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Cross-hole ERT monitoring to investigate mixing processes of freshwater injection in a hyper-saline aquifer

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A freshwater injection experiment was carried out in the hyper-saline aquifer underlying the Molentargius-Saline Regional Park located near Cagliari (Sardinia, Italy). The experiment was monitored using time-lapse Electrical Resistivity Tomography (ERT) through five boreholes, which are positioned in a square with an 8 m long side and one borehole in the centre and with a depth of 20 m. All boreholes are equipped with twenty-four stainless steel cylindrical electrodes, separated by 0.8 m. The aquifer sediments are mostly composed of sands with thin layers of silty sand, clayey sand and silty clay. The water table is stable around 5.2 m depth. Electric fluid logs recorded in the boreholes allowed to discriminate two zones, with a transitional layer in between: (a) from the water table to 7.5 m the water electrical conductivity is about 2 S/m; (b) below 12 m depth the water electrical conductivity reaches 18.5 S/m. We injected 19.4 m³ of freshwater using a double packer system positioned in the central borehole, with an injection chamber located between 13 and 14 m depth. The injection rate was only controlled by the natural pressure gradient. ERT monitoring was achieved by measuring along two 2D ERT planes corresponding to the two square diagonals, thus involving three boreholes at a time with a total of 72 electrodes. A mixture of dipole-dipole and bipole-bipole configurations was used in each acquisition. To investigate mixing processes, numerical flow and transport modeling was carried out using a 3D density-driven mixed-FEM/FV aquifer simulator. The injection borehole was simulated as a preferential flow path and the injection was modeled by imposing higher pressure within the injection chamber nodes. Results at different times show a vertical upward migration of the freshwater body as observed in the ERT field experiment. The salt concentration values of the simulations were converted into electrical conductivity using Archie's law and a 3D geoelectrical forward modeling was performed. The inverted synthetic images are compared with the observed ERT images.