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An efficient multiscale finite-volume method for modeling density driven flow in porous media

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In recent years, a flourishing activity on multiscale modeling has developed in the domain of reservoir modeling. In this context, multiscale modeling is seen as an alternative to traditional upscaling technique in that it targets the full problem with the original resolution through an upscaling-downscaling procedure. Several techniques with different characteristics have been proposed: the Multiscale Finite-Element and Mixed Finite-Element methods, and the Multiscale Finite-Volume (MSFV) method.

Here, we consider the Multiscale Finite-Volume (MSFV) method, which has been developed to solve multiphase flow problems on large and highly heterogeneous domains efficiently. It employs an auxiliary coarse grid, together with its dual, to define and solve a coarse-scale pressure problem. A set of local numerical solutions on dual cells (basis functions and correction function) is used to interpolate the coarse-grid pressure and obtain the approximate fine-scale pressure distribution. This framework is particularly flexible and allows modeling of physically complex flows. For the case of gravity-driven flow, numerical simulations demonstrate excellent agreement between the MSFV solutions for pressure and saturation and the corresponding fine-scale reference solutions.

The advantage of the MSFV method is the computational efficiency for large problems (the method is adaptive and naturally parallel). The natural evolution of this method is towards a framework for multiphysics modeling.