Response to Referee#1 on: "An ensemble of AMIP simulations with prescribed land surface temperatures" by Ackerley et al.

General Comments:

This paper by Ackerley et al. describes a suite of fixed land temperature experiments with a single AGCM and provides a thorough validation of the experiment setup. The fixed land temperature experiments fill an important gap in the current model hierarchy, particularly in terms of understanding the traditional AMIP-style simulations. The paper shows that the land surface temperature can be prescribed in a way that is over all consistent with the free-land setup. These experiments, which are made publically available, therefore are of great scientific value. My only concern with this generally well-written paper is the lack of scientific analysis. While the main purpose of this paper is to provide a description and validation of experiment design, there are a few points that concerns the soundness of the experiments and should be better addressed. Particularly, the positive precipitation bias in the Amazon stands out as perhaps the biggest caveat of the fixed land temperature experiments. If these experiments were to be used to study Amazon rainfall, such caveat needs to be better understood. And I suppose this paper should serve that purpose. The authors may expand on the hypothesis provided in a single sentence in L14-15 and elaborate on the mechanism provided in Cox et al. 1999.

Response: The authors would like to thank the reviewer for undertaking their review of our work and for the positive and helpful comments that have been made. We do fully understand the reviewer's point about scientific analysis; however, we feel that providing a solid (and relatively simple) evaluation of the simulations we have undertaken is very important for others who wish to use these data. Providing in-depth scientific analysis of the runs would likely result in an extremely lengthy paper and make it difficult to simply present the biases associated with these experiments. This is why we made Geoscientific Model Development our publication choice, as it is the perfect platform for such a paper. It is hoped that others will provide more scientific insight (there are two papers the author is aware of that are in review and showcase some of the scientific value of these runs) by downloading the data themselves. The responses to the main points are given below.

The authors also fully agree with the need to provide more insight to the Amazon precipitation in the prescribed land simulations, but unfortunately we did not save the canopy water diagnostics as monthly means throughout the run and cannot re-run all the experiments (the lead author no longer works at the institute). Nevertheless, we did save the canopy water in the restart files (instantaneous values every 3 months, which gives 116 values to average over each run) and we have plotted the difference between A_{PL} and A in Figure R1.1 below. There is higher canopy water storage in the A_{PL} run relative to the A run, which matches the region of higher latent heat flux (Figure S3(a) in the supplementary material) and precipitation (Figure 1(h)) and supports our hypothesis in the main text. Given that this is an average over relatively few instantaneous values, the changes may not be highly statistically significant; however, the result supports the physical interpretation. We will add the figure to the supplementary material as further evidence of the stated process while also stating the associated caveats with the following text (the caption will be the same as that shown in Figure R1.1 below):

"The change in canopy water loading (kg m-2) taken from 116 instantaneous seasonal values (first day of each season over 29 years) from both the Apl and A simulations (Fig. S4). The 116 values are taken from the model restart files as climatological averages were not retained during the simulation. The positive change in canopy water loading corresponds with both the higher precipitation (Fig. 1(h) in the main text) and latent heat fluxes (Fig. S3(a)) that are seen in Apl relative to A, which agrees with the physical mechanism proposed in Section 3.2.1 of the main text."

Specific comments:

1. *It might be worth mentioning the aquaplanet simulations that also have prescribed global surface temperature and have been used to indirectly study the impact of land surface temperature changes. For example, the CMIP6 standard aquaplanet simulations (e.g., He and Soden 2017) and the aquaplanet simulations with land-like temperatures (e.g., Tobias and Bjorn 2014). The lack of land in these aquaplanet simulations is an obvious shortcoming and the fixed land temperature experiments are a perfect solution. Tobias, B., and S. Bjorn, 2014: Climate and climate sensitivity to changing CO2 on an idealized land planet. J. Adv. Model. Earth Syst., 6, 1205–1223, doi:10.1002/2014MS000369. He, J., and B. J. Soden, 2017: Are-examination of the projected subtropical precipitation decline. Nat. Clim. Change, 7, 53–57, doi:10.1038/nclimate3157.*

   Response: We have reviewed both of these pieces of work and agree with the reviewer that they are very useful additions to the cited literature in this paper. The He and Soden (2017) paper uses the opposite approach to our work in that an aquaplanet 4xCO_2 simulation is compared with the standard AMIP 4xCO_2 simulation. The impact of the land is inferred by subtracting one from the other (aqua vs AMIP with land) whereas our simulations suppress the land response (A4xpl) and compare it to the full (A4xpl4x) or land-only (Apl4x) simulations. Becker and Stevens (2014) on the other hand look at the response of various feedback processes in an idealised version of the ECHAM6 model. There are clear parallels between their idealised work and the simulations we have produced with prescribed land. Indeed, the cloud feedback processes highlighted by Becker and Stevens (2014) (e.g. the response of stratocumulus-type cloud to different land and CO_2 configurations) could be looked at in our simulations. We have therefore included references to both pieces of work in the 3rd paragraph of the Introduction.

2. *Page 4, Line 10. Are the land surface types prescribed or allowed to change?*

   Response: The land surface types do not change in the version of the model we have used (i.e. it is not an interactive scheme with respect to surface fractional type definition). They therefore do not change in any of the experiments given in the paper.

