

Biogeosciences Discuss., referee comment RC2
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Comment on bg-2022-166

Anonymous Referee #2

Referee comment on "Reconstructing ocean carbon storage with CMIP6 Earth system models and synthetic Argo observations" by Katherine E. Turner et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-166-RC2>, 2022

In this study Turner et al. reconstruct the ocean carbon storage from first-order relationships between temperature, salinity and atmospheric CO₂ and Dissolved Inorganic Carbon (DIC). The authors use a set of CMIP6 models to assess these relationships and estimate the covariance fields. The inferred statistical relations are then used to reconstruct the carbon storage from hydrographic pseudo-observations. In order to test the capabilities of this approach, two sampling methods are proposed: 1) a complete coverage using CMIP6 co-located observations and 2) Irregular sampling consistent with Argo profiles. While co-located observation (1) is taken as a sensitivity test, the irregular Argo-style observations (2) show the potential of this method to use real Argo measurements to reconstruct the carbon storage. Both of the sampling methods offer a significant improvement compared to the reconstruction based solely on the climatological mean. The study is well-written, presented in a structured logical manner and the results and their implications are easy to follow.

This study represents a significant advancement within the field, offering a powerful method to understand both the spatial and temporal variability of DIC. This method could not only be used to reconstruct the carbon storage from real hydrographic measurements but also, the resulting DIC fields could be used to identify differences between linear and non-linear mapping methods as well as explore the differences in the processes that affect the DIC between different models. Based on the aforementioned, I recommend the publication of this study. Here are just some suggestions I believe would add value to the publication:

General Comments:

- There is an emphasis throughout the manuscript on the application of this method to reconstruct ocean carbon storage from real-world Argo observations. I was expecting such reconstruction at the end of the paper and a comparison to existing reconstructions (such

as GLODAP). I understand that this paper is intended as a "proof of concept" study, followed by another one regarding its "real-world applications". If this is decided as the final form of the study, without including the reconstruction using real Argo measurements, I think the potential application to Argo measurements should be de-emphasized throughout the text.

- The results in this study are focused on the top 100m, however, I couldn't find in the text the motivation to choose such a horizon. Is it because the mixed layer drives the variability in carbon sink? Or, do the statistical relationships between temperature and salinity and DIC break down in the interior ocean?

- Since it is possible to separate the detrended covariance fields into pCO₂ and non-pCO₂ terms, if I understood it correctly, it would also be possible to reconstruct the preindustrial DIC and thus calculate the Anthropogenic Carbon fields as the difference between Total and the Preindustrial DIC. If this is possible, it should be mentioned in the paper as possible applications of the method, as there is a significant interest in the community regarding the drivers of the variability of anthropogenic carbon sink (e.g. Gruber et al., 2018: 10.1146/annurev-marine-121916-063407; Gruber et al. 2019: 10.1126/science.aau5153; DeVries 2017: 10.1038/nature21068).

- When reconstructing the carbon time-series from Argo-style observations in Section 6, two observation locations are used, one at year 2002 (with very sparse observations) and another at year 2015 (with many more observations). As far as I understand, the entire time-series (1955-2014) is reconstructed based on the spatial distribution of Argo observation locations in 2002 and 2015, but the number of locations is constant in time. E.g. carbon storage in 1960s is reconstructed from observations that did not exist in the real world. Why not account for both the temporal and spatial distribution of the observation locations? This would give a true insight into the potential of the real-world Argo measurements to reconstruct the time series of carbon storage.

Comments by Line:

L150: What does it mean "6 months of profiles"? One profile at least in each of the 6 months? 6 profiles in total?

L198: I think there should be a full stop after pCO₂ instead of a coma to make the sentence less confusing.

L199: Should DIC' and T' be in italics?

Figure 4: Would it be possible to use the same colorscale? This would make the comparison of the magnitude of the coefficients more intuitive.

L378: Do you mean Fig 6a and d, instead of a and c?