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Coupling and reduction of hydro-ecological models for the simulation of freshwater aquatic ecosystems

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Algal Bloom is a natural process of rapid population growth of cyanobacteria (a group of photosynthetic bacteria) in aquatic environments, this is a consequence of the artificial enrichment caused by human activity. Our main objective is to build a hydro-ecological model to understand the dynamics of cyanobacteria in aquatic environments, taking into account the various essential factors for its development.

In this presentation we focus on the modelling of cyanobacteria dynamics. Light aside, the main growth limitations of cyanobacteria are phosphorus and nitrogen in their inorganic form. One of the main sources of phosphorus and nitrogen for the growth of cyanobacteria comes from rivers (external loading). But specific hydrodynamic conditions (wind, strong currents) lead to the resuspension of the sediment which provide a second source of phosphorus and nitrogen (internal loading), mainly in their organic form. One survival mechanism of cyanobacteria is the production of an enzyme that transforms the organic phosphorus into inorganic phosphorus when the concentration of inorganic phosphorus is low.

To simulate the cyanobacteria dynamics, we use two-dimensional hydrodynamic models. The hydrodynamics part is based on shallow water equations and is implemented in the SW2D software of the LEMON-INRIA team, to which we added some transport and reaction terms. For the ecological part, we implemented the WASP (Water Quality Analysis Simulation Program) model in which are represented the cycle of Carbon, Phosphorus and Nitrogen of the ecosystem.
To improve the model, we added some terms and equations to represent the liberation of the enzyme by the cyanobacteria and its enzymatic activity based on the model of Michaelis Menten.

The coupled hydro-ecological model was applied on the study case of Lake Taihu in the framework of the French-Chinese ANSWER project funded by the ANR.

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