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High frequency data provides new insights into nitrogen retention in reservoirs

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Freshwater ecosystems including lakes and reservoirs are hot spots for retention of excess nitrogen (N) from anthropogenic sources, thereby providing valuable ecological services for downstream waters and coasts. Despite the intensive investigations, current quantitative understanding on the influential factors and underlying mechanisms of the N retention in lentic freshwater systems is insufficient due to data paucity and limitation of modeling tools. Our ability to accurately predict the N retention for these systems therefore remains uncertain. The emerging high frequency monitoring techniques and well-developed ecosystem models shed light on this issue. In this study, by taking advantage of the high frequency monitoring in a reservoir system located in central Germany, we investigated retention of nitrate during a five-year period (2013-2017) in both annual and weekly scales. We found that on an annual scale, nitrate retention efficiency ranged from 3.80-23.81%. On a weekly scale, we further identified the critical role of Chl-a concentration, in addition to the well-recognized effects from water retention time and water depth, in determining nitrate retention efficiency. We therefore conclude that biological processes including phytoplankton dynamics are equally important as morphological and hydrological characteristics in driving nitrogen retention in reservoirs. Furthermore, our modeling approach showed that an established process-based ecosystem model (PCLake) accounted for 73.0% of the variations in nitrate retention efficiency, whereas statistical models with explanatory variables of WRT, water depth and Chl-a concentration obtained a lower value (46.8%). These results exemplified the superior predictive power of process-based models over statistical models whenever ecosystem processes are at play. Overall, our study highlights the importance of high frequency data in providing new insights into nutrient retention, and demonstrates the necessity of using process-based models in research and management of lakes and reservoirs.