A New Ghost-Node Method for Linking Different Ground-Water Models and Initial Investigation of Heterogeneity and Nonmatching Grids

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A method was developed for flexible and robust grid refinement of ground-water models that use different types of numerical methods. One application is the use of a child (local scale) finite-element model to solve for local heat and (or) solute transport by using boundary conditions derived from a parent (regional scale) finite-difference model. This paper presents a new iterative method that uses ghost nodes to link different models. The models are solved iteratively based on the shared-node method for coupling a parent model that encloses a child model described by Steffen W. Mehl and Mary C. Hill in 2002. Ghost nodes are located within the parent model along a line or plane that passes through nodes of parent cells along the model interface. The links between the parent and child models—specified-flow boundary conditions for the parent model and specified-head boundary conditions for the child model—are achieved by using heads at ghost nodes and flows through the material in model cells between the child and ghost nodes. The ghost-node method can be used to link nonmatching grids that occur when parent-model cell edges/faces do not coincide with child-model cell edges/faces and the parent model nodes do not coincide with a ghost node. The ghost-node method is tested for two- and three-dimensional systems that are either homogeneous or moderately heterogeneous, and for matching and nonmatching grids. The coupled models are simulated by using the finite-difference MODFLOW and finite-element FEHM models for the parent and child grids, respectively. Results for models of two-dimensional, homogeneous systems having matching or nonmatching grids indicate that the new method is as accurate as coupling using shared-node method of two MODFLOW models having matching grids. The three-dimensional systems exhibit similar errors to the two-dimensional homogeneous systems with both matching and nonmatching grids.

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