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# Future streamflow droughts in glacierized catchments: the impact of dynamic glacier modelling and changing thresholds

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In glacierized catchments, snowpack and glaciers function as an important storage of water and hydrographs of highly glacierized catchments in mid- and high latitudes thus show a clear seasonality with low flows in winter and high flows in summer. Due to the ongoing climate change we expect this type of storage capacity to decrease with resultant consequences for the discharge regime. In this study we focus on streamflow droughts, here defined as below average water availability specifically in the high flow season, and which methods are most suitable to characterize future streamflow droughts as regimes change. Two glacierized catchments, Nigardsbreen (Norway) and Wolverine (Alaska), are used as case study and streamflow droughts are compared between two periods, 1975-2004 and 2071-2100. Streamflow is simulated with the HBV light model, calibrated on observed discharge and seasonal glacier mass balances, for two climate change scenarios (RCP 4.5 & RCP 8.5).

In studies on future streamflow drought often the same variable threshold of the past has been applied to the future, but in regions where a regime shift is expected this method gives severe "droughts" in the historic high-flow period. We applied the new alternative transient variable threshold, a threshold that adapts to the changing hydrological regime and is thus better able to cope with this issue, but has never been thoroughly tested in glacierized catchments. As the glacier area representation in the hydrological modelling can also influence the modelled discharge and the derived streamflow droughts, we evaluated in this study both the difference between the historical variable threshold (HVT) and transient variable threshold (TVT) and two different glacier area conceptualisations (constant area (C) and dynamical area (D)), resulting in four scenarios: HVT-C, HVT-D, TVT-C and TVT-D. Results show a drastic decrease in the number of droughts in the HVT-C scenario due to increased glacier melt. The deficit volume is expected to be up to almost eight times larger in the future compared to the historical period (Wolverine, +674%) in the HVT-D scenario, caused by the regime shift. Using the TVT the drought characteristics between the C and D scenarios and between future and historic droughts are more similar. However, when using the TVT, causing factors of future droughts, anomalies in temperature and/or precipitation, can be analysed. This study highlights the different conclusions that may be drawn on future streamflow droughts in glacierized catchments depending on methodological choices. They could be used to answer different questions: the TVT for analysing drought processes in the future, the HVT to assess changes between historical and future periods, the constant area conceptualisation to analyse the effect of short term climate variability and the dynamical glacier area to model realistic future discharges in glacierized catchments.