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On POD-based Deflation Vectors for DPCG applied to porous media problems

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Abstract

We study fast and robust iterative solvers for large systems of linear equations resulting from simulation of flow through strongly heterogeneous porous media. We propose the use of preconditioning and deflation techniques, based on information obtained from the system, to reduce the time spent in the solution of the linear system.

An important question when using deflation techniques is how to find good deflation vectors, which lead to a decrease in the number of iterations and a small increase in the required computing time per iteration. In this paper, we propose the use of deflation vectors based on a POD-reduced set of snapshots. We investigate convergence and the properties of the resulting methods. Finally, we illustrate these theoretical results with numerical experiments. We consider compressible and incompressible single-phase flow in a layered model with variations in the permeability layers up to 10^3 and the SPE 10 benchmark model with a contrast in permeability coefficients of 10^7. Using deflation for the incompressible problem, we reduce the number of iterations to 1 or 2 iterations. With deflation, for the compressible problem, we reduce up to $\sim 80\%$ the number of iterations when compared with the only-preconditioned solver.

Keywords: Deflation, POD, PCG, Single-Phase Flow, Heterogeneous Porous

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