Nested models to simulate groundwater flow at different scales

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A finite difference model at fine scale (spacing 100 m) is developed to simulate groundwater flow in an area whose surface is about 25 km^2 located in the eastern part of the town of Milano (Italy). In this area the Municipal Water Works realized a pumping station, which consists of six couples of wells. The shallow wells are drilled in the "traditional aquifer" whose base is located at a depth of about 100 m; the filtered intervals of the deep wells are located in correspondence of "deep aquifers" located at a depth greater than 120 m and separated by the traditional aquifer from a continuous clay layer.
This fine scale model is nested in a large scale model (spacing 500 m) which simulates the groundwater flow over a region whose extension is about 400 km^2 and which includes the whole area of the town.
The spacing of the large scale model corresponds to the extension of the pumping stations of the Municipal Water Works, so that each cell of the numerical model includes at most one pumping station. The results of the large scale model are used to constrain the fine scale model, in particular to define the boundary conditions of the fine scale model. Dirichlet boundary conditions derived from the large scale model provide a strong constraint, which leads to unsatisfactory results because some of the wells are close to the boundary itself. Neumann boundary conditions permits the fine scale model to give a more flexible response; nevertheless they require the assignation of at least one fixed head node to obtain a unique solution. The choice of the location and of the head value of this node is critical.