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Comment on bg-2022-134

Anonymous Referee #1

Referee comment on "Observation-constrained estimates of the global ocean carbon sink from Earth system models" by Jens Terhaar et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-134-RC1, 2022

Review of "Observation-constrained estimates of the global ocean carbon sink from Earth system model"

The study applies observational constraints to adjust Earth system model estimates of the global ocean carbon sink. The observational constraints are the sea surface salinity in the subtropical-polar front in the Southern Ocean (as applied previously by the authors in Terhaar et al, 2021), the Atlantic Meridional Overturning Circulation (AMOC) and the Revelle buffer factor. These observational choices are plausible and the benefits of applying them are clearly set out in an iterative manner in Figure 3. The outcome is a slight elevation of the global ocean carbon sink and almost a halving of the model uncertainty, which are important improvements.

The study is comprehensive and written up in a detailed manner. In places the level of detail seemed to detract from the central message, such as discussing the details of the biological contributions when that appears to be a rather minor contribution in the global carbon uptake for anthropogenic timescales.

The only concern I raise is the particular choice of the observational constraints and while

this set of choices is plausible, there are other choices that might have led to similar improvements.

So including a discussion of other choices would be helpful to the reader. For example, would a measure of the strength of the winds at key locations provide a similar benefit to the measure of the AMOC or a measure of the winter mixed layer thickness derived from Argo be beneficial? The AMOC might be used here as a proxy for ocean ventilation, but that need not be the case with gyre-scale subduction not being causally related to the AMOC. The use of the Revelle buffer factor is a plausible constraint, but the justification for that could be expanded, see possible theoretical links that can be explored or are there other references that can be utilised?

In summary, this is a comprehensive study that provides a plausible adjustment of Earth system model output to improve their projections of the global ocean carbon sink. I think that this work is important and I recommend acceptance subject to the minor points raised being addressed.

Detailed points;

L47 The text is assuming that the AMOC is leading to the basin-scale subduction. I think that this statement is combining together two different processes. Subduction in ocean basins is primarily linked to the gyre circulation and the vertical and lateral transfer from the winter mixed layer to the thermocline. The AMOC is a longitudinally-averaged overturning circulation that contributes to the ventilation process by redistributing heat and tracers, but is not the same as subduction.

L50 The Revelle factor certainly does affect the capacity of the ocean to take up carbon. This aspect could be expanded more. The air-sea partitioning of carbon is affected by the buffer factor (Goodwin et al., 20008 & 2009; Katavouta et al., 2018). In addition, the air-sea equilibration timescale, tau, for carbon dioxide is affected by the buffer factor, tau =(h/K_g)(DIC/(B CO2) where h is mixed layer thickness, K_g is exchange velocity, DIC is dissolved inorganic carbon, B is the buffer factor and CO2 is dissolved CO2.

L106 Improve syntax,”so-estimated”

L109 Improve wording

L163 Adjust wording

L173 An important point is being made as the role of the salinity and AMOC in determining water-mass formation. A list of 4 references are provided, but are they being cited as to their work on water-mass formation or did they propose the connections tbetween salinity and the AMOC to water-mass formation?

Figure 3 is very clear and key to the study.

L230-231. Perhaps reword to make clearer.

L251 Cut hence.

L297 Buckley and Marshall provided a review of heat transport, but did they make the point about anthropogenic carbon uptake?

Appendix A3 Equation (2) and perhaps (3) are central to the study. I would recommend that this subsection moved into the heart of the paper.

References

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