Multiscale simulations with efficient multiphase coarse solvers

J. O. Skogestad[1], E. Keilegavlen[1], and J.M. Nordbotten[1]

[1]*Department of Mathematics, University of Bergen, Bergen, Norway*

ABSTRACT: Simulation of flow and transport in porous media is computationally demanding, and for many applications it is necessary to seek simplifications to reduce the computational cost. Upscaling is commonly applied both to single phase and multiphase problems. The latter is generally difficult to perform, however with dominating flow processes such as gravitational or capillary forces, the fine scale can be assumed to be in equilibrium, and an equivalent coarse problem can be constructed.

The quality of the coarsened multiphase problem hinges on the suitability of the equilibrium assumption, and in some cases a fine scale simulation is needed to obtain the desired accuracy. In these cases, the coarse problem can serve as a preconditioner for the fine problem, rendering a two-level method. In this work we pursue the idea of a non-linear two-level method for coupled pressure and saturation problems. Combining ideas from the Additive Schwarz Preconditioned Inexact Newton (ASPIN) and the Heterogeneous Multiscale Method (HMM), we formulate the communication between the fine and coarse scale models according to the dominant physical processes. When upscaling is feasible, the multiscale method will recognize this and automatically adapt. The methodology is illustrated by problems that are close to being in vertical equilibrium.