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An integrative data-adaptive approach for global sensitivity analysis: application to subsurface flow and transport

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Predicting flow and transport processes in the subsurface is a challenge since uncertainty in hydraulic properties of the subsurface is ubiquitous. Data sets are limited and costly. For such reasons, stochastic tools are required to support engineering design tasks under uncertainty. One conventional approach for stochastic simulation is the Monte Carlo method (MC). The main drawback associated with MC is their high computational cost. In this work, we propose massive reduction of the initial model to tackle global sensitivity analysis, uncertainty quantification and robust design, based on the arbitrary Polynomial Chaos Expansion technique (aPC). Amongst several advantages, we highlight the following: (1) aPC alleviates the computational burden associated with MC and (2) it allows to condition predictions on all available data sets with swift computations. In addition, the proposed method incorporates the full range of possible outcomes of the investigated model parameters while maintaining a flexible data-adaptive framework. We make full use of a hybrid analytical and numerical formulation that contributes to the computational efficiency of the approach. Our framework provides the tool for control and real-time simulations. Results are illustrated for a groundwater quality problem.