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Telemac3D for aquatic ecological modelling: calibration of the coupled ecological library AED2

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Abstract: The monitoring and preservation of water quality is one of the main challenges in modern society. Anthropogenic stressors originated from urbanization and industrialization can have a strong impact on water resources in terms of pollutant release and nutrient enrichment. Together with the on-going climate change, they can lead to the proliferation of primary producers and the eutrophication of the water bodies. Harmful algal blooms, and in particular cyanobacteria blooms, are an ever increasing concern worldwide as their occurrence strongly increases, expanding to higher latitudes due to warmer water temperature. Cyanobacteria are able to produce toxins that are dangerous to human health and represent a serious threat not only for the balances of an ecosystem but to human society as well. Aquatic ecological models are useful tools that can be used to simulate the biogeochemical cycle in a water body identifying the factors triggering events such as harmful algal blooms, in order to provide stakeholders with reliable projections for decision making. However, their calibration and validation often remains a challenging task: biological and chemical data deriving from field surveys are often sparse in space and time and, due to the complexity of the biogeochemical cycle, these models generally involve a high number of parameters to adjust. Aquatic ecological models need to rely on a robust hydrodynamic simulator, upon which the biogeochemical cycle is simulated. Telemac3D has recently been coupled by EDF R&D with the well-known ecological library Aquatic EcoDynamics (AED2).

In this context, we aim to test the performance of Telemac3D coupled with AED2 on a full scale experimental site by comparison with high-frequency in situ data. The study site is a small and shallow urban lake located in the east of Great Paris metropolitan area. The lake suffers from repeated and severe harmful algal blooms in summer and autumn. Aside from the traditional monitoring via field campaigns and water sampling, the study site is equipped with specific sensors recording data at high-frequency (every 10 minutes) for water temperature, pH, dissolved oxygen and for the concentration of specific pigments to monitor phytoplankton growth (chlorophyll-a and phycocyanin, considered as proxies for total biomass and cyanobacteria biomass, respectively). The use of high-frequency data allows on the first hand to test the capability of the model to reproduce daily cycles and rapid blooms events spanning only a few days, and on the other hand to gain in computational time while calibrating the model on a short time periods of two to three weeks.

Model results are compared with water temperature data at different depths to test the ability of the coupled hydrodynamic model to reproduce thermal stratification in the water column. The ecological module AED2 is set up to simulate two main algal groups present in the study site, green algae and cyanobacteria. High-frequency observations of chlorophyll-a and phycocyanin are used to calibrate the ecological model AED2 and to test its outcomes. Model results show that Telemac3D coupled with AED2 is able to correctly reproduce biomass growth in a water body over short bloom events spanning roughly three weeks. Even though a feedback originated from strong biomass growth can be detected in water temperature results, the model is also able to correctly reproduce thermal water column stratification. These possible feedbacks need to be taken into account when calibrating the heat-exchange budget at the water-air interface.

Proposed session: Water quality, biodiversity, ecology and environmental pollution
Key words: water quality, cyanobacteria blooms, thermal stratification
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