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Improving hydrological model calibration and selection via a better use of evaluation metrics and streamflow sub-samples for operational applications

Hydrological models are used in a large number of engineering, research and management applications, such as streamflow and flood events simulation, reservoir inflow and drought forecast, extreme flow prediction or climate change impact assessment. Hence models are applied on a wide range of hydrological processes and contexts, with a variety of input and output observations and time and space scales. Over the past decades, hydrological modelling science has incredibly evolved and it is now common practice to calibrate hydrological models in a multi-objective framework, diagnose model performance and robustness, assess parameters and model uncertainties, evaluate parameters sensitivities and test alternative modelling hypotheses. However, there is sometimes a gap between up-to-date hydrological science and common operational practice.

Hydrological modelling in an operational context is typically characterised by the need for general and robust models, usable for various applications. Models should also remain simple enough to be understood by different practitioners (field technicians, engineers, forecasters, hydrologists, etc.).

The aim of this contribution is to present how scientific research in hydrological modelling and operational practice converge at the operational hydrometeorological center of EDF (French producer of energy), which develops modelling methodologies and manages a large number of infrastructures for electricity production. We want to focus on our common practice of hydrological model development, model calibration, diagnosis and selection, and uncertainty assessment. Our methodology to get robust modelling tools is based on:

- intercomparing models on sets of watersheds to better understand the behaviour of hydrological models and their differences in simulating usual or extreme flows;

- using simple objective functions and representative streamflow sub-samples adapted to a wide range of applications. For example, the Kling-Gupta efficiency (KGE) measure is computed using either streamflow series, hydrological regime curves, or flood and low-flow samples. It provides improved model diagnoses for different ranges of streamflow and processes, and a better understanding of the balance between correlation and mean/variance biases;

- applying a sequential and hierarchical calibration scheme. This scheme is based on a preliminary search in a parameter library, a sequential calibration using different representative objective functions based on the KGE measure, a hierarchical calibration of a parsimonious version and a full version of the model and the computation of Pareto fronts. This calibration scheme provides a good balance between automatic calibration and the expert knowledge of watershed and model properties. A representative ensemble of best-guess parameter sets is then identified and a limited number of parameter sets adapted to a specific or general application is eventually selected.

Following this methodology, the required properties of hydrological models and their associated uncertainties are better understood for a wide range of applications. We believe that this framework improved the overall calibration process, performance and robustness of our operational models, which is highly needed for enhancing water resources management and supporting decision making.