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A plethora of conceptual models is available: What are the dynamic differences?

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Conceptual models represent the dominant characteristics of various hydrological processes, using stores, fluxes and transformation functions. They are computationally efficient, provide a relatively easy framework to test different hypotheses of the catchment function and have relatively low data requirements. These features tend to result in the need for model calibration during application so keeping complexity low has the benefit of reducing equifinality and parameter identifiability issues. All this has led to a multitude of models being developed that are all different in name, structure, simulated processes and mathematical formulations. Potentially some in-depth knowledge of the catchment is needed to judge the appropriateness of any models overall structure, but this can be hard to acquire or may be unavailable. Currently there is no overview of how prevalent this model structure uncertainty really is and a question thus remains: in a practical sense, how different are the many available versions of seemingly different conceptual model variants?

Our goal is to identify if, given the same input data, different models cover different regions in the model output space. We analyse 45 different conceptual models to identify a wide range of model formulations, meaning the combination of structure (which simulated processes are present in the model and how are they connected) and mathematical descriptions of each process. Each model element is allowed to use all its degrees of freedom through Monte Carlo sampling of its parameters. Then, we use pre-determined climate forcing from a global analysis to run each model element with its Monte Carlo parameter sets and summarize its output into a hydrologically relevant output space (e.g. a comparison of runoff signatures). This enables us to investigate questions such as: given the same climate input and no limitations on calibration freedom (1) ... is the output space uniformly covered or do models cluster around certain regions? (2) ... do certain model formulations cover a larger part of the model output space than others? (3) ... can different model formulations perform the same function? This increases our understanding of how diverse our collection of conceptual functions really is and will open up research directions that link these findings to the hydrological processes occurring in catchments around the world.