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Effects of climate change on deep-water oxygen and winter mixing in a deep lake (Lake Geneva)

Robert Schwefel (1), Wüest Alfred (1,2), and Bouffard Damien (1)

(1) Physics of Aquatic Systems Laboratory, Margaretha Kamprad Chair, Ecole Polytechnique Fédérale de Lausanne, Institute of Environmental Engineering, Lausanne, Switzerland, (2) Eawag, Swiss Federal Institute of Aquatic Science and Technology, Surface Waters – Research and Management, Kastanienbaum, Switzerland

Oxygen is the most important dissolved gas for lake ecosystems. Because low oxygen concentrations are an ongoing problem in many parts of the oceans and numerous lakes, oxygen depletion processes have been intensively studied over the last decades and were mainly attributed to high nutrient loads. Recently, climate-induced changes in stratification and mixing behavior were recognized as additional thread to hypolimnetic oxygen budgets in lakes and reservoirs [Matzinger et al., 2007; Zhang et al., 2015]. Observational data of Lake Geneva, a deep perialpine lake situated between France and Switzerland showed no decreasing trend in hypoxia over the last 43 years, despite an impressive reduction in nutrient input during this period. Instead, hypoxic conditions were predominantly controlled by deep mixing end of winter and in turn by winter temperatures. To test the sensitivity of Lake Geneva on future climate change and changes in water transparency, we simulated the hydrodynamics and temperature of Lake Geneva under varying conditions for atmospheric temperature and water clarity performed with the one-dimensional model SIMSTRAT [Goudsmit, 2002]. The results show, that the stratification in lakes is only weakly affected by changes in light absorption due to varying water quality. For conditions expected for the end of the century, a decrease in the annual mean deep convective mixing of up to 45 m is predicted. Also complete mixing events over the whole lake are less likely to occur. A change in the hypolimnetic oxygen concentration of up to 20% can thus be expected in the future. These results show, that changes in deep mixing have an equally strong impact as eutrophication on the deep-water oxygen development of oligomictic lakes and have to be considered in the prediction of the future development of lakes.

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