

Interactive comment on “A 20-yr reanalysis Experiment in the Baltic Sea Using three Dimensional Variational (3DVAR) method” by W. Fu et al.

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Anonymous Referee #2 Received and published: 29 June 2012 The authors make a 20-yr reanalysis experiment in the Baltic Sea by assimilating T/S profiles into operational ocean model with the 3DVAR method. The ocean reanalysis datasets are very important for many applications. For example validation of model performance. Now there are many studies of ocean reanalysis but mostly focus on the open oceans. And there are also many ocean reanalysis system like BLUELINK. However, the regional areas have few reanalysis studies. The manuscript try to construct a long analysis of T,S and SL and assess the valid of the assimilation system in the long period simulation.

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However the manuscript should be modified before considering publication.

1) One of the purpose of the manuscript is to assess the effect of assimilation system on long period simulation. However, authors give every short depicts of the 3DVAR assimilation system. And the assimilation system only has been tested for a very short period run by zhang et al. (2011). so it is necessary to prove your system is valid in long period integration. I would suggest authors make some comparison with other assimilation system like EnKF or 4DVAR.

Thanks. In Zhuang et al (2011), we presented the description of the assimilation scheme and its validation with 1 year experiment. Since then, we further tested the 3DVAR with both anisotropic and isotropic recursive filter, different correlations scales in the B matrix, dynamical quality-control on the observations to ensure the stability of multi-decadal integration. From our experiments, the current configuration requires affordable computation cost and delivers pretty satisfactory results. We also implemented the Ensemble Optimal Interpolation in the two-way nested model (Fu et al, 2011), some further comparison between the 3DVAR and EnOI in the Baltic Sea is underway. For practical purposes, the 3DVAR is more feasible and manageable than 4DVAR in our institute. As for the comparison with the 4DVAR and EnKF, we plan to run the EnKF for some case studies in the near future. Implementation of 4DVAR may require much more efforts and man power than the 3DVAR and there is no clear plan with respect to this part.

2) the equation 1 uses the error expression of observational operator. In the formula of 3DVAR, it is non-linear, and should not use its linear version in equation 1. Thanks. The equation is modified.

3) Here authors use a 3DVAR method with recursive filter in horizontally direction and EOF in vertically direction. This method isn't new. Some references should be cited in the manuscript e.g. 'Dobricic S, Pinardi N. 2008 An oceanographic three dimensional variational'. Thanks. This reference is added.

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4) In the SST verification, authors mention 'the large seasonal bias in the free run suggests the error from the forcing and/or heat flux parameterization used in the ocean model', author need more detail explanation to support this opinion.

Thanks. The statement is based on the previous validation reports and our experience on the model performance. The HBM model has larger errors in the summer than the winter time. This is largely due to the forcing errors in summer. A few more sentences are added to clarify this statement.

5) Authors make the MLD comparison between reanalysis and free-run. This manuscript depicted the MLD has some changes between free-run and reanalysis. But it is hard to conclude which is better. Authors have no the sufficient support for the results. MLD is very important to the ocean dynamic. Therefore I would like authors can make some validation with climatology data or some other related references.

Thanks for the suggestion. In fig 12, we compared the MLDs at one location where relative complete records permit to calculate the observed MLD. This is also done on some other locations (figure not shown). With the sporadic T/S profiles, the reanalysis shows better agreement with the observations than the free run. In the Baltic Sea, it is now difficult to obtain the map of climatological MLD.

6) Authors only simply depicted the assimilation system setup and more focus on the description of the model setup e.g. forcing or lateral boundary conditions. However, the setup of assimilation system is very important to the reanalysis results. More information of the setup of assimilation system should be introduced e.g. the homogeneous or inhomogeneous of the parameter variance used for recursive filter in B matrix.

Thanks for the suggestion. We add more information on the setup of the assimilation system, which is partly described in Zhuang et al (2011). The parameters in the recursive filter are introduced together with the description of the B matrix.

7) At the introduction, authors say 'reanalysis combining state of art models.....', what

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does the 'art models' mean.? Please make accuracy expression. Thanks. It's a typo error. The text should be "reanalysis combining state-of-the-art models". The HBM model we are currently using is the operational forecasting model in DMI for the North/Baltic Sea. In the past decade, DMI coupled ocean-ice-biogeochemical model HBM-ERGOM has made remarkable achievements, and became the basis of the common model framework for the Marine Ecological Modelling Centre (a virtual centre formed by DTU-Aqua, AU-BioScience and DMI) and for GMES Baltic Sea Marine Service. The HBM is thought to be the best forecasting model in the Baltic Sea at present.

