The Virtual Geophysical Footprint of CO_2 Sequestration

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ABSTRACT

Numerical flow simulations can be used to assess the effectiveness and long-term integrity of reservoirs for carbon dioxide (CO_2) sequestration. In order to mitigate uncertainties in the geological and petrophysical characterizations of reservoir and flow models, geophysical tools are installed on the ground surface or down wells to monitor the initial injection phase and subsequent spreading of the CO_2 plume. Numerical simulations are used to evaluate the suitability of monitoring designs for effective imaging through inversion of the collected observational data. There are a number of geophysical methods available for targeting the recovery of the electric conductivity distribution including electrical resistivity tomography (ERT) and controlled source electromagnetic (CSEM).

To simulate the CO_2 injection and plume spreading, we apply a multiphase multicomponent flow model with components water, CO_2 and NaCl. The solver uses a hybrid finite element-node-centered finite volume discretization method (FEFV) [**?**] providing - among other quantities - predictions for the evolution of saturation, porosity and water salinity from which the distribution of electric conductivity is derived via Archie's law and its variations. An input quantity into Archie's law is the electric conductivity of the pore fluid, in this case the mixture of CO_2 and water, where the salinity of the water is key contributing factor. This model is extended by introducing a complex conductivity tensor to account for phase shifts and anisotropy effects due to fracturing [**?**].

In a post-processing step the resulting geophysical signal for various survey set ups is derived. The appropriate differential equations are solved using the FE method, typically on a much bigger domain than used for the reservoir simulator, in order to take the spatial spread of the electric field into consideration. The inversion problem, to recover the electric conductivity from geophysical measurements as a proxy for spread of CO_2 plume, is solved using the Broyden–Fletcher–Goldfarb–Shanno algorithm [**?**].

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