

## Author's Response- bg-2023-146

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Thank you to the reviewers for reading again the manuscript and the useful comments.

References have been added and corrected in response to reviewer comments.

Figures indicated (1, 6 and 11) have been checked for colour suitability and find that the results still quite clear with the various forms of colour vision deficiencies.

Further minor corrections have been made following another read through by the authors.

Detailed responses to reviewers follow:

## Comment on bg-2023-146

Andrew MacDougall

I am satisfied with the changes that the authors have made to the manuscript and believe that that paper is ready for publication.

Thank you and thanks again for your previous review which helped improve the manuscript.

## Comment on bg-2023-146

Anonymous Referee #2

I find the authors have done a good job in addressing my comments from the first round of review. There are a couple of relatively minor or technical issues that should be addressed before publication in Biogeosciences.

Thank you for reviewing the manuscript again and the useful comments.

Line numbers refer to the tracked changes version of the revised manuscript.

line 1: Wouldn't "Earth system model" be more appropriate instead of "Climate model"?

Yes, this would be more precise.

line 4: "version of" could be deleted.

The phrase is kept here as there are physics-only versions of ACCESS as well.

line 9: I would suggest to delete "or branched".

The phrase is kept here for clarity. Later in the abstract these points where the ESM changes from the 1pctCO2 to zero-emission scenario are referred to as 'branch points' and this is the first occurrence and want the concept to be clear to readers that may be unfamiliar with the running of these climate experiments.

line 32: "of the global climate" and "the amount of" are unnecessary and could be deleted to make this sentence more concise.

The second is deleted to be concise, as suggested, but the first part is kept. The ZEC may not be familiar to all readers and describing it as a property of the 'global climate' could be useful here.

line 38: The authors mean 1.5 (not 1) degree?

Updated.

line 58: "version" should be replaced by "phase".

Updated.

line 64: "50 years into the high ZECMIP branch" maybe better phrased as "50 year after cessation of emissions"?

Suggested phrasing adopted.

line 112: "cumulatively" could be deleted. Also "... after the diagnosed emissions reach 750, ..."

"Cumulatively" is deleted, but keeping "diagnosed emissions" as it refers to the point that these emission budgets must be diagnosed from the *1pctCO2* experiments. This point is spelt out clearer with the rewriting of this sentence.

line 115: Please replace "into the climate historically" by "for the period xxxx to yyyy" and indicate the years for which the 695 Pg are estimated.

Suggested phrasing adopted.

line 124: "Low (high) ZEC branches..." Please define what you mean by low and high (the reader can guess that "high" means > 1000 Pg(?) but this should be stated here).

With the rewriting from the first review, this paragraph is now somewhat redundant. The points from this paragraph are now written into the previous and following paragraphs, to make the manuscript more concise and with consideration of the points raised.

line 134: "variability" -> "internal variability".

Suggested phrasing adopted.

line 154-155: I would recommend a more neutral wording, e.g. "... influencing the climate, and an instantaneous transition to net zero carbon emissions would socioeconomically not be feasible".

The wording here was suggested by the first reviewer and I am comfortable with the latest phrasing as the "global cataclysm" is only in the context of the realism, or not, of these *1pctCO2*-to-ZEC transitions and is not belaboured any further.

line 155-158: The statement that "results from ZECMIP experiments are essentially the same" as for other scenario experiments needs clarification (or should be deleted). Which "other" plausible experiments do the authors refer to? Please add a reference to paper that supports this statement.

The language has been softened ("expected to be the same") and a reference is now added to support this statement.

line 179: "the climate" -> "the climate system"

Suggested phrasing adopted.

line 228: Please provide correct citation for "Meehl and IPCC Climate Change 2007"

Yes, thanks, corrected now.

line 258: appears -> appear

Using time series as a singular in this context; "The" has been added to improve readability.

line 263: "However, changes in the North Atlantic and AMOC have been identified..." Maybe better "... have been identified as important features ..."?

Suggested phrasing adopted.

line 335 and 336: "moves to the right" and "they turn left" sound very odd for a description of time series. Please consider rewording.

Modified to "their CO<sub>2</sub>-temperature trajectories turn left" for clarity.

line 364-365: Please check the logic of this sentence (why "reversed"?). If ZEC is zero, global temperature will be stabilized, but not reversed. Then, in order to stabilize temperatures (in ACCESS) negative emission would be required.

The main point here is that once the Southern Ocean is warming significantly, zero-emissions are not enough and, yes, negative emissions are required, i.e. it is the "global temperature trajectory" (reworded for clarity) that continues to increase, indicating a positive ZEC.

The previous sentence is also rewritten to improve clarity and readability.

line 366: "positions" sounds odd. "thresholds"?

Suggested phrasing adopted.

line 368: Although it might put additional pressure on a system (and eventually push it beyond a tipping threshold), deforestation is not an example of a process related to a tipping point (since it is a deliberate human activity). I guess the authors mean "forest die-back" here?

Yes, "forest die-back" is a better phrase.

lines 369-381: I find the discussion of tipping points lengthy and difficult to read and I would suggest shortening it and making it more concise. I think the main point is that the ongoing warming in the SO isn't a tipping point although the increasing temperatures might cause a crossing of tipping thresholds eventually of components that are not or only poorly represented in ACCESS (Antarctic ice sheet? ocean ecosystems?).

"Climate tipping points" currently receive significant discussion and this paragraph is motivated to point out, in its own small way, that there are other processes that are also significant. I would also add that the Southern Ocean is not a tipping point but still a significant driver of ongoing climate change. The paragraph has been reworked to be more concise and clearer in its message.

line 501: Maybe worth mentioning that ACCESS has a relatively weak (compared to other ESMs) response of AMOC to climate warming?

This and the following sentence are reworked to clarify this point, and that both these AMOC and Southern Ocean responses are plausible climate responses.

line 505: Why is it "reasonable for a climate to be warming"? The low branches traverse the climate states from TCR to ECS without warming, are they "unreasonable"? I would suggest to reword this sentence.

Any trajectory that doesn't cross the bounds of TCR and ECS might be 'reasonable.'

The phrasing has been changed to "not unreasonable" for temperatures to increase with zero-emission scenarios.