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# Parameter estimation and steady-state groundwater flow prediction via three stochastic approaches

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We consider log hydraulic conductivity (Y) as uncertain and predict steady-state groundwater head (h) through three different, independent approaches. The first two of them are based on the ensemble Kalman filter (EnKF), their difference being in the way statistical moments (SM) of state variables and parameters are estimated numerically before the Kalman filter is applied. Whereas in the first approach Monte Carlo simulations are used for this aim, in the second approach the required SM are obtained by solving nonlocal stochastic moment equations (ME) of steady state flow. In the third approach, the ME are subjected to a geostatistical stochastic inversion using a pilot point parameterization. Additionally, a less computationally demanding version for each of the first two approaches was obtained by modifying its algorithm to estimate Y geostatistically (i.e., using generalized kriging) at the pilot points of the third method instead of estimating over the entire grid as its original algorithm does. The three methods and their second versions were applied separately in a synthetic 2D steady-state groundwater flow domain to compare their performances. Our results show that all methods and associated versions were effective in estimating h, reaching at least 81% of predictive coverage. For log hydraulic conductivity similar accuracies were obtained in terms of the mean absolute value error for all methods. In terms of numerical performance, we found that coupling the EnKF methods with kriging reduces the CPU time required for data assimilation while both estimation accuracy and uncertainty do not deteriorate significantly.

## References

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