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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Ensemble Variational Assimilation as a Probabilistic Estimator. Part II: The fully non-linear case" *by* Mohamed Jardak and Olivier Talagrand

M. Bonavita (Referee)

massimo.bonavita@ecmwf.int

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The paper in subject is the second part of a study of the characteristics of the EnsVAR ensemble data assimilation as a probabilistic estimator. This second part aims to extend the results of the first part to the fully nonlinear case. While the basic methodology follows the one used in the first part of the study, the robustness of some the results presented in this second part appears more questionable and some issues need to be explored further, at least to the mind of this Reviewer, in order for the paper to be acceptable for publication. In the following I detail these concerns.

1) In Sect. 3 the Authors compare results of the QSVA EnsVAR, EnKF, PF. Not sur-

prisingly, QSVA EnsVAR shows better results as a probabilistic estimator and also for more standard resolution measures. This is unsurprising, to my mind, because this comparison is not fair. As the Authors noted, the costly QSVA extension is needed to keep EnsVAR assimilation in an approx. linear error evolution regime and thus guarantee good behaviour in this long-window assimilation set-up. To compare apples with apples the Authors should directly compare results of the standard EnsVAR algorithm at the end of the window with those of EnKF and PF. Additionally, it would also be of interest to compare results of QSVA EnsVAR with those of an EnKF whose assimilation is run on shorter assimilation windows, to guarantee linear behaviour, and then cycled;

2) In Sect. 4 on weak-constraint assimilation, I understand that the model error perturbations are drawn from the same error distribution whose covariance is used in the 4D-Var cost function. If this is correct, this is a significant limitation on the potential applicability of the results, as the difficulty in obtaining realistic characterizations of Q is probably the most important cause of the limited success of weak-constraint 4D-Var in realistic applications;

3) In the last paragraph of Sect. 4, the Authors explain that the performance of EnsVAR, EnKF, PF in the weak-constraint case appears in terms of reliability measures (e.g., rank histograms). This could depend on localization used in the EnKF, for example. Have the Authors explored this parameter space?

4) Lines 310-311: " ...many possibilities exist for the reducing the cost of EnsVAR, through simple parallelization or ...". I am puzzled on how parallelization can reduce the computational cost of EnsVAR. Maybe the Authors meant clock time?

5) Lines 319-320: "On the other hand, EnsVAR is largely empirical, with the consequence that, should difficulties arise, conceptual guidelines may be missing to solve these difficulties." I struggle to see what these difficulties might be. In the linear case, EnsVAR (aka EDA) is constructed so as to be a consistent statistical estimators assuming the input data errors are correctly sampled. In the nonlinear case, its behaviour will

depend on the amount of nonlinearity and the ability to track the true global solution. In this respect, EnsVAR is as empirical as the EnKF.

6) Lines 339-340: “EnsVAR has been implemented here on a small dimension system. It has to be implemented on larger dimension, physically more realistic models.”. I suspect the Authors mean QSVA-EnsVAR in this context. Standard EnsVAR has been running at ECMWF and MeteoFrance for a number of years.

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