Review of the manuscript egusphere-2022-434 "Guidance on how to improve vertical covariance localization based on a 1000-member ensemble" by Tobias Necker, David Hinger, Philipp Johannes Griewank, Takemasa Miyoshi, and Martin Weissmann.

Pavel Sakov

August 8, 2022

1 General comments

The the manuscript presents a study conducted in a straightforward way. It considers a set of 1000-member ensembles as representing the true state error covariance, and then investigates how various approaches to the vertical localisation can minimise the vertical correlation errors in 40-member sub-ensembles. This line of research is coherent with the previous efforts of the authors in the atmospheric ensemble DA.

In my opinion, for what it is, the study is done in a methodical and comprehensive way, and provides helpful material for further studies in that direction. However, the manuscript provokes a few questions in a more general context.

2 Questions

There are two main questions to the study for me: (1) how rigorous is the adopted methodology, and (2) how relevant are the results for other geophysical EnKF systems.

1. **On the concept of statistical ensemble.**

The underlying assumption employed in the study is that the EnKF ensemble is a statistical ensemble, i.e. that it is composed of members drawn from the same pool. While this can be true to some degree for some EnKF systems, it also can be demonstrated to be wrong for other systems. The alternative view is that the EnKF ensemble is a unit carrying the state of the DA system, and that ensembles of different size can have rather different statistical properties. For example, it is possible that a 40-member sub-ensemble of a 1000-member EnKF will have qualitatively different correlation errors to an ensemble of a properly set 40-member EnKF.

This real or potential concern could be partly overcome by experimental testing of results with 40-member systems. I say "partly" here because these experiments would still be conducted in a very specific environment.

2. **On the importance of the "right" localisation.**

   While localisation is a necessary attribute of large-scale EnKF systems, the sensitivity of the performance to the details of its implementation can be rather flat. From our experience with global ocean EnKF forecasting systems increasing or decreasing the horizontal localisation radius by say factor of 1.5 results to marginal changes in forecast innovation statistics. (Provided that the observation error variance is scaled proportionally to the localisation radius squared to keep the observation impact at the same level.)

   Therefore, I would suggest, firstly, to moderate claims of the importance of the choice of localisation technique for the forecasting skill of EnKF systems; and secondly, experimentally demonstrate the impact of the proposed taper functions.

3 Conclusion

I reiterate that in my view the study is conducted in a methodical and comprehensive way and would be interesting to specialists working on further advancements in that direction.

In a wider context, there remain grounds for scepticism in regard to the rigoursness of the underlying assumptions and applicability of the results to other systems. It seems to me that the study could benefit from experimental testing of the results. Also, it would be interesting to get some insight on implementation of the vertical localisation in the LETKF systems used.

I recommend to **accept** the paper for publication in NPG.