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Investigating the impact of conceptual model uncertainty and diverging climate change scenarios on groundwater nitrate concentration predictions

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Abstract At the European scale, nitrate concentration is the most important parameter that determines groundwater quality. Since in most cases nitrate input into the aquifer is a non-point source pollution problem, measures to reduce nitrate leaching have to be designed on the aquifer scale. In this context we have coupled the unsaturated, vertical soil water and nitrogen transport model SIMWASER/STOTRASIM with the saturated groundwater flow and transport model FEFLOW in a sequential manner to simulate groundwater nitrate concentrations for the Westliches Leibnitzer Feld aquifer (45 km²) in southeast Austria. However, in Austria, information about the crops grown is only available as percentages on an aggregated level of cadastral municipalities. Thus, from a conceptual point of view, delineation of the spatial distributions of groundwater recharge and nitrogen leaching time series from arable land are highly uncertain. Within this work, three different approaches consisting of increasing spatial and crop differentiation are employed to investigate the impact on groundwater nitrate concentrations: (i) grain maize production for the entire model area, (ii) one crop rotation per cadastral municipality, and (iii) a stochastic procedure that accounts for the unknown crop grown and applied nitrogen fertilizer amount on each particular lot. Furthermore, the influence of four climate change projections on groundwater, where the predicted temperature and precipitation time series have been statistically downscaled, is investigated. Different combinations of soil water and nitrate leachates are processed as input distributions to saturated groundwater flow and transport modelling. In terms of mean nitrate leaching concentrations, the prediction uncertainty due to the different approaches of spatial and crop differentiation is significantly larger than that due to climate projections. It is shown that even the two climate projections yielding maximum and minimum groundwater recharge and nitrogen leaching do not meaningfully alter the resulting groundwater nitrate concentrations in general. However, at certain locations mean groundwater nitrate concentrations changes are of the order of 20% until 2100.

Key words groundwater recharge; nitrate leaching; land-use; coupled modelling; aquifer scale; climate change predictions; groundwater nitrate concentrations