

## ***Interactive comment on “A Hybrid Variational-Ensemble data assimilation scheme with systematic error correction for limited area ocean model” by Paolo Oddo et al.***

**Anonymous Referee #2**

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This paper presents an assessment of a hybrid variational-ensemble scheme and looks at the impact of systematic error correction and the inclusion of systematic bias correction. I generally found this a good and interesting paper. I do have a few mostly minor comments which I'll list below along with the page and line number.

page 1 title. Should be either "error correction for a limited area ocean model" or "error correction for limited area ocean models"

page 1 line 23-25. Slightly confusing sentence. What's "hybrid daily estimates" perhaps this would read better as "and a hybrid of the background error covariance ... ensemble derived errors of the day" or similar

C1

page 1 line 30. present day observations.

page 2 line 10. Divergence happens in chaotic systems even if the model is perfect it's not just a result of model bias.

page 3 line 26. Write "A promising application..." Also it would be useful to be more specific about the findings of Penny et al.

page 3 line 33. I suppose you mean having a long lengthscale for the bias is more straightforward to implement than implementing multiple lengthscales for the control variables.

page 4 line 8. independent on the -> independent of the

page 4 equations onwards. Inconsistent bolding of vectors. Check the journal style but I think you should use bold roman for vectors and bold roman capitals for Matrices.

page 5 line 16. Say a bit more about how this adjustment is made.

page 6 line 4. You don't use the ensemble to estimate the horizontal lengthscales here. You should say so to avoid confusion

page 6 line 21. I'm not sure I agree that inaccurate initial conditions produce a systematic error or bias. Initial condition error is likely to average to zero over time and is not therefore systematic.

page 6 line 25. "This idea ... " I don't understand this sentence. Can you rewrite it.

page 7 line 4. Should be "It is worth mentioning that the..."

page 7 line 7. Should be "simulation allows us to retrieve..."

page 7 line 21. This is true if there is no bias in the observations.

page 7 line 30. Add brackets something like  $\min(J(dx))$

page 8 line 12 "Sardinia has been conducted" -> "Sardinia was conducted"

C2

page 8 line 17 "accounting for" -> by. Remove "data"

page 8 line 19. "remote sensing" -> "remotely sensed"

page 8 line 28. "Fig.01" -> Fig. 1 and similar elsewhere.

page 8 line 32. "mean" -> "means"

page 9. line 1-10. I found the perturbation of the observations confusing and not well explained. Are you vertically subsampling the profiles? Please clarify the text.

page 10. ~Line 20. I wonder if you need to perturb things other than the observations and following on from my previous comment are you perturbing the observations enough. See also p 14. Surely it's better to perturb everything even is the effect is limited by the short integration time.

page 11. Line 31. Remove "biases in"

page 12. Line 16. "while goes" -> "while it goes"

page 12. Line 18. "that also" -> "also that"

page 12. Line 25. "Mean" -> "mean"

page 13. Are you statistics computed after or before assimilation is it observations compared to analysis or observations compared to model background. Or are the CTD data used for comparison independent? It's not clear.

page 13. It might be worth not abbreviating in all cases as it makes it more difficult to read. For example MB perhaps just write mean bias. Similarly with SS = skill score.

page 13. Line 13-14 "capable of significantly reducing this bias (error)". Perhaps remove the error?

page 13. Line 32. Remove "can"

page 15. Line 18. Typo "indicating"

C3

page 16. Line 2 "of" -> "by"

page 16. Line 10. Do you plan to use this Bayesian method?

page 16. References - inconsistent "Mon. Wea. Rev."

page 17. Reference Mirouze has a typo "LOCKLEY" in the author list.

Table 3. Why is the 0-50 mean bias worse in the bias corrected runs?

Table 3. Not enough significant figures to see anything useful. I think it would more useful to use MB and SDE rather than the squares. Either that or add a significant figure.

Figure 1. Could say the date range over which the observations are plotted.

Figure 2. Would be good to add a legend to this plot and some axis labels.

Figure 3. Don't understand the explanation of the middle panel. Label x axis

Figure 5. Spread == standard deviation of ensemble ?

Figure 6. Are both matrices are for the same location?

Figure 7. Give the depths of the horizontal slices. Typos in the caption.

Figure 8 (also Figure 9). Consider plotting MB and SDE rather than the squares it will make it easier to distinguish the lines particularly where the errors are lower. A legend would be useful on this plot too.

Figure 8 (also Figure 9). I notice that the non-hybrid results are quite good sometimes better than the hybrid results why might this be? It may be a case of needing to do more tuning perhaps and that not making it worse is quite a good result perhaps. It might be worth saying a bit more about this in the text.

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C4