The paper presents a study of sensitivity analysis in variational assimilation, based of the adjoint of the optimality system associated with the assimilation process (second order adjoint). It largely repeats the contents of a previous paper by Shutyaev *et al*. (2017), which has almost the same title. There are two differences in the new paper : sensitivity with respect to observations is now determined for forcing parameters (instead of initial conditions), and a numerical example, built on a model of the dynamics of the Baltic sea, is presented.

The authors write that this new paper is a generalization of the previous one. That is a bit of an exaggeration. Presenting a variant of the sensitivity analysis and a simple numerical example does not really constitute a generalization.

I suggest, before the paper can be accepted, that the authors show more clearly in what it is original, and that they also describe and discuss in more detail the numerical example that they present. It would also be desirable to extend the scope of the paper, as said just below.

1. The analysis presented in the paper is entirely based on the hypothesis that the initial state of the system under observation is known, and that it is only 'parameters' (heat fluxes in the numerical application) that are to be determined from the observations. From a physical point of view, that is highly unrealistic. I presume the authors intended their paper at being only a theoretical and numerical presentation of sensitivity of assimilation-determined parameters to observations. A much more realistic situation would be one where the assimilation is intended at determining both the initial conditions of the system and, in addition, boundary conditions and/or forcing terms. The sensitivity analysis would apply as well to such a situation. I would like to see that point discussed in some detail. In particular, could it be possible to perform an assimilation and a sensitivity analysis in those more general conditions ? I reserve my opinion on acceptance or rejection of the paper on additional information on that aspect.

And I mention that it is not said which initial conditions T_0 was chosen for the numerical experiment described in Section 5. That should be mentioned in case that experiment is discussed in a future version of the paper.

2. The second order approach to sensitivity analysis in variational assimilation is described in detail (and in very clear terms) in Sections 2 and 3. But, as shown in particular in the references the authors give (such as Le Dimet *et al*., 1997, in which the same approach is described), it is classical. That should be made perfectly clear, and it must be said that Sections 2 and 3 are only reminders, with possibly minor changes in detail, of already published material.

3. Concerning the numerical application, too little is said about it. Whatever you will put in a future version, a number of things have to be specified explicitly. For instance

- what was the numerical dimension of the problem (how many scalar parameters to be determined from how many scalar observations) ?

- and say more about the results. For instance, in the present case, was the minimizing Q significantly different from the guess $Q^{(0)}$?

- and try to interpret the results physically. In the present case, can it be explained why the sensitivity to the observations is larger in shallow areas (Fig. 1) ?

Additional remarks.

3. As said above, the title of the present paper is almost the same as the one of the paper Shutyaev *et al.* (2017). There should be more difference. I do not make suggestion at this point, since an appropriate title may depend on the content of the final paper.

4. Eqs 5.1. Is the velocity U assumed to be known from the start ? What is $U_n^{(-)}$? And it is the same on both sides of the third equation (is there not a $U_n^{(+)}$)? And what is d_T ?

5. P. 9, ll. 15-16. I understand you are referring to a sequence of coefficients α_n, with $\alpha_n \to 0$ when $n \to \infty$.

6. P. 3, l. 10. The proper spelling is *Fréchet* (with an acute accent on the first *e*)

7. P. 2, ll. 19-20. There is a slight inconsistency of notation there. If φ belongs to space X, then the operator F must be defined on X x Y_p. Is the derivative $\partial\varphi/\partial t$ supposed to belong to a different space (Y) than φ ? And it might be useful for some readers to state explicitly that the scalar product on Y involves a time integral.

P. 6, l. 8. … *the operator* $\mathcal{H}$, *which acts on w belonging to* Y_p, …

P. 8, Eq. 5.2. Say what B is (the identity operator here, I presume ?).

References

Le Dimet, F.-X., Ngodock, H. E., Luong, B., and Verron, J.: Sensitivity analysis in variational data assimilation, *J. Meteorol. Soc. Japan*, **75** (1B), 245-255, 1997.

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