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Automated Model Order Reduction via Method of Freezing

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We aim to develop multi-phase hydraulic models that uniquely combine high predictive capacity and low complexity. The objective is to enable their usage in drilling automation strategies for down-hole pressure management during Managed Pressure Drilling operations. The Drift Flux Model (DFM) [1], a system of multiscale non-linear Partial Differential Equations, is a hydraulic model typically used to adequately capture the salient dynamics of wave propagation phenomena. Classical numerical techniques, yielding high fidelity models, are not suitable for real-time estimation and control or multi-query simulations due to the high computational time and data storage required. The development of reduced-order modelling techniques is hence an indispensable step.

Convection dominated problems, such as the DFM, admit solutions, which possess a diagonal structure in space-time diagram and demonstrate high solution variability. Reduced order model representations of such problems can be effectively described by introducing the idea of method of freezing [2]. We combine this idea with non-linear reduced basis approximation [3] to deal with the scenario where multiple wave-fronts co-exist and interact. This is an important extension to develop a reduced order model of DFM, which is characterized by multiple fronts. Moreover, we include the effect of source terms, non-linear boundary conditions and investigate the impact of their inclusion on the reduced-order modelling framework. Finally, we present numerical experiments and discuss the efficacy of such an approach in terms of computational speed up and computational accuracy.

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