

2 Response to reviewer 2

General Comments

This manuscript provides an alternative procedure to estimate the historical ocean carbon sink by combining ocean-only models forced by atmospheric reanalysis and ESMs. This hybrid approach gives a total ocean sink that is close to the estimate of the Global Carbon Budget but with a significantly reduced uncertainty. The manuscript is clear and it would represent a valuable contribution to the effort of improving our estimates of ocean carbon sink. I think the manuscript is close to a form that could be published. I only have two observations regarding the significance of the results and the way they are presented.

Response:

We thank the reviewer for their positive evaluation and the indeed very constructive and helpful comments, which have substantially improved the manuscript. We have taken each comment into account, provide responses to each point below, and adapted the manuscript accordingly.

Comment 2.1

The main “selling point” of this analysis is the reduced uncertainty in the hybrid estimate of total ocean carbon sink. However, part of this small uncertainty comes from a good agreement of the interannual variability across GOBMs, as it is highlighted by Fig. 1d. It is briefly mentioned that most models use either JRA55-do or ERA5 atmospheric forcing and that two models that use a different atmospheric forcing show some deviations. I think adding some considerations about this point would improve the manuscript. Maybe provide a count of how many models used each atmospheric forcing to give an idea of the diversity in the choices. Most interannual variability in these simulations will come from the atmospheric forcing and therefore, if there is little variability in the atmospheric forcing, you can't expect a large interannual variability in the ocean CO₂ uptake.

Response:

As suggested by the reviewer, we now added a count of how many models used the respective atmospheric forcing datasets:

"Small common differences in the anomalies exist in 1985 and 1998 for the GOBMs NorESM1-OCv1.2 (Schwinger et al., 2016) and MPIOM-HAMOCC6 (Lacroix et al., 2021b) (Fig. 1b), likely because both use the NCEP reanalysis data (Kanamitsu et al., 2002) to force the simulations and not the JRA55-do (Tsuji et al., 2018) that is used by 7 GOBMs or ERA5 reanalysis datasets (Hersbach et al., 2020) that is used by one GOBM."

Furthermore, we have added a consideration about the influence of the low diversity in atmospheric forcing data and have put it into the context of the total differences in the simulated carbon sink that is simulated by GOBMs:

"While the differences in the anomalies might be too small due to the small diversity in atmospheric forcing datasets, even the difference in the anomalies between GOBMs that use different forcing data is much smaller than the difference of the absolute fluxes simulated by GOBMs (Fig. 1a), which was removed by calculating the anomalies. Thus, the overall strong agreement in simulated anomalies of the global ocean carbon sink across these 10 GOBMs as expressed by the small multi-model standard deviation and between GOBMs that use different atmospheric forcing data gives high confidence in the multi-model mean estimate of the high-frequency variability of the simulated global ocean carbon sink by GOBMs (Fig. 1d)."

Comment 2.2

I understand that the procedure to extract the strengths of both classes of models is performed only considering global integrals of the ocean carbon uptake. Since, again, the main added value of this approach is the reduced uncertainty, and considering that regional differences across models in ocean C uptake might cancel each other's out – i.e. a low Southern Ocean C sink might be compensated by a high N Atlantic C sink and show a similar global uptake of another model with opposite regional characteristics – I think it would be beneficial for the papers to briefly discuss this potential caveat. It is suggested that this approach could also be applied to regional budgets. That would be the place to briefly discuss the possibility of a larger uncertainty across GOBMs in a given region.

Response:

As suggested, I now have added a brief consideration about the possibility of larger regional differences compared to global differences, both in ESMs and GOBMs:

"Regionally composite estimates might, however, have larger uncertainties as differences in regional carbon sink estimates are often larger than global estimates (DeVries et al., 2023; Yasunaka et al., 2023; Hauck et al., 2023b; Perez et al., 2023; Terhaar et al., 2021c, 2022, 2021a, 2024), possibly due to a compensation of regional carbon fluxes, e.g., a low Southern Ocean carbon uptake can be compensated by a high North Atlantic Ocean carbon uptake."

Comment 2.3

- Line 83: a verb seems to be missing.

Response:

I am really sorry, but I cannot find the place where a verb might be missing. As a non-native speaker, the sentence appears to be correct. I would be grateful if the reviewer could point me exactly to the part of the sentence where the word seems to be missing, so that I can correct the wording.

Comment 2.4

- Line 130: a year is missing after "until"

Response:

Following the reviewers comment, the sentence was corrected by removing the word "until".