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Joining direct and indirect inverse calibration methods to characterize karst, coastal aquifers

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Parameter estimation is extremely relevant for accurate simulation of groundwater flow. Parameter values for models of large-scale catchments are usually derived from a limited set of field observations, which can rarely be obtained in a straightforward way from field tests or laboratory measurements on samples, due to a number of factors, including measurement errors and inadequate sampling density. Indeed, a wide gap exists between the local scale, at which most of the observations are taken, and the regional or basin scale, at which the planning and management decisions are usually made. For this reason, the use of geologic information and field data is generally made by zoning the parameter fields. However, pure zoning does not perform well in the case of fairly complex aquifers and this is particularly true for karst aquifers. In fact, the support of the hydraulic conductivity measured in the field is normally much smaller than the cell size of the numerical model, so it should be upscaled to a scale consistent with that of the numerical model discretization.

Automatic inverse calibration is a valuable procedure to identify model parameter values by conditioning on observed, available data, limiting the subjective evaluations introduced with the trial-and-error technique. Many approaches have been proposed to solve the inverse problem. Generally speaking, inverse methods fall into two groups: direct and indirect methods. Direct methods allow determination of hydraulic conductivities from the groundwater flow equations which relate the conductivity and head fields. Indirect methods, instead, can handle any type of parameters, independently from the mathematical equations that govern the process, and condition parameter values and model construction on measurements of model output quantities, compared with the available observation data, through the minimization of an objective function.

Both approaches have pros and cons, depending also on model complexity. For this reason, a joint procedure is proposed by merging both direct and indirect approaches, thus taking advantage of their strengths, first among them the possibility to get a hydraulic head distribution all over the domain, instead of a zonation. Pros and cons of such an integrated methodology, so far unexplored to the authors' knowledge, are derived after application to a highly heterogeneous karst, coastal aquifer located in southern Italy.