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From 1D to 2D: Impact of extreme weather events and climate change on the heavily stressed urban Lake Tegel in Berlin, Germany

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Due to their intense human usage and close proximity to various water management measures, the hydrodynamics and biogeochemical cycles of urban lakes are complex and sudden shifts are difficult to predict. We investigated Lake Tegel in Berlin, Germany, as a prominent example for a shallow urban lake with a dendritic morphometry. Lake Tegel experienced intense eutrophication events in the last century. As part of the restoration strategy a surface water treatment plant was built to reduce the inflow's phosphate concentrations. Although the restoration concept was successful in restoring the lake system, there are recent management concerns about emerging micropollutants accumulating in the lake and the possibility of reoccurring cyanobacteria blooms due to the projected climate change and extreme weather events.

To investigate how the lake management could be optimized to face future challenges, we collected field data and set up different numerical models. During 2015-2018 we collected water samples and additionally monitored water temperatures, dissolved oxygen as well as electrical conductivity in different depths at the deepest site. The data supported the analysis of the stratification period and strength. Further, in a previous study we employed the 1D vertical lake model GLM-AED2 to investigate the response of Lake Tegel to future climate change and alternative management operations. The model projected a future increased duration of the summer stratification period and higher surface water temperatures due to climate change. Although the 1D vertical model could sufficiently replicate the thermal structure and dynamics of Lake Tegel, the stochastic wind-induced river mixing events were challenging the horizontal uniformity assumption.

Therefore, in this study we set up a 2D vertically averaged hydrodynamic and water quality model of Lake Tegel using TELEMAC-MASCARET with a fine mesh resolution of 3-31 m. The model will be calibrated with the bottom roughness coefficient and a suitable turbulence model using field data of electrical conductivity and water temperature measured in 2009. By including water quality processes – oxygen, biomass and heat dynamics – we intend to investigate the impact of extreme storm events on the potential formation of phytoplankton blooms in Lake Tegel. This will be done by exploring different wind setups affecting the lake flow field as well as high and low discharges of the respective inflows. Our hypothesis is that extreme weather events, which could become more intense and/or more frequent in the future due to climate change, will cause increased loadings of nutrients into Lake Tegel and a complete mixing of the lake water column enabling the formation of phytoplankton blooms in the aftermath.