Thèse de doctorat en cotutelle
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Influence of hydrodynamics on phytoplankton behaviour in urban lakes
through high-frequency measurements and three-dimensional numerical modelling
Application to Lake Champs-sur-Marne (France) and Lake Pampulha (Brazil)
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Abstract

The main objective of this thesis is to characterize the hydrodynamics of shallow urban lakes to better understand its influence on spatial and temporal variability of phytoplankton biomass through high-frequency measurements and three-dimensional numerical modelling. To achieve this objective, two experimental study sites were investigated: Lake Champs-sur-Marne, a small and shallow urban lake in France, and Lake Pampulha, a medium-sized urban reservoir, in Brazil.

In Lake Champs, a three-dimensional hydrodynamic and ecological model was calibrated using high-frequency measurements (5mn time step) of temperature and chlorophyll-a. The water velocity computed by the hydrodynamic model was validated with the measurements of a current profiler (ADCP). The phytoplankton was simulated with the validated ecological model for scenarios with different nutrient concentrations. The wind influence on the phytoplankton spatial distribution was also investigated.

The main results on Lake Champs showed that:

✓ The influence of brief meteorological episodes on the lake hydrodynamics as well as the high temporal variation of phytoplankton biomass were captured by the high-frequency monitoring;

✓ The lake hydrodynamics and the alternation of mixing and stratification can be represented by the hydrodynamic model (Delft3D-Flow) at a small time-scale;

✓ The phytoplankton concentrations and its spatial heterogeneity were simulated by the ecological model (Delft3D-Bloom);

✓ The 3D model results can be used to improve the lake monitoring design, highlighting regions with different behaviour;

In Lake Pampulha, the three-dimensional hydrodynamic model Delft3D-Flow was calibrated and validated using high-frequency temperature measurements (hourly time step).

The main results on Lake Pampulha showed that:

✓ The most sensitive calibration parameters of Delft3D-Flow are the Wind factor and the Dalton coefficient

✓ High-frequency measurement was able to detect sudden changes of water temperature with different amplitudes depending on the depth;

✓ An episode of the main river underflowing into the lake deeper layers was correctly simulated by the model and the results showed a good agreement with the measured temperature.

✓ The model was able to accurately reproduce the alternation of stratification and mixing over the simulated periods

✓ The model results provide new insights on the thermal regime of a medium-size tropical reservoir and can be used for a further analysis of its hydrodynamics.