Cross-correlations and JWST
An alternate route towards atmospheric composition

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Abstract

JWST observed for the first time the hot-Jupiter WASP-39b on July 2022 as part of the JWST Transiting Exoplanet Community Early Release Science (JTEC ERS) Program. Since then, several atomic and molecular species (e.g Na, H_2O, CO_2, SO_2) have been detected in its transmission spectrum. In the initial analysis, CO was detected using NIRSpec PRISM transit observation. However, this detection could not be confidently confirmed in the initial analysis of the higher resolution observations with NIRSpec G395H disperser. In this context, we performed an alternative analysis of NIRSpec G395H data using cross-correlation techniques, which confirmed the detection of CO in the atmosphere of WASP-39b. Here we present our cross-correlation approach as a prospective tool to study atmospheric compositions with JWST.

Methods

We searched for the CO signal in the unbinned transmission spectrum of the planet (at 1-pixel resolution) between 4.6 and 5.0 μm, where the contribution of CO is expected to be higher than that of other anticipated molecules in the planet's atmosphere.

We generated two different cross-correlation templates using petitRADTRANS atmospheric models based on HITEMP line lists containing only the main isotopologue of CO ($^{12}C^{16}O$) and containing all isotopologues of CO.
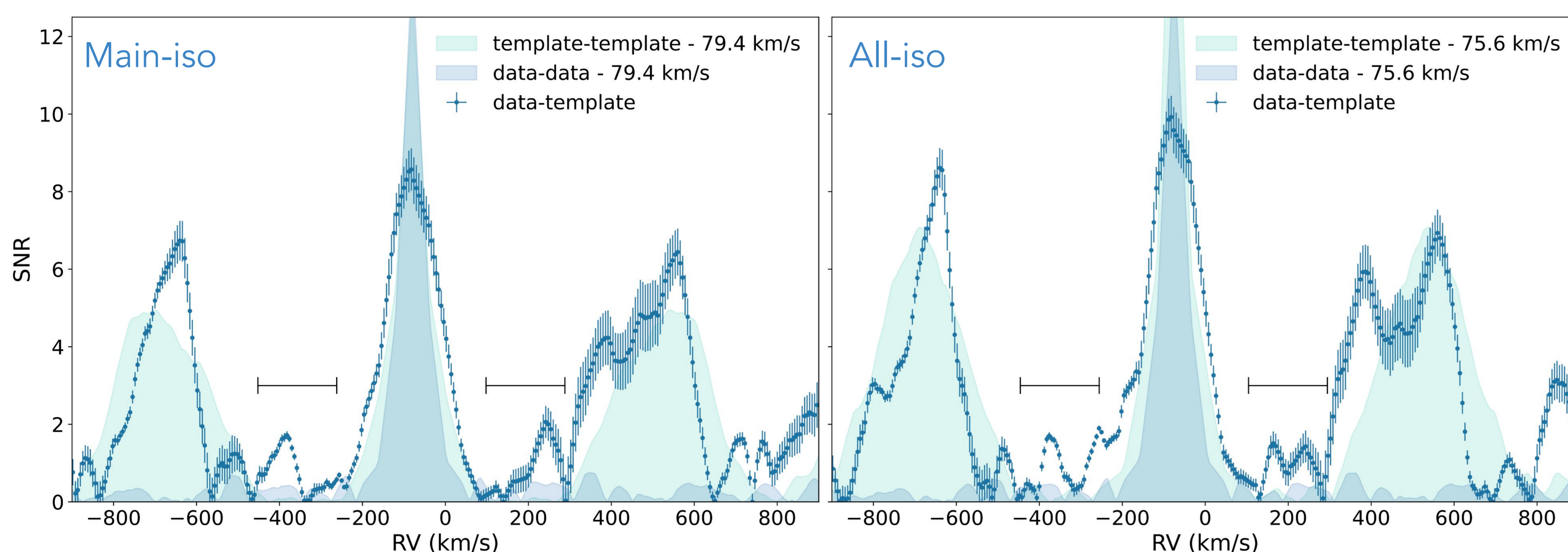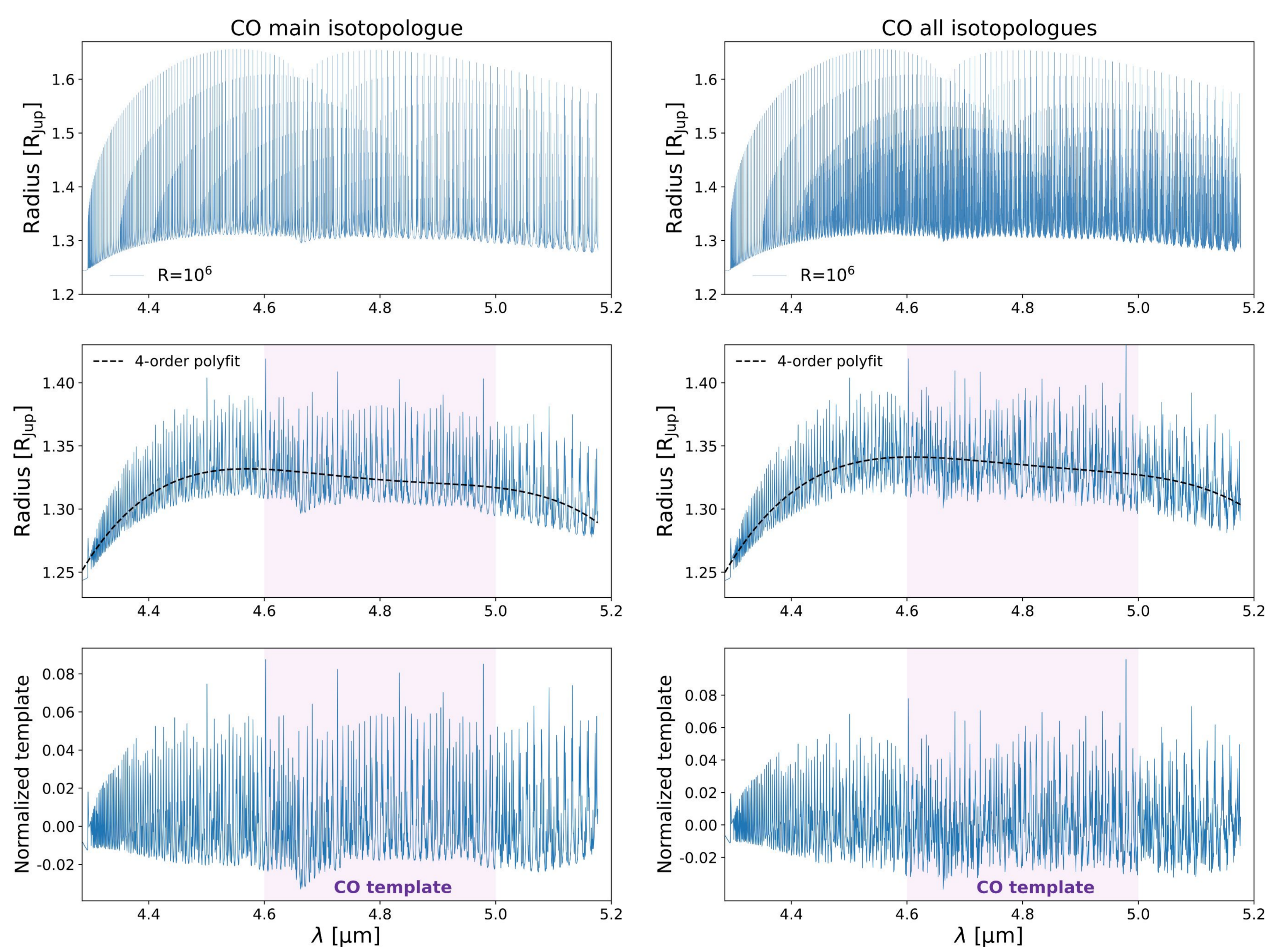
Cross-correlation results

Our search results in a **detection of CO** with a cross-correlation function (CCF) significance of 6.6σ when using a template with only $^{12}C^{16}O$ lines. The CCF significance of the CO **signal increases** to 7.5σ when including in the template lines from **additional CO isotopologues**, with the largest contribution being from $^{13}C^{16}O$.

