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Spatial capability of the catchment model HYPE to simulate nitrate and phosphorus concentration in the mixed land use Selke catchment, Germany

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Semi-distributed hydrological models are broadly used for estimating nonpoint source pollutant inputs to receiving waterbodies and their source areas and predicting the effects of climate and land-use change on water quality. However, satisfactory assessment of such models is required to test their ability to represent different physiographical characteristics of subjected catchments for future predictions. This spatially-distributed internal model validation is rare. To cover this aspect, the semi-distributed model HYPE (Hydrological Predictions for the Environment) was used to simulate nitrate-N (NO_3-N) and total phosphorus (TP) concentrations for spatially distributed non-calibrated internal gauging stations. First, HYPE model was applied at a mesoscale nested catchment Selke (463 km^2) in central Germany to simulate discharge, NO_3-N and TP concentrations at three gauging stations in main river, which represent the whole geographical features of the catchment from upstream forest-dominant to downstream agricultural-dominant land use. An automatic calibration procedure and uncertainty analysis using the DiffeRential Evolution Adaptive Metropolis (DREAM) tool and a multi-site and multi-objective calibration approach was conducted. Second, the model performance was evaluated using additional internal stations not used for model calibration.

Results showed that HYPE could represent reasonably well discharge for both calibration (1994-1998) and validation (1999-2014) periods with lowest Nash-Sutcliffe Efficiency (NSE) of 0.75 and percentage bias (PBIAS) of less than 18% with lower predictive uncertainty. There is a decreasing behavior in model performance during the validation period compared to the calibration period, which can be explained by the reduction of precipitation stations. Model performance declined substantially when only the outlet gauging station, representing the mixed land use of the study catchment, was used instead of multisite calibration. Well representation of NO_3-N and TP load dynamics were resulted by the model showing a highest PBIAS of -16% and -20% for NO_3-N and TP loads simulations, respectively. Results confirmed that changing seasonal pattern of NO_3-N concentrations were controlled by combined effects of both hydrological and biogeochemical processes. TP concentration simulations were strongly impacted by the availability of accurate point source data. Results, also, showed the capability of HYPE to simulate spatio-temporal dynamics of NO_3-N and TP concentrations at eight internal[MRr1] [SGg2] validation stations with PBIAS values varies in the range of -9% to 14% and -25% to 34% for NO_3-N and TP concentrations, respectively. Overall results suggested that combination of multi-site and multi-objective calibration using key archetypes gauging stations can strongly support spatio-temporal performance of the semi-distributed HYPE model.

Keywords: HYPE model, Nitrate-N, Phosphorus, Internal validation, Uncertainty analysis, multi-site and multi-objective calibration and archetype gauging stations.