A Direct Method of Hydraulic Conductivity Structure Identification for Subsurface Transport Modeling

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Abstract: Solute transport in aquifers is strongly influenced by the spatial variability of hydraulic conductivity (*K*). Due to the high cost of drilling, *K* of most aquifers is poorly known. To characterize such environments, we present an efficient direct inverse method to simultaneously identify aquifer *K* pattern, values, and the flow field under unknown aquifer boundary conditions [Jiao & Zhang, 2016]. This method ensures fluid flow continuity using local approximate solutions of the governing equation conditioned to limited measurements, while physics of flow is enforced making the problem well-posed. A single system of equations is assembled and solved, from which parameters and flow field can be simultaneously estimated. For a set of synthetic steady-state problems, inversion is demonstrated using different measurement types, quality, and quantity. When measurement error is increased, the estimated *K* pattern is relatively insensitive to error, although the inverted flow field suffers greater inaccuracy. Local *K* and Darcy flux measurements are found to have similar information content, although subtle differences exist when long-term contaminant release is simulated in the inverted flow fields. Local *K* measurements lead to better identification of *K* pattern, values, and the hydraulic head; Darcy flux measurements lead to more accurate estimation of the velocity field and thus transport prediction. Overall, velocity fields estimated based on hydraulic data can lead to reasonable predictions of contaminant migration and breakthrough, while fine-scale heterogeneity can be recovered at increased sampling density. However, given the cost of field data acquisition, we argue that the goal of pattern inversion is to recover a *sufficient* level of detail to make *approximately accurate* transport prediction. Fine scale details may be ignored by employing appropriate upscaling techniques [Zhang et al., 2006; Zhang & Zhang, 2015]. Our recent work has developed a sequential inversion technique whereas hydraulic and tracer data are sequentially inverted. Future work will (1) evaluate sample network design to optimize data collection; (2) develop joint inversion techniques using hydraulic, tracer, and geophysical data; (3) quantify uncertainty in inversion and forecast.

Reference:

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