Real-time unit hydrograph optimization based on K-NN and meta-heuristic algorithm

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Objectives

The objective of this paper is to develop a real-time unit hydrograph (UH) optimization method utilizing the K-NN in combination with meta-heuristic algorithm. The K-NN algorithm is utilized as a recommendation model, which realizes the selection of rainfall-runoff samples for UH analysis based on the real-time rainfall process, characterized as storm centroid, net rainfall intensity, and the net rainfall temporal patterns. Then the meta-heuristic algorithm is used to build a calibration model to achieve the optimization calibration of instantaneous UH.

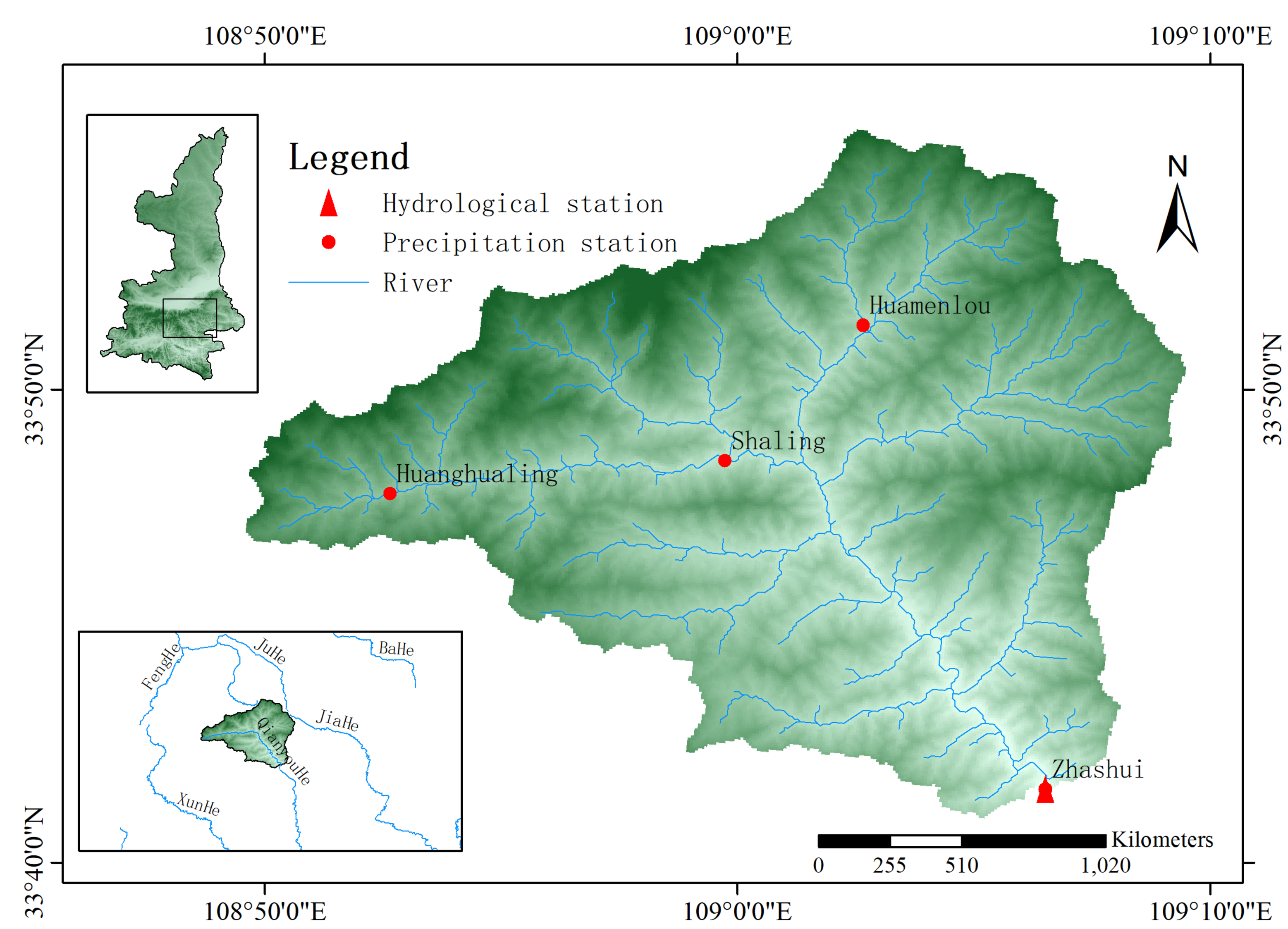

Figure 1 Location and station distribution of study watershed

Methods

- ✓ The rainfall-runoff samples were extracted based on the collected hydrological data, followed by an analysis of their features and the construction of a sample set.
- ✓ During flood forecasting, rainfall features are analyzed based on real-time data and the K-NN is utilized to select appropriate rainfall-runoff samples from a set of samples.
- ✓ The selected samples is utilized with a meta-heuristic algorithm for the UH optimization.

