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On the use of inverse modeling to improve subsurface drainage simulations

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The application of inverse modeling approaches has been expanded to the field of hydrology this last decade. Here, the inverse modeling has been used to adjust the input parameters of a new agricultural subsurface drainage model (SIDRA-RU) using observations of the model output. SIDRA-RU is a semi-conceptual and semi-analytical model that transforms the rainfall into a daily drainage discharge. The model is divided into two modules. The first one consists of a conceptual reservoir that converts the net rainfall into recharge; the second module simulates the drainage discharge and the water table level above the mid-drains, based on the resolution of the Boussinesq equation.

The adjoint model of SIDRA-RU has been successfully generated by means of the automatic differentiation tool (TAPENADE). First, this adjoint model is used to explore the local and global adjoint sensitivities of the valuable function defined over the drainage discharge simulations (model output), with respect to the model input parameters. Next, the most influential parameters are estimated using both the classical calibration algorithm (PAP-GR) and the variational data assimilation method (4D-VAR). For the latter method, a simple stochastic procedure has been proposed to avoid trapping the minimization process in the local minimum points.

Our results have shown that the quality of the drainage discharge simulations obtained using the 4DVAR method is better than the ones performed by the PAP-GR calibration algorithm, in terms of the water balance in particular. Indeed, less than 5 mm of the cumulative discrepancy was registered between simulated and observed water volume based on the five-year daily drainage discharge data of the Chantemerle agricultural field. However, some numerical tests, conducted to investigate the convergence of the variational calibration method, indicate the potential presence of the equifinality issues. This could be highlighted by the self-compensation of the physical soil parameters (K_{sat} and μ) and those managing the conceptual SIDRA-RU reservoir (S_{inter} and SSDI). The performed sensitivity analysis has shown that the parameters having the most impact on the drainage discharge are those controlling the nervousness and recession of the water level in soils followed by those managing the start of the drainage season.