Aquifer Inversion with Simultaneous Estimation of Parameters, Source/Sink, and Boundary Condition

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Abstract. A two-dimensional direct inversion method has been developed to simultaneously estimate multiple hydraulic conductivities, source/sink strengths, and BC, for both confined and unconfined aquifers. Unlike the objective-function-based parameter estimation techniques, this method does not require forward groundwater flow simulations to assess the data-model misfits, thus the knowledge of BC is not needed. The method directly incorporates noisy observed data (hydraulic heads, groundwater fluxes) at the measurement points in a single step, without solving a boundary value problem. Given sufficient measurement data, the method yields well-posed systems of equations that can be solved efficiently with a coarse inversion grid and nonlinear optimization. The solution is also stable when measurement errors are increased. For a given set of measurement data, the accuracy of the inverse method increases with grid refinement. For both confined and unconfined aquifers, the method has been successfully tested on two-dimensional groundwater flow problems with regular and irregular geometries, different heterogeneity patterns, variances of heterogeneity (maximum K_{max}/K_{min} tested is 10,000), and error magnitudes. When error-free data are used, the estimated conductivities and recharge rates are accurate within ±5% of the true values; when data contain increasing errors, the estimated parameters become less accurate. For problems where the underlying parameter variation is unknown, given error-free data, the method yields equivalent conductivities and average recharge rate within ±5% of the true values. Below shows the inversion results for a two-dimensional confined aquifer, when data are error-free and with ±1% measurement data.