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Hydrology and Earth System Sciences Discussions

Interactive comment on "Sensitivity analysis and parameter estimation for the distributed modeling of infiltration excess overland flow" *by* W. Castaings et al.

Anonymous Referee #1

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The paper presents a very interesting application of a variational procedure based on the adjoint method for sensitivity analysis and parameter estimation in hydrological modelling. The variational method has been widely applied in meteorology and oceanography but so far only few applications have been reported in rainfall-runoff modelling, which is considered in this paper. The variational method has certainly an interesting potential in hydrological modelling and its advantages and drawbacks compared to other more established sensitivity analysis and parameter estimation methods should be investigated. The present paper makes a valuable contribution to this research. However, some points need further elaboration as well as a final polishing of the paper before it can be published.

In my opinion there are two major reasons why the adjoint methodology has not found wide applicability in hydrological modelling despite its success in other fields. The first reason is related to the problem of equifinality. A large number of publications have addressed this issue and found that local procedures are often insufficient for proper sensitivity analysis and parameter estimation, and hence global procedures have been advanced in hydrological modelling. This issue is discussed by the authors but it has not been shown if the adjoint (local) procedure is appropriate for their model. There is no doubt that the adjoint method has several advantages for application in distributed hydrological modelling as compared to traditionally applied local procedures (e.g. one-at-at-time local sensitivity analysis and gradient-based local optimisation), but how it performs compared to global procedures has not been adequately addressed in the paper. In this regard, one should consider also the trade-off between computational requirements and model complexity and parameterisation issues of the different methods.

The second reason is related to the implementation of the adjoint method in existing computer models. Although quite advanced automatic differentiation programmes have been developed (as also described in the paper), tremendous amount of work is often required to derive the adjoint. I would expect that for a complex model that integrates different process descriptions and has a long coding history several man-years of work is required to derive the adjoint. I think this critical issue needs to be further elaborated in the paper. What are the authors' experiences with the model presented in the paper and with other models?

Specific comments:

1. The abstract is very short and should be extended to provide a brief summary of the paper including the major findings.

2. Page 369, line 14. It seems that something is missing after the "greater than" sign.

3. Page 375, line 8. Be more precise: "The resulting elements of S Ě."

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4. Page 375, line 22. Actually the first two eigenpairs explains more than 97% of the variability.

5. Page 374, line 27 + page 377, line 12. What is the “multi-directional mode” of TAPENADE?

6. Page 379, line 23. The equifinality problem is related to the model structure, quantitiy and quality of data, and the applied objective function. Use of good prior parameter values does not solve the equifinality problem.

7. Page 379, line 24: 2004 -> 2007.

8. Page 381, line 1. Clarify that different initial parameter values have been used for the results shown in Fig. 10.

9. Page 382, line 1. The parameterisations P1 and P2 have not been defined. Furthermore it is not made clear in the text how the singular value spectra can be derived for the different model parameters, and how this information is used to define the other parameterisations.

10. Table 2. Explain the content of the 2nd column in the table caption.

11. Table 3. Explain n_K, n_n etc. in the table caption, and explain in the text the relation between these numbers and the applied parameterisations.

12. Table 4. How are these error statistics derived?

13. Fig. 1+5+7+8. Include legend with colour/grey scale.

14. The written English should be improved.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 363, 2007.