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Incorporating Hydrological Signature-based Criteria for Auto-Calibrating Hydrologic Models

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The incorporation of important hydrological signatures such as flow-duration curve partitioning into automatic calibration of hydrologic models leads to better parameter identifiability. In this study, the HEC-HMS, HBV-EC, and WATFLOOD hydrologic models that Manitoba Hydrologic Forecast Center has developed for streamflow forecasting purposes are updated and calibrated for the Shellmouth basin in the Prairie region of Canada, which is known as the graveyard of the hydrologic models due to its highly complex hydrological processes such as snow-wind redistribution, the presence of abundant potholes, sloughs, wetlands, and dugouts that greatly affects the timing and response of runoff. These models have completely different structural complexities. The predictive accuracy of the Shellmouth basin outflow rate is important to the Manitoba Hydrologic Forecast Centre due to the multi-purpose functionality of the Shellmouth Reservoir at the outlet of the basin. The model calibrations are set up as multi-objective optimization problems to optimize NSE and three bias error metrics that are defined to fit the mid-segment slope (20%-60% time of exceedance), low-flow volume (60%-100% time of exceedance), and high-flow volume (0-5% time of exceedance) of the flow-duration curve of simulation to those of observation. The Pareto Archived- Dynamically Dimensioned Search (PA-DDS) multi-objective global optimization algorithm is used for fine-tuning the models' parameters. The multi-objective calibration strategy successfully finds parameter sets with superior objective values compared to the previously calibrated hydrologic models of the Shellmouth basin at the Hydrologic Forecast Center of Manitoba Infrastructure, Canada. Superior goodness-of-fit values of flow-duration curve segmentation signify better simulation of the soil storage capacity, quick runoff, and low flow component of the hydrologic system. Therefore, the signature-based multi-objective auto-calibration yields parameter sets with hydrologically consistent streamflow time series in comparison with the previously used hydrologic models.