

## ***Interactive comment on “Limitations of the 1 % experiment as the benchmark idealized experiment for carbon cycle intercomparison in C<sup>4</sup>MIP” by Andrew H. MacDougall***

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Received and published: 1 November 2018

First, I want to disclose that I received a draft of the manuscript before it was published in GMDD and my summer intern used the provided scenarios in our research that is hopefully published at some later time. Although this can be perceived as a minor conflict of interest, I have currently no plans to collaborate with Dr. MacDougall and believe I can deliver an impartial review of the manuscript.

The manuscript describes a new idealized scenario that could be used in C4MIP carbon cycle model intercomparison and potentially replace the standard 1% scenario. The author has also conducted model simulations with the UVic ESCM, an Earth sys-

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tem model of intermediate complexity, to study how the proposed scenarios compare with the 1% scenario. He presents convincing arguments of the limitations of the 1% scenario and how the proposed scenarios could address these. Thus the scenarios presented are potentially an important contribution to model intercomparisons. In addition, they can be valuable in single-model studies as well when idealized scenarios are needed. In our case, we needed a CO<sub>2</sub>-only scenario that would be of similar length as a historical (1750-2005) + RCP run until 2100. 1% scenario was impractical because the CO<sub>2</sub> concentration increase is so much faster compared to the historical scenario. The manuscript is clearly structured and mostly clearly written, although I would prefer more punctuation, as some sentences are hard to read. I recommend the manuscript to be published with some minor improvements.

The other reviewer had many good comments and suggestions, and I agree on almost all of them. One exception is that I think that diagnosed emissions should be shown as they are now. They are used in the discussion of the results and are an important part of understanding the source-sink transitions for example.

Minor comments:

I do not know the conventions, but I would consider using increasing and decreasing emissions instead of accelerating and decelerating emissions. I think that would be more clear. “Accelerating” could be potentially interpreted (or at least misinterpreted) that the rate of change of emissions is increasing, but you seem to imply only that emissions are higher on year  $n$  than on year  $n-1$ .

Page 1, Line 6: I agree with the first reviewer that it should be made more clear when you are talking about the experiment design and when about the results of the simulations.

Page 1, Line 20: I’m aware that there are several ways to spell out what TCRE stands for. Gillet et al. (2013) used “Transient climate response to cumulative carbon emissions”. H. D. Matthews recommended to use “Transient climate response to cumulative

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CO2 emissions” (personal communication, 2016). Although the form used here is consistent with the abbreviation (even more than most other versions), I think that including the word carbon or CO2 would be informative here.

Page 4, Line 29: I think these stages are not fully exhaustive. Constant emissions would be at least one easily conceived idealised state of emissions.

Page 5, second lines 3-5 (in 2.3, the line numbering is confusing here): I have been doing some tests with the UVic ESCM by taking restart files from the preindustrial state with prescribed constant CO2 concentration and used them in a zero-emission driven simulation. The sudden transition from concentration driven to emission driven has caused some imbalances in the model’s carbon cycle, and the model was not in equilibrium anymore in contrast with my expectations. Therefore, I would guess there might be something similar happening in your case as well when you do the switch to zero emissions. Did you notice anything like that?

Page 5, second lines 6-7: The wording is a bit imprecise here. The negative emission scenario is only the negative emission part of 1% up, 1% down scenario. Maybe there is a way to be precise and keep the sentence still readable?

Page 6, line 16-17: Are the emissions raw model (annual) output or have you applied some running-mean averaging or something similar?

Page 6, line 27: I think the word “near-surface” is somewhat misleading here. It lead me to think whether only surface-ocean is included. I think that deep ocean carbon is farther away from surface than many fossil carbon reservoirs.

Page 6, Line 36 (or 2?): I would use “decrease” instead of slow. This sentence is also an example that would be more readable with a comma (As emissions slow, the land system. . .). Without comma, the beginning of the sentence could be misunderstood so that emissions slow the land system.

Page 6, Line 37 (or 3): What do you mean with “net emissions” here? Diagnosed fossil

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fuel emissions or are you taking into account the carbon released from land? If the former, the sentence might be more clear without the word “net”. If the latter (which I doubt), it should be written explicitly.

Page 7, Line 12: I would recommend replacing “not captured” with “not visible” or “not present” or something similar. To me, “not captured” sounds like a phrase you would use when a model cannot capture some process due to lack of relevant physical description.

Page 7, line 14: I would refer to Fig. 5c here.

Page 7, line 27: It’s probably clear to most readers, but I think it would be better to avoid the potential interpretation that slower warming itself is the cause when the cause is approximately that for a given warming, the longer simulation releases more carbon. Thus, I would rephrase the sentence. Page 7, second Line 8: I think the “when emissions cease” could be interpreted also to mean “after emissions cease”. Could you make it clearer that you are referring to the very moment of transition (e.g. at the turning point).

Page 8, Line 15: Can you explain the difference in ZEC between the experiments? Ehlert and Zickfeld (2017) would probably be a good reference here.

Page 10, Lines 21 and second 8: I would recommend using “I” instead of “we” in single-author paper.

Figure 2. This figure is basically replicating part of Figure 4, right? Is it necessary redundancy? Also, the lines are quite hard to read due to overlapping. Could you at least on the 1% side divide the line to 2X,4x,and 8x parts and say that 8x includes also the other two. I know that correcting this and keeping all the figures looking consistent is hard, but especially in Fig. 2b and d it’s hard to tell the lines apart.

Figures in general: The style is not entirely consistent. In some figures, the time axis is only to the end of the simulations while in others there is some empty space which I

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see no reason for (especially in Fig. 5bdf.)

Technical corrections: Page 4, Line 18: UVic ESCM

Page 5, Line 20 and elsewhere: I'm not sure of journal style, but I think normally you should capitalize "Figure" when coupled with a number.

Page 7, Line 32: Remove either "will" or "s"s in increases, deceases...

Figure 1 caption: add missing % after 0.46

REFERENCES Ehlert, D. & Zickfeld, K. What determines the warming commitment after cessation of CO<sub>2</sub> emissions? *Environ. Res. Lett.* 12, 015002 (2017).

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Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2018-150>, 2018.