Ocean Science Discussions

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Review of "Observation System Simulation Experiments in the Atlantic Ocean for enhanced surface ocean pCO2 reconstructions" by Denvil-Sommer et al.

Luke Gregor (Referee)

Referee comment on "Observation system simulation experiments in the Atlantic Ocean for enhanced surface ocean pCO_2 reconstructions" by Anna Denvil-Sommer et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-17-RC2, 2021

The manuscript submitted by Anna Denvil-Sommer and colleagues investigates 11 sampling strategies for the Atlantic Ocean in simulation experiments (OSSEs) using model output. The goal of this study is to evaluate the performance of a feed-forward neural network (FFNN) with additional sampling platforms compared to SOCAT only FFNN output, which is typically used gap-filling approaches. In addition to SOCAT, Argo floats are tested at various sampling densities and moorings are included. Overall, I enjoyed reading the manuscript and I think that the study is interesting and presents very interesting information about the potential biases that undersampling has on air sea CO2 fluxes when using the FFNN approach. However, there are changes that need to be made before the manuscript is suitable for publication.

Below, I have listed some of my major concerns and recommendations and I've made in-text comments in the PDF attached as a supplement (use Adobe Reader for best results).

DISCUSSION

I feel that the study could be more strengthened by adding a discussion section where the implications of the study and limitations of the approach are addressed. Some points that would be good to add here are (not in order of importance):

- **Higher resolution compared with previous studies**: This is a considerable step up from the typically used 1° by monthly resolution. The high temporal resolution is particularly interesting, especially considering the inclusion of mooring data, which could provide data at a daily resolution. An interesting question is then related to scale, are these improvements realized when the experiment is run at lower resolution? This

is perhaps not a question for this study, but it would be interesting to test at some point.

- **Sampling frequency of floats and representation error:** In your study the sampling frequency is 5 days. Typically, Argo floats sample at 10 days. Further, Argo floats that sample at a 10-day resolution are only briefly at the surface. This topic is discussed in Monteiro et al. (2015, https://doi.org/10.1002/2015GL066009). In a dynamic region, this might introduce representation error (where the in-situ measurement is not representative of the 5-day mean). This is perhaps a limitation of the study that should be mentioned.
- **Other gap-filling methods:** the method used here, FFNN, uses latitude and longitude as feature variables. Do the authors think that this could also apply to other approaches such as SOMFFN which uses "remote" information through the clustering approach?
- **The comparability of the simulated environment to reality:** One has to make the assumption that the model output is some representation of reality in OSSE work. However, it would be good for the authors to make some statement about the model's ability to represent the seasonality and variability of pCO2.
- **The uncertainty of measurements:** The authors state that they will address this in their next study. A bit more depth on this topic would really show the need for the study that they are planning to publish.

INTRODUCTION

The introduction could be bolstered with a paragraph dedicated to previous work on OSSEs. See the following literature:

- Kamenkovich, I., Haza, A., Gray, A. R., Dufour, C. O., & Garraffo, Z. (2017). Observing System Simulation Experiments for an array of autonomous biogeochemical profiling floats in the Southern Ocean. Journal of Geophysical Research: Oceans, 122(9), 7595–7611. https://doi.org/10.1002/2017JC012819
- Majkut, J. D., Sarmiento, J. L., & Rodgers, K. B. (2014). A growing oceanic carbon uptake: Results from an inversion study of surface pCO2 data. Global Biogeochemical Cycles, 28(4), 335–351. https://doi.org/10.1002/2013GB004585
- Lenton, A., Bopp, L., & Matear, R. J. (2009). Strategies for high-latitude northern hemisphere CO2 sampling now and in the future. Deep-Sea Research Part II: Topical Studies in Oceanography, 56(8–10), 523–532. https://doi.org/10.1016/j.dsr2.2008.12.008
- Scheel Monteiro, P. M., Schuster, U., Hood, M., Lenton, A., Metzl, N., Olsen, A., Rodgers, K. B., Sabine, C. L., Takahashi, T. T., Tilbrook, B., Yoder, J. A., Wanninkhof, R. H., & Watson, A. J. (2010). A Global Sea Surface Carbon Observing System: Assessment of Changing Sea Surface CO2 and Air-Sea CO2 Fluxes. Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society, 1, 702–714. https://doi.org/10.5270/OceanObs09.cwp.64

FIGURES

I like the choice of figures, but I feel that they could be improved by keeping the following in mind:

- Increase the axes label and legend text size
- Improve subplot title and number placement
- Captions should be more descriptive. There is very little information at the moment.
- The data to ink ratio is sometimes skewed too heavily toward the latter. The data should always be prioritized. Some pointers in this regard:
  - Remove excess axes lines (e.g. target plots have a lot of empty space)
  - If axes limits are shared, only the leftmost and bottom figures would need axes labels.
  - For maps, don't draw rivers – they are not important for your study.
  - Scale the color bars proportionately to the figures.
- I've noticed that markers for OSSEs 1, 3, 4, and 10 are in bold. Be explicit why these are bold.

Please also note the supplement to this comment:
https://os.copernicus.org/preprints/os-2021-17/os-2021-17-RC2-supplement.pdf