EGU25-18108
EGU General Assembly 2025

Towards Transparent and Unbiased Hydrological Model Comparisons: A Case Study of the 2021 Floods in Belgium.

Christophe Dessers, Pierre Archambeau, Benjamin Dewals, Sébastien Erpicum, Anne-Lou Borgna, and Michel Pirotton
ULiege, Applied Sciences, Urban and Environmental Engineering, Liège, Belgium (c.dessers@uliege.be)

Comparing the performance and sensitivity of various hydrological models, or the hypotheses underpinning some of their components present considerable challenges. Biases can be introduced by a multitude of factors, including the expertise or preferences of users and developers, numerical discretisation techniques, input data, preprocessing procedures, calibration strategies, and rounding errors. To minimise these biases, we propose a standardised framework for model comparison and model structure sensitivity analysis.

A flexible hydrological tool, WOLFHydro, has been developed to integrate models organised in modular components. It accommodates models of different natures–with diverse underlying hypotheses– (empirical, conceptual, or physically based) and spatial discretisation approaches (lumped, semi-distributed, or gridded). This tool ensures consistent preprocessing, input data management, semi-distributed catchment discretisation, modelling of anthropogenic structures (e.g., dams and reservoirs) , numerical scheme implementation, and calibration procedures, providing a robust basis for fair inter-model comparisons.

The 2021 floods in most severely impacted Belgian catchments serve as a benchmark case to illustrate the methodology. This study involves comparing hydrological models, which aim to represent the same hydrological processes, but with varying structures, formulations, and nature. It includes an in-house gridded conceptual/physically-based model and widely used lumped models such as GR4H, HBV, NAM, SAC-SMA (Sacramento), and VHM. The proposed framework ensures that the models' physical outcomes and performance can be compared on equal footing.

This approach not only addresses the issue of equifinality by identifying optimal scenarios but also highlights the strengths and limitations of each model formulation. It emphasises the representation of hydrological processes (runoff coefficient, average contribution of different type of flow in hydrographs, probability of exceedance, etc) over reliance on parameter values alone. This focus would facilitate the parameters transferability of model parameters, particularly in conceptual models where parameters lack explicit physical meaning. Ultimately, this methodology offers a comprehensive framework for improving the transparency, reliability and interpretability of hydrological model comparisons.