Hints for the oral examination of the course "Modelling aquatic ecosystems"

Main goals of the course: The students are able to:

- build mathematical models of aquatic ecosystems that consider the most important physical, chemical, biogeochemical, biological, and ecological processes.
- explain the interactions between these processes, especially between ecological and biogeochemical processes, and the behaviour of the system that results from these interacting processes based on a model they developed themselves.
- formulate, implement and apply simple ecological models.
- consider stochasticity and uncertainty.

The oral exams are aligned with these objectives. However, the technical model implementation with R is not part of the examination.

Important aspects of the exams are:

1. Formulation of mass balance equations and transformation processes; consideration of conservation laws for elements and charge for the formulation of biological and chemical transformation processes, parameterization of process rates, process table notation, important processes in aquatic ecosystems (lakes and rivers)
2. Qualitative behaviour of model solutions; how model outputs change due to changes in parameter values or external influence factors; important interactions in model outputs (interdependencies between state variables), dominant mass fluxes in the models (and the systems described by the models)
3. Important sources for stochastic behaviour and uncertainty in model outputs; how they can be considered in the model.

Half of the time of the oral exam will be devoted to discussing the model that the students prepared themselves. The other half will cover other course topics.

Minimum requirement for passing is that the student can correctly describe how to derive the stoichiometric coefficients and how to formulate the transformation rate for a given biological process.

UPDATE: The oral exams will take place on 4 and 5 June 2020 **via ZOOM**. The candidate must be visible on camera during the entire examination with the sound turned on. The exams will be graded.

Typical examples for examination questions

Explain the model that you have developed during the course. What were the most important changes compared to the model 11.4? Please describe the temporal development of the state variables. Explain the results of your sensitivity analysis.

Given the process x, how can you derive the stoichiometric coefficients for this process? How can you find out if additional constraints are needed? Which are drawbacks of the simplified approach to address this question?

How can you formulate the additional stoichiometric constraints that are needed for the growth of secondary producers (e.g. zooplankton)?

Given the process x, how can you formulate the process rate? What are the typical elements for process rates of biological processes?

How can you decide for which substances in the process rate a limitation term is needed?

Which alternatives may be used to formulate the limitation and inhibition terms?

Sketch the food web of the benthic (pelagic) zone of a river (lake).

Explain the process table notation using a simple lake model as an example. For a simple box model, explain how to derive the differential equations based on the process table.

How can you assess the potential behavior of the solution of these differential equations?

How can you find fixed points (stationary solutions) of such a model and how to determine their stability?

Which transformation processes have to be considered in a lake model to describe the phosphorus (nitrogen) cycle?

Which transport processes have to be considered in such a model?

How can you calculate the total net transformation rate for a single substance, which is involved in several transformation processes?

When do you need to introduce a yield for the death process of algae and zooplankton? What would be an alternative solution to the introduction of such a yield?

How can you estimate the spread of a tracer or pollutant pulse in a lake at a given time point?

Which alternatives do you know to model the mineralisation of organic material in aquatic ecosystems?

How can you estimate, after which distance the lateral inflow to a river is mixed across the whole width?

Which processes affect the oxygen concentration in a river?

What must be considered when discretizing a river model as a system of mixed reactors?

How can you assess the sensitivity of a model to single parameters in a simple way?

What are the important sources of uncertainty and stochasticity? How can they be considered in a model?

How can you use observed data to improve your parameter estimates?

Other examples are the questions from the exercises.

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