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Coupled vs. uncoupled hydrogeophysical inversion via ensemble Kalman filter assimilation of ERT-monitored tracer test data

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Recent advances in geophysical methods have been increasingly exploited as inverse modeling tools in groundwater hydrology. In particular, several attempts to constrain the hydrogeophysical inverse problem to reduce inversion error have been made using time-lapse geophysical measurements through both coupled and uncoupled inversion approaches. The main advantage of coupled approaches is that the numerical models for the geophysical and hydrological processes are linked together such that the geophysical data are inverted directly for the hydrological properties of interest. On the other hand, uncoupled approaches allow assessing in advance the reliability of the data, thanks to the geophysical inversion that is carried out before estimating the hydrological variable of interest. In spite of the recent popularity of fully coupled inversion approaches, we argue that their superiority over uncoupled methods still needs to be proven. The objective of this work is to shed some light on this debate. An approach based on the Lagrangian formulation of transport and the ensemble Kalman filter (EnKF) is here applied to assess the spatial distribution of hydraulic conductivity (K) by assimilating ERT data generated for a synthetic tracer test in a heterogeneous aquifer. In the coupled version of our inverse modeling tool, the K distribution is retrieved by assimilating raw ERT voltage data without the need for a preliminary electrical inversion. In the uncoupled version, K is estimated by assimilating time-lapse cross-hole electrical resistivity tomography (ERT) images derived by an electrical inversion. We compare the performance of the two approaches in a number of simulation scenarios and assess the impact on the inversions of the choice of the prior statistics of K.