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Assessment of hydraulic tomography data by means of MCMC geostatistical analysis: a field case

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Knowledge of spatial variability of the hydraulic conductivity it is of crucial importance in aquifer modeling; a large number of methodologies has been developed in the last two decades to investigate the aquifer properties. The Quasi Linear Geostatistical Approach (QLGA) is a valuable methodology to estimate hydraulic conductivity fields based on few observed hydraulic heads due to natural groundwater flow or to pumping tests performed on the study area and constrained using prior information on the structure of the fields themselves. Recently the QLGA was improved with a Monte Carlo Markov Chain (MCMC) allowing the estimation of large contrast hydraulic conductivity fields generating equally likely conditional realizations that are accepted or rejected on the basis of the Metropolis Hastings scheme. This methodology was applied to evaluate hydraulic conductivities of a well field using the head data collected during tests performed in 2009. AIPO (Interregional Agency for the Po River Management), during the summer 2008, built a well field at the Boretto Research Site (Reggio Emilia) Italy. The field is constituted of a main well (diameter 323 mm) and four monitoring wells (125 mm) that can be also used for extraction. The aquifer is confined with a thickness of about 16 m. The Po River stage affects the well field groundwater level because of its closeness.
The considered methodology is very accurate in case of strong heterogeneity but, on the other hand, it requires a computational effort not negligible. It needs a numerical model of the study area able to reproduce the boundary conditions, the geometry of the aquifer and the pumping tests. In this work the groundwater flow process has been simulated by means of a version of MODFLOW_2005 that is able to efficiently calculate sensitivities of observations to estimable parameters needed in the inverse procedure. Five pumping tests, in hydraulic tomography way, were performed and the collected data were processed by means of the previous methodology to estimate the aquifer hydraulic conductivity field. The aquifer is described through one layer and it is discretized by 100 x 50 cells with a grid resolutions of 3 m x 3 m, resulting in 5000 unknown hydraulic conductivity values. 1000 conditional realizations were generated and the first 500 were considered as training period of the chain. The Metropolis Hastings algorithm accepted about 50% of the realization achieving a heterogeneous hydraulic conductivity field consistent with the alluvial nature of the aquifer.