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Monitoring brine migration in analog transport models using surface-to-hole ERT

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Deep saline aquifers are target formations for both, the geological storage of carbon dioxide and geothermal applications. As a consequence of fluid or gas injection processes, deep subsurface brines are displaced, implicating a potential salinization of shallow freshwater resources in the presence of hydraulic conduits. The Electrical Resistivity Tomography (ERT) is sensitive to compositional changes of groundwater resources and can help to elucidate preferential flow pathways of saline water in the near-surface region and the vicinity of electrodes-equipped boreholes. In this respect, numerical simulations can make a valuable contribution by identifying probable brine migration scenarios, and thereby guiding an optimum sensor network layout within the scope of an early warning system. In this study, the performance of frequently used electrode configurations to detect laterally uniform intrusion of a synthetic brine into a freshwater-saturated porous medium is evaluated for a practical surface-to-hole setup. The workflow includes numerical flow and transport simulations of the salinization scenario to support the experimental realization and to validate modeling and monitoring results. The experiment exhibited a good agreement of observed and simulated saltwater arrival, underlining the predictive capability of the numerical flow and transport model. Inversion results of bipole-bipole and Wenner measurements reveal superior imaging capability compared to the remaining configurations, most likely owing to the variable spacing of current and potential electrodes throughout the measuring sequence.