

TRAPPIST-1 HABITABLE ATMOSPHERE INTERCOMPARISON (THAI). MOTIVATIONS AND PROTOCOL VERSION 1.0.

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Introduction: TRAPPIST-1 is one of the most promising targets for follow-up observations due to the depths of the planetary transit signals. The transits of the seven rocky planets in this system are relatively deep because the system is located about 12~pc away, and the star is relatively small (0.121 R), even for an M-type star. Among the star's seven planets, three orbit within the Habitable Zone where surface temperatures would allow surface water to exist. Amongst these three habitable zone planets, TRAPPIST-1e has been identified, by previous 3-D climate simulations, as the most habitable planet, for which surface liquid water can be present for an extended set of atmospheric configurations. TRAPPIST-1e is therefore considered the favorite target for atmospheric characterization by transmission spectroscopy with JWST. This has all caused a considerable amount of interest in TRAPPIST-1E, and simulations thereof, in order to derive constraints on its possible atmosphere and serve as a guideline for future observations.

In this context, the modeling of its potential atmosphere is an essential step prior to observation. Global Climate Models (GCMs) offer the most detailed way to simulate planetary atmospheres. However, intrinsic differences exist between GCMs which can lead to different climate prediction and thus observability of gas and/or cloud features in transmission and thermal emission spectra. Such differences should preferably be known prior to observations.

We present a planetary GCM intercomparison protocol and preliminary results [1] using TRAPPIST-1e as a benchmark and four different simulations. The four test cases included two land planets composed of a modern Earth and a pure CO₂ atmospheres, respectively, and two aqua planets with the same compositions. While our focus is TRAPPIST-1e, the methodology is applicable to other rocky exoplanets in the Habitable Zone. Currently, there are four participating models (LMDG, ROCKE-3D, ExoCAM, UM), however this protocol is intended to let other teams participate as well.

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References:

[1] Fauchez, T., Turbet, M., Wolf, E. T., Boutle, I., Way, M. J., Del Genio, A. D., Mayne, N. J., Tsigaridis, K., Kopparapu, R. K., Yang, J., Forget, F., Mandell, A., and Domagal Goldman, S. D.: TRAPPIST-1 Habitable Atmosphere Intercomparison (THAI). Motivations and protocol, *Geosci. Model Dev. Discuss.*, <https://doi.org/10.5194/gmd-2019-166>, in review, 2019.