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Multi-scale data integration for the hydrogeological characterisation of a dual-porosity aquifer

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We investigate the impact of model complexity and multi-scale prior hydrogeological data on the interpretation of pumping test data in a dual-porosity aquifer (the Chalk aquifer in UK). Different approaches ranging from a traditional analytical solution (Theis approach) to more sophisticated numerical models with automatically calibrated input parameters are applied to to characterize the hydrogeological properties. Comparisons of results from the different approaches show that neither traditional analytical solutions nor a numerical model assuming a homogenous and isotropic aquifer is effective for reproducing the experimental drawdowns. Significant increments in model accuracy in seven monitoring locations are achieved when medium and local scale prior data about the vertical hydraulic conductivity profile is taken into account to constrain the model calibration process. In particular, the integration of medium scale vertical hydraulic conductivity (K) variations based on flowmeter measurements lead to an improvement in the goodness-of-fit of the simulated drawdowns of about 30%. Further improvements (up to 70%) were obtained when a simple upscaling approach was used to integrate small-scale K data to constrain the automatic calibration process of the numerical model. Although our analysis focuses on a specific case study considering the Chalk aquifer in England, these results provide insights about the representativeness of the estimates of hydrogeological properties based on different interpretations of pumping test data, and highlight the importance of integrating multi-scale prior information for the parameterisation of heterogeneous aquifers in complex hydrogeological settings.