Author's response to "Tipping points in ocean and atmosphere circulations"

We thank Axel Kleidon for handling our manuscript and the reviewers for their feedback to improve our manuscript, which we have revised accordingly. Below are the original comments from the reviewer in black and our corresponding responses in blue. The line numbers refer to the resubmitted manuscript.

Sina Loriani for the author team

Reviewer 1
Overall, the authors have now thoroughly addressed my comments and have substantially revised their manuscript accordingly. I congratulate them for their achievement to write such a comprehensive review.

Thank you for the thorough and constructive feedback! We are quite grateful for the scrutiny (especially given the length of the paper) and appreciate how it helped to significantly improve the comprehensiveness of the manuscript.

I only have two comments that can probably be addressed easily:

1. Tipping as a system property versus scenario driven:
I believe the choice of the authors to consider the existence of any tipping point in principle, whether it is plausible to be reached by future forcing or not, makes sense. Thank you for clarifying. Despite this convincing reply, I did not see this mentioned in the new manuscript, which would mean that this clarification is lost to the readers. I suggest to add it (unless I overlooked something).

Thanks for catching that – we added a short note in the introduction (line 132).

2. Definition of tipping:
a) The authors now refer to "the IPCC definition" (page 4), but it would help to state what it is. Their definition given above includes positive feedbacks, which are not part of the IPCC definition.

Agreed, we have added that now (line 69ff and 128ff).

b) The definition is now clearer. The authors appear to understand "tipping" as a phenomenon where positive feedbacks take over regardless of the trajectory / speed of the future forcing ("positive feedbacks change a system in a self-sustained fashion", "at a rate largely determined by the system itself").
This seems to match exactly the definition of a catastrophic bifurcation where a stable attractor disappears, a mathematically well-defined phenomenon. Then, the authors should call it by its name. However, they only mention bifurcations twice on page 11, without explanation of the term.

If the authors however wish to include stable transitions, with only one stable attractor that may nonlinearly shift with the forcing (my impression is that this is intended to be included in the McKay definition?): The dominating mechanisms that determine the system's dynamics

will then always be negative feedbacks, at least if the change in forcing is slow. In other words, in this situation, the notion that positive feedbacks determine the dynamics, does not appear adequate.

Thank you – we have adapted the text in the introduction where we define tipping points (line 69ff and 129ff).

Additionally to these reviewer comments, we made the following minor amendments to the last submitted manuscript:

- Updated affiliations and acknowledgements
- Added references to answer the reviewer's questions
- Added one extra reference for TIPMIP
- Minor rewording in the ENSO section (l 832ff)