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The Uncertainty of Unsteady-State Relative Permeability Measurement Protocols

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For the field development planning for carbon capture and sequestration and the underground storage of hydrogen, it is important to have a consistent set of relative permeability and capillary pressure-saturation functions. Regulatory requirements and minimum standards of operators may require conducting these measurements with well-established industrial protocols which have been developed over 3-4 decades, in many cases for good reasons because of the long-standing experience how non-standard workflows can result in systematic mistakes and unacceptably large uncertainty ranges.
However, because of the specific thermophysical and molecular properties of carbon dioxide and hydrogen, and a potential impact on wetting properties, ripening phenomena etc. which all potentially impact relative permeability, it may be required to perform respective measurements with the actual fluids and not with model fluids, which may be a challenge for traditional measurement protocols. For instance, in steady-state type of measurements a large fluid volume needs to be injected which can be a challenge. Although there are precedence cases where steady-state experiments for CO2 have been successfully demonstrated, the more convenient type of experiments are the unsteady-state type of experiments. However, the unsteady-state type of experiments are more difficult to interpret and the simple analytical interpretation is deceptive with respect to systematic errors and large model-based uncertainty ranges.
By using inverse modelling on a synthetic data set which serves as the ground truth, we demonstrate how unsteady-state experiments conducted at a single flow rate and without measuring in-situ saturation profiles can result in uncertainty ranges many times larger than the instrumental error. By using in-situ saturation profiles and multiple flow rates to properly constrain the inverse model, we demonstrate that the uncertainty ranges can be reduced to that of the instrumental error, which is in the range of a few percent.

Participation

In-Person

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