Optimality-based ecohydrological modelling - opportunities and challenges

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Environmental change and the rising recognition that the past alone may not be a good predictor for the future call for a fundamental reconsideration of the modelling approaches on which we base societal decisions. Complex interactions between a multitude of processes are often modelled for predicting the behaviour of natural systems. However, the more detailed such models are, the more parameters they usually contain, which need to be quantified either through direct observations or calibration. At the same time, it is not always clear if parameter estimations that were valid in the past can be expected to be valid under future conditions. For example, parameters related to vegetation, such as rooting depths, photosynthetic capacity or phenology, are known to adjust to changing conditions and given that future environmental conditions, most notably elevated atmospheric CO_2 concentrations, have no precedent in the recent past, we cannot easily predict such adjustments based on past observations.

Here, optimality theory is a promising way forward, as it is based on presumably general principles (e.g. natural selection of the fittest) and hence should be applicable as much or as little to the future as it is to the past. Optimality assumptions greatly reduce the need for parameter calibration, as they enable us to predict the optimal parameter set for a given environment, e.g. optimal tree cover and rooting depths to maximise the plants' net carbon profit. Reduced need for calibration implies more opportunities for model testing, while the generality of the underlying optimality principles implies that model performance in the past is likely indicative of model performance in the future.

In this presentation, we will explain the assumptions underlying the Vegetation Optimality Model (VOM) and illustrate some promising applications and recently identified challenges. We will further highlight important missing knowledge about trade-offs related to plant-environment interactions, some of which are being systematically investigated in the WAVE project (Water and Vegetation in a changing environment) at LIST, while others require a deeper understanding about local hydrological processes.