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Lake on life support: Evaluating urban lake management measures by using a coupled 1D-modelling approach

Robert Ladwig (1), Georgiy Kirillin (1), Reinhard Hinkelmann (2), and Michael Hupfer (1)

(1) Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany , (2) Chair of Water Resources Management and Modeling of Hydrosystems, Technische Universität Berlin, Berlin, Germany

Urban surface water systems and especially lakes are heavily stressed and modified systems to comply with water management goals and expectations. In this study we focus on Lake Tegel in Berlin, Germany, as a representative of heavily modified urban lakes. In the 20th century, Lake Tegel received increased loadings of nutrients and leached heavy metals from an upstream sewage farm resulting in severe eutrophication problems. The construction of two upstream treatment plants caused a lowering of nutrient concentrations and a re-oligotrophication of the lake. Additionally, artificial aerators, to keep the hypolimnion oxic, and a lake pipeline, to bypass water for maintaining a minimum discharge, went into operation. Lake Tegel is still heavily used for drinking water extraction by bank filtration. These interacting management measures make the system vulnerable to changing climate conditions and pollutant loads. Past modelling studies have shown the complex hydrodynamics of the lake. Here, we are following a simplified approach by using a less computational time consuming vertical 1D-model to simulate the hydrodynamics and the ecological interactions of the system by coupling the General Lake Model to the Aquatic Ecodynamics Model Library 2. For calibration of the multidimensional parameter space we applied the Covariance Matrix Adaption-Evolution Strategy algorithm. The model is able to sufficiently replicate the vertical field temperature profiles of Lake Tegel as well as to simulate similar concentration ranges of phosphate, dissolved oxygen and nitrate. The calibrated model is used to run an uncertainty analysis by sampling the simulated data within the meaning of the Metropolis-Hastings algorithm. Finally, we are evaluating different scenarios: (1) changing air temperatures, precipitation and wind speed due to effects of climate change, (2) decreased discharges into the lake due to bypassing treated effluents into a near stream instead of Lake Tegel, and (3) increased nutrient elimination at the upstream treatment plants. We are focusing on quantifying the impact of these scenarios on lake stability as well as the abundance and distribution of nutrients.