High-resolution adaptive algorithms for subsurface flow

A. S. Almgren *, J. B. Bell *, **G. Pau** † and M. J. Lijewski *

Simulations of subsurface flow play an important role in assessing the long term fate of groundwater contaminants around waste disposal sites, evaluating strategies for carbon sequestration and a variety of other applications. Here, we describe a computational framework for high-fidelity simulation of multiphase-multicomponent flow in porous media. Our approach is based on a sequential formulation that treats pressure implicitly, combined with a semi-implicit treatment of convection, diffusion and reactions. The convective component of the discretization uses a second-order variation of Godonov's method that provides a robust and accurate treatment of nonlinear waves. This basic discretization methodology is integrated into a parallel adaptive mesh refinement framework. The adaptive refinement strategy is based on a hierarchical approach using structured grids. The parallelization of the methodology is based on a coarse-grained distributed memory model in which grid patches are distributed to processors. We briefly describe the elements of the discretization approach and discuss the issues associated with incorporating the basic discretization methodology into the adaptive framework. Finaly, we demonstrate the overall methodology and discuss parallel performance on some representative model problems.

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†Center for Computational Sciences and Engineering, Lawrence Berkeley National Laboratory, Berkeley, CA 94720. Research supported by an Alvarez Fellowship at LBNL under contract No. DE-AC02-05CH11231.