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Earth System Dynamics
Discussions

Interactive comment on "Irreversible ocean thermal expansion under negative CO_2 emissions" *by* Dana Ehlert and Kirsten Zickfeld

Anonymous Referee #3

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The authors investigated the reversibility of the ocean thermal expansion (the thermosteric sea level rise) to idealized CO2 forcing using a climate model of intermediate complexity. In their experiments, they first ramped up the CO2 concentration by 1% yearly to quadrupling and then decreased it by 1% yearly back to the preindustrial value, after which the simulations were carried on for another 1000 plus years with fixed CO2 concentration. They found that the thermosteric sea level rise is irreversible on human time scales and it continues to rise 80 years after the reversal of CO2 forcing. They further reported that the rates of sea level rise/decline in their model generally increase with higher vertical diffusivity, with exceptions of overshoot of ocean circulations.

The manuscript deals with an important issue of climate change and could contribute

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Discussion paper

to understandings of the reversibility of the climate system. The experiments and analyses are systematic and comprehensive. However, I feel that some issues should be addressed before it can be accepted. Please see my detailed comments bellow.

Major comments:

1. It would be useful if the authors can list the equilibrium climate sensitivity of the model they used, and briefly compare it with the current generation of climate models (the IPCC models). It may also help the readers if the authors can also compare the transient climate sensitivity across the sensitivity experiments with different mixing in their study. This can give the readers an idea of the effect of ocean mixing on the climate sensitivity.

2. The authors used a coupled model to carry out long simulations (longer than 1000 years). It is unclear whether the model is run with flux adjustment or the model is subject to large trend in the deep ocean. If there is any trend in the deep ocean, how does this influence the current results?

3. It surprises me that the mean sea level change lags the CO2 forcing by the same amount of time (80 years) in all the sensitivity experiments. It seems that the lag time is not dependent on the details of ocean mixing. Then, the question is what is setting this lag time? Is it possible that the lag time is model dependent? It looks to me that equation on Page 5 Line 20 is the place to start discussing this problem more carefully.

4. When reviewing previous studies on the reversibility of the climate system, I think Wu et al. (2010) is worth mentioning, in which paper the author described the hysteresis behavior of the hydrological cycle in response to a ramping down of CO2 forcing.

5. Mignot et al. (2007) is one of the first papers discussing the subsurface warming and the overshoot of the AMOC, which process is closely related to the overshoot of the AMOC reported in the present manuscript.

Minor comments:

1. Page 2, Line 22: Boutes et al. SHOULD BE CHANGED TO , Boutes et al.
2. Page 2, Line 26: are that is has SHOULD BE CHANGED TO are that it has

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