Engineering Risk Analysis Group
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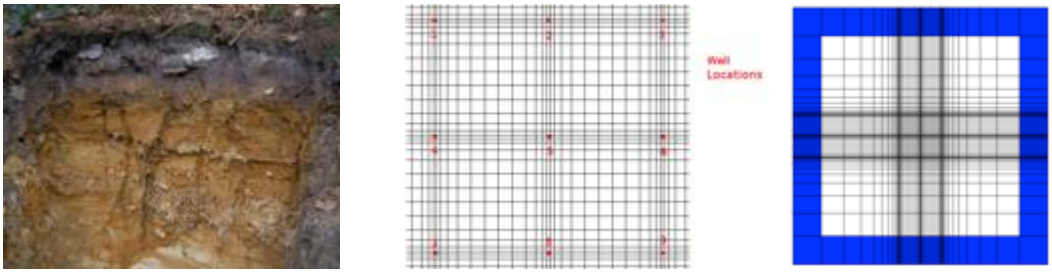
MSc thesis

Application of Subset Simulation to Hydraulic Tomography

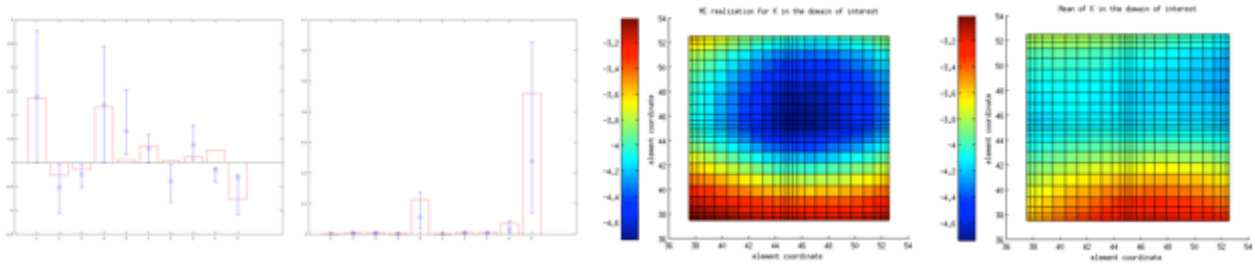
Barbara Rudnick, June 2015

Background

The properties of soil regarding groundwater flow are highly heterogeneous. The structure of pores and the ability of storage and release of fluids in the underground govern the flow processes. In cases of soil or water contamination, the exact prediction of these parameters, the so-called hydraulic conductivity (K) and specific storage (S), becomes essential to minimize risks for humans, animals, or whole ecosystems. A probabilistic method is applied to estimate the aquifer parameters by means of measurement data obtained from sequential pump tests, also called hydraulic tomography.



Soil structure, location of pumps in domain of interest, complete groundwater model



Mean and variance for first 5 Eigenmodes of logK- and logS-field, MC realization and posterior mean of logK-field

Methodology

The uncertain aquifer parameters were modeled as a discrete random field by truncated numerical Spectral Decomposition. The estimation of the distribution of this random field was performed through Bayesian Updating with Structural Reliability Methods (BUS) and Subset Simulation. A two-dimensional synthetic aquifer was modeled and parameter studies of the updating procedure with the linearized model were conducted. For testing of the actual groundwater model, the estimation of a Monte-Carlo realization was performed.

Results

The mean and standard deviation of the updated distribution are estimated satisfactorily on average in the linear case. Increasing the number of measurements for the updating procedure decreases the uncertainty of the estimation but also the efficiency, while an increase of the dimension of the random field only has a small effect on both. For the actual model case, the distribution mean was not close to the realization, probably due to the variability of the subset simulation estimator and the fact that only one run was conducted. However, comparison of drawdown curves of both realization and estimated model gave a close match.

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