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Adjoint-based sensitivity analysis and parameter estimation for distributed hydrological modeling

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Distributed modeling of catchment hydrology became an attractive approach for the analysis and forecasting of the transformation of rainfall into runoff. However, limited knowledge of model inputs (initial and boundary conditions, parameters) and observations of the hydrological response (specially for extreme events) make the underlying problems of calibration, sensitivity analysis and uncertainty analysis very challenging. Besides, rainfall-runoff is a typical case where the dimension of the system response to be analyzed (or cost function to be optimized) is small compared to the number of inputs to be prescribed. In this case, variational methods using the adjoint technique are very efficient in computing the gradient of an objective function w.r.t. all model inputs (i.e potential control variables). In this prospective study, we focus on parameter uncertainty for a distributed flash flood model and illustrate the potential of variational methods, a framework to carry out both sensitivity analysis and data assimilation. It is demonstrated that the adjoint sensitivity analysis provide usefull guidelines for the choice of the parameters to be calibrated, the specification of calibration criteria and trends for the set up of a consistent parametrization leading to a well posed parameter estimation problem.