ID: 8.1c

Title: Preconditioner methods applied to simulations of two-phase flow in porous media

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When simulating the flow of two phases such as oil and water through a porous medium [1, 2, 3] it is necessary to repeatedly solve systems of linear equations which are both large and sparse. In order to consider flow under steady-state conditions we embed a two-dimensional model porous medium on a torus, resulting in bi-periodic boundary conditions which affect the sparsity structure of the Cholesky factors. A variation of the Incomplete Cholesky preconditioned Conjugate Gradient (ICCG(n), [4]) solver is considered, where instead of only including additional diagonals, a neighbourhood search is used to identify the sparsity structure of the incomplete Cholesky factors. Also, a viscosity ratio between the two fluids requires us to update the preconditioner at irregular intervals. How often this should be done depends on the magnitude of the viscosity ratio, on the cost of updating the preconditioner and on how quickly the simulation configuration changes. A dynamic preconditioner update criterion is considered, which analyses cost versus likely benefit at each iteration of the simulation. [1] F.A.L. Dullien, Porous Media: Fluid Transport and Pore Structure, 2nd ed. (Academic Press, San Diego, 1992). [2] E. Aker, K.J. Maloy, A. Hansen, and G.G. Batrouni, Transport in Porous Media 32, 163 (1998). [3] H.A. Knudsen, E. Aker, and A. Hansen, Transport in Porous Media 47, 99 (2002). [4] J.A. Meijerink and H.A. van der Vorst, Mathematics of Computation 31, 148 (1977).