8) The assimilation is performed daily with the any available observations. Many reanalysis systems have used the time-windows. But it isn't clear whether or not the manuscript used daily observations or similar multi-day observations with timewindows. If authors use it, have authors already tested it how long of the time-windows should be used?

Thanks. The observations are assimilated into the HBM daily if available. Zhuang et al (2011) and Fu et al (2011) tested the impact of observations in delayed-model on the following forecasts. In geneal, the impact can last for 2-3 weeks. In this paper, the time-window is one day. It is also a natural way because we don't consider the influence fator due to time lag within the time window, which is usually empirical.

9) In the data preparation for reanalysis, authors excluded the data if "the differences between it and model data larger than three standard deviations". What is the three standard deviations?it implied that it has three threshold values to exclude observations. It is confusing here. If authors use one criterion, so why select the three standard deviations? Whether or not authors have tested it? what it happens if observations larger than 3 standard deviations have been used in the assimilation experiment.

Thanks. Again this is a typo error. The text should be "the differences between it and model data larger than triple standard deviations". We use both static and dynamical quality control on the observations to ensure a stable multi-decadal integration. Before

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assimilation, the observations have gone through quality checks. The model standard deviation can be obtained from the free run for each model grid. This standard deviation is used as criteria to select observations. During the assimilation, the observations will be excluded if the innovation is larger than the triple standard deviations. In the beginning of the integration, the empirical criteria are particularly important because some observations cause spikes in the vertical stratification of the model, and some times model crash.

10) For figure 1, the author say it is the domain of DMI-BSHcmod, why you text it 'HIROBM-BOOS (HBM)'. Are they different models or the same one? If not, which one you used? Furthermore, the figure 1 has very bad quality. It isn't clear which region the model domain covered. Thanks. Fig 1 is updated with the focus on the Baltic Sea. The captions are also modified in a clear way. The domain with nesting grid is also demarcated in the new figure.

11) Authors use a two-way nested model, have authors done some special work for it in the assimilation system? It is very important to the assimilation of the North Sea and Baltic Sea. If it has been done please depicts it in this manuscript.

Thanks. A finer grid is embeded in the Danish water and two-way nested to the North/Baltic Sea. The nesting helps to better resolve the complex bathmetry in the Danish water. The transport through the Danish strait is important for the simulation in the Baltic Sea. The two-way nesting scheme is referred to the scientific report of the HBM and the specific treatment of assimilation for the nested grids is referred to Fu et al. (2011).

12) The model domain covered both North Sea and Baltic Sea and the region of observation also covered the North Sea, but only the results of the Baltic Sea are discussed. Have you also assimilated the observations in the North Sea? If it has been done, whether it has help to enhance the quality of the assimilation of the Baltic Sea . Authors can make some experiments to test what happens if the observations haven't

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been assimilated into the North Sea.

Thanks for the suggestion. The assimilation is conducted in both the North and Baltic Sea. The assimilation in the North Sea could have effect on the simulation of the Baltic Sea, but its effect has not been documented in literatue. To the inner part of the Baltic, the assimilation in the Danish water could be more important because which controls the water exchange between the North Sea and the Baltic Sea. For this reason, some other Baltic-Sea models cover only the Baltic Sea (8.9E-30E). This manuscript focuses on the results in the Baltic Sea, but the effect of the assimilation in the North Sea on the Baltic can be interesting and the reanalysis in the North Sea will be addressed in the future.

13) The manuscript say the reanalysis can capture the inflow than free-run in 1993 and 2003, however the free-run also depicts these process from Figure 7. Comparing reanalysis and free-run with observation, the trend of the free-run is closer to observation. Furthermore, reanalysis has a bigger salinity change in 2007. Does it produce error inflow or outflow there in reanalysis?

Thanks. The major problem of the free run in the bottom Baltic Proper is the systmatic bias, the model salinity is much smaller than the observations. According to the criteria used for observations, the saline inflow is difficult to be identified. The reanalysis largely mitigates the problem. The salinity of the reanalysis in 2006-2007 displays changes absent from the observations. We are carrying our more experiments during this period to explore the reason.

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