Geoscientific Model Development Discussions

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Comment on gmd-2022-98

Anonymous Referee #2

Referee comment on "Observing system simulation experiments reveal that subsurface temperature observations improve estimates of circulation and heat content in a dynamic western boundary current" by David E. Gwyther et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-98-RC2, 2022

In this paper, the impact of a dense XBT observation network in the East Australian Current (EAC) system is examined using Observing System Simulation Experiments (OSSEs). The OSSEs have been assessed using subsurface temperature, mean kinetic energy, ocean heat content. An experiment which assimilates the southern XBT transection showed improvement around the upstream of the EAC. The EAC separation latitude is an important factor for the impact of the XBT OSSEs on the velocity fields. It is interesting if the best XBT observation lines are decided adaptively by taking into account the separation latitude of the EAC. However, the authors need to assess the performance of the OSSE more quantitatively. It is difficult to find out which experiments are the most accurate in OSSE without using objective statistical metrics.

General comment

In general, if much observations are assimilated, the result will show higher accuracy. However, the authors have shown that the experiment assimilating both southern and northern XBT observations did not show the best performance. I am wondering if the cost function was properly reduced. How were the convergence conditions defined, such as the ratio of the final to the initial value of the cost function or the gradient of the cost function?

The authors also show the XBT-S experiment is the best among the OSSEs. How does the observed information propagate upstream (to the north)? As I see the Figure 6 in Kerry et al. (2018), the impact of the XBT is limited to the vicinity of the observation latitude. An influence scale of 600 km seems distant relative to the spatial scale of analysis increment. If there is an impact of the XBT-S observations on the northern boundary, it should be clarified in the manuscript.

These points are discussed in section 4, but it would be better if you could briefly introduce the discussion part in the results section, for example after L316. When I read section 3.4, I wondered how the southern XBT line would affect the upstream regions far from 600 km.

This study focused on the XBT observation network. However, in realistic situations, other networks exist, such as Argo floats, HF radars, and sea gliders. Why did the authors investigate the impact without using other observation network? Of course, I admit that it makes sense to evaluate the impact of XBT observations.

Temperature observations per model cell may be too dense to account for representation errors. It may be better to consider the super-observation or thin out the observation. Also, if you want to show the advantage of the high density XBT observations, it would be useful to demonstrate an additional experiment which assimilate the XBT at regular observation interval. In addition, the manuscript mentions observation errors of XBT, but it is unclear whether the representation errors are considered. How about you clarify this point?

The authors often use the term “best” to specify which experiment represents good performance (such as L262 and L356). However, it should be better to quantify the experiment using statistical metrics such as area-averaged biases and RMSEs. In addition, it would be useful to specify the improved ratio of each OSSE relative to the surf-only experiment or the baseline when comparing the impact of observations across each OSSE (for example L297 and Figure 6).

The upper ocean heat content (OHC) in the OSSEs in Figure 8a and 8b showed similar temporal evolution until March or April 2012. Why the observation impacts were less?

Conversely, why did the difference of the upper OHC occur after April 2012? Does it relate to the EAC phase?

The vertical temperature section for the ~35.5S transect in Fig. 7n shows a large RMSE below 1000 m depth, whereas the upper OHC above 2000 m of the XBT-S in Fig. 8b and 8c (green dash line) is better represented than in other experiments. Based on the fact that the 35.5S transect locates between box b and box c shown in Figure 3b, the vertical temperature in Figure 7n would be expected to be best represented. However, it is not, and appears to be inconsistent. How should we interpret this point?

Specific comments

P5 L134: The Reference state and the baseline experiment is forced by BARRA-R while the OSSEs have applied the ACCESS reanalysis as surface forcing. Is it right? If so, how about you emphasize that such condition leads to additional perturbations?

P6 L143-149: Was the initial condition for OSSE chosen from the Reference state 8 days later or 8 days earlier as perturbation? In other words, is it a lagged initial condition? It would be easier to understand if you describe the date of the initial condition used in OSSE.

P9 L198: Transect PX30 represents the Brisbane to Noumea line (southeast direction) in this study. However, in the previous studies (Kerry et al., 2016, 2018), PX30 refers to the Brisbane - Fiji route (northeast direction). Does this mean the observation line PX30 has changed?

P20 L398: It should be better mention about the EKE based on the Figure B.

Technical comments

P4 L82: Please add “variational” for the abbreviation of “4DVar”.

P11 Figure4: It would be useful to point out the velocity directions for the EAC southern extension, the EAC return flow and so on. It is also in Figure. 5 and 9. This study will attract not only the oceanographers but also data assimilation community. It will help for the readers who are not familiar with the EAC circulation.

P16 Figure 7: Please draw the temperature color-bar for the Ref state in an easily recognizable location.