Interactive comment on "TRAPPIST-1 Habitable Atmosphere Intercomparison (THAI). Motivations and protocol" *by* Thomas Fauchez et al.

Anonymous Referee #2

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This brief paper describes a protocol for inter comparing GCMs for TRAPPIST-1e in anticipation of future observations. The goal is to determine the differences in climate states when the models are run under similar configurations. These states can be related to spectra or thermal phase curves anticipated from future observations such as JWST. Four GCMs have signed on so far but only preliminary results are available; more detailed analysis will follow. This is a good idea and should be a useful effort.

The biggest uncertainty is the mass and composition of the atmosphere. The only constraint seems to be that HST observations do not favor an extended H2 atmosphere for TRAPPIST-1e. Thus, heavier atmospheres consisting mainly of N2 and CO2 are considered. The models are configured to sort out the effects of the dynamical core, physical packages, and moist processes. This is achieved by comparing four different runs for each model with different surface and atmospheric conditions. The approach seems reasonable and should give the authors a good start on what will surely be a challenging but stimulating research project.

We would like to thank the reviewer for their positive words and their helpful comments, which have allowed us to make improvements to our manuscript. We have addressed each of the referee's comments below and noted the resulting changes we have made to the paper.

The authors might consider a few things.

1. If the goal is to determine the differences in model climate states with similar run configurations, it is not clear how model numerics will be separated from model physics. Different dynamical cores running at different resolutions with different numerical schemes will produce different climates. How does one distinguish these differences from those due to real physical processes? I think BEN1/BEN2 should get at some of this but not all of it. Perhaps one way is to run with simple Newtonian cooling using a common relaxation field and time constant.

We agree with referee #2 that a simulation with "Newtonian cooling" is an interesting idea. However, this increases the load of simulations to perform and we think that in order to have this intercomparison working in a reasonable time frame, the number of simulations should be low.

Also, the goal of this intercomparison is not to understand exactly why those models differ but to understand how these differences can have an impact on the observables from synthetic spectra. The four simulations we propose cover a large enough parameter space to answer this question. He have added the paragraph below before the conclusion:

”Note that while additional simulations with a simple Newton cooling model, a 1-D column model, or with cloud radiative effects disabled would help to better understand the differences due to the dynamical cores and cloud physics, they will also dramatically increase the computational time, amount of data and effort. Yet, THAI aims to be easily reproducible and not time consuming in order to reach many GCM user groups. The five simulations propose in THAI should be enough to understand the main differences between the GCMs and their impact on the observable. THAI could also be used as a benchmark for a future GCM intercomparison that will specifically aim to understand each differences between the models.”

2. Once that is clarified then an even more daunting task is to isolate changes due to different physics prescriptions. Is the intent to go to that level of detail or to describe what the differences are without analyzing the reasons? Some brief discussion about this would be helpful.

What we are looking for with this intercomparison is the most important effects between the models, the ones that can have a first order impact on the climate. We therefore do not consider subtle effects due to the numerical schemes, resolution etc. As mentioned in our answer to referee #2 first question, the objective is to quantify the impact of the model differences on the observables, not to understand all the differences between the models which would require another experimental protocol.

3. With suppressed CO2 condensation nightside surface temperatures are likely to be much warmer than when condensation is included. Without latent heat release atmospheric temperatures will cool and the surface must warm to maintain energy balance. Feedbacks related to moist processes may be affected and this may complicate the interpretation.

We agree with referee #2 about the potential effect of disabling CO_2 condensation. However, this is something we have to set up in the future because not all the models include CO_2 condensation. For a similar reason we did not consider ocean heat transport (OHT). In the future, we hope that CO_2 condensation and OHT will be integrated in all the models.

4. The radiative effects of clouds, both CO2 and H2O, can be very different between models. Runs with passive clouds might help isolate those effects. Of course, this adds to the analysis work (as does running with Newtonian cooling), but it is a point worth considering.

Disabling the radiative effects of clouds has also been suggested by referee #1. We agree that this is a very interesting suggestion. However, as also mentioned in the answer of the first question of referee #2, this would increase the number of simulations required for the intercomparison. As an example, Hab1, Hab1* and Hab2 require about 65Gb of data each. Running the model with the radiative effects of clouds disable would require starting new simulations from the initial conditions. We believe that in order to be successful, the number of simulations in THAI should stay small (we already have 5) with the objective to stay focused on understanding the impact of the differences on the observable. A paragraph added before the conclusion discusses about this.

“Note that while additional simulations with a simple Newton cooling model, a 1-D column model, or with cloud radiative effects disabled would help to better understand the differences due to the dynamical cores and cloud physics, they would also dramatically increase the computational time, amount of data and effort. THAI aims to be easily reproducible and not time consuming in order to reach many GCM user groups. The five simulations propose in THAI should be enough to

understand the main differences between the GCMs and their impact on the observables. THAI could also be used as a benchmark for future GCM intercomparisons that specifically aim to understand each differences between the models."

5. The authors hope to add more models into the mix which will increase the workload. Recognizing that this is not a proposal, it still begs the question of having adequate support and manpower to do the work. Is there?

The first author, Thomas Fauchez, has a NASA SEEC proposal funded to work on this project with two THAI members as co-Is (Ravi Kopparapu, Mike Way). Therefore, we think that we have the adequate resources to successfully perform this intercomparison.

Also a THAI workshop is currently being planned around fall 2020 to discuss about THAI results and their perspectives (this is now mentioned in the revised version of the conclusion):

"The results of the comparison of these four models will be given in a second paper and a THAI workshop is planned for fall 2020."