Nonlin. Processes Geophys. Discuss., 2, C452–C454, 2015
www.nonlin-processes-geophys-discuss.net/2/C452/2015/

Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Expanding the validity of the ensemble Kalman filter without the intrinsic need for inflation" *by* M. Bocquet et al.

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Received and published: 28 September 2015

We would like to thank the reviewer for his/her time, his/her input and valuable suggestions. Please find below our answers to your questions and how we have handled your suggestions.

- *(1) p.11, L. 17-18: Can the problem be stated in terms of new pdfs, followed by a straightforward derivation from Bayes formula without requiring additional changes (e.g., gauge fixing, etc.) in any of the steps of the filter/smoother?*

  Using state space variables, the predictive prior can be derived without the gauge fixing difficulty as shown in Bocquet (2011). Thus, the answer to the referee's question is 'yes'. However, the difficulty comes from the additional elaboration of

deriving the predictive prior in terms of , which is a redundant parameterization. Accounting for the gauge degrees of freedom in cannot be avoided and our derivation is the most immediate we could find. It is genuinely based on the use of the probability density function of the predictive prior (as opposed to Bocquet (2011) where the gauge fixing is performed in the cost function, not the pdfs, which is less convincing). In other words, what you suggest is actually what we have done.

- *(2) p. 18-19, Section 5: Could you diagnose results using the spread vs. skill tests, at least in some of the experiments? Such results may be more revealing than the individual RMSE and standard deviation results.*

  The use of the RMSE indicator is very stringent because of the cycling over very long runs. We also occasionally use the spread of the ensemble to diagnose specific difficulties. As suggested, we have added the plot of the spread in Fig. 4, for the two panels. The spread is quite consistent with the RMSE as long as the nonlinearity is not too strong. When the nonlinearity is stronger, the Gaussian statistical view of the ensemble is not valid anymore and the RMSE diverges from the spread. This corresponds to the regime where iterative methods such as the iterative ensemble Kalman filter/smoother become significantly more efficient than the EnKF. Thank you for the suggestion.

- *(3) p.29, L.21: Eq.(57) requires the inverse of $\mathbf{X}\mathbf{X}^{\mathrm{T}}$ and square root calculations. How practical is this formulation, given that a realistic state is of high dimensions effectively prevent such matrix operations, while a low-dimensional system in principle does not require localization?*

  This was a typo. This is not the inverse but the generalized inverse or Moore-Penrose inverse †. This comes directly from Eqs.(54,55). Thank you for spotting this inconsistency! This Moore-Penrose inverse can be obtained for instance from the low-dimensional singular value decomposition of $\mathbf{X}$ (of rank $\leq N -$

1). The inverse square root and the second square root of this formula are the numerically costly part of the formula, which for high-dimensional systems could only be estimated through Lanczos/Arnoldi-type methods.

- *Technical corrections:*

  (1) p.43: Fig.5 (also discussion on p.30, L.1-20): The axes labels (numbers) are not visible. Could you redraw this figure to make axes labels more visible?

  We agree. Thank you for the suggestion. We have redrawn the figure with more visible labels in the revised manuscript.

Bocquet, M.: Ensemble Kalman filtering without the intrinsic need for inflation, Nonlin. Processes Geophys., 18, 735–750, 2011.