Creative Tools for Scientific Writing, Preparatory assignment 1

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November 2016

1 Introduction.

Often, most computational time in the simulation of multiphase flow through porous media is taken up by the solution of the pressure equation. This involves solving large systems of linear equations as part of the iterative solution of the time and space discretized governing nonlinear partial differential equations. The time spent in solving the linear systems depends on the size of the problem and the variations of permeability within the medium. Solution of large-cale problems or problems with extreme contrasts in the permeability values may lead to very large computing times. Iterative methods are known to be the best option to solve the above mentioned problems. However, sometimes the iterative methods are not sufficient to solve these problems in a reasonable amount of time and finding a way to accelerate the convergence of these methods becomes neccesary.

Preconditioners and Reduced Order Models (ROM) have been studied as tools to improve computational efficiency [1, 2] for problems involving large variations of permeability. Among ROM methods, Proper Orthogonal Decomposition (POD) has been investigated in [3, 4, 5] with encouraging results. The use of a POD-based preconditioner for the acceleration of the solution is proposed by Astrid et al. [6] to solve the pressure equation resulting from two-phase reservoir simulation, and by Pasetto et al. [4] for groundwater flow models. The POD method requires the computation of a series of 'snapshots' which are solutions of the problem with slightly different parameters or well inputs. Once the snapshots are computed, the POD method is used to obtain a set of basis vectors that capture the most relevant features of the system. These basis vectors can be used later to speed-up the subsequent simulations.

Problems with a high contrast between the permeability coefficients are sometimes approached through the use of deflation techniques; see, e.g., [7]. The use of deflation techniques involves the search of good deflation vectors, which are usually problem-dependent. Following the ideas of [6, 3, 4, 5], we propose the use of POD of many snapshots to capture the system's behavior. Furthermore, we combine this technique with deflation to accelerate the convergence of iterative methods.

In this work, the basis obtained with POD is studied as an alternative choice of deflation vectors to accelerate the convergence of the pressure solution in reservoir simulation.

References

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