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Applying well flow adapted filtering to transient pumping tests

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Transient pumping tests are often used to estimate porous medium characteristics like hydraulic conductivity and storativity. The interpretation of pumping test drawdowns is based on methods which are normally developed under the assumption of homogeneous porous media. However aquifer heterogeneity strongly impacts on well flow pattern, in particular in the vicinity of the pumping well.

The purpose of this work is to present a method to interpret drawdowns of transient pumping tests in heterogeneous porous media. With this method we are able to describe the effects that statistical quantities like variance and correlation length have on pumping test drawdowns. Furthermore it allows inferring on the statistical parameters of aquifer heterogeneity from drawdown data by invers estimation, which is not possible using methods for homogeneous media like Theis' solution.

The method is based on a representative description of hydraulic conductivity for radial flow regimes. It is derived from a well flow adapted filtering procedure (Coarse Graining), where the heterogeneity of hydraulic conductivity is assumed to be log-normal distributed with a Gaussian correlation structure. applying the up scaled hydraulic conductivity to the groundwater flow equation results in a hydraulic head which depends on the statistical parameters of the porous medium. It describes the drawdown of a transient pumping test in heterogeneous media.

We used an ensemble of transient pumping test simulations to verify the up scaled drawdown solution. We generated transient pumping tests in heterogeneous media for various values of the statistical parameters variance and correlation length and evaluated their impact on the drawdown behavior as well as on the temporal evolution. We further examined the impact of several aspects like the location of an observation well or the local conductivity at the pumping well on the drawdown behavior.

This work can be understood as an expansion of the work of Zech et al. [2012], where a corresponding method to interpret stationary well flow is presented. However steady state pumping tests require a high number of monitoring wells, where not only the number but also the location of the piezometers is of importance for the quality and reliability of estimation results of aquifer heterogeneity. By using temporally resolved drawdown data of transient pumping tests we can circumvent the lack of sparse data in space.

Zech, A., C. L. Schneider, and S. Attinger, 2012, The Extended Thiem's solution: Including the impact of heterogeneity, Water Resour. Res., 48, W10535, doi:10.1029/2012WR011852.