An open-source R-package and web application for high-quality probabilistic predictions in hydrology

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Probabilistic predictions provide crucial information regarding the uncertainty of hydrological predictions, which are a key input for risk-based decision-making. However, they are often excluded from hydrological modelling applications because suitable probabilistic error models can be both challenging to construct and interpret, and the quality of results are often reliant on the objective function used to calibrate the hydrological model.

We present an open-source R-package and an online web application that achieves the following two aims. Firstly, these resources are easy-to-use and accessible, so that users need not have specialised knowledge in probabilistic modelling to apply them. Secondly, the probabilistic error model that we describe provides high-quality probabilistic predictions for a wide range of commonly-used hydrological objective functions, which it is only able to do by including a new innovation that resolves a long-standing issue relating to model assumptions that previously prevented this broad application.

We demonstrate our methods by comparing our new probabilistic error model with an existing reference error model in an empirical case study that uses 54 perennial Australian catchments, the hydrological model GR4J, 8 common objective functions and 4 performance metrics (reliability, precision, volumetric bias and errors in the flow duration curve). The existing reference error model introduces additional flow dependencies into the residual error structure when it is used with most of the study objective functions, which in turn leads to poor-quality probabilistic predictions. In contrast, the new probabilistic error model achieves high-quality probabilistic predictions for all objective functions used in this case study.

The new probabilistic error model and the open-source software and web application aims to facilitate the adoption of probabilistic predictions in the hydrological modelling community, and to improve the quality of predictions and decisions that are made using those predictions. In particular, our methods can be used to achieve high-quality probabilistic predictions from hydrological models that are calibrated with a wide range of common objective functions.