Contribution ID: **23** Type: **Oral Presentation**

Uncertainty Quantification of Relative Permeability Measurements by Inverse Modelling

Wednesday, 2 June 2021 14:00 (15 minutes)

Multiphase flow in porous media plays a key role for many energy-related processes, ranging from transport in gas diffusion layers in fuel cells to the recovery of oil and gas from subsurface geological formations. Uncertainty assessment of e.g. hydrocarbon recover processes is typically performed on the basis of field-scale flow simulations which use a continuum mechanics formulation based on Darcy's law and phenomenologically extended to multiphase flow. One of the consequences of that phenomenological extension is the introduction of empirical parameters such as the relative permeability-saturation function which need to be determined experimentally. The field-scale model predictions have a very high sensitivity on the uncertainty in the relative permeability-saturation functions. Therefore, it is important to understand the uncertainty of relative permeability associated with the experimental measurements and data interpretation.
Relative permeability is obtained by interpreting production, saturation data and pressure drop from flow experiments by either analytical methods or inverse modelling. Traditionally, inverse modelling is performed by manually which does not provide a systematic estimate of the associated uncertainty. We have developed a framework for a consistent uncertainty assessment of relative permeability measurements. Inverse modelling is automated using the Python optimization toolbox coupled a flow simulator. Either conventional flow simulation packages such as reservoir simulators are coupled with a wrapper, or a native Python implementation is used which is a factor 400 faster. That allows to go beyond the gradient-based optimization approaches but apply a Markov-chain Monte Carlo (MCMC) scheme on 10 or more parameters within an acceptable time.
We find in practically all cases considered signature of non-uniqueness, which can be suppressed by involving more and different types of data, e.g. saturation profiles but not fully eliminated. By matching the flow model directly to the data provides significantly smaller uncertainty ranges than first performing a manual match and then fitting the resulting tabulated relative permeability with an analytical function. Due to the phenomenological history of the 2-phase Darcy approach, it is furthermore not clear which parameterization for relative permeability should be used. By comparing a Corey with a LET representation we see better consistency with the data using the LET function, but still residuals have non-Gaussian structure, suggesting that current models are not a fully adequate representation of the experimental reality, which calls for a more in-depth understanding of the flow experiments und underlying flow regimes.

Time Block Preference

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

References

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Session Classification: MS14

Track Classification: (MS14) Uncertainty Quantification in Porous Media