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Identification of Aquifer Stochastic Properties by Oscillatory Pumping Tests with Application to Boise Aquifer Test

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Characterization of spatially variable aquifer properties is a necessary first step towards modeling flow and transport. A recent technique, known as oscillatory pumping tests, consists of injecting periodic discharge into an aquifer and measuring head response along vertical piezometers surrounding the well. The aim is to identify the specific storativity s and conductivity K of the aquifer by an inversion procedure. Recently, an analytical solution for oscillating head in a homogeneous formation was derived and applied to the Boise aquifer test site. Equivalent properties (s_{eq}, K_{eq}) were identified by best fit of the computed and measured heads. Here, this approach is generalized for heterogeneous aquifers of spatially variable log-conductivity (Y=lnK), which is modeled as a stationary space random function characterized by K_G (geometric mean), σ_Y^2 (variance), I and I_v (horizontal and vertical integral scales). The aim is to identify these parameters by solving first the forward problem for the head H and subsequently fitting the measured heads. Semi-analytical solutions are obtained for the mean head amplitude ($\langle|H|\rangle$) and phase by a first order approximation in σ_Y^2. Application to a given realization requires a large ratio between the well length and I_v, as well as availability of a large number of measurements (ergodicity). We define a correction term, ψ, representing the impact of heterogeneity on $\langle|H|\rangle$. Investigating the dependence of ψ upon the distance from the pumping well reveals the existence of a few regimes, namely a near well region in which it is independent of period and far away region, where the solution pertains to a homogeneous aquifer of effective properties. The solution is applied to the Boise aquifer test by a best fit of $\langle|H|\rangle$ with the measured head in 3 piezometers, for a given value of σ_Y^2 = 0.5. In spite of the departure from ergodicity, the identification of K_G is quite robust and in agreement with previous tests while that of I is subject to uncertainty.