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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 #3

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General comments

Summary

The article's main question is how the climate system reacts to different CO2 concentration pathways to a fixed global surface warming by 2100. Having RCP4.5 as a standard scenario, the authors set up two new different CO2 pathways to 1.5K warming, the "stabilization" and "overshoot" scenarios, with the goal of reflecting two extremes of hypothetical short-term and long-term climate policy. Conducting their simulations with the GFDL-ESM2M earth system model, the authors document the global climate response in the 21st century in what respects AMOC intensity and steric sea level

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rise and give the climate state by 2100 of surface temperature, sea level rise and sea ice concentration. The experiment main conclusions for overshoot pathway relative to stabilization pathway by 2100, are: (i) overshoot achieves the same global average temperature target with greater cumulative carbon emissions, but, leads to stronger ocean acidification (not quantified), higher global mean steric sea level rise and lower AMOC volume transport; (ii) overshoot forcing causes the ocean surface to be cooler over the subpolar NAtlantic and some regions of the SO with associated expansion of sea ice, suggesting a negative radiative feedback; (iii) geographic patterns of sea level rise are sensitive to the selected pathway, with overshoot forcing producing up to 10 cm of additional sea level rise in some cities of the east coast of NAmerica

Overall evaluation

This paper addresses a very relevant scientific question with huge societal implications. Authors carry a numerical experiment with a well-tested state of the art Earth System Model, and their results are supported by suitable simulations setup and appropriated analysis methods. The document is well structured, and its language is fluent and precise. The credit given to related work is very well balanced and authors contribution is clearly indicated. The principal study findings are clearly stated and flow natural from the presented results.

Specific comments

Abstract

The abstract gives a correct summarized perspective of the different components of the paper and it can be understood without reading the remainder document. I just have a few considerations:

- because the research is based on a single model experiment, the GFDL-ESM2M model, it should be, in my opinion, explicitly declared (line 3)

- due to its importance for marine ecosystems, I would like to see the “ocean acidifi-

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cation" Included in the list of other climatic metrics that show important differences in response to different CO2 concentration pathways (lines 10-11)

- rephrase lines 12-13, to make clear that the overshoot relative to the stabilization simulations gives a higher global steric sea level rise and a reduced AMOC volume transport.

1. Introduction

pg 2, line 2: to be more precise, "negative emissions" designation should also include "on-site capture of CO2"

pg 2, lines 18-23: the use of RCP4.5 and RCP8.5 scenarios in the simulations, justifies, in my opinion, to quote a summary reference(s) on these scenarios (e.g. Moss et al., 2010; van Vuuren et al., 2011)

pg 2, line 24: before paper's outline, I think that will be more appropriate to give here the justification for setting up the "stabilization" and "overshoot" pathways, than later in page 3 lines 23-25 ("Our goal in setting up the two new pathways (i.e. 'stabilization' and 'overshoot') was . . .")

2 Methods

Some of the comments intend to improve the results traceability

pg 3, line 6 – What were the criterions for choosing the number of elements in each ensemble? Why five?

pg 3, line 8 – "very tiny perturbation" . . . "similar to the approach by Wittenberg et al. (2014)". Could you please be more specific? How "tiny" is this perturbation and how "similar" is to Wittenberg et al. approach?

pg 3, line 11 – "the final year of the simulation"; do you mean 2100? The simulations period was not yet clearly stated in the text.

pg 3, line 14 – “limiting atmospheric CO2 growth rates to approximately 0.25 ppm year−1”; please mention the period for which this growth rate is valid. (2070-2100)?

pg 3, line 20-22 – from the observation of figures 1c and the supplementary S1 (large dots), I got somewhat different values for the three scenarios: 1.92K, 1.45K and 1.52K respectively RCP4.5, stabilization and overshoot. Did I miss something?

pg 3, line 30 – “run of GFDL-ESM2M under 1% CO2 increase”; rate is missing (1% per year).

3 Global average properties

pg 6, line 23 – suggestion: add “(TCR)” just to indicate that there is a definition behind the words “transient climate response”

pg 7, line 5 – “. . . year 2086, respectively”; refer Figure 1b

pg 7, line 9 – instead of “(Figure 1c)”; refer (Figure 1a,c).

pg 7, line 24 – “AMOC reaches its lowest point in 2075 (13.6 Sv)”; it is not possible to check this value in figure 1d! It is somewhat confusing to discuss annual values in the text and to observe 10-year running average values in the figures!

4 Regional patterns tied to the ocean circulation perturbation

pg 10, line 10 – “stabilization pathway by 2100.”; refer (Figure 1e).

Figure 5, caption – please clarify “vertically-averaged sea ice concentration”

pg 13, lines 1-2 –refer Figure 6a,b for Boston and St. John’s, and Figure 6d,e for Charleston and Miami

pg 13, lines 5-6 –observing Figure 4 “on the other side of Atlantic”, I would be a little bit more precise and replace “southern Europe” by “southern Iberian Peninsula” and “while Northern Europe . . .” by “while further north the western European coast . . .”

pg 13, line 7 – in this line, only mention Figure 4 and refer Figure 6f at the end of the

paragraph.

pg 13 - for the analysis of the sea level change results, presented in figure 6, it would be useful to have an estimation of the internal variability (ensemble spread)

5 Conclusions

A few questions for your consideration:

- why it is omitted in your document the simulations results for the distribution of salinity by 2100? The relevance of this oceanic parameter for the AMOC dynamics and for the local steric sea level term, doesn't justify its inclusion in the discussion of the presented results?

- from the model output, is it possible to quantify ocean acidification and elaborate a little more on the evolution of this oceanic parameter under the selected scenarios?

- it should be brought to the discussion in this final section, the limitations/weaknesses of the used model that can affect the quality/representability of the obtained results (e.g. no representation of interactive ice sheets or glaciers; transient climate response (TCR); ACC position; salinity anomaly over the subtropical Atlantic (Jackson et al., 2014); AMOC depth (Kostov et al.,2014); . . .). You have already made some comments at the end of section 2 (pg6, lines 15-19) that can be revisited in the context of this discussion.

Technical corrections

pg 1, line 11 – insert the (AMOC) acronym and remove the full designation in line 13

pg 2, line 33 – Anderson et al. 2004 is missing in the references list

pg 3, line 16 – "reaching a peak of 537 ppm"; observing Figure 1a this value looks like a typing error (probably, should be 573 ppm)

pg 6, equation 3 – dz is missing in the integration

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pg 6, line 4 – H (the bottom depth) is not declared

pg 6, line 28 and following lines – use the same units for cumulative carbon emissions in text and Figure 1b (Pg C)

pg 9, Figure 2 – latitude and longitude labels are missing

pg 11, Figure 4 – latitude and longitude labels are missing; in figure caption should be RCP4.5 minus stabilization and overshoot minus stabilization and not the other way around

pg 13, line 2 – word “under” is repeated twice

References

Anderson et al. 2004 is missing

Gasser et al 2015; journal’s name is missing: Nat. Commun.; DOI link is incorrect (http://10.1038/ncomms8958)

Gillett et al 2013; list of authors is repeated

Herweijer et al 2005; DOI link is incorrect (https://doi.org/10.3402/tellusa.v57i4.14708)

Trenberth et al 2014; list of authors is repeated

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