Comment on essd-2021-194

Anonymous Referee #4

General comment: The technical contents and descriptions are good enough to understand about BRAN2020 reanalysis system. Main conclusion of the paper is about the contribution of multi-scale data assimilation (DA) approach to resolve mesoscale features of ocean conditions. Overall quality of the paper is fairly acceptable. But acceptance decision can be made once a few requests are followed up and discussed.

Thank you for reading the manuscript and the useful comments.

Technical comments:

1. BRAN2020 combines both coarse and fine resolutions in its multi-scale DA approach. One of the main issues is that sea ice model is not included. This naturally leads to what is the benefit of increasing ocean model resolution without considering coupled sea ice ocean modeling system. Concern is that the absence of realistic sea ice condition may deteriorate the analysis result in high latitude areas. Not enough information is provided about the issue along the high latitude areas.

A paragraph has been added to the introduction to give better background and context to our motivations and work presented. 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 under the influence of processes associated with sea ice at this stage. To reduce any impact on the properties of deep/dense waters, the model restores temperature and salinity below 2000 m towards climatology.
The Bluelink Project intends to include sea ice in future versions of BRAN to increase the utility of the product for research.

2. As relatively fine scale ocean model is used in the multi-scale approach, another natural question is about its benefit on circulation dynamics. Climate index comparisons are described but questions still remain about dynamics: currents, transports, etc.

There is a new subsection added to the paper that compares boundary currents around Australia from the new reanalysis with previous versions. The results are entirely consistent, giving confidence that the multiscale data assimilation has been able to reduce the bias without having an impact on the overall transports and dynamics.

3. Super-observation scheme is used in the reanalysis run from 1993 to 2019. It will be great if authors can provide information about overall computational cost and quantification of observation data quality improvement of the super-obbing in the BRAN2020 system.

The construction of super observations is a preprocessing step, error information is propagated so that the quality of the analysis is the same as if observations were used individually. The preprocessing is relatively quick and cheap, and the difference is the massive saving in DA computation, particularly for SST. For example, where there would be 100M + global observations from a 3-day window, this can be reduced to 2M on the high-resolution grid, or 50k on the coarse grid.

4. In page 10 (line #217), authors used the term "we think" to talk about observation error specification issue. They consider that better analysis result might be obtained if larger error is used for avhrr sst data. To make a conclusive opinion, they have to provide a direct evidence. A small set of analysis experiment might be possible. Without such a direct evidence, it will end up to a simple guessing.

As the text now indicates, in a short test of ~20 cycles the AVHRR SST observation error was increased to 0.3 and showed some improvements in the TEM (0-50m) results (reductions of ~3% in analysis and ~0.5% in background errors) which explain part of the differences seen between BRAN2020 and BRAN2016.

5. The study claims that multi-scale DA approach is beneficial even for non-argo time period (especially before 2000). Most of the comparisons of the study is based on data sets applied in the DA system. OISST and climate index comparisons are provided but additional comparison can be made against another third party reanalysis products.

There has been rewriting in the section comparing values in Tables 2 and 3 and the performance of various DA metrics from BRAN2020

and BRAN2016, including SST. The text now emphasises that the impact of the multiscale DA is primarily in the assimilation of sparse subsurface observations; which is supported by results in Chamberlain et al. (2021a, doi:10.1016/j.ocemod.2021.101849), which is now available and discussed in more detail in the last paragraph of section 3.1.
The improvements in SST (like with SLA) found with BRAN2020 relative to BRAN2016 are smaller than in the subsurface, and are attributed to the new compilations of data that were assimilated into BRAN2020.

Please note that while comparisons are calculated with the same data, forecast/background calculations are made before assimilation.

It is not entirely clear what further comparisons would be most helpful here. In the spirit of the suggestion, a time series was calculated for the RMS of differences between the versions of BRAN and HadISST (see below). Results were consistent with values in the manuscript Tables, the SST background innovations in particular; namely, the RMS of differences between BRAN2020 and HadISST are ~10% less relative to BRAN2016 in the 1990s, whereas the improvement is only ~ a few % in the 2000s and 2010s. While this comparison is useful, it doesn't add new information and is somewhat complicated to explain, for example, why are the RMS values below substantially greater than values in the Tables (related to different processing), hence this is not added to the manuscript.

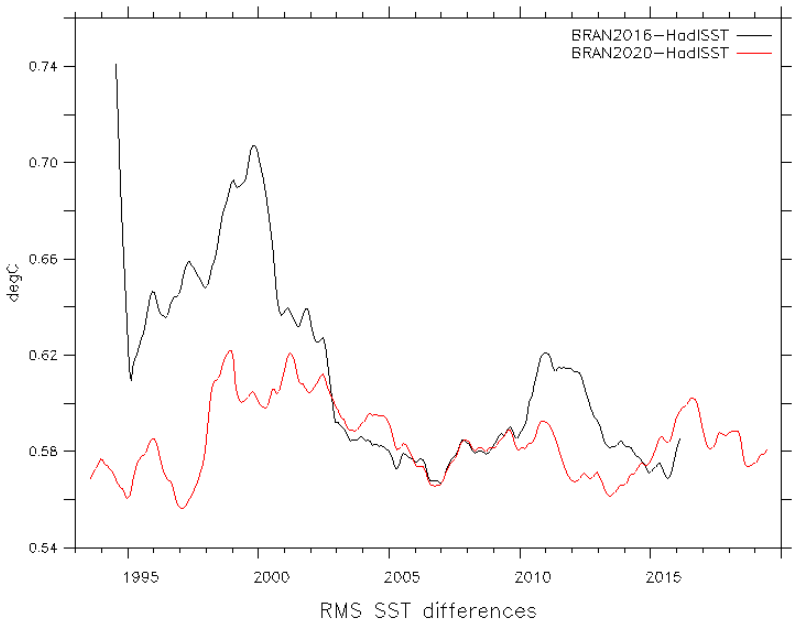

Figure: RMS of differences between versions of BRAN and monthly HadISST (http://www.metoffice.gov.uk/hadobs/hadisst)

6. Additional minor editorial comments can be provided once enough technical discussion and feedback is provided.

Thank you again for reviewing the manuscript.
We are prepared to consider further comments if required.