Earth System Dynamics Discussions

Earth Syst. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/esd-2022-39-RC2, 2022

Comment on esd-2022-39

Kirsten Zickfeld (Referee)

Referee comment on "Emit now, mitigate later? Earth system reversibility under overshoots of different magnitudes and durations" by Jörg Schwinger et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2022-39-RC2, 2022

Schwinger et al investigate the reversibility of the Earth system for a range of idealized scenarios that differ with regard to the amount and duration of overshoot. They consider a change to be reversible if the modelled ensemble mean of an overshoot simulation returns to the reference simulation within the range of internal variability. Consistently with earlier studies they find that most Earth system changes are reversible, except for aspects with longer response timescales, such as permafrost carbon and seawater properties of the deep ocean. They do not identify tipping points in their simulations following overshoot.

The manuscript by Schwinger et al. is a valuable contribution to a relatively small body of literature that investigates Earths system reversibility in emissions-driven simulations, allowing for feedback between climate and the carbon cycle. The manuscript is well written, the methodology is adequate and sufficiently documented, and the conclusions are supported by the findings. There are a few instances where the manuscript would benefit from additional explanations, or definition of terminology for an interdisciplinary readership.

Specific comments:

l.185: Comparing reversibility for a given year has the disadvantage that it does not allow for a clean separation of the effect of overshoot duration, as differences could also be due to shorter time left to adjust to the final forcing level in the longer vs. shorter overshoot simulations.

l. 265: It could be pointed out that atmospheric CO2 in the overshoot simulations temporarily “undershoots” CO2 levels in the reference simulation.

l. 283: Before discussing fractional quantities in Fig. 4 I suggest to discuss the cumulative fluxes (Fig. 3), which don't have the denominator changing at the same time and are therefore more intuitive. Here the reason for the decline in the cumulative fluxes during the negative emissions phase could be explained (e.g. the reversal in pCO2 gradient mentioned in l. 387-388.).

l. 350: Section 3.5: I suggest to define and explain the meaning of the biogeochemical quantities discussed in this section (preformed vs. remineralized carbon, AOU etc.) to make sure the findings are accessible to an interdisciplinary readership.

l. 377: Mention that inclusion of vegetation dynamics could affect reversibility.

l. 387-388: This is the first time this is mentioned. I suggest to discuss this earlier (e.g. in section 3.3.).

l. 390: Irreversibility of thermosteric sea level rise was also investigated in Ehlert & Zickfeld, 2018, https://doi.org/10.5194/esd-9-197-2018.

l. 395 – 398: I don't follow this argument. Perhaps the amount of sea-level rise corresponding to a 1.5C global warming limit was "implicitly accepted", but not the additional sea level rise resulting from overshoot of the warming limit?

Figure presentation: Vertical lines showing the positive emissions, negative emissions and zero emissions phases could be included. Also, it would be helpful to have the legend repeated in figures where changes are non-monotonic as a function of overshoot size or duration (e.g. Figs. 5 and 6).