Geophysical Research Abstracts,
Vol. 11, EGU2009-9349, 2009
EGU General Assembly 2009

Point-to-point connectivity, an abstract concept or a key issue for risk assessment studies?

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Connectivity of high/low permeability areas has been recognized to significantly impact groundwater flow and solute transport. The task of defining a rigorous quantitative measure of connectivity for continuous variables has failed so far, and thus there exist a suite of connectivity indicators which are dependent on the specific hydrodynamic processes and the interpretation method. Amongst the many existing indicators, we concentrate on those characterizing connectivity between the points involved in a hydraulic or tracer test. The flow connectivity indicator used here is based on the time elapsed for hydraulic response in a pumping test (e.g., the storage coefficient estimated by the Cooper-Jacob method, S_est). Regarding transport, we select the estimated porosity from the breakthrough curve (m_est). According to Knudby and Carrera (2005) these two indicators measure connectivity differently, and are poorly correlated. Here, we use perturbation theory to analytically investigate the intrinsic relationship between S_est and m_est. We find that m_est can be expressed as a weighted line integral along the particle trajectory involving two parameters: the transmissivity point values, T, and the estimated values of Sest along the particle path. The weighting function is linear with the distance from the pumping well, thus the influence of the weighting function is maximum at the injection area, whereas the hydraulic information close to the pumping well becomes redundant (null weight). The relative importance of these two factors is explored using numerical simulations in a given synthetic aquifer and tested against intermediate-scale laboratory tracer experiments. We conclude that the degree of connectivity between two points of an aquifer (point-to-point connectivity) is a key issue for risk assessment studies aimed at predicting the travel time of a potential contaminant.