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An adaptively coupled multiphysics model for compositional two-phase flow targeting underground gas storage

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Compositional flow is an important feature of numerical models in the context of gas storage in the subsurface. In practice, not only maximum inflow and outflow rates, development of reservoir pressure and gas plume shape in time are important, but because the gas is to be extracted and, e.g., combusted in a turbine, its molecular composition is of great interest. In addition, dissolution of the storage gas into the brine phase reduces the total amount of retrievable and thus commercially usable gas. Due to uncertainties associated with geological data, efficient and accurate models for energy storage in the underground need to be developed, which is additionally challenging since modeling compositional effects generally increases the complexity of models and with that the computational cost. The concept of vertical equilibrium (VE) [1,2] can be exploited in the context of compositional flow to develop fast models that give accurate solutions. In addition to phase equilibrium, which develops when a less dense gas phase is injected into the resident brine and moves upward to pool below an impermeable barrier, chemical equilibrium forms along the vertical direction driven by the chemical potential between the phases and diffusion within the phases.
In this talk we present a vertically integrated compositional model which is adaptively coupled to a compositional full multidimensional model. We use the compositional VE model in regions of the domain where the compositional VE assumption is valid, and the compositional full multidimensional model everywhere else. We develop and analyze local criteria to identify
where the compositional VE assumption is valid in the domain, including extraction and hysteretic effects on the coarse scale. During runtime of the multiphysics model, VE subdomains are identified by the local criterion and the models are assigned adaptively to those regions. We use two test cases: gas injection into a horizontal layer and gas storage with reversed flow in an idealized dome-shaped aquifer, and show efficiency and accuracy of the compositional VE model and the compositional multiphysics model.

[1] Y. Yortsos. A theoretical analysis of vertical flow equilibrium. Transport in Porous
Media, 18(2):107–129, 1995.
[2] L. W. Lake. Enhanced oil recovery. Prentice Hall Englewood Cliffs, 1989.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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