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How does observation uncertainty influence which stream water samples are most informative for model calibration?

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Streamflow isotope samples taken during rainfall-runoff events are very useful for multi-criteria model calibration because they can help decrease parameter uncertainty and improve internal model consistency. However, the number of samples that can be collected and analysed is often restricted by practical and financial constraints. It is, therefore, important to choose an appropriate sampling strategy and to obtain samples that have the highest information content for model calibration. We used the Birkenes hydrochemical model and synthetic rainfall, streamflow and isotope data to explore which samples are most informative for model calibration. Starting with error-free observations, we investigated how many samples are needed to obtain a certain model fit. Based on different parameter sets, representing different catchments, and different rainfall events, we also determined which sampling times provide the most informative data for model calibration. Our results show that simulation performance for models calibrated with the isotopic data from two intelligently selected samples was comparable to simulations based on isotopic data for all 100 time steps. The models calibrated with the intelligently selected samples also performed better than the model calibrations with two benchmark sampling strategies (random selection and selection based on hydrologic information). Surprisingly, samples on the rising limb and at the peak were less informative than expected and, generally, samples taken at the end of the event were most informative. The timing of the most informative samples depends on the proportion of different flow components (baseflow, slow response flow, fast response flow and overflow). For events dominated by baseflow and slow response flow, samples taken at the end of the event after the fast response flow has ended were most informative; when the fast response flow was dominant, samples taken near the peak were most informative. However when overflow occurred, the mixing processes were more complex and the information content of streamflow samples decreased. Therefore, for these cases, samples taken at the start or end of overflow were most informative. We, furthermore, investigated how observation errors influenced the multi-criteria calibration process. Preliminary results show that more than two samples are needed to maintain a similar simulation performance when observation errors in precipitation or streamflow are included. These results provide guidance on suitable event-based sampling strategies for different conditions.