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An ensemble Kalman filter approach to identify the hydraulic conductivity spatial distribution from electrical resistivity tomography time-lapse monitoring of three-dimensional tracer test experiments

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An approach based on the Lagrangian formulation of transport and the ensemble Kalman filter (EnKF) is applied to assess the spatial distribution of hydraulic conductivity K by assimilating time-lapse cross-hole electrical resistivity tomography (ERT) images generated for a synthetic tracer test in a heterogeneous aquifer. Assuming that the solute spreads as a passive tracer, for high Peclet numbers the spatial moments of the evolving plume are dominated by the spatial distribution of the hydraulic conductivity. The assimilation of the electrical conductivity 4D images allows updating both the hydrological state in terms of solute concentration and the spatial distribution of K. Thus, delineation of the tracer plume and estimation of the aquifer heterogeneity at the local scale can be achieved at the same time by means of this interpretation of time-lapse electrical images from tracer tests. We assess the impact on the performance of the hydrological inversion of the uncertainty inherently affecting ERT inversions in terms of tracer concentration and the choice of the prior statistics of K. The results show that realistic ERT images can be integrated into a hydrological model even within an uncoupled inverse modeling framework, the reconstruction of the hydraulic conductivity spatial distribution being satisfactory in the portion of the domain directly covered by the passage of the tracer. Aside from the issues commonly affecting inverse models, the proposed approach is subject to the problem of the filter inbreeding and the retrieval performance is sensitive to the choice of K prior geostatistical parameters.