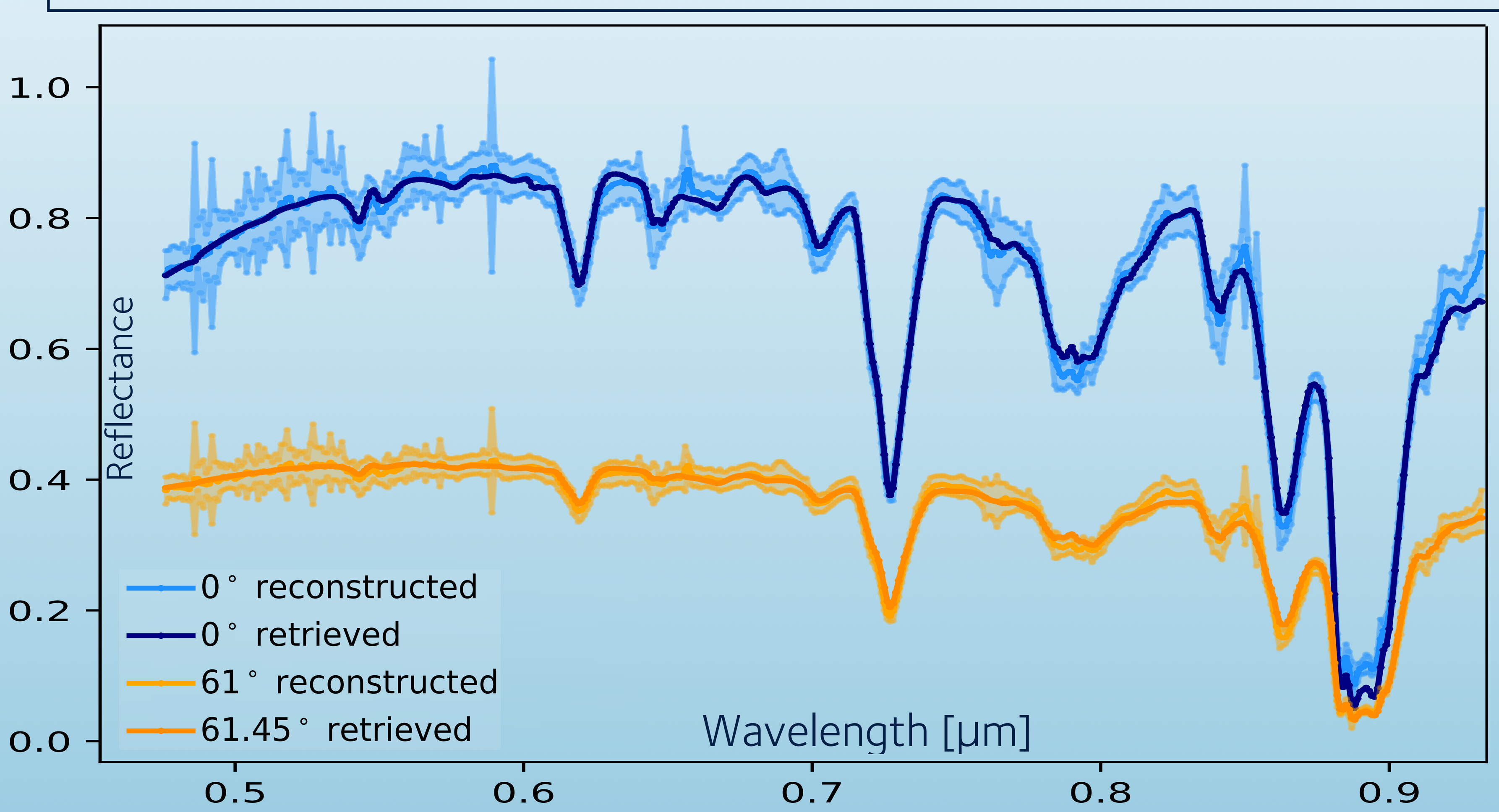


FIG 4 Current best retrieval, simultaneously fitting two viewing angles whilst retrieving the imaginary refractive index of the cloud, with all other cloud parameters fixed. $\chi^2/n=0.45$.

TWO CLOUD RETRIEVALS

- Now with a fixed cloud location plus a stratospheric haze, retrievals are undertaken to fit the refractive index of the cloud.
- Other parameters also need to be found so to avoid degeneracy when fitting, values are tested whilst being fixed, such as particle radius, a retrieval is shown in Figure 4.

CONCLUSIONS

- Snippet retrievals reveal that all latitudes have a single main cloud layer that resides at the same pressure level (1.4bars), found using simultaneous retrials fitting to two viewing angles.
- Further work needs to be undertaken to fit all parameters, but initial results indicate that a tow cloud model is able to reproduces observations of Jupiter. Now retrievals can be undertaken with an additional fixed parameter, reducing the amount of degeneracy in the problem.

REFERENCES [1] Sromovsky et al., (2017), Icarus, 291 [2] Baines et al., (2019), Icarus, 330 [3] Braude et al., (2020) Icarus, 338 [4] Pérez-Hoyos et al., (2020), Icarus, 352 [5] Irwin et al., (2022), JGR Planets, 127.

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