Multiscale domain decomposition methods for the subsurface flow simulation of oil recovery

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Abstract. The Multiscale Robin Coupled Method (MRCM) is a domain decomposition method that has been introduced to efficiently approximate velocity and pressure fields for single-phase flows in highly heterogeneous porous media (Guiraldello et al., 2018). Its discrete variational formulation generalizes other well-established multiscale domain decomposition mixed methods, such as the Multiscale Mortar Mixed Finite Element Method (MMMFEM) (Arbogast et al., 2000 & 2007), the Multiscale Hybrid Mixed Finite Element Method (MHM) (Harder et al., 2013), and the Multiscale Mixed Method (MuMM) (Francisco et al., 2014). The MRCM rely on the imposition of a Robin-type boundary conditions on the interfaces between the non-overlapping subdomains, such that the solution of all these methods can be recovered by a suitable choice of the Robin boundary parameter and the approximation spaces for the interface unknowns, which are in fact the interface pressure and normal fluxes. The individual choices of discrete spaces for both these quantities introduces a great deal of flexibility to the method (Guiraldello et al., 2019). The MRCM was well explored for the solution of single-phase flows and has been recently extended for two-phase flows in porous media. By introducing an operator splitting strategy, the scalar conservation law for the saturation of one of the phases and the velocity field can be updated sequentially. In this scenario, the suitable choice of parameters and discrete interface spaces for the MRCM is thoroughly investigated. Results show unprecedented improvement in accuracy when compared to other multiscale mixed methods available in the literature, when simulating highly heterogeneous petroleum reservoirs.