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A fuzzy rule based metamodel for monthly catchment nitrate fate simulations

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The high complexity of nitrate dynamics and corresponding deterministic models make it complicated to find suitable tools for decision support (DS) in large river catchments. Models for DS should ideally be easily applicable, fast, parsimonious in data requirements, easy to understand even for non-experts, able to reproduce sub-annual nitrate dynamics in order to evaluate temporal mitigation measures, and capable of scenario analysis. All these characteristics can be met with fuzzy rule based modelling.

As a machine learning technique fuzzy rules have to be trained on data. Especially for nitrate, rarely enough data in sufficient temporal and spatial resolution is available. To circumvent this problem, the metamodelling approach can be used to train the fuzzy rules. This means a well-calibrated deterministic catchment model is used to generate "observed" data, which in a second step serve as training data for the fuzzy model.

This study presents a fuzzy rule based metamodel consisting of eight fuzzy modules, which is able to simulate nitrate fluxes in large watersheds from their diffuse sources via surface runoff, interflow, and base flow to the catchment outlet. The fuzzy rules are trained on a database established with a calibrated SWAT model for an investigation area of 1000 km^2. The metamodel performs well on this training area and on two out of three validation areas in different landscapes, with a Nash-Sutcliffe coefficient around 0.5-0.7 for the monthly calculations. The fuzzy model proves to be fast, requires only few readily available input data, and the rule based model structure can be interpreted to a certain degree, which deems the presented approach suitable for the development of decision support tools.