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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "A Bayesian Approach to Multivariate Adaptive Localization in Ensemble-Based Data Assimilation with Time-Dependent Extensions" *by* Andrey A. Popov and Adrian Sandu

Anonymous Referee #2

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1 General comments

The manuscript presents a new approach to adaptive localization of ensemble background error covariance for ensemble data assimilation. Localization parameters are estimated by minimizing a variational DA-like cost function with additional terms for localization parameters. The authors extend the problem to support multiple localization radii for different state variables. The paper contains new and significant results. I recommend revising the manuscript to address several issues, please see specific

comments below.

2 Specific comments

- Several important references are missing from the Introduction, e.g. Menetrier et al, 2015 (https://journals.ametsoc.org/doi/10.1175/MWR-D-14-00157.1), Flowerdew, 2015 (https://www.tandfonline.com/doi/full/10.3402/tellusa.v67.25257) considered optimal localization, Buehner et al., 2015 (https://www.tandfonline.com/doi/full/10.3402/tellusa.v67.28027) suggested scale-dependent localization.
- I suggest rearranging the text so that everything related to multivariate localization is in section 3.2 (Extension to multivariate localization functions). I think describing univariate case first, and then introducing groups for different localization radii (currently P5, L7-13) when extending to multivariate localization functions might improve the manuscript readability.
- Questions and comments on the experiments
  - There seems to be a contradiction between 4.2 and 4.3. P11, L27-28 state that the problem is better suited for multivariate localization, while P12, L11-12 state that the canonical L96 model is ill suited for multivariate adaptive localization.
  - I would like to see more details on the L96 multivariate localization experiment setup (Figure 5). Were the groups fixed throughout the experiment? How were they chosen? Did the groups use the same mean and variance parameters at each assimilation cycle? If the groups were fixed, it would be interesting to see how the estimated localization radii vary for different groups throughout the experiment.

- I see that in L96 experiments half of the domain is more sparsely observed than the other. Introduction (P2, L34-35) states that optimal localization may depend on observation properties. In L96 experiments, did you see evidence of the optimal localization radii being dependent on observation density?
- Section 4.4.1, Figure 8. If instead of fixing the mean parameter to be the same as the constant suboptimal radius at each assimilation cycle, the adaptive localization radius estimated at the previous DA cycle was used to estimate the mean parameter, would the adaptive localization radius converge to the optimal one after some DA cycling?

- Questions on extensions of the method

  I think it would be good to address the following questions in the manuscript to show more clearly how the method may fit into existing large geophysical data assimilation applications.

  - How does this method extend to the ensemble DA algorithms other than DEnKF?
  - For large DA applications like NWP, ensemble filters similar to DEnKF typically assimilate observations sequentially, and use $P^f H^T$ localization instead of Schur-product P^f localization which becomes too expensive. Would the method still be applicable in this case, and if so, how would it change?
  - Do you have a recommendation on how the groups for multivariate adaptive localization should be chosen?

3 Technical comments

What is subscript i in Equation 10?

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