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

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Since the start of JWST operations in mid-2022, a major goal of the exoplanet community has been to determine whether rocky planets orbiting M-dwarf stars can retain atmospheres. More than one thousand hours of observing time have already been devoted to this question, including the 500-hour DDT *Rocky Worlds* program.

So far, the overall results have been largely negative: aside from a few still-debated exceptions (e.g. August et al. 2025), most well-observed rocky planets show no evidence for atmospheres (Kreidberg & Stevenson 2025). This is notably the case for TRAPPIST-1 b, for which extensive observation programs (multi-wavelength eclipses, phase curves, and transmission spectroscopy) concluded the absence of atmosphere (Gillon et al. 2025, Maurel et al. 2025).

An empirical framework known as the *cosmic shoreline* (Zahnle & Catling 2017) suggests that more massive and less irradiated planets are more likely to retain atmospheres. In this context, the super-Earth LHS 1140 b stands out as the prime target, with a mass of about five Earth masses and an insolation of ~0.4 times that of Earth – i.e., well within the habitable zone of its host star. Initially thought to be a mini-Neptune due to its low density, early JWST transmission spectroscopy has ruled out the presence of an H_2/He envelope (Cadieux et al. 2024, Damiano et al. 2024). LHS 1140 b is therefore currently one of the most promising rocky planet candidates to host volatiles, possibly including water, and a secondary atmosphere.

Several large JWST observing programs are now dedicated to this planet, including multiple transit spectroscopy observations with NIRISS and NIRSpec (partly completed and partly forthcoming), as well as an ambitious secondary eclipse program with MIRI within the DDT *Rocky Worlds* program.

In support to these observations, we have performed numerical simulations using the 3D climate model *Generic PCM*, coupled with the 3D radiative transfer code *Pytmosph3R*, to generate realistic transmission and emission spectra. These models account in particular for the effects of water and CO_2 clouds expected for the range of possible compositions and insolation of LHS1140b. We compare our simulations with merged, existing JWST datasets and provide predictions for upcoming observations, with the aim of determining whether LHS1140b possesses an atmosphere and if so, what it is made of. We will present the results of our work.