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# Tracer tomography (in) rocks!

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Physical behavior of fractured aquifers is rigorously controlled by the presence of interconnected conductive fractures, as they represent the main pathways for flow and transport. Ideally, they are simulated as a discrete fracture network (DFN) in a model to capture the role of fracture system geometry, i.e. fracture length, height, and width (aperture/transmissivity). Such network may be constrained by prior geological information or direct data resources such as field mapping, borehole logging and geophysics. With the many geometric features, however, calibration of a DFN to measured data is challenging. This is especially the case when spatial properties of a fracture network need to be calibrated to flow and transport data.

One way to increase the insight in a fractured rock is by combining the information from multiple field tests. In this study, a tomographic configuration that combines multiple tracer tests is suggested. These tests are conducted from a borehole with different injection levels that act as sources. In a downgradient borehole, the tracer is recorded at different levels or receivers, in order to maximize insight in the spatial heterogeneity of the rock. As tracer here we chose heat, and temperature breakthrough curves are recorded.

The recorded tracer data is inverted using a novel stochastic trans-dimensional Markov Chain Monte Carlo procedure. An initial DFN solution is generated and sequentially modified given available geological information, such as expected fracture density, orientation, length distribution, spacing and persistency. During this sequential modification, the DFN evolves in a trans-dimensional inversion space through adding and/or deleting fracture segments. This stochastic inversion algorithm requires a large number of thousands of model runs to converge, and thus using a fast and robust forward model is essential to keep the calculation efficient. To reach this goal, an upwind coupled finite difference method is employed to estimate pressure, fluid velocity and temperature fields within the DFN model and to calculate the tracer travel times between sources and receivers.

The algorithm yields an ensemble of equally probable DFNs. This is demonstrated with a synthetic two-dimensional cross-well example. The ensemble can be used to construct fracture network geometry for semi- and/or fully deterministic simulations of the fractured medium. The ensemble also contains stochastic information to assess the uncertainty of the DFN characterization. This is shown by means of fracture probability maps and associated preferential transport trajectories.