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Large-scale DC geoelectric measurements at the CO_2 pilot storage Ketzin: Time-lapse inversion and evaluation of imaged volume

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The geophysical monitoring programme at the Ketzin pilot site comprises DC geoelectric measurements in three different setups (surface-to-surface, surface-to-downhole and crosshole). The first two setups are performed as Dipole-Dipole measurements on crossed profiles as well as two rings centred around the injection well. The latter two setups make use of a permanent well installation with 45 electrodes deployed in three wells. These measurements are intended to monitor subsurface resistivity changes associated with the migration of the injected CO_2. Laboratory measurements on core samples and Archie fluid substitution indicate a resistivity increase of a factor of about 2-3. Based on this increase a model is created, which integrates the geologic setup and well logged resistivities. The model is used for sensitivity studies and cross-evaluation with field data. Pre-inversion field data of the surface-downhole measurements indicate a relevant resistivity increase in the injection depth interval being consistent with the observations of the crosshole geoelectric monitoring.
Inversion is performed with BERT (Boundless Electrical Resistivity Tomography) using unstructured triangulated meshes and structural constraints. Structural constraints are collected from the lithology and interpretation of seismic measurements. These constraints allow to consider for the sparseness of the surface measurements and to regularize the equivalent model space. The inversion scheme takes the data quality in an error-weight scheme into account, which is shown to be essential to deal with the ambient noise and the temporally progressing degradation of the subsurface installation. Inversion results show a clear increase in resistivity in the injection formation, but raise question for the extent of the imaged volume. This question is addressed by pre-inversion analysis of electrode configuration specific sensitivities and post-inversion analysis of the depth/volume of investigation. Sensitivities are observed to decrease rapidly with increasing distance to the wells, making imaging of thin layered CO_2 migration at a distance of several electrode distances from the well infeasible. The contribution is finished with a discussion about modification of the geoelectric imaging by variation of surface-downhole acquisition based on the Ketzin experience.