Bundesministerium
für Bildung
und Forschung

GETAS

Coupled Hydrodynamic and Ecological Simulation for Use in Reservoir Management

HYDROMOD

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Overall project aim Drinking water supplies from surface waters require sustainable solutions which reconcile demands for environmental protection and social and economic development, as well as the conservation of our natural heritage. With the goal of providing such solutions project GETAS is funded by the Bundesforschungsministerium (Federal Ministry of Research and Technology). The project combines aspects of hydrobiology, lake physics, meteorology / climatology and water management to develop a new management tool which, utilising a user friendly model interface, provides scientific advise for reservoir operating agencies and authorities.

Structure of the coupled model system
Components of the GETAS project and the structure of the coupled model system are visualised in Figure 1. The coupled model itself consists of modules. Further components - such as measuring campaigns, data analyses, calculations of the wind field or 3-D simulations - can be added. Supplementary specialised process models enhance system understanding in research and practice.

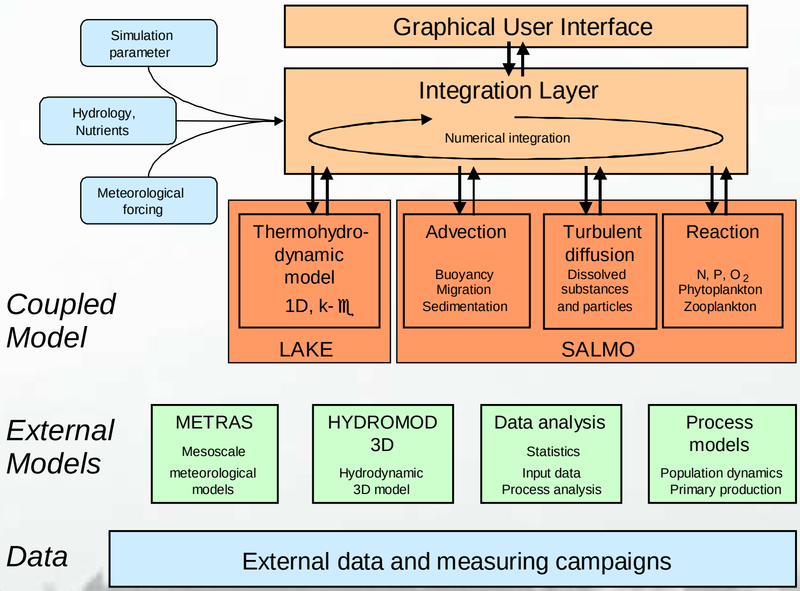

Figure 1: The GETAS model system.

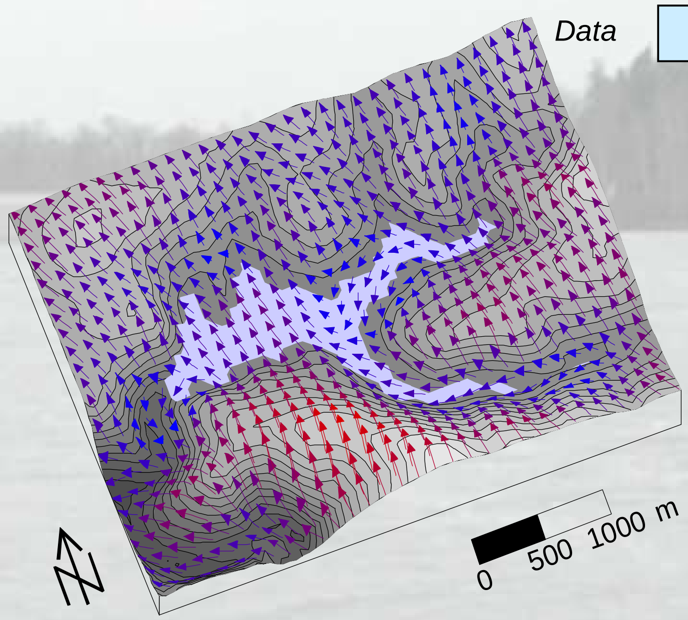

Figure 2: Calculated wind field over Saidenbach reservoir with an incoming high level flow from southwest.

Meteorology Since hydrophysical and biological processes strongly depend on the input of energy into the system, the most important meteorological parameters, wind and photosynthetically active radiation (PAR), have to be quantified as two-dimensional arrays above the reservoir. Depending on the variable under consideration and the availability of measurements, computations are based on different methods - ranging from extrapolation of measurements to numerical meteorological models of high complexity.

