Comment on essd-2021-194

Anonymous Referee #2

Referee comment on "Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020" by Matthew A. Chamberlain et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2021-194-RC2, 2021

Review of “Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020” manuscript.

The Next generation of Bluelink ocean reanalysis with multiscale data assimilation: BRAN2020” manuscript presents a new attempt to better estimate ocean dynamics in the multi-decadal global ocean arena. The structure of the manuscript is well organized and scientific ideas are correctly exposed.

Thank you for reading the manuscript and the useful comments.

General comment:

In the manuscript, the authors applied the EnKF-C method to propagate observations information inside the ocean model. In my opinion, omitting sea ice in the system is a major problem, it is an important phenomenon influencing dynamics in the Southern Ocean. Using analysis every 3 days seems too frequent for the global ocean model having a spatial resolution of 1/10 degree. For example, GLORY NEMO experiment is using a 14-days assimilation window. Some discussion along the lines would be necessary; how authors decided for 3-days as an appropriate assimilation window. Seems to me that it’s quite short (or is quite often – every 3 days) time span between analysis, and is a way of imposing stiff control over the ocean system i.e. suppressing model physics to fully develop. Initialization of the temperature fields by using the daily averaged values seems strange, the model vertical resolution in the surface layers is 5m which is prohibiting diurnal oscillations to fully develop. In that sense, the model is not resolving diurnal SST dynamics (not sure about the temporal frequency of atmosphere forcing), and this shouldn’t be the reason for using daily fields (which are dynamically unbalanced). As assimilation is done on the two different scales, could the time step for applying analysis be different (longer for large scale and shorter for mesoscale)?

A paragraph has been added to the introduction to give a better context to the work done.
The development of BRAN is in support of operational ocean forecasting around Australia and has found many other applications across this broad region, now listed in the introduction as well. As such, BRAN does not focus on dynamics close to Antarctica or processes associated with sea ice at this stage.
However, the Bluelink Project intends to include sea ice in future versions of BRAN.

GLORYS12 has recently been published (Lellouche et al. 2021., Frontiers in Earth Science, doi:10.3389/feart.2021.698876) and is a similar configuration to BRAN, in domain and resolution. GLORYS12 used a data cycle of 7 days and overall obs.-model differences are very comparable, even though the two systems implement corrections differently; e.g., see panels (d) from Fig.s 7 and 8 here alongside panels C and D of Lellouche et al. 2021.
3-day cycles have been used in BRAN for several years (e.g. Oke et al. 2018, doi:10.1016/j.dsr2.2018.09.012), and now cited in Section 2.1.

In 3rd version of BRAN (Oke et al. 2013, doi:10.1016/j.ocemod.2013.03.008), the analysis cycle was reduced from 7 to 4 days, which was shown to substantially reduce both misfits to observations and magnitude of corrections applied.

The objective in these reanalyses is to follow the observed mesoscale dynamics as much as possible and not allow the model physics to drift too far.
Over this time frame, error growth is about linear, the longer the analysis cycle the further any model will drift from the observed ocean. The benefits of a shorter cycle lengths are smaller errors, at the cost of extra computation. Other free-running experiments might be better suited to studying internal ocean processes where model physics are free to develop.

To clarify, daily averaged temperatures are used just as background fields to the data assimilation (described in section 2.1). The correction/increment calculated is applied back to the original, instantaneous restart, so that the model does simulate subdiurnal processes (even though they are not saved). The temporal resolution of the JRA55-do forcing is subdiurnal.

During development of the multiscale DA system, applying coarse DA on a longer timestep was tested but it was found that errors accumulated due to model bias over the longer cycle.

Specific comments:

Line 54: Are authors referring to common term residuals of data assimilation when they talk about the difference between the analysis and observation?

The analysis innovations are similar to the 'residuals' as they are described in some papers.
'Also, referred to as "residuals,"' is added to the text here.

Line 180: Not sure if this is a typo mistake: " super-obing". It sounds a bit strange, usually, we refer to "super-obs" or "super-observations".

This short-hand term has been replaced with the full term, "super-observations," as suggested.

Line 197: Analysis innovations are sensitive to the observation errors, and in that sense are the observation errors constant in space/time or they are varying (for specific observation type)? If not do authors think it would improve the assimilation system?

Different observation types are used to manage varying observation errors, these errors are constant within a type. Note that there are different SST types in Table 1 with different errors that are assimilated into the reanalysis for years they were available.
We have captured most of the evolution of observation errors over the course of this new reanalysis, with the exception of AVHRR-SST which should have a larger error, as has been discussed in the manuscript.
Also, as noted in the text, the observation error assigned here should include representation error as well as instrumental error, i.e., the uncertainty of a 'point' observation to represent the grid cell it is applied to (which is, as stated, poorly known).