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Steady-state hydraulic tomography: The role of signal-to-noise ratio and conditioning on hydraulic conductivity tomograms

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Hydraulic tomography is a cost-efficient technique for characterizing subsurface heterogeneity of hydraulic parameters. During hydraulic tomography surveys a large number of hydraulic head data are collected from a series of cross-hole pumping or injection tests in the subsurface. These hydraulic head data are then used to interpret the spatial distribution of hydraulic parameters of the aquifer using inverse modeling. In this study, we utilize the sequential successive linear estimator (SSLE) for interpreting data from steady-state hydraulic tomography to obtain the hydraulic conductivity (K) tomogram of aquifers. We examine the influence of signal-to-noise ratio and biases on inversion results using synthetic data generated through numerical simulations and real cross-hole pumping tests conducted in a synthetic aquifer built in the laboratory. We then show that the order of test data included into SSLE has a large impact on the K tomogram and show its relation to the signal-to-noise ratio of each data set. We also examine the role of conditioning on the computed K tomogram and find that different data are not created equal. That is, some data can refine the K tomogram, but others can worsen the quality of the K tomogram. Overall, these results show that the quality of the K tomogram depends on the design of cross-hole hydraulic tests, their conduct, the order that they are included in the inverse code, and the quality of additional data that are used in its computation.