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Coupling hydrological and impact assessment models to explore nutrient cycling in freshwater systems

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The IMAGE-Global Nutrient Model (GNM) is a new globally distributed, spatially explicit model in which the hydrology model PCR-GLOBWB is coupled to the integrated assessment model IMAGE to simulate nitrogen (N) and phosphorus (P) delivery, and then with a spiraling ecological approach to simulating instream biogeochemistry. Routing the water with dissolved and suspended N and P from upstream grid cells occurs simultaneous with N and P delivery to water bodies within grid cells from diffuse and point sources (wastewater). IMAGE-GNM describes the following diffuse sources associated with the water flow: surface runoff, shallow and deep groundwater, riparian zones. Depending on the landscape features, all these flows may be present within one grid cell. Furthermore, diffuse N and P inputs occur through allochtonous organic matter inputs via litterfall in (temporarily) inundated river floodplains, and atmospheric deposition. In the spiraling concept, the residence time of the water and nutrient uptake velocity determine N and P retention in water bodies. Validation of model results with observations yields acceptable agreement given the global scale of the uncalibrated model. Sensitivity analysis shows shifts in the importance of the different sources, with decreasing importance of natural sources and increasing influence of wastewater and agriculture. IMAGE-GNM can be employed to study the interaction between society and the environment over prolonged time periods. Here we show results for the full 20th century.