Title: Towards computational early warning systems for cyanobacteria blooms in fresh-water swimming waters and drinking water reservoirs. By Alten PTS and Deltares

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Challenge:
The challenge is to construct an initial predictive, computational model of toxic scum formation of the fresh water cyanobacterium Microcystis aeruginosa, prepare it for the assimilation of satellite data and for integration into existing predictive models for surface water quality. Buoyant cyanobacteria accumulate in dense scums at the lake surface (see picture), forming blooms in which cell densities go up to extreme levels. Because cyanobacteria produce many bioactive compounds, some of which are highly toxic, a minute volume of surface scum material in drinking water reservoirs and recreational water bodies can harm humans and animals. Solving this challenge will enhance robust early warning systems of scum formation and may eventually lead to prevention of scum formation.

Surface scum of Microcystis in Lake Chaohu, China (left); Microcystis colony made up of dozens of individual cells embedded in common mucilage (right)

The main challenges are (a) how to interface ecological modeling approaches (using, e.g., ordinary and partial differential equations) with existing surface water modeling approaches, (b) how to inform the model using data assimilation techniques.
Our first goal is to develop means to run existing, simple ecological models in realistic geometries. Such a first model could consist of a simple exponential or logistic growth model in space, which to first approximation have only a few parameters that can be estimated from data later on. Later versions would include compartmentalisation into single-celled algae and buoyant colonies, which will be more apparent on satellite data. The growth rates, carrying capacity, transition rates to buoyant states and so forth are influenced by physical parameters, e.g., temperature, nutrient levels and so forth. The second team will work on the methodology to estimate such parameters satellite data. Matching the simulations with observations of the temporal and spatial development of blooms can be used to estimate growth-related parameters, while first estimates of the way that these parameters are affected by the physical parameters can be obtained by integrating individual measurements (including times and locations of the measurements) with local estimates of algal growth. Although not all the required data might be available to the workshop participants yet, a number of example datasets will be, whereas other data might need to be estimated. Apart from developing first methodology to assimilate data into this type of growth-prediction models, an important output of the work will consist of recommendations on the types of data that is needed to better inform the models, and also which data is less important.
This initial work will hopefully leverage a longer-term plan of building a multiscale, predictive computational model that would take into account buoyance of cyanobacterial colonies and eventually also the molecule scale drive the growth and transition into the buoyant phase. Depending on the process of the case study during the workshop, the organizers aim to write a joint follow--up proposal for this plan.