Experiments 1

Optimal scheme: The simulated flood process is derived from each net rainfall process and its corresponding UH.
Normal scheme: The simulated flood process is deduced by considering each UH as the only one of the basin.
Target scheme: The simulated flood process is derived from the net rainfall and the non-corresponding UH, and the one with the highest NSE is selected as the target scheme.

Experiments 2

The recommended UH was optimized based on the sample selection with distinct and comprehensive features .

Experiments 3

The recommended UH was optimized based on the sample selection with comprehensive features and different sample numbers.

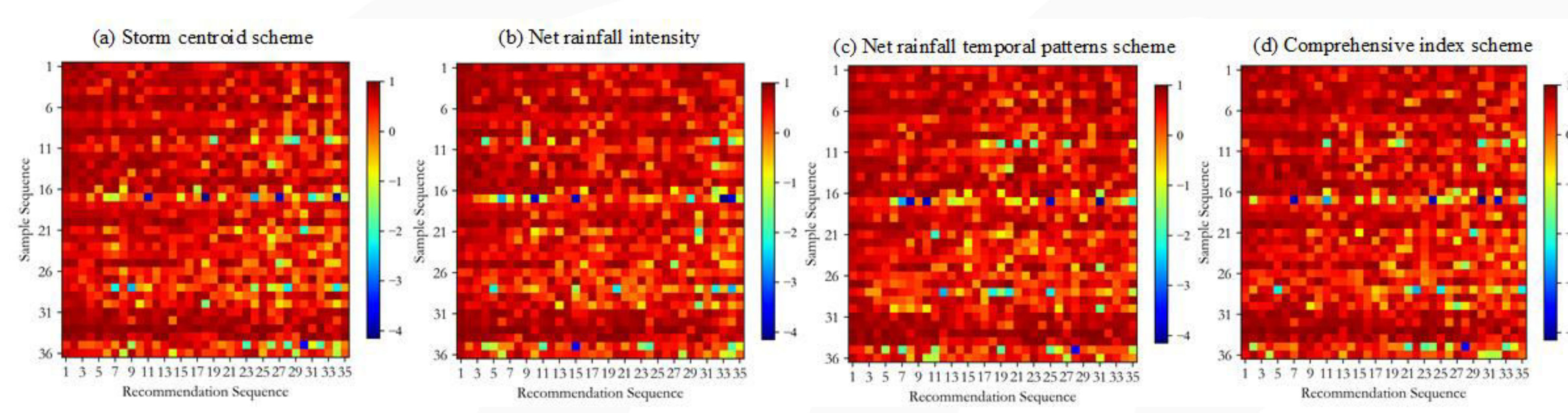

Figure 4 NSE heat map for each scheme

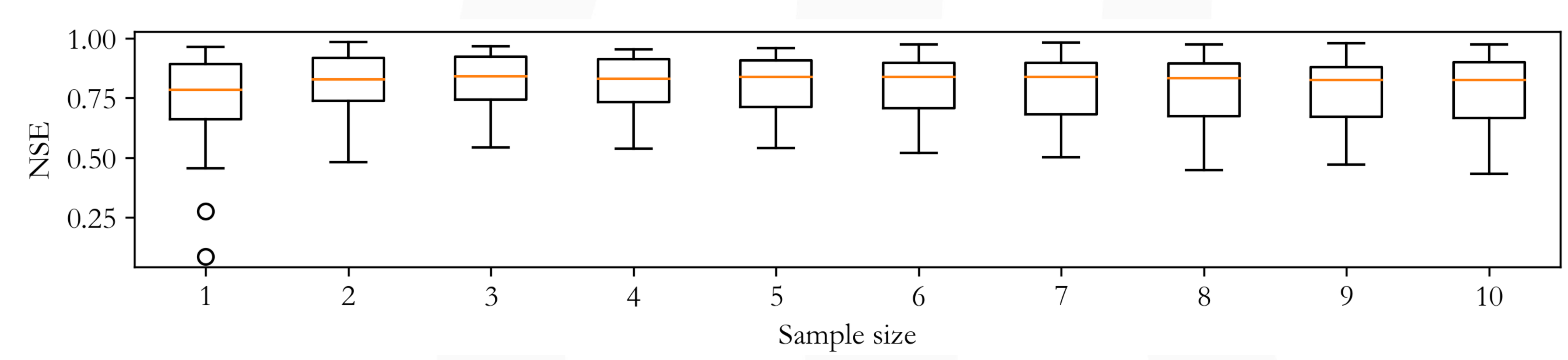

Figure 5 NSE box diagram of Experiment 3

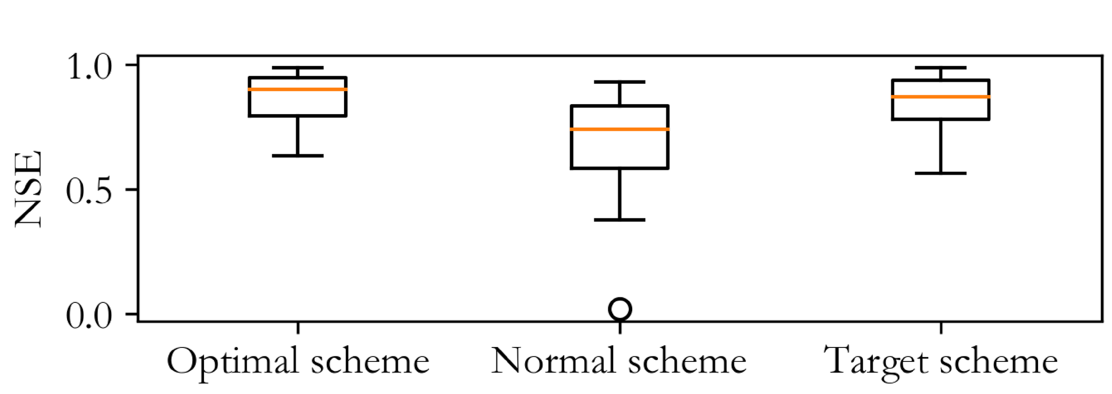

Figure 2 NSE box diagram of Experiment 1

Results

- ✓ The simulation accuracy achieved using rainfall features for sample recommendation surpasses that of the normal scheme.
