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Prediction of phosphorus loads in an artificially drained lowland catchment using a modified SWAT model

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Eutrophication is still one of the main environmental problems in the Baltic Sea. Currently, agricultural diffuse sources constitute the major portion of phosphorus (P) fluxes to the Baltic Sea and have to be reduced to achieve the HELCOM targets and improve the ecological status. Eco-hydrological models are suitable tools to identify sources of nutrients and possible measures aiming at reducing nutrient loads into surface waters. In this study, the Soil and Water Assessment Tool (SWAT) was applied to the Warnow river basin (3300 km^2), the second largest watershed in Germany discharging into the Baltic Sea. The Warnow river basin is located in northeastern Germany and characterized by lowlands with a high proportion of artificially drained areas.
The aim of this study were (i) to estimate P loadings for individual flow fractions (point sources, surface runoff, tile flow, groundwater flow), spatially distributed on sub-basin scale. Since the official version of SWAT does not allow for the modeling of P in tile drains, we tested (ii) two different approaches of simulating P in tile drains by changing the SWAT source code.
The SWAT source code was modified so that (i) the soluble P concentration of the groundwater was transferred to the tile water and (ii) the soluble P in the soil was transferred to the tiles. The SWAT model was first calibrated (2002-2011) and validated (1992-2001) for stream flow at 7 headwater catchments at a daily time scale. Based on this, the stream flow at the outlet of the Warnow river basin was simulated. Performance statistics indicated at least satisfactory model results for each sub-basin. Breaking down the discharge into flow constituents, it becomes visible that stream flow is mainly governed by groundwater and tile flow. Due to the topographic situation with gentle slopes, surface runoff played only a minor role.
Results further indicate that the prediction of soluble P loads was improved by the modified SWAT versions. Major sources of P in rivers are groundwater and tile flow. P was also released by surface runoff during large storm events when sediment was eroded into the rivers. The contributions of point sources in terms of waste water treatment plants to the overall P loading were low. The modifications made in the SWAT source code should be considered as a starting point to simulate P loads in artificially drained landscapes more precisely. Further testing and development of the code is required.