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Global sensitivity analysis for the geostatistical characterization of a regional-scale sedimentary aquifer

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We perform a variance-based global sensitivity analysis to assess the impact of the uncertainty associated with (a) the spatial distribution of hydraulic parameters, e.g., hydraulic conductivity, and (b) the conceptual model adopted to describe the system on the characterization of a regional-scale aquifer. We do so in the context of inverse modeling of the groundwater flow system. The study aquifer lies within the provinces of Bergamo and Cremona (Italy) and covers a planar extent of approximately 785 km2. Analysis of available sedimentological information allows identifying a set of main geo-materials (facies/phases) which constitute the geological makeup of the subsurface system. We parameterize the conductivity field following two diverse conceptual schemes. The first one is based on the representation of the aquifer as a Composite Medium. In this conceptualization the system is composed by distinct (five, in our case) lithological units. Hydraulic properties (such as conductivity) in each unit are assumed to be uniform. The second approach assumes that the system can be modeled as a collection of media coexisting in space to form an Overlapping Continuum. A key point in this model is that each point in the domain represents a finite volume within which each of the (five) identified lithofacies can be found with a certain volumetric percentage. Groundwater flow is simulated with the numerical code MODFLOW-2005 for each of the adopted conceptual models. We then quantify the relative contribution of the considered uncertain parameters, including boundary conditions, to the total variability of the piezometric level recorded in a set of 40 monitoring wells by relying on the variance-based Sobol indices. The latter are derived numerically for the investigated settings through the use of a model-order reduction technique based on the polynomial chaos expansion approach.