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From Prediction in Ungauged Basins to Prediction Under Change: a small step for Optimality Theory.

A very exciting challenge of Prediction in Ungauged Basins was the lack of localised data for model calibration. This necessitates a giant leap for modellers, namely to not only formulate process and conceptual equations and tune their parameters to fit the data, but to also predict the parameter values.

This step calls for new theory, as physical laws alone do not constrain parameter values sufficiently to allow useful predictions. A number of approaches have been developed to avoid this difficult step, e.g. calibration of the unknown parameters to historical data from 'similar' catchments. However, avoidance of this step is not an option when it comes to predicting the response of catchments to changing environmental conditions for the following reasons:

1. Varying boundary conditions. Projections into the future can no longer be guided by observations in the past to the same degree as they could when the boundary conditions were considered stationary.
2. Ecohydrological adaptation. Common model parameters related to vegetation properties (e.g. canopy conductance, rooting depths) cannot be assumed invariant, as vegetation dynamically adapts to its environment.
3. No analog conditions for model evaluation. Climate change and in particular rising atmospheric CO_2 concentrations will lead to conditions that cannot be found anywhere on Earth at present. Therefore it is doubtful whether the ability of a hydrological model to reproduce the past is indicative of its trustworthiness for predicting the future.

On the other hand, optimality theory promises the prediction of model parameters independently of any calibration data. Optimality theory builds on the hypothesis that natural systems self-optimise to attain certain goal functions (or “objective functions”). This permits an independent prediction of system properties that would otherwise require direct observations or calibration. The resulting reduction of the parameter space and hence reduced need for calibration data frees up information that can be used for independent model testing and falsification. As opposed to some of the predicted parameter values, the optimality principle itself is unlikely to change from catchment to catchment or over time with changing boundary conditions. This presentation will use the Vegetation Optimality Model as an example to demonstrate the potential of optimality-based models to allow predictions in ungauged basins and under changing atmospheric CO_2 concentrations. The presentation will also highlight some weaknesses of the optimality approach and research required to take it forward.