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Detectability of biosignatures on LHS 1140 b

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Rocky extrasolar planets orbiting M dwarfs are prime targets in the search for habitable surface conditions and biosignatures with near-future telescopes like the James Webb Space Telescope (JWST) and the Extremely Large Telescope (ELT). Even for the closest known targets the capabilities to characterize Earth-like or CO_2-dominated atmospheres with JWST or ELT might still be limited to a few molecules such as CO_2 or CH_4. Hence it would be difficult to draw conclusions on the surface conditions and potential habitability of these planets. In clear H_2-He atmospheres the molecular features in transmission spectra could be much larger and hence potential biosignatures might be detectable.

In this study, we investigate the detectability of the potential biosignatures NH_3, PH_3, CH_3Cl, and N_2O, assuming different H_2-He atmospheres for the habitable zone super-Earth LHS 1140 b. Recent observations of the atmosphere of LHS 1140 b suggest that the planet might hold a clear H_2-dominated atmosphere and might show an absorption feature around 1.4 µm due to H_2O or CH_4 absorption. Here we use the coupled convective-climate-photochemistry model 1D-TERRA to simulate H_2 atmospheres of LHS 1140 b with different amounts of CH_4 and assuming that the planet has an ocean and a biosphere.

The destruction of the potential biosignatures NH_3, PH_3, CH_3Cl, and N_2O shows a weak dependence on the concentrations of CH_4. For weak abundances of CH_4 only 5 to 10 transits are required to detect these molecules with JWST or ELT. However, for CH_4 surface mixing ratios of a few percent only NH_3 and N_2O might be detectable with less than 10 transits. A scenario with large abundances of CH_4 is consistent with the spectral feature at 1.4 µm and such an atmosphere might allow habitable surface temperatures. If this spectral feature at 1.4 µm originates from H_2O absorption, the planet is likely not habitable at the surface.