Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2017-105-RC2, 2018

Earth System Dynamics
Discussions

Interactive comment on "Climate, ocean circulation, and sea level changes under stabilization and overshoot pathways to 1.5 K warming" *by* Jaime B. Palter et al.

Anonymous Referee #2

Received and published: 25 February 2018

This study examines the climate system response to three different emissions scenarios in one climate model. One scenario (RCP4.5) reaches 2.0C of global temperature rise above pre-industrial levels at 2100, while the other two scenarios (stabilization and overshoot) aim to reach 1.5C warming via different emission pathways by 2100. The study documents the response of global mean temperature, sea level, AMOC, and sea ice.

The manuscript addresses an important topic – the effects of different pathways to 1.5C or 2.0C warming on the climate system. It well written, well organized and the figures are clear. I believe it offers several important new messages, but needs more

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evidence to back these up properly. I recommend it be accepted subject to moderate revisions (no option for this in the list of recommendations).

Comments:

1. The manuscript currently documents the responses of a range of variables to do with “Climate, ocean circulation, and sea level changes” (AMOC, sea ice, surface temperature, sea level, mixed layer heat budget for the NAtl), which is fine, but it ends up feeling a little “light” or qualitative. Many of the statements in the manuscript could easily be backed up by using the model output. It seems that sea level rise is one of the main points the authors are emphasizing? Or perhaps the North Atlantic warming hole? If so, the manuscript would benefit from some reworking to solidify these aspects . For example:

– Pg 8, paragraph starting on L5: I’m not sure I fully understand the point being made about the North Atlantic warming hole. The warming hole is “stronger” (i.e., colder) in the stabiliization and overshoot scenarios than in RCP4.5. However, a) the heat budget perturbation is similar for all three scenarios while b) the AMOC weakens more for the overshoot and RCP4.5 than for the stabilization. Furthermore, the authors speculate that a “slowdown in advective heat supply may suggest a role for the horizontal gyre circulations” (should be for all three scenarios since the heat budget changes are similar for all three, but not entirely clear to me)? In the end, I’m still not sure why the warming hole is stronger in the stabilization and overshoot scenarios, thought I could speculate. All the relevant pieces of information seem to be here, they just need to be linked and interpreted together. Perhaps some zoomed in figures of the North Atlantic would help, including showing the actual changes in the gyres (Sverdrup transport) or surface heat fluxes if these are indeed important.

– Pg 7, L13-14: Could the authors show the response of the total ocean heat content and TOA radiative imbalance in the three scenarios (since these determine the steric sea level rise)?

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– Fig. 2 and 4 and the global mean temperature curves suggest some interesting differences in ocean heat uptake between the three scenarios. It would be nice to see what is happening, e.g., some maps of ocean heat content, to show where the ocean ends up sequestering heat.

– What are the contributions of the global steric term and local steric term to the differences in sea level rise between the three scenarios. Figure 6 suggests that both contribute. This could be quantified for the various locations.

2. It would be useful to show some measure of how strong the signals in the 2096-2100 averages are compared to the ensemble spread (even though these are small ensembles), and internal variability (from the time series in Figure 1, it is clear there is quite a lot of interannual to decadal variability in the responses).

3. To provide some context for this single-model study, it would be useful to have some idea of how GFDL-ESM2M performs relative to other CMIP models in the RCP4.5 scenario. This is done on pg 10 for the ACC, but it would be nice to see similar discussion for variables/features that are the main focus of the manuscript.

Other comments:

1. Figure 1: the text labels are quite small, especially in panel b, and the thin lines for indivdual ensemble members are too faint.

2. Equation 3 seems to be missing a dz in the integral.

3. Pg 6, L12: arises -> arise

4. Pg 7, L10-11: "... the pathway to a given forcing does not factor prominently in the annual mean, global average surface air temperature change in response to that forcing." This statement seems a bit odd to me given that the stabilization and overshoot emissions pathways were constructed with an aim of achieving 1.5C warming at 2100. Maybe it's just that I have misunderstood the description of how the scenarios were designed, in which case the authors could try to clarify this instead (pg 3 last

paragraph).

5. Figure 5: What is “vertically-averaged” sea ice concentration?

6. The implications of these results for ocean acidification is mentioned in the conclusions. This seems to be a very important point. Would it be worth including this in the results, with some analysis of the model output to back this up?

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