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Interactive comment on "Ensemble Variational Assimilation as a Probabilistic Estimator. Part I: The linear and weak non-linear case" *by* Mohamed Jardak and Olivier Talagrand

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We thank M. Bonavita for his comments and suggestions. We give below a first response to some of these. Our responses are below the referee's comments and suggestions.

The paper in subject is a valuable addition to the ongoing debate on the best strategy to perform ensemble data assimilation. The Authors evaluate the performance of an EDA type system (which they call EnsVAR) as a probabilistic estimator in linear and weakly-nonlinear regimes for two toy models. This is new, as most of the previous literature on the subject had focused on its performance as a deterministic estimator or as a tool

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to compute error estimates for a reference unperturbed analysis system. I found the paper interesting and well-written. Before recommending it for publication i suggests that some aspects, which I detail below, be further improved or better clarified.

1) Lines 54-56: I am not aware of the paper by le Gland et al, 2009, and I am not sure it is generally available as it appears to be an internal research memo of a specific institution. Further, I do not think it is actually necessary in this context, if we take the view that the EnKF converges to the KF for large ensemble size and the KF is a consistent bayesian estimator for linear dynamics and gaussian errors;

We think the reference is appropriate since it is certainly useful to know for sure that EnKF cannot be Bayesian in general in the nonlinear case.

3) Line 102-105: The Bardsley et al. 2014 reference appears to be missing. Some further discussion of their method would be useful here, as the response of the EnsVAR method to nonlinearities is the central issue of this paper;

The Bardsley et al. paper is actually referenced in the maunscript, but at the wrong alphabetical place. And the question of further discussion has also been raised with some emphasis by Reviewer 2. We will modify our paper accordingly.

4) Lines 177-179: I do not understand this remark and the implied derivations behind it. Can the Authors please expand?

Since Bayesianity is ensured under the two conditions of linearity and Gaussianity, one can legitimately wonder what can be said when only linearity is present. That is the reason for our remark. We will reformulate it in order to make our point clearer.

6) Lines 444-447: Can the lack of sensitivity of the analysis pdf to the pdf of the observations be considered a consequence of the Central Limit Theorem, or do the Authors have an alternative explanation?

The fact, which has been mentioned just before, that the ensembles produced by the assimilation are close to Gaussianity is certainly a consequence of the Central Limit

Theorem. That the ensembles are insensitive to the shape of the pdf of the errors in the observations seems rather natural in these conditions, but we cannot really say more at this stage.

8) Regarding the EnsVAR and EnKF comparison, I would expect the two systems to give equivalent results in the purely linear case. Have the Authors verified that this is the case, or if it is not why?

Yes, one could expect similar results in the linear (and also Gaussian) case from EnsVAR and EnKF, since both are then bayesian (as indeed PF is also supposed to be). But there is actually a slight difference. EnsVAR produces a set of independent realizations of the conditional pdf for any ensemble size, while EnsVAR or PF do not. And we have not made the comparison. The reason for that is that our paper is concentrated on EnsVAR, and we have used the linear and Gaussian case, not for evaluating it per se, but as a benchmark for evaluation of the nonlinear case.

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