3. *Page 7, Line 3. How is the plant physiological effect switched off? Can it be explained in a couple of sentences?*

   Response: The calculation of photosynthesis in the vegetation scheme relies on the CO_2 concentration specified at the start of the run, as does the radiation scheme. In the 'rad' experiments, this is bypassed within the vegetation scheme by manually setting the CO_2

concentration to 346 ppmv in the code (whereas the atmosphere still 'sees' the specified value e.g. 1384 ppmv when quadrupled). This is how the physiological effect is 'switched off' i.e. it is a hard-wired bypassing of the value read in at the start of the run, which would normally be applied to both the vegetation and radiation schemes. We have therefore added:

"…and denoted as Arad4x from here on). This is done by setting the CO_2 concentration used in the photosynthesis calculation in the vegetation scheme to 346 ppmv but allowing the radiation scheme to 'see' the quadrupled value (i.e. 1384 ppmv)."

4. *Have the authors considered prescribing soil temperature and moisture separately (i.e., fix one and allow the other to change freely)?*

   Response: The authors have considered such experiments; however, the aim of these experiments was to produce a set of AMIP prescribed land experiments that reproduced the free land experiments as closely as possible. Therefore, both the soil temperatures and moisture needed to be prescribed together to maintain consistency. This allowed us to initially identify any systematic errors that may have been present in the prescribed land runs. The soil temperature and moisture fields were then prescribed together in the individual forcing experiments to again remain consistent with the prescribed land experiments. This would then allow us to have confidence in whether the climatic changes seen in the simulations were 'land driven' (i.e. temperature and soil moisture) or not. Furthermore, by prescribing both fields together we are able to maintain the strong coupling between soil moisture and land temperature, segregating the two processes could be considered unphysical. Also, given the ~30 year length of the model simulations, there may be a long spin-up period required for the soil moisture field if it is allowed to vary freely with prescribed land temperatures, which could reduce the statistical significance of any observed changes in climate. The necessary testing for such an experiment was therefore beyond the scope and resources of the ensemble we have produced. Nevertheless, we would certainly advocate running such experiments in the future or encourage others to do so with the code that has been made available.

Figure

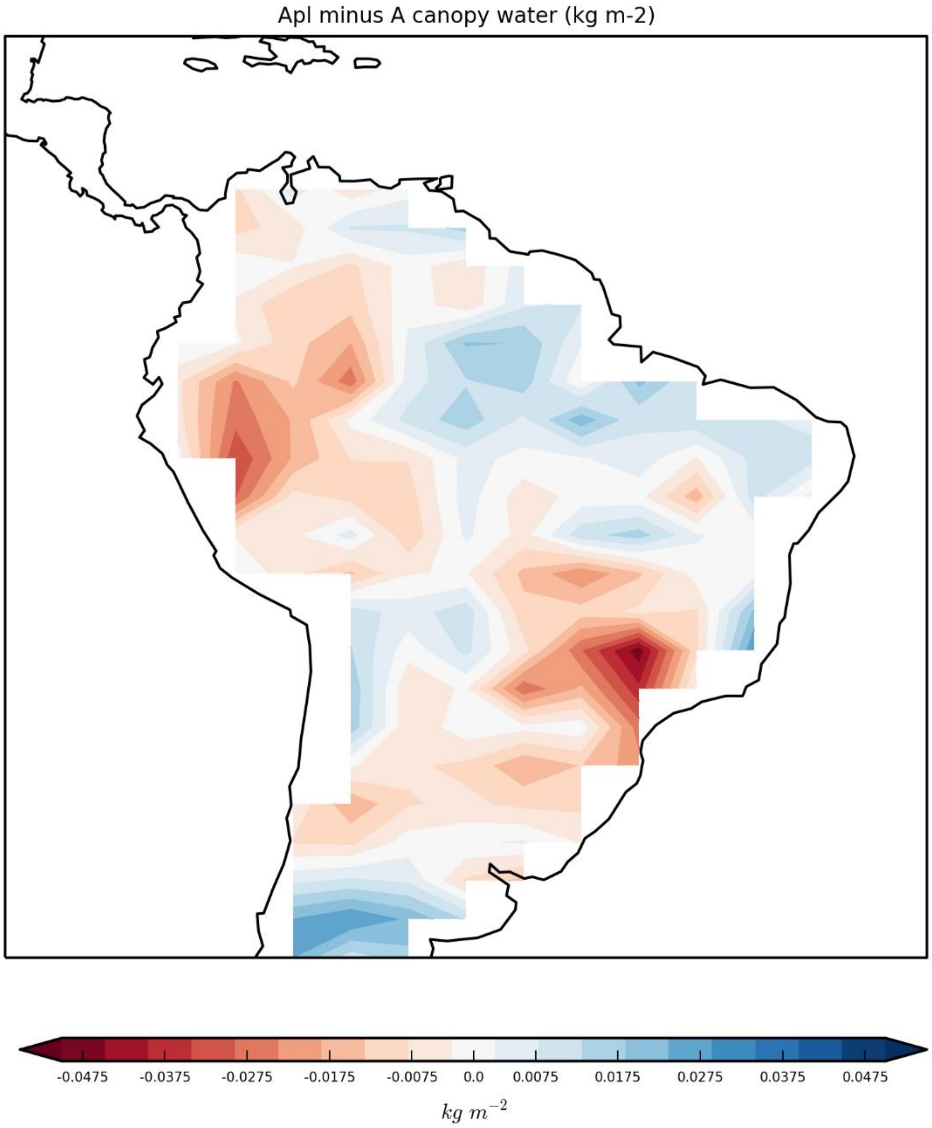

Figure R1.1: The difference in the canopy water loading (kg m^{-2}) in the A_{PL} simulation relative to A.