Norwegian Institute for Water Research

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Linking the Benthic Cycling of Phosphorus to its Surface Water Dynamic in Lakes

Background

MyLake is a MATLAB script for the 1D, daily time-step, simulation of water column temperature, ice formation and phosphorus (P) dynamic [**1**].

Matsedlab is a MATLAB script for the 1D, variable time-step, non steady-state diagenetic modelling of carbon, nutrients, and trace elements [**2, 3**].

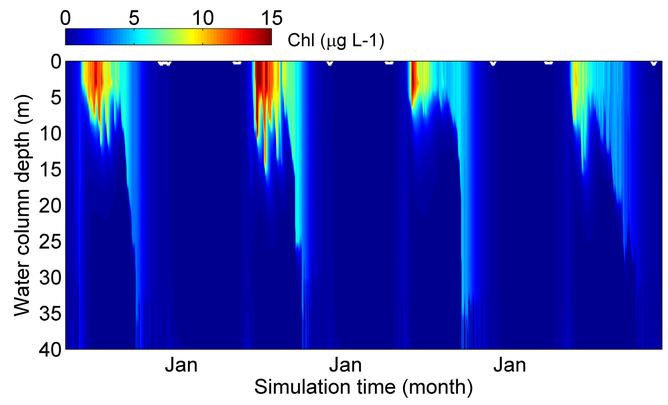


Figure 1. ***Output from MyLake.*** *Predicted chlorophyll concentration in the water column over a 4 year period. Data and boundary conditions from Ref. [**1**]*

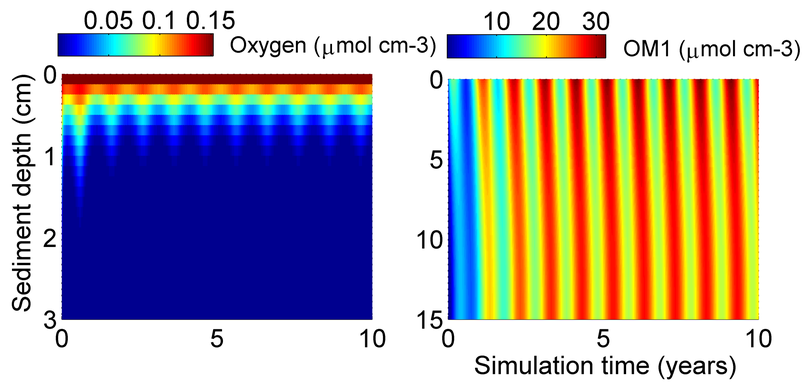


Figure 2. ***Output from Matsedlab.*** *Predicted concentration of dissolved O_2 and of labile organic carbon (OM1) in the sediment column over a 10 year period.*

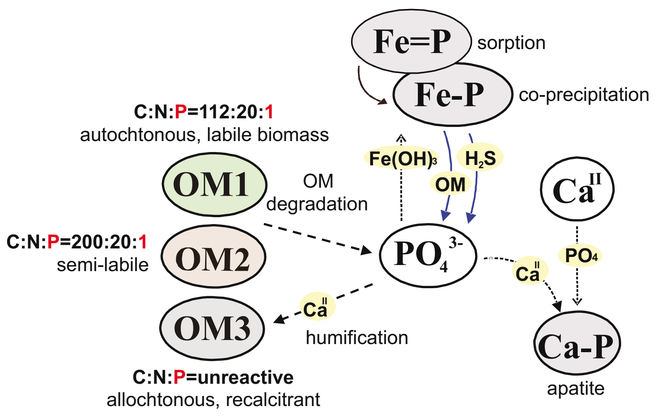
Goal

The goal of this project is to develop a model for nutrient dynamics in lake systems that: (1) fully integrates sediment and water column interactions and (2) is suitable for parallel computing, high throughput scenario profiling, uncertainty analysis and water quality forecasting.

Methods

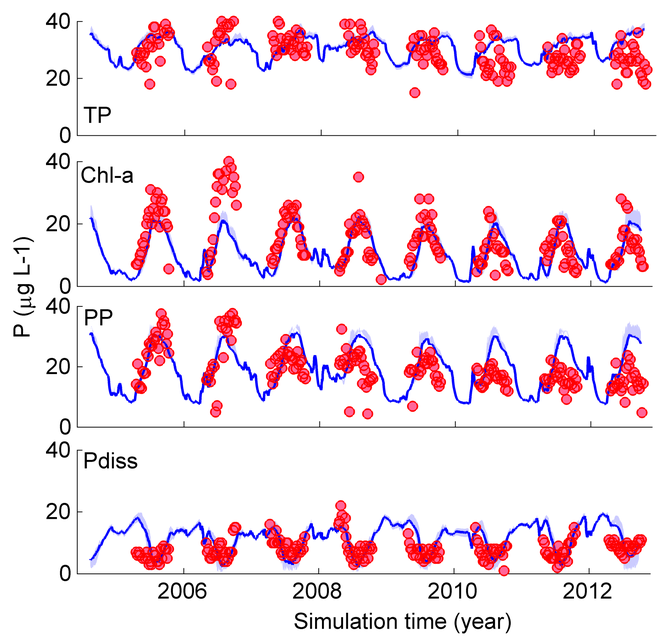
- Implementation of the reaction network (see **Fig. 3** below) in both Matsedlab and MyLake.
- Calibration of Matsedlab and MyLake against existing datasets on P concentrations in lake sediment pore water and the water column.
- Coupling of Matsedlab to MyLake, species by species.
- Validation of the coupled model against a dataset to be acquired from Lake Vansjø.

