05

Estimating optimum electrode locations for high-resolution cross-hole resistivity monitoring

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Cross-hole electrical resistivity tomography has recently been recognized as a method to monitor the migration of carbon dioxide injected into deep saline aquifers due its specific sensitivity to pore fluid changes. Given the potential environmental impacts and the substantial installation costs, the design of permanent electrode arrays becomes particularly important. In former studies, the model resolution has been identified as a computationally expensive but valuable image appraisal quantity, as it combines both sensitivity and linear interdependence of the measurements involved. By an iterative and parallelized evaluation of the model resolution on modern computing architectures, a methodology was realized to estimate optimum electrode locations along the borehole trajectories for given geologic scenarios with the objective to maximize the resolution within a prescribed target horizon. Based on synthetic experiments for a realistic CO_2 plume migration scenario, we present optimized layouts for different borehole spacings and reservoir thicknesses. Our results indicate that sparse setups with a refinement of the electrode spacing within the target horizon can yield comparable tomographic performances with respect to rather dense arrays.