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Delineation of geologic facies in heterogeneous aquifers by the Truncated Plurigaussian Method

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We provide a geostatistically-based reconstruction of the spatial distribution of the main litho-facies characterizing the geological makeup of the groundwater system contributing to the major natural springs in the area of Cremona, Italy. Over-exploitation of the groundwater system for agricultural and industrial uses in the study area can result in significant lowering of the water table, thus threatening the environmental conditions favored by the natural springs in the area under study. The groundwater system is constituted by two main productive aquifers, which are separated by a locally discontinuous aquitard. We start from an existing data-base comprising detailed sedimentological information as well as data on time-evolution of groundwater levels in the two major aquifers. A set of (conditional) three-dimensional lithofacies distributions within the system is simulated in a Monte Carlo framework estimated by means of (a) an indicator-based approach and (b) the Truncated Plurigaussian method. While the former methodology only relies on a variogram-based analysis, the latter allows integrating geological concepts, $e.g.$, relative locations and proportions of the different lithofacies, in the simulation procedure. As such, the truncated plurigaussian simulation method provides a way of using both local/regional and conceptual geological information (from various sources) to infer the distributions of geo-materials and, ultimately, the associated hydraulic parameters. It retains the main advantages of the truncated Gaussian method, in the sense that it produces permissible sets of indicator semi-variograms and cross-semi-variograms, and overcomes some of its limitations, most notably the fact that the truncated Gaussian method only reproduces sequentially ranked categories. The resulting aquifer reconstructions are then adopted to provide multiple realizations of the groundwater flow field to assess the impact that various scenarios involving groundwater extraction from the system have on the water availability to the springs.

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