3-D VERSUS 2-D MODELING OF NATURAL AQUIFERS: THE EXPERIMENTAL SITE OF SETTOLO, ITALY

Francesco Zovi, Department of Civil, Environmental, and Architectural Engineering, University of Padova, +39 049 827 5438, francesco.zovi@unipd.it

1. Francesco Zovi, Department of Civil, Environmental, and Architectural Engineering, University of Padova
2. Matteo Camporese, Department of Civil, Environmental, and Architectural Engineering, University of Padova
3. Paolo Salandin, Department of Civil, Environmental, and Architectural Engineering, University of Padova

In the practical framework of modeling natural aquifers it is often difficult to determine in advance whether the increased effort required by the use of a 3-D over a 2-D model is justified by a higher quality of the expected results and a proper description of the physical processes. There are actually cases, such as modeling of regional or large-scale flow, where the difference between the results obtained from a 2-D and a 3-D model is negligible. In other cases, mostly characterized by smaller scales (for example, flow toward a well), there is a substantial improvement if a three-dimensional model is used, because 2-D and 3-D schemes treat in a different way mechanisms like, e.g., extraction from wells and recharge from watercourses and lakes. In particular, a 3-D model can deal with partially penetrating wells and limited-depth lateral recharge, while a 2-D model cannot handle these typically three-dimensional dynamics, being all the involved quantities depth-averaged.
The objective of this study is to model the behavior of a natural aquifer where such circumstances emerge clearly by means of both 2-D and 3-D finite-element models. Our test field is the alluvial phreatic aquifer of Settolo, a piedmont area in Northeastern Italy, with an extension of approximately 6 km2 and that exhibits heterogeneities of the geological structures both at the local and intermediate scales. The subsurface is crossed by paleo-riverbeds and characterized by different facies, with an average aquifer thickness of 50 m . The interactions between watercourses and the aquifer, the recharge linked to the precipitation, as well as the dynamics of partially penetrating extraction wells must be properly reproduced for an effective protection and a sustainable exploitation of the water resources. In order to do so, a careful site characterization is in progress, with a number of different measurements and scales involved. The models used are i) a two-dimensional solver on an unstructured grid of the nonlinear Dupuit-Boussinesq equation and ii) a three-dimensional solver of the Richards equation that uses a structured horizontal grid with a variable vertical discretization of the 3-D mesh.
The results of this study give some useful insights on the pros and cons associated to the use of 3-D versus 2-D models, in terms of consistency to the physical processes, complexity, and computational effort, when dealing with a real aquifer of medium size, i.e. within an intermediate scale range.