Review#2

Review of "Subsurface oxygen maximum in oligotrophic marine ecosystems: mapping the interaction between physical and biogeochemical processes" by Di Biagio et al.

The authors analyzed an existing coupled physical-biogeochemical model and mapped the subsurface oxygen maximum concentration and depth in the Mediterranean Sea. They proposed SOM to be a suitable feature in oligotrophic seas to evaluate and monitor the ecosystem state.

This manuscript is very well written and structured, and its topic is interesting enough. However, I have one major concern. The model applied data assimilation for biological variables. How would this artificial factor impact vertical structures of biological variables and their budget analysis? Does their present conclusion/result still stand? This concern has to be addressed to insure that the analysis is meaningful and make their story convincing.
Citation: https://doi.org/10.5194/bg-2022-70-RC2

Reply

We are very thankful for the Reviewer#2's overall comment on the manuscript, which gave us the opportunity to discuss an important aspect.

The dissolved oxygen budget is closed and the mass conservation of oxygen is respected (i.e., no artificial fluxes are introduced). Physical data assimilation corrects ocean dynamics but the solution of the transport of oxygen respects mass conservation. Biogeochemical assimilation changes only phytoplankton biomass and not oxygen concentration.

In particular, the observations assimilated in the biogeochemical reanalysis are satellite chlorophyll measurements, and not oxygen profiles. In the data assimilation procedure, the content of chlorophyll, carbon, nitrogen, phosphorus, and silicon of four phytoplankton groups (i.e., diatoms, autotrophic nanoflagellates, picophytoplankton and large phytoplankton) is updated at a weekly frequency during the simulation. The processes of production/consumption of oxygen indicated in Eq. 1 of the manuscript are instead dynamically and consistently solved within the model. Therefore, the oxygen budget has not been influenced directly by the data assimilation procedure. In other words, data assimilation did not directly cause creation/destruction of oxygen content in the seawater.

Indeed, a hindcast simulation could have produced to verify the impact of assimilation on oxygen dynamics and budget, however we would like to highlight that the chlorophyll data assimilation proved to be fundamental to better simulate the vertical dynamics of the marine ecosystem and in particular the depth of the deep chlorophyll maximum (Teruzzi et al, 2014; Salon et al, 2019), that is connected also with subsurface oxygen production. In particular, we have recently analysed the variability of dissolved oxygen in the Southern Adriatic Sea by using the same biogeochemical reanalysis and we estimated that the summer SOM dynamics are positively correlated with the chlorophyll concentration in 30-80 m layer hosting the deep chlorophyll maximum (Di Biagio et al., in review). Reanalyses are widely used for investigating not only ocean state and variability but also both physical and biogeochemical processes (e.g., Liu et al., 2017; Ford et al., 2018; Pinardi et al., 2019; de Boisseson et al., 2022; Ozer et al., 2022).

Moreover, the off-line oxygen budget has been computed on monthly means of dissolved oxygen, where this average computation further filtered variations due to the internal dynamical adjustment of the model after assimilation (Cossarini et al., 2019 - Fig. 11 - analyse the time scale of the biogeochemical model adjustment after assimilation).

We propose to include a synthetic version of this reply in the Discussion section of the manuscript as follows:

The oxygen budget has been reconstructed in retrospect by using the reanalysis output. Since data assimilation procedure does not directly affect the oxygen budget, this latter is closed and consistent. Moreover, it has been computed on monthly means of dissolved oxygen, where the average computation further filtered variations due to the internal dynamical adjustment of the model after data assimilation (Cossarini et al., 2019).

Di Biagio V., Martellucci R., Menna M., Teruzzi A., Amadio C., Elena, Mauri E., Cossarini G.: Dissolved oxygen as indicator of multiple drivers of the marine ecosystem: the Southern Adriatic Sea case study, State of the Planet, 7th edition of the Copernicus Marine Service Ocean State Report (OSR 7), in review.

Liu, Y., Meier, H. E. M., and Eilola, K. , (2017). Nutrient transports in the Baltic Sea – results from a 30-year physical–biogeochemical reanalysis, Biogeosciences, 14, 2113–2131, https://doi.org/10.5194/bg-14-2113-2017.

Ford, D., Key, S., McEwan, R., Totterdell, I., & Gehlen, M. (2018). Marine biogeochemical modelling and data assimilation for operational forecasting, reanalysis, and climate research. New Frontiers in Operational Oceanography, 625-652.

Pinardi, N., Cessi, P., Borile, F., & Wolfe, C. L. (2019). The Mediterranean sea overturning circulation. Journal of Physical Oceanography, 49(7), 1699-1721.

de Boisseson, E., Balmaseda, M., Mayer, M., and Zuo, H. (2022): Monitoring and predictions of Marine Heatwave events in the North East Pacific from ocean reanalyses and seasonal forecasts, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-4079, https://doi.org/10.5194/egusphere-egu22-4079.

Ozer, T., Gertman, I., Gildor, H., & Herut, B. (2022). Thermohaline Temporal Variability of the SE Mediterranean Coastal Waters (Israel)–Long-Term Trends, Seasonality, and Connectivity. Frontiers in Marine Science.

Cossarini, G., Mariotti, L., Feudale, L., Mignot, A., Salon, S., Taillandier, V., ... & d'Ortenzio, F. (2019). Towards operational 3D-Var assimilation of chlorophyll Biogeochemical-Argo float data into a biogeochemical model of the Mediterranean Sea. Ocean Modelling, 133, 112-128.