Hydrophysical components A 1-D layer model (LAKE) simulates the main mixing relevant thermo-hydrodynamic processes, whilst a powerful 3-D current and transport model is used to describe the complex hydrophysical processes. The simulated transport of substances by means of these models allows conclusions to be drawn concerning the management of water quality (e.g. layering of nutrients and suspended matter, loss of harmful substances) which until now have not been possible.

The ecosystem model The dynamical ecosystem model SALMO enables the user to simulate the effects of external sources (nutrients, organic compounds) and internal measures (water level drawdown, partial circulation, biomanipulation) on the water quality of reservoirs and lakes. The basic structure of the water quality model SALMO is shown in figure 3 with the six state variables phosphorus (P), nitrogen (N), phytoplankton (X_i), zooplankton (Z), detritus (D) and oxygen (O).
Input values are volume, inflow, import of P and N, solar radiation, layer thickness and water temperatures. For any number of layers the complex interactions are determined by algebraic functions and parameters which are derived from laboratory experiments. Therefore they normally are not calibrated.

Model applications Relevance of the hydrodynamical processes becomes apparent in the simulation shown in figure 4. Varying the mixing efficiency and keeping the nutrient import constant leads to different distributions of plankton biomass (left figure maximum biomass 6 mg L^{-1}, right figure 10 mg L^{-1}).

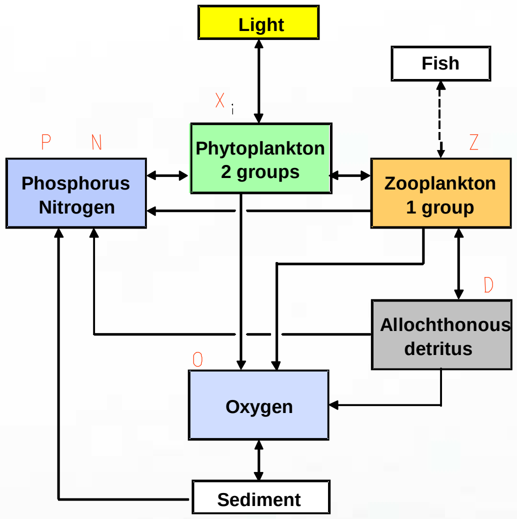

Figure 3: Ecosystem model SALMO.

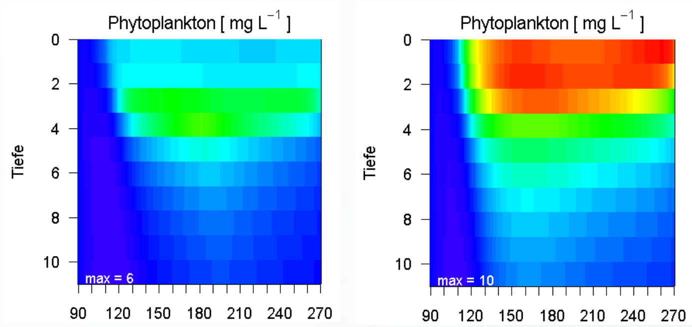

Figure 4: Temporal development of the vertical distribution of phytoplankton biomass with the same nutrient import but low (left) and high (right) internal mixing; colour scale from blue (low values) to red (high values).

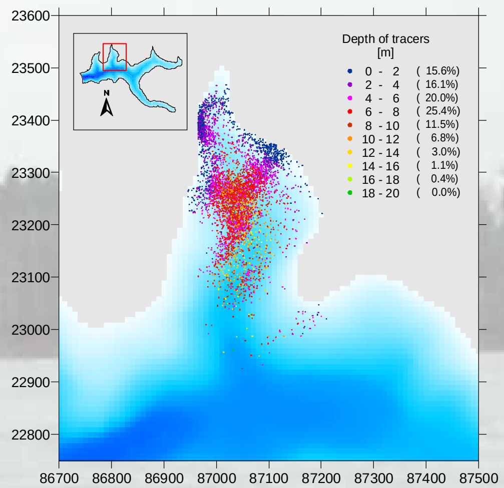

Figure 5: Example of the distribution of tracers in the Saidenbach reservoir.

One result of the 3-D simulation is depicted in figure 5. It shows the distribution of marked particles (tracer) of the cooler water of Hoelzelbergbach in the Saidenbach reservoir, approx. 80 hours after release from a point source. Besides the depth of the particles the legend also shows the percentage present in each layer.

As a forcing condition a variable wind field, calculated using the meteorological model METRAS, was used. The inflow calculation shown in figure 5 is performed under prevailing westerly and southwesterly wind.

Figure 6: Measurements at Saidenbach reservoir, autumn 2002.

