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Source Flow in Heterogeneous Aquifers with Application to Hydraulic Tomography

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Enhanced spreading of contaminants by groundwater (macrodispersion) is governed by advection by the velocity field, whose spatial variability is caused by the heterogeneity of the hydraulic conductivity K. Characterization of K distribution in space is a major topic of research. While considerable knowledge has been accumulated for natural gradient flows, hydraulic tomography methods have been forwarded only recently. A typical setup consists of short segments of a well through which water is pumped (injected) and the head H response is measured by pressure transducers along observation piezometers at different distances and elevations. Attempts in the past were done mainly to derive K from measured H by numerical inversion of the flow equation accordingly to a global optimality condition. The present study considers stochastic hydraulic tomography by which measured H are employed in order to identify the statistical parameters of the log-conductivity Y= ln K field (mean, variance, integral scales). As a first step we investigate and present the solution of the steady flow equations relating H statistical moments to those of the K field for the strongly nonuniform source flow, which approximates the main constitutive element of the tomographic setup. This is achieved by numerical simulations for values of the Y variance up to 4 and the derivation of type curves which helps in the identification of K statistics. Application to identification of logconductivity moments for a hydraulic tomography setup is illustrated by a synthetic example.