EGU2020-9292
https://doi.org/10.5194/egusphere-egu2020-9292
EGU General Assembly 2020

River water quality modeling using continuous high frequency data allows disentangling whole-stream nitrogen uptake and release pathways

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River water quality models offer studying spatio-temporal variation and processes of nitrogen (N) turnover. However, the infrequent temporal resolution of monitoring data commonly limit the reliability of modeling instream N processing. These limitations of the temporal data resolution can result in equifinality of model parameter sets and considerable uncertainties due to insufficient ability of validating internal turnover processes. The combination of emerging high frequency monitoring techniques and water quality modeling may support continuous quantification of instream N processing pathways with higher reliability.

In this study, we set up a hydrodynamic and river water quality model (WASP 7.5.2) in the 27.4-km reach of the 5^{th} order river Bode in Central Germany for a 5-year period (2014-2018). High frequency data (15-min interval) of discharge, nitrate, dissolved oxygen (DO) and Chlorophyll-a (Chl-a) at the upstream and downstream station were used as model inputs and for model testing, respectively. Chl-a and DO data were used for disentangling uptake via phytoplankton and benthic algae. Furthermore we identified the most important N-removal and release processes including denitrification, excretion from phytoplankton and benthic algae at daily, seasonal and annual scales.

The PBias of lower than 20% between the simulated and measured high-frequency values for the four variables showed general good performance of the model. Results showed that on an annual scale, net N uptake efficiency ranged from 0.2-17.2% and increased with decreasing discharge resulting in highest value for the extreme low-flow year 2018. Among seasons, net uptake efficiency was found to be the highest in summer. Over 50% of the N loading was taken up at the extreme low flow in the summer of 2018. The contributions of each pathway to total N uptake decreased from assimilatory uptake via benthic algae, denitrification, and assimilatory uptake via phytoplankton. However, in the extreme low-flow summer of 2018, the importance of denitrification was largely increased compared to former years. Besides, in autumn, the reach became a net N source, because remineralization of N from benthic algae surpassed uptake processes.

Our study highlights the value of high frequency data to support river water quality modeling

allowing continuous quantification of whole-stream N uptake and release pathways.