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Interactive comment

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Nonlinear Processes in Geophysics Discussions
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Interactive comment on "Parametric covariance dynamics for the nonlinear diffusive Burgers' equation" *by* Olivier Pannekoucke et al.

Anonymous Referee #2

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[thmsa,a4paper,amsfont,12pt]article amsmath

Referee's Report on

Parametric covariance dynamics for the nonlinear diffusive Burgers' equation
Olivier Pannekoucke, Marc Bocquet, and Richard Ménard

The submitted manuscript considers a new methodology for the numerical approximation of the forecast error covariance matrix in a nonlinear setting. The methodology is applied to the nonlinear dynamics given by Burgers' equation. The results are extensions of works of the first two authors, Bocquet (2016) and Pannekoucke et al. (2016). More precisely, in Pannekoucke et al. (2016), the evolution of the error correlation function is approximated using a second order Taylor expansion with the resulting methodology not being able to reproduce the complexity of the Burgers dynamics. In this work, the authors use a fourth order Taylor expansion which much better results. The paper benefits from a nice background introduction on the uncertainty propagation and covariance dynamics. The numerical simulations presented illustrate the ability of the parametric dynamics to reproduce the main features of the true covariance dynamics emerging from a forecast Monte Carlo experiment.

The paper is very well written and the results as well as the numerical work are interesting and with potentially strong consequences to data assimilation. As such it is my recommendation that the paper is accepted for publication in the Nonlinear Processes in Geophysics journal. I have a list of minor comments/misprints that the authors should take into account when submitting the final version:

◦ page 1 Abstract: I am not sure if you can say that "this study extends the PFF to nonlinear dynamics". Rather, It is a required preliminary step.

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Discussion paper

○ page 2 line 20 “numerical test*s*

○ page 3 line 2 “*B*ackground on the"

○ page 4 line 15 I am not really keen to use a semigroup in order to define a multivariate matrix. What stops you writing the matrix explicitly ?

○ page 5 line 10 “meaningful"

○ page 5 line 13 The dimension of the space plays no role in here.

○ page 6 line 5 Can I suggest that you avoid using the term “nonlinear Kalman filter". The Kalman filter is, by definition, linear. Yes, there are extensions of the Kalman filter methodology to nonlinear frameworks (the extended Kalman Filter, the ensemble Kalman filter, etc), but I believe that here you are referring to the framework which is either nonlinear or linear (Kalman).

○ page 6 line 12 “deduced from the difference"

○ page 7 line 21 As I understand it, $\overline{\partial_x \varepsilon^2}$ is the expectation of $\partial_x \varepsilon^2$, not the approximation obtained by the ensemble average.

○ page 9 line 13 There is a comma missing after the exponential.

○ page 10 line 8 “expressed”

○ page 10 line 23 How large is the ensemble for the numerical experiment ? Why do you call it nonlinear ?

○ page 11 Caption for Figure 1: the figure has 6 curves. I assume you plot the solution at 0.8T too (same for Figure 4 page 15, Figure 5 page 16).

○ page 13 line 17 What does the 17.6% figure signify ?

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Discussion paper

○ page 14 Figure 3 What is the maximum difference between the two graphs ?

○ page 15 line 10 In the case of Burgers' equation, can you provide an estimate of the length of the time interval throughout which the method presented in the paper gives meaningful results.

○ page 16 Figure 16. Again, it would help to know how large is the ensemble used in the numerical experiments.

○ page 17 line 22 "The aim of this section"

○ page 18 line 2,4 Something went wrong with the display of the formulae (A3) and (A4)

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Discussion paper