

Dear Dr. Bond-Lamberty,

We are grateful for the positive feedback on the revised manuscript and thank the reviewer for their time and constructive feedback. We provided a detailed response to the reviewer's comments and revised the manuscript for further improvement.

Sincerely,

Negar Vakilifard, Corresponding author

## *Detailed response to the reviewers' comments*

### Overall Assessment

The revised version of the paper is greatly improved from the original version and most of my critiques have been satisfactorily addressed. There are a few remaining issues that need to be addressed before publication but these can be addressed with more careful explanations and wording of the paper. Once these issues are addressed I believe that the paper will be ready for publication.

**We thank the reviewer for their supportive comments on the revisions made to address the critiques. We have implemented the reviewer's suggestions in this version of the manuscript to improve the clarity of the paper.**

### 1. General Comments

1.1. While improved from the original version of the paper the use of ZEC is still not quite correct. ZEC is 'Zero Emission Commitment', however in your experiments emissions of non-CO<sub>2</sub> greenhouse gases and aerosols continue for the period where ZEC is assessed. To avoid confusions and apples to oranges comparisons I recommend defining an 'effective Zero Emissions Commitment' eZEC analogous to eTRCE used in the paper. By clearly defining such a metric future research and reviews will not so easily get tripped up by inconsistent definitions of ZEC.

**Thank you for your insightful comment. We agree with the recommendation in using an eZEC notation that parallels an eTCRE notation when non-CO<sub>2</sub> forcing is included. In the revised manuscript, section 1, we have changed to the recommended notation of the effective ZEC referring to the continued surface warming after the cessation of the CO<sub>2</sub> emissions while the non-CO<sub>2</sub> greenhouse gases and aerosol forcings evolve. Accordingly, we revised Figure 11, sections 5, 5.3, 6 and the abstract.**

1.2 Organization of the paper is a bit weird. Results basically begin at line 200, part-way through the Methods section.

**Thanks for your comment. We removed the parts related to the results from section 3.1 in the previous version and moved them along with sections 3.2 and 3.3 to a new section (section 4) with the heading "GENIE-1 model responses". We then re-numbered the following headings.**

### 2. Specific Comments

2.1. Abstract: There is not enough context in the abstract to clearly understand what Lines 41 to 42 and 45 to 46 mean. I recommend re-writing the abstract to either add context or remove these sentences.

**Thank you for bringing this up. We addressed this comment by removing line 41 from the abstract and revising lines 45 and 46. It now reads: "If net negative emissions are included, there is a reduction in atmospheric CO<sub>2</sub> and there is a decrease in temperature overshoot, so that the eZEC is positive in only 5 % of the ensemble members".**

2.2. Line 53: Add a citation to the text of the Paris Agreement.

**In the revised manuscript, we added the reference for the Paris Agreement in sections 1 and references.**

2.3. Line 87: Add a comma after 'biosphere'

**We made this revision in the manuscript, section 1.**

2.4. Line 100: 86 is not really a 'large' ensemble. Similar studies have used 250 or 1000 model variants (e.g. Steinacher & Joos 2016, MacDougall et al. 2017). Maybe just say 'an ensemble'

**Thank you for pointing this out. We have replaced the term 'large ensemble' with 'an ensemble' throughout the revised manuscript, including the title of the paper. Please also see sections 1 and 6.**

2.5. Line 101: You should add a sentence to acknowledge the very high uncertainty in land-use reconstructions prior to about 1800 CE. Although the 850 CE start date was used by Eby et al. 2013 and other models intercomparison and studies, it is now well known that the land-use reconstructions used for forcing those experiments was based a very poor population estimate data-sets and Eurocentric conceptualizations of land-use. See Koch et al 2019, for a review of the problems in the Americas (the reconstruction used by Eby et al is designated P08 in Koch et al 2019).

**Thank you. We have addressed this comment by adding a sentence in section 1, mentioning the limitations of the land use change emission reconstructions prior to 1800 CE and cited the recommended reference.**

2.6. Line 103: Add 'climate' after pre-industrial

**We made this revision in the manuscript, section 1.**

2.7. Line 181: How did you account for the transition from historical RCP datasets ending in 2005 to SSP 2.6 beginning in 2015? Are there any discontinuities in the forcing data-sets?

**Thank you for your comment. There are no discontinuities in the forcing data-sets. We made an adjustment to the non-CO<sub>2</sub> radiative forcing of SSP1-2.6 by adding a constant value of 0.446 Wm<sup>-2</sup> to make it consistent with the RCP2.6 spin-up at 2005. This adjustment can be reconciled as contributions from land-use change albedo (explicitly modelled in GENIE-1, Fig 1c) and from non-anthropogenic forcings which were modelled in the historical spin-up (Eby et al., 2013), comprising volcanic forcing of 0.184 Wm<sup>-2</sup>, and solar forcing of 0.059 Wm<sup>-2</sup> in 2005. In the revised manuscript, we added this explanation to section 3.**

2.8. Figure 1: Add CE after year for clarity. Model years and years BP are also commonly used in ESM studies.

**In the revised manuscript, we added CE after year in Fig. 1.**

2.9. Figure 2: Gray lines with a mean value in black or another colour on-top would be clearer than the rainbow shown.

**We revised Fig. 2 and showed the spread of the results in grey and the mean values in black.**

2.10. Line 254 and 255: You are conflating the natural world and your model here. In your model the ocean is the only major energy sink, while it is in the natural world that the ocean takes up ~90% of heat.

**Thank you for bringing this up. In the revised manuscript, section 4.3, we mentioned that the ocean heat uptake is used to represent the planetary heat uptake, as the model ocean is the principal energy sink and the model does not take into account the energy stored in the lithosphere or consumed in the melting of the ice sheets. We then added that in real world, the ocean is responsible for storing over 90 % of the Earth's total energy increase (Church et al., 2011).**

2.11. Line 273: Also cite Koven et al. 2022

**We added this reference in the revised manuscript, sections 5 and references.**

2.12. Figure 7: Be clear that these are cumulative not instantaneous fractions.

**Thank you for your comment. In the caption of Fig. 7, we added that the y-axis shows the cumulative fraction of CO<sub>2</sub> which remains in each carbon inventory.**

2.13. Line 425: Cite MacDougall et al. 2017 here, which had a similar result for climate sensitivity.

**We cited the recommended reference in the revised manuscript, section 5.2.2.**

2.14. Line 476: Reword for clarity. When a nation-state no longer wants to abide by a treaty they 'leave' it. Thus the wording here is very confusing. Revise to specifically mention temperature targets.

**Thank you. In the revised manuscript, section 6, we added the Paris agreement temperature targets to bring more clarity to the manuscript.**

## *References*

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