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Use of apparent water age at groundwater production wells to evaluate maps of long term average groundwater recharge

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The long-term average groundwater recharge typically varies greatly in space due to differences in climate, soil, landuse, topography and groundwater levels. Long-term average recharge is a key input to steady- state groundwater models. This type of models is frequently used to determine the long-term safe yield to aquifer systems and to predict the fate of human-derived contaminants in capture zones of groundwater production wells. An accurate quantification of the spatial distribution of recharge is therefore important but difficult to achieve as it cannot be directly measured at regional scales. Several methods have been applied to indirectly estimate the spatial distribution of long-term average groundwater recharge including spatially distributed hydrological modelling and the regionalisation of catchment scale recharge estimated from long-term average baseflows. In the context of a groundwater model, it is difficult to evaluate the reliability of these recharge maps if groundwater levels are the only data set available for model calibration. Concentrations of environmental tracers measured at groundwater wells can be used to interpret the apparent groundwater age, which in turn is significantly influenced by the magnitude and spatial distribution of recharge contributing groundwater to the well. Thus, the apparent groundwater age at wells may be useful to assess the reliability of maps on long term average groundwater recharge. To test this hypothesis, a steady-state groundwater model was set up for a 180 km^2 area in SW Germany, which is extensively used for groundwater production from a confined limestone aquifer. We tested three maps of long-term average recharge that were all computed using different methods. For each recharge map, the steady-state groundwater model was calibrated against water levels and mean groundwater ages were calculated for groundwater production wells from particle tracking methods. These computed groundwater ages were subsequently compared to apparent groundwater age estimated based on concentrations of tritium and sulfur hexafluoride using a combined exponential-piston flow model with admixture of an ancient and tracer free water component. All of the three recharge maps differed significantly and thus resulted in substantially different estimates of groundwater age. A lack of fit for groundwater ages partially resulted from the uncertainty in interpreting tracer concentrations measured at the wells. However, the sensitivity of modelling results to recharge suggests that groundwater models can be used to estimate the spatial distribution of recharge if accurate observations on both heads and groundwater age are available.