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Three-dimensional approach using two coupled models for description of hydrological and biogeochemical processes at the catchment scale

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Hydrological and biogeochemical transport through changing landscapes has been well described during the past years in literature. However, the uncertainties of combined water quality and water quantity models are still challenging, both due to a lack in process understanding as well to spatiotemporal heterogeneity of environmental conditions driving the processes. In order to reduce the uncertainty in water quality and runoff predictions at the catchment scale, a variety of different model approaches from empirical-conceptual to fully physical and process based models have been developed.

In this study we present a new modelling approach for the investigation of hydrological processes and nutrient cycles, with a focus on nitrogen in a small catchment from Hessen, Germany. A hydrological model based on the model toolbox Catchment Modelling Framework (CMF) has been coupled with the process based biogeochemical model LandscapeDNDC. States, fluxes and parameters are exchanged between the models at high temporal and spatial resolution using the Python scripting language in order to obtain a 3-dimensional model application.

The transport of water and nutrients through the catchment is modelled using a 3D Richards/Darcy approach for subsurface fluxes, a kinematic wave approach for surface runoff and a Penman-Monteith based calculation of evapotranspiration. Biogeochemical processes are modelled by Landscape-DNDC, including plant growth and biomass allocation, organic matter mineralisation, nitrification, denitrification and associated nitrous oxide emissions. The interactions and module connectivity between the two coupled models, as well as the model application on a 3.7 km^2 catchment with the runoff results and nitrogen quantification will be presented in this study.