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Insights on CO_2 migration by means of a fully-coupled hydrogeophysical inversion

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Permanent crosshole electrical resistivity tomography has received consideration as a powerful and cost-effective tool for continuous monitoring of CO_2 storage reservoirs, as the electrical subsurface properties are highly sensitive to fluid substitution processes. In conventional approaches, geoelectrical data sets are collected at specific points in time and processed independently. Obtained tomographic images can then be used to derive information on the spatiotemporal development of CO_2 saturation. While this approach has proven its feasibility and practical value at several test sites worldwide, it suffers from the common merits of ill-posed tomographic inversions and strongly depends on data quality, data coverage, and regularization constraints. We circumvent the need for repeated geoelectrical inversions by directly feeding the entire time-lapse ERT data into a fully-coupled hydrogeophysical inversion in order to constrain a multi-phase flow simulation of the CO_2 storage reservoir at Ketzin, Germany. Modeled changes in CO_2 saturation are translated to changes in electrical resistivity, honoring an experimentally determined petrophysical relation, and subsequently used for geoelectrical forward modeling. Transport relevant parameters of the Ketzin reservoir are then estimated based on an iterative comparison between measured and simulated apparent resistivity curves.

Finally, we integrate our results with other observational data including hydraulic pumping tests, CO_2 arrival times, and pressure observations and discuss their individual sensitivities on the estimated parameter distribution.