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Three-Dimensional Non-Multi-Gaussian Simulation by Including Multiple Types of Information at Non-Colocated Locations

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The incentive of this presentation is the age-old quest of stochastic hydrogeology: Are we able to better match observed long-tailed breakthrough curves by an improved description of the spatial dependence of saturated hydraulic conductivity (K)?

This contribution considers two innovations: We include more information than usual by incorporating multiple types of observations at non-collocated locations (*data fusion*), and we extract more information than usual from the available measurements by analysing statistical properties that go further than typical second-order moments-based analyses (*non-Gaussian geostatistics*).

The evaluation of these innovations in geostatistical simulation methodologies of spatially distributed fields of K is performed against real-world tracer-tests that were performed at the site of the K measurements. The hypothesis is that fields that contain the most information match the observed solute spreading best.

The spatially distributed K- fields were geostatistically simulated using the multi-objective phase annealing (PA) method. To accelerate the asymmetry updating during the PA iterations, a Fourier transform based algorithm is integrated into the three-dimensional PA method. Multiple types of objective functions are included to match the value and/or the order of observations as well as the

degree of the “non-Gausianness” (asymmetry). Additionally, “censored measurements” (e.g., high-K measurements above the sensitivity of the device that measures *K*) are considered.

The MAcroDispersion Experiment (MADE) site is considered the holy grail of stochastic hydrogeology as among the well instrumented sites in the world, the variance of the hydraulic conductivity measurements at the MADE site is fairly large and detailed observations of solute spreading are available. In addition to the classic *K*-measurements obtained via 2611 flowmeter measurements, recently a large set of 31123 *K* measurements obtained via direct push injection logging (DPIL), are available, although not at the same locations where the flowmeter measurements were taken.

The influence of including different types of information on the simulated spatially-distributed fields of *K* are evaluated by analyzing the ensemble spatial moments and the dispersivity of numerical conservative solute tracer tests performed using particle tracking. The improved dependence structure of *K* with all of the above knowledge contains more information than fields simulated by traditional geostatistical algorithms and expected as a more realistic realization of *K* at the MADE site and at many other sites where such data-fusion approaches are necessary.