EPSC Abstracts
Vol. 13, EPSC-DPS2019-349-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

TRAPPIST-1 Habitable Atmosphere Intercomparison (THAI): Motivations, experimental protocol and preliminary results

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Abstract

Upcoming telescopes such as the James Webb Space Telescope (JWST), the European Extremely Large Telescope (E-ELT), the Thirty Meter Telescope (TMT) or the Giant Magellan Telescope (GMT) may soon be able to characterize, through transmission spectroscopy, the atmospheres of rocky exoplanets orbiting nearby M dwarfs. One of the most promising candidates is the late M dwarf system TRAPPIST-1 which has seven known transiting planets for which Transit Timing Variation (TTV) measurements suggest that they are terrestrial in nature, with a possible enrichment in volatiles. Among these seven planets, TRAPPIST-1e is the most likely to have habitable surface conditions, receiving ~66 % of the Earth's incident radiation, and thus needing only modest greenhouse gas inventories to raise surface temperatures to allow surface liquid water to exist. TRAPPIST-1e is therefore one of the prime targets for JWST atmospheric characterization. In this context, the modeling of its potential atmosphere is an essential step prior to observation. In this context, 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. In this paper we present a protocol to inter-compare planetary GCMs. Four testing cases are considered for TRAPPIST-1e but the methodology is applicable to other rocky exoplanets in the Habitable Zone. The four test cases included two land planets composed of pure N_2 and pure CO_2, respectively, and two aqua planets with a modern Earth and a CO_2 rich composition. Currently there are 4 participating models (LMDG, ROCKE3D, ExoCAM, UM), however this protocol is intended to let other teams participate as well.

Acknowledgements

T. Fauchez, G. Villanueva, G. Arney, R. Kopparapu, A. Mandell and S. Domagal-Goldman acknowledge support from GSFC Sellers Exoplanet Environments Collaboration (SEEC), which is funded in part by the NASA Planetary Science Divisions Internal Scientist Funding Model. This project has received funding from the European Research Council (ERC) under the European Unions Horizon 2020 research and innovation program (grant agreement No. 724427/FOUR ACES). This project has received funding from the European Unions Horizon 2020 research and innovation program under the Marie Sklodowska-Curie Grant Agreement No. 832738/ESCAPE.