Figure 3. ***Reaction network.*** *Selected processes controlling the diagenesis of P.*



Results: **MyLake**

Figure 4. *Measured P speciation (circles) in the water column of Lake Vansjø at Vanemfjorden for total P (TP), chlorophyll (chl-a), particulate P (PP) and phosphate (Pdiss) along with MyLake-simulated daily quartile statistics (lines). Model input and parameters from ref. [**4**].*



Results: **Matsedlab**

Figure 5. *Left panel: Time evolution of the concentration of P sorbed onto $Fe(OH)_3$ (Fe-P, left y axis) at 0 cm (blue line), 3 cm (red line), 15 cm (green line) and 20 cm depth (purple line). OM1 deposition fluxes are taken from Fig. 2. Right panel: Fe-P concentration (color map) as a function of sediment depth (right y axis) for simulation years 150-200.*

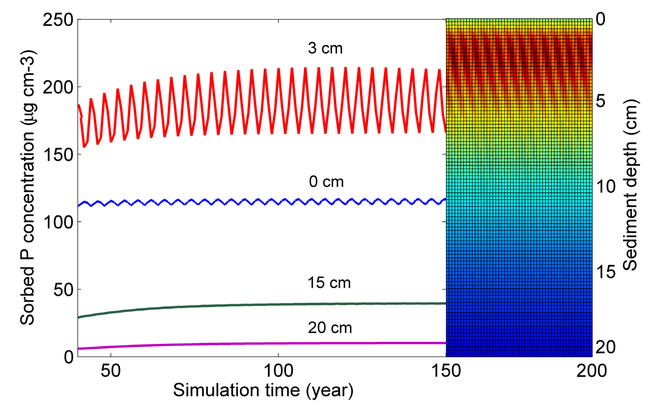
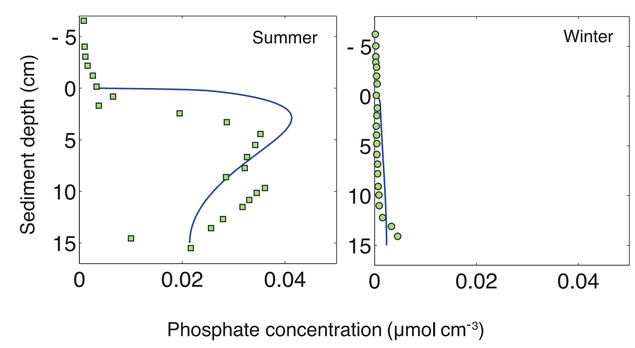


Figure 6. *Sediment depth profiles of measured (open symbols) and simulated (lines) pore water phosphate concentrations ($PO_{4(aq)}$) in summer (August) and in winter (January) in the eutrophic lake Okeechobee (USA). Data and boundary conditions from Ref. [**5**].*



Outcome and Perspective

- The sediment module responds to boundary conditions from the lake model and reproduces seasonal P dynamics.
- The new coupled model is computationally fast, making it possible to carry out large number of simulations.
- Comprehensive datasets combining lake water column time series, sediment column measurements and pore water profiles need to be gathered.

Funding

NIVA REFRESH ecohydrology research group

References

[**1**] Saloranta T.M., Andersen T., 2007. *MyLake - A multi-year lake simulation model code suitable for uncertainty and sensitivity analysis simulations.* Ecol. Model. 207, 45-60.

[**2**] Couture R.M., Shafei B., Van Cappellen P., Tessier A., Gobeil C., 2010. *Non-Steady State Modeling of Arsenic Diagenesis in Lake Sediments.* Environ. Sci. Technol. 44, 197–203

[**3**] Shafei B., Couture R.-M., Tu N. Z., Van Cappellen P. MATSEDLAB (v. 1.0): *A Multi-Component, Non-Steady State Biogeochemical Simulation Module of Early Diagenesis in MATLAB®.* In prep.

[**4**] Tominaga, K. (2013) *Lake modelling: an interdisciplinary context.* PhD thesis, Department of biosciences, University of Oslo, Norway.

[**5**] Moore, P.A., Reddy, K.R., Fisher, M.M., 1998. *Phosphorus flux between sediment and overlying water in Lake Okeechobee, Florida: Spatial and temporal variations.* J. Environ. Qual. 27, 1428-1439.