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Beyond Thiem - a new method for interpreting pumping tests in heterogeneous aquifers

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We present a new mathematical method for interpreting a single field scale pumping test in heterogeneous aquifers by making use of multiscaling techniques. Usually, the heterogeneous character of aquifers prevent a consistent interpretation of pumping tests based of Thiem's formula which is developed for homogeneous aquifers. We aim at developing a more general approach valid for heterogeneous aquifers.

By combining a multiscale technique called Coarse Graining with Renormalization Group analysis, we derive an effective formula for the hydraulic conductivity in a radial two dimensional well flow field. In particular, the effective conductivity behaves radial distance dependent from the well and equals the local conductivity close to the well and the geometric mean in the far field of the well. Our results imply that properties of the hydraulic conductivity like the geometric mean as well as aquifer structures characterized by a correlation length can be infered from a single pumping test, while the variance can only be estimated from pumping tests that average over depth (across the vertical axis).

We show numerical investigations using MODFLOW that support our results. Using the proposed method, we are able to infer the geometric mean and the correlation length of statistically generated conductivity fields from a single two dimensional field scale pumping test, while in addition the variance could be infered from data of a pumping test that averages over depth.