

Review for *Quantifying land carbon cycle feedbacks under negative CO₂ emissions* by Chimuka et al., submitted to Biogeosciences

The authors present a new approach to quantify the land carbon cycle feedback under negative CO₂ emission. The UVic ESCM, an Earth system model of intermediate complexity (EMIC), is utilized to conduct the CDR-reversibility experiment, where the model is driven by 1-percent ramp-up and ramp-down of atmospheric CO₂ concentration. With the C4MIP-type setup of BGC and RAD, where only the biogeochemical and radiation effects are included in the model in order to separate the CO₂ concentration effect and climate effect, the carbon cycle feedback parameters of land and ocean are quantified for the ramp-up and ramp-down phases respectively. The authors further conduct the emission-driven Zeroemit experiments, which stop the emission and have the carbon cycle freely evolving. The results are again used to calculate the feedback parameters. By comparing the feedback parameters calculated from the ramp-down phase and Zeroemit experiments, the effects of climate inertia are isolated, and the resulting feedback parameters of negative emissions are then closer to that of positive emissions.

The manuscript is well-written and clearly structured. The results are also nicely presented. There are only some issues remain to be clarified in the manuscript. Please see below for my comments.

1. I have some issues with the terminologies used in the manuscript. For example, in the first research questions raised by the authors, the magnitudes of carbon cycle feedbacks under negative and positive emissions are to be compared. However, it is answered in the manuscript that the feedbacks are different because of the climate inertia after the ramp-up phase. However, under a paleoclimate or future climate change context, negative emission does not necessarily immediately follow a ramp-up phase as in the CDR-reversibility experiments.
2. While the results of the current study is helpful for understanding the climate system, it would be better if implications can be drawn connected to current climate change and possible future scenarios corresponding to our climate targets.
3. The authors are encouraged to further connect the results of the current study more to the context of some of the following studies:
 - Jeltsch-Thömmes, A., Stocker, T. F., & Joos, F. (2020). Hysteresis of the Earth system under positive and negative CO₂ emissions. *Environmental Research Letters*, 15(12), 124026. <https://doi.org/10.1088/1748-9326/abc4af>
 - Koven, C. D., Arora, V. K., Cadule, P., Fisher, R. A., Jones, C. D., Lawrence, D. M.,

Lewis, J., Lindsay, K., Mathesius, S., Meinshausen, M., Mills, M., Nicholls, Z., Sanderson, B. M., Séférian, R., Swart, N. C., Wieder, W. R., and Zickfeld, K.: Multi-century dynamics of the climate and carbon cycle under both high and net negative emissions scenarios, *Earth Syst. Dynam.*, 13, 885–909, <https://doi.org/10.5194/esd-13-885-2022>, 2022.

- MacDougall, A. H.: Estimated effect of the permafrost carbon feedback on the zero emissions commitment to climate change, *Biogeosciences*, 18, 4937–4952, <https://doi.org/10.5194/bg-18-4937-2021>, 2021.

Minor comments:

- The authors are encouraged to provide some insights of what the differences might be between using a comprehensive Earth system model and an EMIC as UVic.
- L12: UVic is not an Earth system model. I would prefer to always specify out that UVic is an EMIC.
- L13-L14: The carbon cycle feedbacks differ in ramp-up and ramp-down phases, not because the difference between positive and negative emission, but because the climate inertia, as mentioned in the manuscript.
- L125-L129: How long is the Zeroemit simulation? Additionally, it is not mentioned in the manuscript at which time point the feedback parameters are calculated.
- L301-L305: I would expect at which time point the feedback parameters are calculated should already be presented in Section 2.
- L353:
 - Figure 7 caption: Should be *(e)* soil carbon change and *(f)* ocean carbon change.
 - The meaning of *A//* is not explained.
- L368-L371: The sentence could be rewritten to made simpler.