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Using environmental tracers and transient hydraulic heads to estimate groundwater recharge and conductivity

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Regional groundwater flow strongly depends on groundwater recharge and hydraulic conductivity. While conductivity is a spatially variable field, recharge can vary in both space and time. None of the two fields can be reliably observed on larger scales, and their estimation from other sparse data sets is an open topic. Further, common hydraulic-head observations may not suffice to constrain both fields simultaneously. In the current work we use the Ensemble Kalman filter to estimate spatially variable conductivity, spatiotemporally variable recharge and porosity for a synthetic phreatic aquifer. We use transient hydraulic-head and one spatially distributed set of environmental tracer observations to constrain the estimation. As environmental tracers generally reside for a long time in an aquifer, they require long simulation times and carries a long memory that makes them highly unsuitable for use in a sequential framework. Therefore, in this work we use the environmental tracer information to precondition the initial ensemble of recharge and conductivities, before starting the sequential filter. Thereby, we aim at improving the performance of the sequential filter by limiting the range of the recharge to values similar to the long-term annual recharge means and by creating an initial ensemble of conductivities that show similar pattern and values to the true field. The sequential filter is then used to further improve the parameters and to estimate the short term temporal behavior as well as the temporally evolving head field needed for short term predictions within the aquifer. For a virtual reality covering a subsection of the river Neckar it is shown that the use of environmental tracers can improve the performance of the filter. Results using the EnKF with and without this preconditioned initial ensemble are evaluated and discussed.