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From connected subsurface structures to travel time distributions or from travel time distributions to media characteristics: linking the forward and the backward approach

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Reliable estimates of transport parameters are crucial for predicting solute transport and fates. This problem is well understood in homogeneous and heterogeneous soil media with Gaussian covariance structure. Mixing is perfectly symmetrical in the sense that each solute molecule experiences the whole range of possible velocities many times. In the far field the central limit theorem is applicable and transport parameters, especially the dispersions coefficient, may be derived from the variance of either the travel time or travel distance, both are in turn related to the variance of the hydraulic conductivity field. However, symmetry of perfect mixing is ?broken? when either clearly identifiable preferential flow paths are present or the media are structured in the sense that spatial covariance of extreme high values is stronger than in the case of a multivariate Gaussian field. Fast travelling solute molecules in these connected, highly permeable structures will never mix with slow molecules. Hence, the travel time or travel distance distribution will have a fat tail and early breakthrough of contaminants will occur.

The objective of this study is to better understand how transport in structured porous media translates into signatures of travel time distributions. To this end we will generate a sample of structured media with non Gaussian covariance structures of different ?strength? with and without clearly identifiable preferential pathways. These media will be analysed using a) copulas b) usual indicator geostatistics and c) connectivity measures to quantify the deviation from well behaved Gaussian media. Flow and tracer transport in these media will be simulated using a physically based model for different precipitation forcings. The simulated travel time distributions will be analyzed using higher order moments (third and fourth), bi-modal distributions, possibly copulas. The idea is to define and quantify suitable fingerprints of connected structures in travel time distributions (forward step) and to understand in a backward step how we may use these fingerprints to generate structured media with the corresponding covariance structures.