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Nonlinear Processes in Geophysics
Discussions

Interactive comment on "Sensitivity analysis with respect to observations in variational data assimilation" *by* Victor Shutyaev et al.

Anonymous Referee #2

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General Comments:

The manuscript presents a theoretical framework to evaluate the observation sensitivity in a variational data assimilation (VDA) system aimed at estimating model parameters. The approach relies on adjoint-modeling to derive the continuous sensitivity equations from the first order optimality system in (VDA), as put forward in a general context by Le Dimet et al. (1997). The mathematical procedure is standard, albeit lengthy, and the authors note that the equations presented here are an extension of their previous work. The theoretical results are of interest for practical applications where first- and second-order adjoint models have been developed. Some aspects need to be further clarified and the article will benefit from insertion of numerical experiments that provide an easily reproducible proof-of-concept. Further details are also needed to explain the

significance of the numerical results.

Nevertheless, in my opinion, the theoretical equations derived by authors provide a valuable, nontrivial contribution to advance the current status of science of sensitivity analysis in VDA and the manuscript may be considered for publication after revision.

Specific comments:

1. It is not clear whether the current formulation of the data assimilation system may not be simply incorporated into the previous case of initial condition estimation through a state augmentation procedure for joint state and parameter estimation, see for example, Dee (2005), Smith et al. (2013). As such, the authors should clearly state the need for the re-derivation of several equations presented here and whether the current context may not by reduced to a previously developed theory through an appropriate change in notation.

2. The significance of the numerical results is only briefly discussed and it appears that the sole purpose of the experiments is to illustrate the practical ability to evaluate the observation sensitivity in a non-trivial application. Little can be learned from these results and, in particular, important practical issues need further clarification. For example, the observation sensitivity calculations are derived from the first order optimality system however, in practice, only an approximate solution to the minimization problem is obtained through an iterative procedure. As such, solving the continuous sensitivity equations may result in inconsistencies between the optimization process and the observation sensitivity calculations. It is not clear what approach has been adopted here: discretize-then-optimize or optimize-then-discretize? Some practical issues regarding the accuracy of the sensitivity estimates should be discussed in the manuscript.

3. In my opinion, the manuscript will benefit from the insertion of a proof-of-concept with a simple model and numerical results using an easily reproducible assimilation setup where several practical aspects can be investigated and illustrated.

References:

Smith, P. J., Thornhill, G. D., Dance, S. L., Lawless, A. S., Mason, D. C. and Nichols, N. K. (2013), Data assimilation for state and parameter estimation: application to morphodynamic modelling. Q.J.R. Meteorol. Soc., 139: 314-327. doi:10.1002/qj.1944

Dee, D. P. (2005), Bias and data assimilation. Q.J.R. Meteorol. Soc., 131: 3323-3343. doi:10.1256/qj.05.137

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