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Application of partially-coupled hydro-mechanical schemes to multiphase flow problems

Elena Tillner and Thomas Kempka

GFZ German Research Centre for Geosciences, Fluid Systems Modelling, Telegrafenberg, 14473Potsdam, Germany (etillner@gfz-potsdam.de)

Utilization of subsurface reservoirs by fluid storage or production generally triggers pore pressure changes and volumetric strains in reservoirs and cap rocks. The assessment of hydro-mechanical effects can be undertaken using different process coupling strategies. The fully-coupled geomechanics and flow simulation, constituting a monolithic system of equations, is rarely applied for simulations involving multiphase fluid flow due to the high computational efforts required. Pseudo-coupled simulations are driven by static tabular data on porosity and permeability changes as function of pore pressure or mean stress, resulting in a rather limited flexibility when encountering complex subsurface utilization schedules and realistic geological settings. Partially-coupled hydro-mechanical simulations can be distinguished into one-way and iterative two-way coupled schemes, whereby the latter one is based on calculations of flow and geomechanics, taking into account the iterative exchange of coupling parameters between the two respective numerical simulators until convergence is achieved. In contrast, the one-way coupling scheme is determined by the provision of pore pressure changes calculated by the flow simulator to the geomechanical simulator neglecting any feedback.

In the present study, partially-coupled two-way schemes are discussed in view of fully-coupled single-phase flow and geomechanics, and their applicability to multiphase flow simulations. For that purpose, we introduce a comparison study between the different coupling schemes, using selected benchmarks to identify the main requirements for the partially-coupled approach to converge with the numerical solution of the fully-coupled one.