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Towards understanding nitrogen legacies in European catchments

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Reducing nitrogen (N) levels in European water bodies is a pressing issue, as evidenced by the recent fines imposed by the European Count Justice on countries such as France, Germany and Greece for exceeding the regulatory limits for nitrate (World Bank report on “Quality Unknown: The Invisible Water Crisis” by Damania et al., 2019). N levels can depend not only on current N inputs to the landscape, but also on the past N inputs that have accumulated through time in the soil root zone and the groundwater in so-called ‘legacy stores’. Effective N management strategies should therefore account for these N legacies.

This study aims to gain a better understanding of the impact of N legacies on in-stream nitrate concentration and loading at annual time scale in European catchments. To this end, we apply a parsimonious nitrate model, called ELEMENT (Van Meter et al., 2017, Global Biogeochem Cycles), given the limited amount of information available to constrain and test the model simulations. We construct a nitrogen input dataset (N-surplus) to force the model from the early 19th Century, thus ensuring the build-up of the model soil and groundwater legacy stores. We estimate the model parameters based on the application of ‘soft rules’, to account for the uncertainty in the model inputs and the output measurements, and we examine the model controlling processes using sensitivity analysis.

We present here the results for the case of the Weser catchment, a large catchment in northern Germany that discharges into the North Sea. In particular, our results show that the model reproduces well nitrate stream loading. Despite the parsimonious structure of the ELEMENT model, we identify the presence of parameter equifinality, when the model is constrained using in-stream concentration and loading only. We discuss the possibility of using additional information (such as soil organic N content) to improve parameter identifiability and the overall simulation results.