- ✓ The validity of sample recommendation is determined by the net rainfall intensity, storm centroid location, and net rainfall temporal pattern, ranging from high to low.
- ✓ The NSE of the flood process simulated by the UH analyzed by the first recommendation sample is not necessarily the best, and selecting the appropriate number of samples can effectively reduce the generalization error and improve the simulation accuracy.

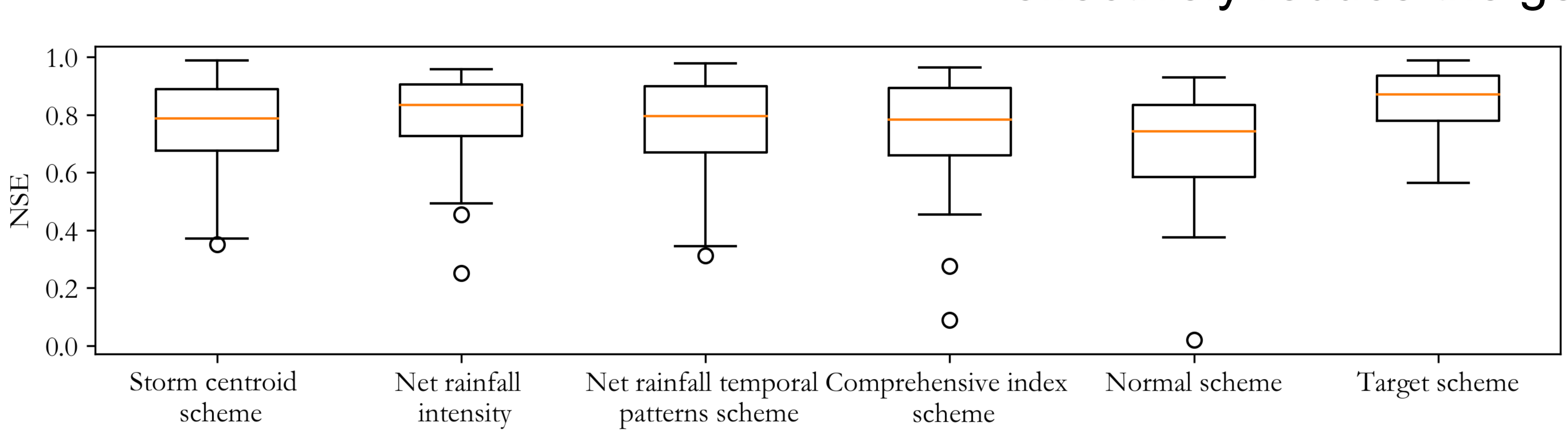

Figure 3 NSE box diagram of Experiment 2

Conclusions

A real-time optimization method for the UH is proposed based on the K-NN and meta-heuristic algorithm, which can select samples for real-time unit hydrograph optimization calibration based on rainfall features such as storm centroid, net rain intensity, and rainstorm temporal pattern. The research results show that the method proposed in this paper can effectively improve the accuracy of concentration calculation and flood forecasting.