

### 3 Review 3

General comments

The manuscript presented a simplified (ensemble) Kalman smoother as a post-processing for improving reanalysis. It derived smoother equations (including uncertainty estimation) under a simple decay assumption and demonstrated the proposed method in a Lorenz system (1963). RMSEs were significantly reduced, which is very promising. I find the manuscript is well written and reader-friendly. I have some specific comments and suggest the authors revise the manuscript.

**Thank you for your interest in this work. It has been useful to consider the points you raise about what EnKF data may be available for smoothing.**

Specific comments

L34 "Ensemble Kalman filters" should say "The EnKF" **Not done.**

L170 In reality, model has bias and is not perfect. I am wondering when the authors consider model bias, will they converge to the same conclusion?

**We briefly note potential problems with model bias in the Discussion section of this paper. Dong et al (2021) noted that it is possible to correct for model bias if the bias component of the filter increments can be identified and these could then be removed prior to applying smoothing. It is possible that better ways of identifying bias could be developed by following error covariances as described here however we must leave that as future work.**

L259–270 I understand in the KS case you should introduce the simple approximation (i.e. Eq 12 or 13). But in the EnKS case, all needed information (ensemble mean, covariance, time cross covariances...) can be derived from the ensemble  $X^a$  that have been restored any way during the simulation. I do not understand why the simplification is necessary. Do the authors store only the ensemble mean and covariance (uncertainties) rather than all individual ensemble members? That is not common.

**In fact only saving the EnKF analyses alone is not sufficient to perform the smoothing. The reason for this is that it is not possible to separately identify the contribution of the observations, i.e. the innovations, to the analysis ensemble, and therefore it is not possible to use that information for smoothing. One could additionally save the EnKF forecasts immediately doubling the expense, or at minimum the ensemble mean increments (Eq 16) along with the ETKF transformation matrices (Eq 26 in our paper), or in the simple smoother framework you need the IP error covariance increments in our Eq 19.**

**In our paper we point out explicitly that the full past ensembles are NOT**

**NEEDED for the simple smoother. We agree that current groups investigating smoothing have tended to save all ensemble members but we do not think this is truly practical for big operational models at full resolution with large ensembles due to the massive storage requirements, and in any case it is still not enough to allow smoothing. The approach presented here would save a huge amount of computer storage allowing for example larger ensembles of higher resolution to be run and still smoothed. (See also comments to Reviewer 2, point 1.)**

L286 "The increments are smaller than those from the ExtKF/KS (Fig. 2)"

**Done**

L287 "the ensemble runs" **Done**