Constraining flow and reactive transport models with environmental tracer data

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Groundwater flow models often provide the basis for important water resources management decisions while reactive transport models serve as tools to analyse and predict spatial and temporal changes in groundwater quality, particularely in polluted aquifers. However, bost types of numerical models suffer to some degree from non-uniqueness. For groundwater flow models an important source of non-uniqueness is that any model calibration procedure that solely relies on hydraulic heads as calibration constraints can primarily provide estimates of the ratio of hydraulic conductivity to recharge, but nor for both of them independently. This induces considerable predictive uncertainties, for example in the assessment of recovery time-scales after anthropogenic disturbances. Also, many reactive transport transport models, e.g., those that simulate the evolution of point source or diffuse pollution problems over several decades, may only be constrained through measured concentration snapshots that describe the present day spatial distribution of the contaminant concentrations and other reactants. On the other hand, environmental tracers such as ^{3}H, ^{39}Ar, ^{14}C *and* ^{36}Cl have been used for several decades to estimate groundwaters residence times, while being underutilised as direct model calibration constraints.

In this study we present several illustrative examples of reactive transport models in which we not only quantify a wide range of biogeochemical processes but also jointly consider the fate of one or more environmental tracers to better constrain the migration rates and mass fluxes of groundater pollutants. Vice versa, we also use the integrated simulation approach to asses how geochemical processes, besides physical flow and transport processes, may affect the fate of environmental tracers in groundwater systems and quantify the impact of these processes on interpreting groundwater ages.