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

Anonymous Referee #2

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The author investigated the reversibility of ocean heat uptake and sea level due to thermal expansion by linearly increasing and then decreasing atmospheric CO2 in the UVic ESCM. They found that the sea level continues for several decades after atmo- spheric CO2 starts to decline and does not return to the pre-industrial level. They fur- ther tested the sensitivity of vertical sub-grid scale ocean mixing and concluded that, in most cases, both rise and decline rate of sea level increase with increasing vertical ocean mixing.

This paper is potentially interesting and focuses on an important topic in the context of the Paris Agreement. I recommend this manuscript to be published in Earth System Dynamics pending on minor revisions. I have detailed my comments below.

Response: We want to thank the reviewer for a positive review.

1. The authors may want to explore more about the path of ocean heat take and storage beyond the AABW formation and AMOC. For example, either observations and coupled climate models show that anthropogenic warming enters the Southern Ocean along the downwelling branch of the residual MOC (Liu et al. 2016), and heat is mostly stored preferentially stored around 45S where surface waters are subducted to the north (Armour et al. 2016). The authors' results also reveal this path, and moreover, show that it is independent from the AABW formation. In Fig. 7, either the default mixing or other settings (e.g., B&L high, constant 1.0) show a warming tongue extending from surface around 45S to deep ocean. By contrast, cooling occurs along the shelf of the Antarctic as related to the AABW formation.

Response: Thank you for pointing to these interesting articles. We included a discussion on the warming tongue seen in Figure 3 and the findings from the above mentioned articles in the manuscript.

2.Page 12, lines 3-4 "AMOC responses to global warming have been well studied (Stocker and Schmittner, 1997; Rahmstorf, 2006; Meehl et al., 2007) and the decline in the AMOC under warming is due to surface warming and freshening of North Atlantic surface waters (Rahmstorf, 2006)." Herein the authors may want to notice that the AMOC response to global warming is also related to AMOC stability (Liu et al. 2017). The AMOC may moderately weaken or collapse in response to CO2 increase, depending on which stability regime it resides in current climate.

Response: Thank you for pointing to this interesting article we cited in the manuscript.

3. Besides the global sea level change, I (also many other readers) am interested in the regional sea level change since it is critical to particular coastal regions. I am wondering whether the authors can make some discussions about this. One key is that a great change of ocean circulation, for example, the AMOC weakening or overshoot, can modulate the dynamic sea level in the Atlantic and Southern Ocean.

Response: Regional sea level changes in an interesting research question. However, this manuscript focusses on global mean sea level rise and including analyses and discussions around regional sea level changes is beyond the scope of this paper.

References

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3. Armour KC, J Marshall, J Scott, A Donohoe and ER Newsom, 2016, Southern Ocean warming delayed by circumpolar upwelling and equatorward transport. Nature Geosci., 9, 549–554.

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