

Multilevel techniques lead to accurate numerical upscaling and scalable robust solvers for reservoir simulation - DTU Orbit (08/11/2017)

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This paper demonstrates an application of element-based Algebraic Multigrid (AMGe) technique developed at LLNL (¹⁹) to the numerical upscaling and preconditioning of subsurface porous media flow problems. The upscaling results presented here are further extension of our recent work in ³. The AMGe approach is well suited for the solution of large problems coming from finite element discretizations of systems of partial differential equations. The AMGe technique from ^{10,9} allows for the construction of operator-dependent coarse (upscaled) models and guarantees approximation properties of the coarse velocity spaces by introducing additional degrees of freedom associated with non-planar interfaces between agglomerates. This leads to coarse spaces which maintain the specific desirable properties of the original pair of Raviart-Thomas and piecewise discontinuous polynomial spaces. These coarse spaces can be used both as an upscaling tool and as a robust and scalable solver. The methods employed in the present paper have provable $O(N)$ scaling and are particularly well suited for modern multicore architectures, because the construction of the coarse spaces by solving many small local problems offers a high level of concurrency in the computations. Numerical experiments demonstrate the accuracy of using AMGe as an upscaling tool and comparisons are made to more traditional flow-based upscaling techniques. The efficient solution of both the original and upscaled problem is also addressed, and a specialized AMGe preconditioner for saddle point problems is compared to state-of-the-art algebraic multigrid block preconditioners. In particular, we show that for the algebraically upscaled systems, our AMGe preconditioner outperforms traditional solvers. Lastly, parallel strong scaling of a distributed memory implementation of the reservoir simulator is demonstrated.

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