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Interactive comment on "Assessing the impact of multiple altimeter missions and Argo in a global eddy permitting data assimilation system" *by* Simon Verrier et al.

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The reviewer made some comments about our study and the associated manuscript. We are thankful for the time and the energy spent to address these comments. The following will answer one by one the comments and questions that have been raised up from the first version of the manuscript.

"Define the scientific problem more rigorously! If you are just asking what's been observed then clearly more altimeters observe more detail. Is that all this paper shows with the sea level errors? To go beyond this you need to discuss how well the model can extrapolate sea level in space and time, either between tracks or from one analysis to the next (forecast). Perhaps there is enough data from 1 altimeter for a good model

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and good assimilation scheme to extrapolate very well, in which case further altimeters will not lead to improvement? The paper seeks to emphasize the models failure to do this rather than asking how well is has done and whether that's likely to be a limitation for future systems."

- Our study is in deed revisiting works that was carried out 10 years ago. We are using here assimilation systems that are very close to systems that are running operationally. As explained in introduction this allow us to much better characterize analysis and forecast errors. This can only be done through OSSEs. Since 10 years, the forecasting system has deeply changed and conclusions have changed in consequence (concerning small scales for examples), these changes needed to be assess. Also we analyzed both velocity, temperature and salinity errors analysis and forecast. One of the objective is to better understand how the data assimilation system work. We modify the abstract to better emphasis the goal of the study.

"Do the 7 day forecasts beat persistence in sea level error for Sat 1, 2,3? The results show that errors grow quickly from the analysis and they grow faster with more altimeters. Sat3 presumably has more small scales which should evolve faster so and be less well captured by persistence? However Page 6 line 4 seems to suggest that the forecast error growth appears strongest at larger scales âĹij300km which would run counter to this argument."

- This point deals with forecast and analysis improvements when adding a new altimeter. We did compute FS relative to persistence and in general, except in WBCs, FS beats persistence. This probably reflects that at this resolution (1/4°) the model has not enough skill to forecast small scale features. Looking at the variance preserving error spectrum (new fig in the manuscript and Sup1 in the supplementary figures joined to this answer), it appears that the error growth between analysis and forecast occurs around scales of 300km. We do not have explanation on the forecast error that grows faster with more altimetry data assimilated.

"The assimilation of absolute sea level page 3 line 38 is likely to have a big impact on the results. Each new altimeter assimilated brings a further "correction" of the MDT towards the 1/12 values. Deserves discussion."

- The comment is about assimilating the MDT. Our results do not account for MDT errors and this should be taken into account when comparing our results with those derived from operational system (in OSEs). Analyzing the effect of MDT error (that are quite complex to characterize) on ocean analysis and forecasting is a topic by it self. But we found that the first altimeter allows the largest improvement, then the additional altimeters do not bring further improvement on the MDT. We modified the end of the paragraph by : "We thus chose to assimilate the absolute sea level (witch include the MDT and the SLA) from the NR at 1/12°".

"The paper claims to examine complementarity between Argo and altimeters. But the results do not show result for assimilating Argo alone (I suspect Argo 1 results in Fig14 would be very similar). Are Fig 14 analyses similar or better than forecasts? Also you do not show any impact of Argo on sea level errors? Perhaps forecast errors in sea level might reduce?"

- The reviewer recommends making a new simulation using only the Argo float and it is true we did not run an OSSE with Argo data alone. Analyses and forecasts are now compared in a new Figure 14. The Argo simulation is made to assess the complementarity concerning deep fields of in situ observations assimilated in addition of altimetry data. We rephrase the sentence p7 l18 to highlight that. Sea level results are not significantly changed by the assimilation of Argo observations.

"Say more about why salinity is not improved? Surely T-S error covariances should give some S improvement if T is improved because a lot of error is heave which preserves T-S relationships?"

- This comment is about how well sub surface temperature is improved by assimilating altimetry observations compared to salinity. Except in the Gulf Stream (Sup2 and Sup3

in the supplementary figures joined to this answer), salinity is not significantly improved when assimilating altimetry data. It is because in the system, sea level errors are well correlated to upper temperature errors and less to salinity's through the model covariance error matrix. Those covariances are build from a free model simulation. We modified the end of the second paragraph p7 like this: "As density variations are mainly correlated to temperature variations and less salinity variations in most of the ocean regions, this explains why assimilating altimeter data improves the representation of the temperature fields (e.g. Guinehut et al., 2012)."

"Use of "relative reductions" and MSE reductions rather than using RMSE reductions always relative to the free run makes the % reductions for each satellite appear larger. I think at least the errors in RMSE should also be quoted as this then reflects reductions in sea level units i.e. cm rather than cmËĘ2."

- The reviewer suggests using RMSE but our results in % are given from MSE, same score using RMSE would have been different. For assimilation system, scores are always given in MSE. We agree that error reduction would have been smaller when considering RMSE. Also the altimeter community is more naturally considering energy rather than the RMS.

"page 3 line 35 Would altimeter errors not have some error correlation along tracks? Explain more whether the SAM2 assimilation method is still an ensemble method, and how many members are used. This is relevant to capturing T-S correlations for example. You might then explain what "Evolutive" means bottom P2 Also is an analysis and 7 day forecast done every day or are all the diagnostics showing averages of analyses and forecasts at 7 day intervals?"

- Finally, we did not simulate correlated errors along tracks that Is why we used a white noise. We will better explain the assimilation system used in our experiments. Here we have used 349 members in a fixed pre-computed basis (ensemble of model anomalies) and their selection is explained in Lellouche et al. 2013. We add the explanation of

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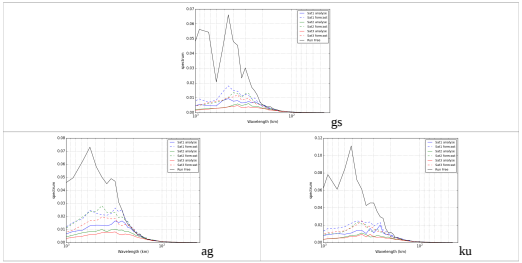
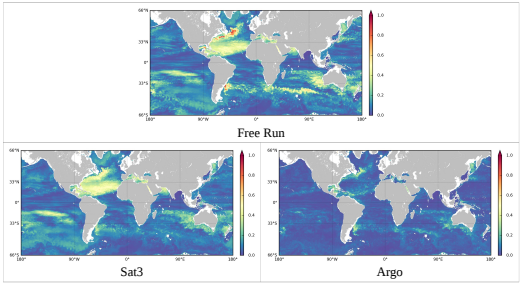
“Evolutive” in the text (model error covariance propagated by the dynamical model). Analyses results are given for the 7 days of the cycle and forecast (one forecast is made each 7 days) results are given only for th 7th (last) day of the cycle.

Other comments deal with lay out suggestions or small corrections that we made in the manuscript.

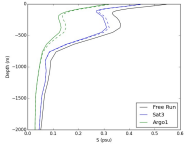
Interactive comment on Ocean Sci. Discuss., doi:10.5194/os-2016-104, 2017.



Sup 1 : Variance preserving error spectrums in Gulf Stream (GS), Aghulas (Ag) and Kuroshio (Ku)



Sup 2 : Salinity RMSE (Experiment - NR) at 318 m in psu



Sup 3 :Salinity RMSE (Experiment - NR) profiles in Gulf Stream in psu

Fig. 1.

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