

# ***Interactive comment on “Diverging responses of high-latitude CO<sub>2</sub> and CH<sub>4</sub> emissions in idealized climate change scenarios” by Philipp de Vrese et al.***

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de Vrese and coauthors present modeling study that investigates the response of the continental high latitude carbon cycle under "idealized" transient climate change with trend inversion at different points in time during the course of this century. The paper is in general very clear and addresses the important question of how the carbon cycle reacts under overshoot scenarios. It provides interesting into the complex interplay between the numerous processes and factors that would determine the trajectory of the climate system under overshoot scenarios, although it is clear that the current uncertainties (appropriately acknowledged in the paper) preclude firm predictions of

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the evolution of continental high latitude CO<sub>2</sub> and CH<sub>4</sub> fluxes under such scenarios.

The paper is well structured and also well written, although, as far as I can judge (I'm not a native speaker either), the English could be improved in many places (for example: 1 - there are many commas that would be in place in German but not in English; 2 - the possessive case is often wrongly used [" 's " should be used only for person, not for things as far as I know]; 3 - hyphenation is probably used too often between two nouns, just to give a few examples of what I think are repeated errors).

I have some comments and suggestions that I hope might be useful to clarify some aspects of the paper.

- L. 52-54: Clarify that large-scale models actually represent the thaw depth and do not represent processes like thaw settling and thermokarst, which occur faster ("abrupt"); these are indeed local processes but why should their occurrence be widespread?

- L.72-76: Indeed there isn't much literature focusing on the behaviour of the Arctic continental ecosystems under overshoot scenarios. But there are several global studies, I think, from which information about the Arctic might be extracted. Maybe also check what the IPCC SROCC and SR1.5 say?

- L.117: Hard to understand what is done here with  $r_{cin}$ . Maybe a schematic could help?

- L.125-129: The vertical discretization is better described later. The short description here is frustrating because one misses some detail.

- L.275: parameterization of permafrost acting against drainage: please justify (e.g. by citing appropriate references)

- L.365: "likely scenario" - in principle, the IPCC scenarios have no likelihood attached. Maybe sufficient to say that SSP585 is not "business as usual" (see the comment by Hausfather and Peters, Nature 2020)

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- L.371: Please specify which member of the historical ensemble was used (presumably the first?)

- L.455: Unclear whether the permafrost-affected area changes in time and between the perturbed physics ensemble members in terms of the analysis, or whether it is fixed. What is the impact on the results?

- L.470: CH<sub>4</sub> emissions small. Specify that this is also the case in terms of forcing in your model. Aren't these CH<sub>4</sub> emissions a bit low compared to current estimates?

- L.491: higher end of previous estimates: I have the impression that the near-surface permafrost extent in the MPI model has a very strong sensitivity to GSAT, compared to other models. Is this correct? If yes, what is the reason? Is the Arctic amplification particularly strong in this model or does the soil react very quickly and strongly?

- L.506-519: This tree fraction hysteresis is interesting and intriguing. Can you discuss this a bit more? What happens exactly? Why aren't these trees here in the first place? Is this realistic?

-L.520-531: Discussion a bit unclear. This got me really confused. Does this NPP increase lead to more litter? Is this increased litter fraction the reason for the emissions? Otherwise hard to see how there can be an emission increase without increasing soil carbon emissions. The carbon must go somewhere, and come from somewhere... Or does the vegetation carbon increase?

-L.660: At the end of this section, one wonders where all the sensitivity tests went. I have the impression that there could be made a better, clearer explicit use of the 40 members in terms of an assessment of the uncertainties.

-L.671: Soil methane oxidation increase: could refer to Oh et al. 2020 and discuss similarities & what is new

Some very minor specific suggestions:

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- L.4: "drive the model" might be better than "force the model"
- Abstract, L.7: not only GHG decrease, but also reverse climate change is imposed on the land surface model
- L.32: Arctic temperature increase twice the global mean - it might be more appropriate to compare the Arctic continental temperature change to the global continental average (but the numbers wouldn't be very different, probably)
- L.39: scenarios project a temperature increase between 3 and 8°C - it would be good to explicitly state that this uncertainty by 2100 comes to a very large degree from the diversity of the emission scenarios, not on the inter-model differences or internal variability
- L.43: timing of switch from sink to source highly uncertain - please provide some references here (maybe SROCC?)
- L.48: define what "near-surface permafrost" is.
- replace "arctic" or "artic" (found several times) by "Arctic"
- not sure "aerob" and "anaerob" are English words (should it read "(an)aerobic") - please check
- L.52: "permafrost-affectED soils"
- L.68: "the study's goal" -> "the goal of the study" (several such errors)
- L.72: Given that this refers to political temperature targets, it might be useful to use more post-Paris 2015 references here
- L.203: "be including" -> "by including"
- L.227 "Permafrost-physics" -> "Permafrost physics" (there are many more examples of what I suspect is wrong hyphenization is this text)
- L.335: "water tale" -> "water table"

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- L.343: CO<sub>2</sub> and CH<sub>4</sub> -> 2 and 4 are index, please.
- L.343: Please consider providing the equation even though many people know what a Q10 is
- L.360: simulation period: CMIP6 historical period finishes in 2014, not 2015. Please check.
- L.382: "One key factor, determining..." - I think this is one example of a comma that shouldn't be there
- L.402, Eq. 25: "n<sub>sim</sub> = n<sub>c,soil</sub> \*... \* n<sub>c,CH<sub>4</sub></sub> = 40" (add "= 40") - would make things clearer
- L.690: "Le Quéré", not "Quéré"
- L.701: "not one model included an adequate representation..." - this might be a bit harsh. CCSM4, for example, probably isn't that far from being adequate, depending of course of what one thinks is adequate.

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