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MULTISCALE METHODS AS SPATIOTEMPORAL GRID-REFINEMENT TECHNIQUES

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In the last decade, multiscale methods have been developed and proposed to efficiently solve large reservoir models. These techniques allow reducing the computational cost by decreasing the size of the largest problem to be solved: the initial fine-scale problem is divided into a set of independent local problems coupled by a coarse problem which is smaller than the original problem. This approach can be seen as a refined upscaling technique, which uses local numerical solutions to compute coarse parameters and to reconstruct the (approximate) fine-scale details of the solution.

Here, we focus on the Multiscale Finite-Volume (MsFV) method [1, 2], which is usually interpreted as an adaptive upscaling/downscaling technique aimed at reducing the computational cost. In many problems, however, the original discretization (dictated, for instance, by the geological heterogeneity) might be inadequate to accurately describe the physical processes of interest. Typical examples are flow instabilities that require very fine grids to capture the instability onset. In this case, the essential components of the MsFV method can be used to construct an adaptive grid-refinement algorithm, which can be applied to model density-driven instability [3, 4], to couple Darcy-scale and pore-scale descriptions of multiphase flow [5], and to allow different time stepping at coarse and fine scale [6].

Compared with classic grid-refinement techniques this approach has the advantage that the size of the largest problem to be solved is bounded by the size of the original (unrefined) problem; also, the MsFV framework naturally allows using different physical descriptions at different scales in a truly multiphysics framework and offers great flexibility in devising adaptive strategies to limit the cost of the refinement.

REFERENCES

[1] Jenny, P., S. H. Lee, and H. Tchelepi, Multi-scale finite-volume method for elliptic problems in subsurface flow simulation, *J. Comp. Phys.*, 187(1):47–67, 2003.

[2] Lunati, I., and S. H. Lee, An operator formulation of the multiscale finite-volume method with correction function, *Multiscale Model. Simul.*, 8(1):96–109, 2009.

[3] Künze, R., and I. Lunati, An adaptive multiscale method for density-driven instabilities, *Journal of Computational Physics*, 231, 5557–5570, 2012, `http://dx.doi.org/10.1016/j.jcp.2012.02.025`,

[4] Künze, R., P. Tomin, and I. Lunati, Local modelling of instability onset for global finger evolution, *Advances in Water Resources*, 2013 (under review)

[5] Tomin, P., and I. Lunati, A Hybrid Multiscale Method for Two-Phase Flow in Porous Media, *Journal of Computational Physics*, 250, 293–307, 2013 `http://dx.doi.org/10.1016/j.jcp.2013.05.019`

[6] Tomin, P., and I. Lunati, Local-global splitting and spatiotemporal-adaptive Multiscale Finite Volume Method, *Journal of Computational Physics*, 2013 (under review)