Motivation

Underground storage of synthetic gas from renewable energy

- Large domains and limited data require efficient models that adapt locally to varying domain/process complexity.
- Our adaptive multiphysics model currently couples two models: a full-multidimensional model and a vertical equilibrium (VE) model, both for immiscible two-phase flow.
- We extend the two-model hierarchy, e.g., to include compositional models for full multidimensions and vertical equilibrium.

Conceptual compositional VE model

We consider two phases (brine, gas) and two miscible components (water, gas).

Assumed vertical profiles

We neglect the influence of vertical pressure gradient on density and miscibility. Reference pressure is the pressure at the bottom.

Tools & Methods

C++, DuMuX

Governing equations

Full multidimensional pressure and transport equation:

\[
\frac{\partial p}{\partial t} - \sum_{n} \frac{\partial}{\partial x_n} \left( \sum_{\alpha} X_{\alpha}^n \dot{q}_n^\alpha \right) - \sum_{\alpha} \frac{\partial}{\partial x_n} \phi^\alpha = \phi - \frac{\partial}{\partial t}
\]

Vertically integrated pressure and transport equation:

\[
\frac{\partial V}{\partial t} - \sum_{n} \frac{\partial}{\partial x_n} \left( \sum_{\alpha} X_{\alpha}^n \dot{q}_n^\alpha \right) - \sum_{\alpha} \frac{\partial}{\partial x_n} Q^\alpha = \Phi - \frac{\partial}{\partial t}
\]

VE criteria

VE criteria are based on vertical profiles of parameters \( \beta \), e.g., saturation or relative permeability.

\[
c_{\beta} = \frac{\int_{0}^{H} |\beta - \beta'| dz}{H_{VE}}
\]

Preliminary results

Brooks-Corey cap. pressure: \( \lambda = 2 \), \( p_0 = 1 \) bar
Depth: 1000 m
Temperature: 52 \( ^\circ \)C
Injection rate: \( q^{CH4} = 552 \, t/m^2/a \)

Collaboration

- PN 5-2b: Development and analysis of the optimization framework.
- TU Delft: Lab- and field-scale experiments of gas storage.
- PN 5-1: Identification and description of global optimization spaces.
- PN 1-5: Model hierarchy for porous medium / free flow interfaces.