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Sparsified coarse-scale operators for multiscale methods

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Generating a solution for the pressure in reservoir models with fine-scale heterogeneities, modeled at a meter scale, can be compute-intensive. Multiscale methods aim at reducing the runtime for the solution of Poisson-type equations by solving coarsened flow problems that account for fine-scale variations. To obtain a coarse-scale operator one needs to project the fine-scale operator using prolongation and restriction transfer operators. The choice of transfer operators determines the sparsity pattern and the quality of the coarse-scale operator. Multiscale restriction-smoothed basis (MsRSB) method and the classical multiscale finite volume (MSFV) method provide coarse-scale operators with MPFA-like stencils even when TPFA fine-scale operator is used at the fine level. Typically, the use of a denser MPFA operator is justified by its ability to capture tensorial permeability effects unlike TPFA or multiscale coarse-scale operators.
In this work, we show an algorithm that reduces the sparsity pattern of the coarse-scale operator for multiscale methods irrespective of the choice of prolongation and restriction operators. Once the choice is made on the transfer operators, the algorithm sparsifies the coarse-scale operator to the desired sparsity pattern. We test the algorithm on the state-of-the-art MsRSB method to solve the elliptic pressure equation on 2D layers of the 10th SPE comparative solution project. The SPE10 problem has uniform structured grids with diagonal permeability tensor which motivated our choice of reducing the coarse operator sparsity to a TPFA-like stencil structure. Results show the potential of this approach as we were able to reduce the coarse-scale stencil size and get solutions with tolerable errors compared to the reference solution.

Participation

In-Person

References

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