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A process-based model for simulation of lake oxygen and dissolved inorganic carbon

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Freshwater lakes are important in carbon cycling especially in the boreal zone, ventilating carbon originally fixed by the surrounding terrestrial system. However, the number of mechanistic models simulating carbon cycle in boreal lakes is low. Advances in long-term high-frequency measurement of surface water concentration and air-water flux of carbon dioxide form the basis for model development and enable reliable model validation.

We present a one-dimensional process-based model for simulating the vertical distribution and the air-water exchange of dissolved oxygen and dissolved inorganic carbon (DIC) in boreal lakes. Our model is intended to serve as a starting point for more detailed modelling of evasion of greenhouse gases. The final aim of the study will be to study the effect of higher atmospheric temperatures and increased carbon loading on the dynamics of greenhouse gases in boreal lakes.

The model is an extension of a lake model MyLake, which simulates lake thermodynamics and phosphorus-phytoplankton dynamics. The model includes oxygen production by photosynthesis and surface aeration as well as oxygen consumption by phytoplankton respiration and the degradation of organic carbon both in the water column and in the sediment. It uses a previously developed module for microbial and photochemical degradation of dissolved organic matter in the water column. The production of carbon dioxide is coupled to oxygen consumption.

We set up a model application for Lake Kuivajärvi, a small, humic boreal lake, for two consecutive years. In the calibration we made use of the comprehensive measurement data available on carbon inflow and the concentrations of DIC and dissolved organic carbon in the lake during the simulation period. The results along with our prior modelling studies indicate that the model is quite capable of describing seasonal dynamics of dissolved oxygen and DIC.