EGU2020-8010
https://doi.org/10.5194/egusphere-egu2020-8010
EGU General Assembly 2020

Modelling sub-daily phytoplankton dynamics and analysing primary production controls in the lower Thames catchment, UK

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River phytoplankton provide food for primary consumers, and are a major source of oxygen in many rivers. However, high phytoplankton concentrations can hamper river water quality and ecosystem functioning, making it crucial to predict and prevent harmful phytoplankton growth in rivers. In this study, we modify an existing mechanistic water quality model to simulate sub-daily changes in water quality, and present its application in the River Thames catchment. So far, the modelling studies in the River Thames have focused on daily to weekly time-steps, and have shown limited predictive ability in modelling phytoplankton concentrations. With the availability of high-frequency water quality data, modelling tools can be improved to better understand process interactions for phytoplankton growth in dynamic rivers. The modified model in this study uses high-frequency water quality data along a 62 km stretch in the lower Thames to simulate river flows, water temperature, nutrients, and phytoplankton concentrations at sub-daily time-steps for 2013-14. Model performance is judged by percentage error in mean and Nash-Sutcliffe Efficiency (NSE) statistics. The model satisfactorily simulates the observed diurnal variability and transport of phytoplankton concentrations within the river stretch, with NSE values greater than 0.7 at all calibration sites. Phytoplankton blooms develop within an optimum range of flows (16-81 m^3/s) and temperature (11-18° C), and are largely influenced by phytoplankton growth and death rate parameters. We find that phytoplankton growth in the lower Thames is mainly limited by physical controls such as residence time, light, and water temperature, and show some nutrient limitation arising from phosphorus depletion in summer. The model is tested under different future scenarios to evaluate the impact of changes in climate and management conditions on primary production and its controls. Our findings provide support for the argument that the sub-daily modelling of phytoplankton is a step forward in better prediction and management of phytoplankton dynamics in river systems.