Inverse Modeling of Groundwater Flow in a Fractured Aquifer under Confined Condition

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Abstract. A new approach has been developed to simultaneously estimate steady-state hydraulic conductivities (K), state variables, and boundary condition for a two-dimensional fractured aquifer under confined condition. This method directly incorporates noisy observed hydraulic head and flow rate data at the measurement points, without solving a boundary value problem. Given sufficient measurement data, the method yields well-posed systems of equations that can be solved efficiently with linear optimization. The solution is also stable when measurement errors are increased. In this work the method is tested on inverting groundwater flow for a confined fractured aquifer. Computational experiments have been performed for five fracture patterns, where the observation data are obtained from a true model without imposing measurement errors. The results have proved the validity of this new approach. The first pattern is a domain penetrated by a single vertical fracture, and the error of the estimated fracture conductivity ($K_{fracture}$) is almost 0. The second pattern is a domain penetrated by a single horizontal fracture, and the error of the estimated $K_{fracture}$ is 4.57%. The third pattern is a domain penetrated by a vertical fracture and a horizontal fracture, and the error is 5.29%. The fourth pattern is same as the third, except that the fracture volume is 25 times greater, and the error is 0.70%. All of the previous patterns have been tested for a $K_{fracture}/K_{background}$ ratio of 10. The fifth pattern is a domain penetrated by a set of orthogonal fractures, two of which runs from the left bottom corner to the right top corner and the other one runs from the left top corner to the right bottom corner. This pattern has been tested for a $K_{fracture}/K_{background}$ range of 10^1 to 10^6, and the biggest conductivity estimation error among this set of numerical experiments is 5.27%.