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How good does Automatic Model Structure Identification work? A Benchmark Study with 6915 Model Structures.

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Recent investigations have shown it is possible to simultaneously calibrate model structures and model parameters to identify appropriate models for a given task (Spieler et al., 2020). However, this is computationally challenging, as different model structures may use a different number of parameters. While some parameters may be shared between model structures, others might be relevant for only a few structures, which theoretically requires the calibration of conditionally active parameters. Additionally, shared model parameters might cause different effects in different model structures, causing their optimal values to differ across structures. In this study, we tested how two current "of the shelf" mixed-integer optimization algorithms perform when having to handle these peculiarities during the automatic model structure identification (AMSI) process recently introduced by Spieler et al. (2020).

To validate the current performance of the AMSI approach, we conduct a benchmark experiment with a model space consisting of 6912 different model structures. First, all model structures are independently calibrated and validated for three hydro-climatically differing catchments using the CMA-ES algorithm and KGE as the objective function. This is referred to as standard calibration procedure. We identify the best performing model structure(s) based on validation performance and analyze the range of performance as well as the number of structures performing in a similar range. Secondly, we run AMSI on all three catchments to automatically identify the most feasible model structure based on the KGE performance. Two different mixed-integer optimization algorithms are used – namely DDS and CMA-ES. Afterwards, we compare the results to the best performing models of the standard calibration of all 6912 model structures.

Within this experimental setup, we analyze if the best performing model structure(s) AMSI identifies are identical to the best performing structures of the standard calibration and if there are differences in performance when using different optimization algorithms for AMSI. We also validate if AMSI can identify the best performing model structures for a catchment at a fraction of the computational cost than the standard calibration procedure requires by using "off the shelf" mixed-integer optimization algorithms.

Spieler, D., Mai, J., Craig, J. R., Tolson, B. A., & Schütze, N. (2020). Automatic Model Structure Identification for Conceptual Hydrologic Models. Water Resources Research, 56(9). https://doi.org/10.1029/2019WR027009