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Which runoff measurements are most informative for constraining hydrological models for almost ungauged catchments?

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Applications of runoff models usually rely on long and continuous runoff time series for model calibration. However, many catchments around the world are ungauged and simulating runoff for these catchments is challenging. In this study we investigated the value of individual runoff measurements at certain points in time for using a bucket-type runoff model (HBV) in ungauged catchments. Based on the assumption that a limited number of runoff measurements can be taken, we sought the optimal sampling strategy (i.e. when to measure the streamflow) to obtain the most informative data for constraining the runoff model. We used twenty gauged catchments across the eastern U.S., pretended that these catchments were ungauged and applied different sampling strategies. Here we assumed that we can exactly pick certain points in time such as the annual maximum flow. We tested strategies ranging from simply using monthly flow maxima to a more process oriented selection of observation times, to select twelve runoff measurements within a year. The twelve runoff measurements were used to find the 100 best parameter sets by a Monte Carlo calibration approach. Runoff simulations were evaluated in an independent validation period by means of Nash-Sutcliffe efficiency of the hydrograph and the mean absolute relative error of the flow-duration curve. The flow-duration curve was best estimated with strategies that capture the full range of runoff magnitudes of a catchment. The mean absolute relative error of all catchments ranged between 0.19 and 0.5 for the different strategies indicating a distinct difference in model performance for the flow-duration curve depending on the strategy. The Nash-Sutcliffe efficiencies varied from 0.57 to 0.67 for the different strategies. For simulating the hydrograph, the strategies to collect runoff values at the time of the monthly maxima and on event recessions were generally most valuable.