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High resolution modelling of the biogeochemical processes in the eutrophic Loire River (France)

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A biogeochemical model was developed, coupling a physically based water temperature model (T-NET) with a semi-mechanistic biogeochemical model (RIVE, used in ProSe and Riverstrahler models) in order to assess at a fine temporal and spatial resolution the biogeochemical processes in the eutrophic Middle Loire hydrosystem (≈10 000 km^2, 3361 river segments). The code itself allows parallelized computing, which decreased greatly the calculation time (5 hours for simulating 3 years hourly).
We conducted a daily survey during the period 2012-2014 at 2 sampling stations located in the Middle Loire of nutrients, chlorophyll pigments, phytoplankton and physic-chemical variables. This database was used as both input data (upstream Loire boundary) and validation data of the model (basin outlet). Diffuse and non-point sources were assessed based on a land cover analysis and WWTP datasets.
The results appeared very sensible to the coefficients governing the dynamic of suspended solids and of phosphorus (sorption/desorption processes) within the model and some parameters needed to be estimated numerically.
Both the Lagrangian point of view and fluxes budgets at the seasonal and event-based scale evidenced the biogeochemical functioning of the Loire River. Low discharge levels set up favorable physical conditions for phytoplankton growth (long water travel time, limited water depth, suspended particles sedimentation). Conversely, higher discharge levels highly limited the phytoplankton biomass (dilution of the colony, washing-out, limited travel time, remobilization of suspended sediments increasing turbidity), and most biogeochemical species were basically transferred downstream. When hydrological conditions remained favorable for phytoplankton development, P-availability was the critical factor. However, the model evidenced that most of the P in summer was recycled within the water body: on one hand it was assimilated by the algae biomass, and on the other hand it was released by mineralization of the dead cells.
The high resolution of the model allowed understanding some fine temporal scale events, especially during some minor flood events occurring in summer. Paradoxically such events played two opposite roles: first it was disturbing the phytoplankton by diluting the biomass and remobilizing suspended sediments; then, it indirectly re-supplied the system with more available phosphorus, mainly because the washed-out phytoplankton could not assimilate the P available upstream.
The model also pointed out the significant role played by Corbicula invasive clams in the river biogeochemical functioning, substantially reducing the phytoplankton biomass, and thus impacting the nutrients, oxygen and carbon cycles. However, the temporal and spatial distribution of Corbicula was questioned, and highlighted the need for data collection on this topic.