WASP-39b NIRSpec G395H NRS2 trasnimssion spectrum at 1-pixel resolution reduced with Tiberius
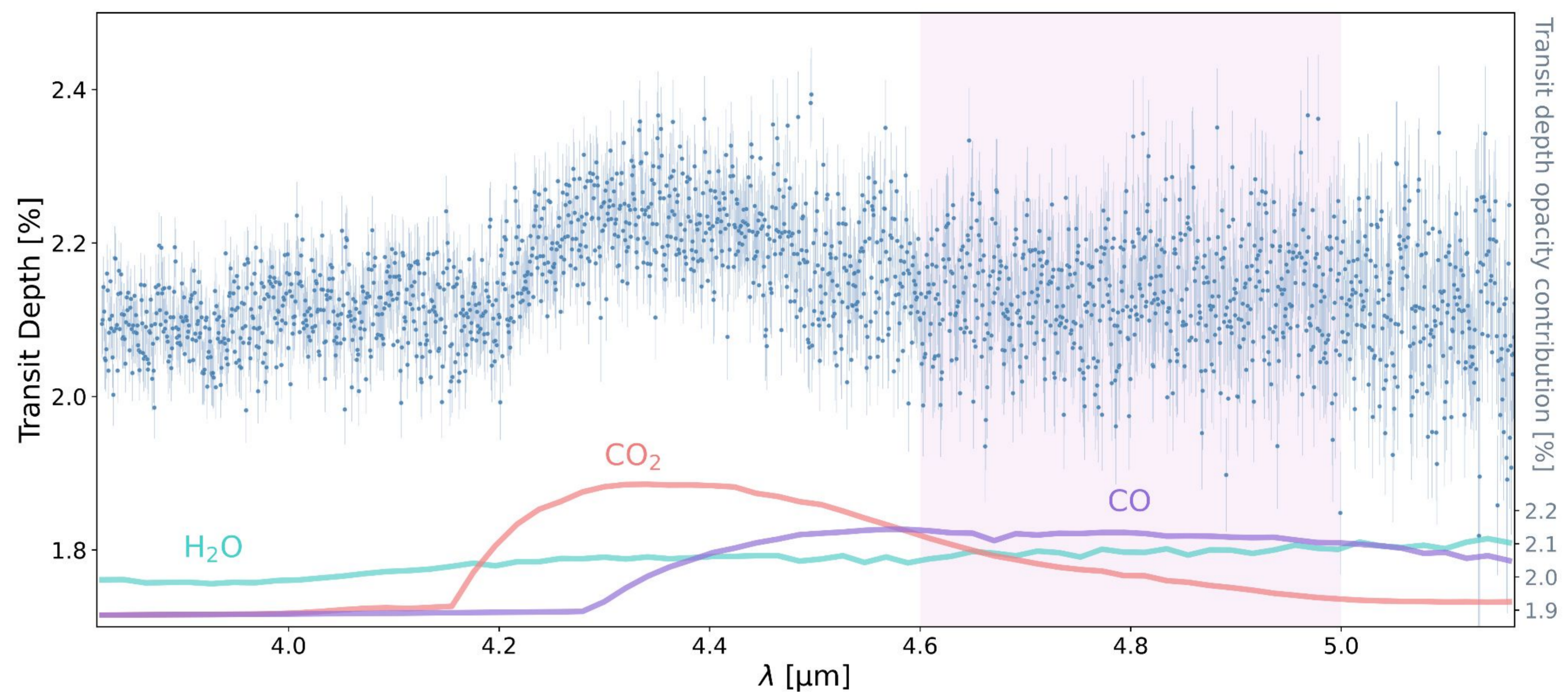
CO template generation considering different isotopologues

Esparza-Borges et al. (2023)
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Cross-correlation techniques can be a powerful tool for unveiling the chemical composition of exoplanetary atmospheres from medium resolution transmission spectra, including the detection of isotopologues.