Quantitative CO2 monitoring at the CaMI Field Research Station (CaMI.FRS), Canada, using a hybrid structural-petrophysical joint inversion

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A key requirement by the European CCS directive for the safe operation of geological CO\textsubscript{2} storage is the operator’s responsibility to demonstrate containment of the injected CO\textsubscript{2} and conformance between its actual and modelled behavior. Understanding the subsurface behavior and long-term fate of the injected CO\textsubscript{2} requires the quantification of key reservoir parameters (e.g. pore pressure, CO\textsubscript{2} saturation and strain in the overburden). Reliable quantification of these parameters and distinction between them pose a challenge for conventional monitoring techniques, which could be overcome by combining advanced multi-disciplinary and multi-method monitoring techniques in a joint inversion.

Within the aCQurate project, we aim to develop a new technology for accurate CO\textsubscript{2} monitoring using Quantitative joint inversion for large-scale on-shore and off-shore storage applications. In previous applications of joint inversion to CO\textsubscript{2} monitoring, we successfully combined the strengths and advantages of different geophysical monitoring techniques (i.e. seismics with its high spatial resolution and geoelectrics with its high sensitivity to changes in CO\textsubscript{2} saturation), using a cross-gradient approach to achieve structural similarity between the different models. While this structural joint inversion provides a robust link between models of different geophysical monitoring techniques, it lacks a quantitative calibration of the model parameters based on valid rock-physics models. This limitation is addressed by extending the previously developed structural joint inversion method into a hybrid structural-petrophysical joint inversion, which allows integration of cross-property relations, e.g. derived from well logs.

The hybrid structural-petrophysical joint inversion integrates relevant geophysical monitoring techniques in a modular way, including seismic, electric and potential field methods (FWI, CSEM, ERT, MMR and gravity). It is implemented using a Bayes formulation, which allows proper weighting of the different models and data sets, as well as the relevant structural and petrophysical joint inversion constraints during the joint inversion.
The hybrid joint inversion is designed for on-shore and off-shore CO$_2$ storage applications and will be demonstrated using synthetic data from the CaMI Field Research Station (CaMI.FRS) in Canada. CaMI.FRS is operated by the Containment and Monitoring Institute (CaMI) of CMC Research Institutes, Inc., and provides an ideal platform for the development and deployment of advanced CO$_2$ monitoring technologies. CO$_2$ injection occurs at 300 m depth into the Basal Belly River sandstone formation, which is monitored using a large variety of geophysical and geochemical monitoring techniques. In preparation for the application to real monitoring data, we present the application of the joint inversion to synthetic full waveform inversion (FWI) and electrical resistivity tomography (ERT) data, derived for a geostatic model with dynamic fluid flow simulations.

In addition to obtaining a better understanding of the subsurface behavior of the injected CO$_2$ at CaMI.FRS, our goal is to mature the joint inversion technology further towards large-scale CO$_2$ storage applications, e.g. on the Norwegian Continental Shelf.

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