Navigating through extreme flood simulations with intelligently chosen parameter sets

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NEED FOR CHOOSING REPRESENTATIVE SETS?

Uncertainties of environmental model simulations are often represented by an **ensemble** with few to thousands of members. Commonly used methods for deriving reliable uncertainty ranges require running a large number of model simulations. To reduce computational and time requirements of such model simulations, some kind of a parameter selection of **representative sets** would be beneficial for hydrological simulations in general.

This study aims at designing such **an innovative selection method of a representative sample** of model parameters of a limited size to be used within a complex model chain (Fig. 1). As this selection might be most challenging for extremes, which are also of most interest, we thus **focus here on the simulation of extreme floods** and use annual flow maxima for developing the approach. The methodology is tested in Switzerland using a bucket-type hydrological model (the HBV model) and synthetic continuous precipitation-streamflow data.

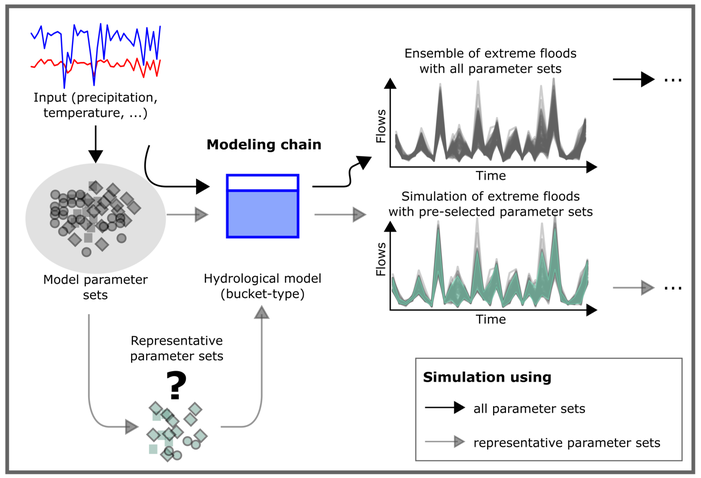

Fig. 1. Overview of the project concept — selection of the representative parameter sets.

RESULTS

1) Three methods led to the selection of different representative parameter sets (Figure 4);
2) Predictive bands derived with three methods covered different ranges of the model simulation ensembles (Figure 4);
3) Cross-validation revealed that prediction bands where represented best by the sets selected based on clustering followed by those based on quantiling, whereas those selected by ranking performed poorest (Figure 5).

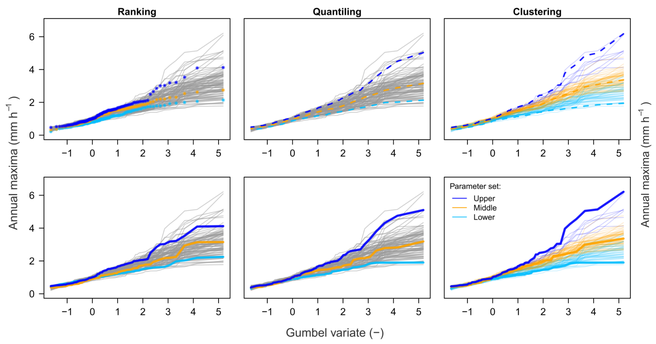

Fig. 4. Selected representative parameter sets using three selection methods.

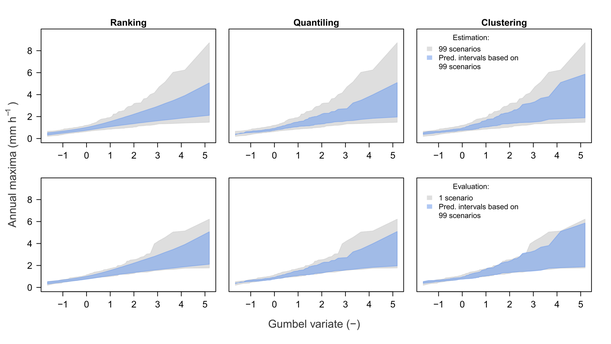

Fig. 5. Cross-validation of three selection methods using 100 scenarios.

STUDY CONCEPT AND FRAMEWORK

The HBV model was calibrated based on years 1990-2005 of observed precipitation, temperature and runoff data using the Genetic Algorithm with 100 independent trials. This resulted in an **ensemble of 100 parameter sets** which were then used to simulate **100 years of pseudo-observations of flow** using synthetic precipitation data generated with the weather generator. Use of synthetic data is crucial as it enables having a long enough dataset needed for the analysis of extremes (floods).

Next, three approaches were proposed to select the representative sets (Fig. 2):

1) Ranking,

2) Quantiling,

3) Clustering.

All these approaches are based on the simulation of annual maxima (AM).

The three different methods were tested based on the simulations of AMs for the catchment of the River Dünnern at Olten (196 km², Fig. 3). The methods were evaluated with 100 different meteorological scenarios.

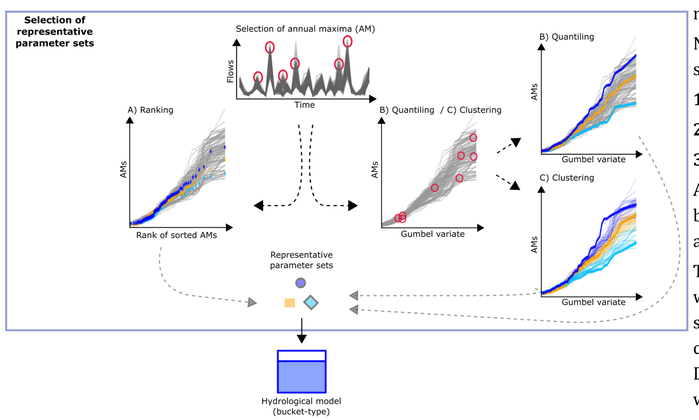

Fig. 2. Selection of the representative parameter sets based on annual maxima (AM).

Fig. 3. Location of the Dünnern at Olten catchment.

SUMMARY AND FURTHER READING

1) Three methods were proposed for **a selection of representative parameter sets** of a hydrological model. These methods are based on their ability to simulate annual maximum runoff values.
2) Proposed methods are very promising as they enable to reduce significantly computational requirements of hydrological simulations.
3) Application to the study catchment demonstrated general capabilities but also differences of the three tested approaches.
4) Our results indicate that the **clustering method was performing the best** while the ranking was the worst performing method.

Potential practical applications include studies using large data sets, extreme-event estimation, medium to short-range forecasting, operational systems, and designing flood constructions. Results need to be confirmed for more catchments.

Reference:

Sikorska-Senoner, A. E., Schaefli, B., and Seibert, J.: Downsizing parameter ensembles for simulations of extreme floods, *Nat. Hazards Earth Syst. Sci. Discuss.*, https://doi.org/10.5194/nhess-2020-79, in review, 2020.

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