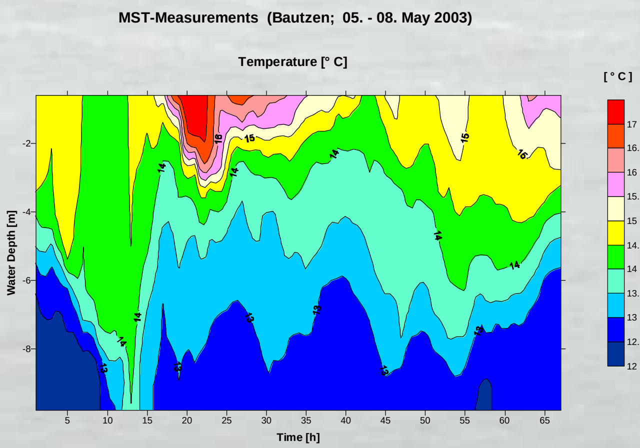

Figure 7: Vertical temperature profile in Bautzen reservoir, measured with a microstructure probe during the spring measurement campaign 2003.

Measurements In spring and autumn 2002 and 2003 measurement campaigns have been performed in the reservoirs Saidenbach and Bautzen. Measurements of wind, air temperature, relative humidity and global radiation were used to test and evaluate different techniques for the calculation of meteorological parameters. The acquisition of hydrophysical parameters, as well as phyto- and zooplankton measurements, provided the appropriate data to validate the SALMO model and to evaluate the accuracy of the coupled hydrodynamical and ecological model.

The coupled model system allows for a distinctly higher temporal and spatial resolution of hydrobiological and thermodynamical processes, thus, opening up a number of new applications in reservoir management, testing for environmental compatibility and ecotechnological lake restoration. Examples include controlling water quality, setting up management plans (e.g. optimisation of drinking water inventory and flood retention capacity) and operating event management. Thus, GETAS provides a capable instrument for the implementation of the EU water framework directive in the supply and distribution of water.

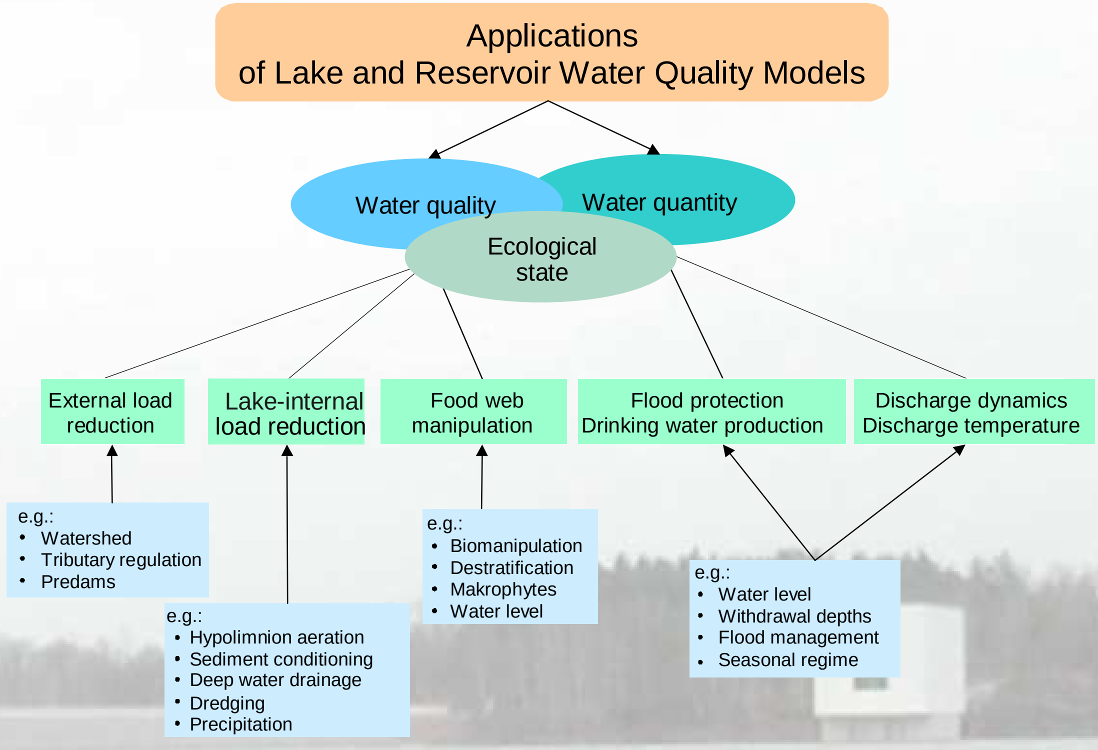

Figure 8: Potential applications of the coupled GETAS model system.

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