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Integrated modeling of nitrate loss and flowpaths in the mesoscale Bode catchment, Germany

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The understanding of nutrient flowpaths and their influences on nutrient input in rivers with help of high temporal resolution time series data at catchment scale is important for better management of water resources and land use. Although the Bode River is moderately to heavily polluted by agricultural nutrients inputs, the knowledge about the paths of nutrients transporting from the basins to the stream, as well as their temporal/spatial changes is still poor. The objective of the study is to (i) assess runoff and nitrate loads in the surface water of the Bode subbasin Selke River; (ii) investigate the effects of hydrological mechanisms on streamwater nitrate dynamics at different hydrological conditions. A coupled HYPE model and two-component mixing model was used. The HYPE model is an integrated process-oriented water and nutrient model, developed to simulate stream flow, transport and turnover of nitrate N, phosphorous, and DOC at the catchment scale. The HYPE model was used to calculate runoff and internal flow variables (surface flow, interflow at different soil layers and groundwater flow) and streamwater nitrate concentration. High resolution time series data of nitrate concentration, δ18O and electric conductance were used as tracers to implement hydrograph separation at events respectively using a two-component mixing model (event water and pre-event water) integrated in the HYPE model. Multi-site and multi-objective functions were used to calibrate runoff and the internal flow variables and nitrate concentration with observed daily time series data of discharge and nitrate at certain gauge stations. Through analysis of the relationship between hydrological mechanisms and nitrate dynamics, the dominant transport pathways of nitrate were determined.
The runoff simulation was carried out for the Selke catchment from 1991 to 2000 at daily timesteps for three discharge gauge stations. The calculated discharge represents the measured water flow dynamics at the gauge stations well with average Nash-Sutcliffe value 0.64, especially for high flow conditions. Though a significant under-prediction could be noticed during low flow conditions. The potential evapotranspiration rate (vegetation-dependent) was found to be the most important and sensitive parameter for runoff calculation. Whereas different parameters involved in modules of runoff generation processes were interdependent, meaning the calibration should be done on parameter sets instead of individual parameters. High resolution time series data of water quality constituents (nitrate, turbidity, electric conductance, and SAK) monitored at Meisdorf gauge station show a strong correlation to the discharge. The results show that shallow quick subsurface flow was the dominant flowpath transporting nitrate from basins to the stream during rainfall events. Besides the effects of hydrological mechanisms on nitrate exports, the availability of nitrate sources is also a key factor. Through calibration and validation of the coupled HYPE and two-component mixing model with help of the high resolution time series data of water stable isotope values and water quality constituents, it will be possible to be transferred to other catchment for analysis of nitrate flushing mechanisms.