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Impacts of a Changing Climate on Spatio-Temporal Trends and Patterns of Streamflow Droughts Using a Large-Sample Dataset

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Streamflow droughts play a fundamental role in the management of rivers and influence the balance between in-stream uses such as aquatic life and recreation, and out-of-stream uses such as reservoir regulation. Consequently, knowledge on the occurrence, development and severity of streamflow droughts is important for many aspects of water resources management including hydropower planning, determining allowable water transfers and withdrawals or decisions regarding environmental flows. Sweden, although historically a region abound with water, is not exempt of streamflow droughts. Especially the 1976 Northwest European drought and the 2003 European heatwave will long be remembered for their devastating effects in Europe including Scandinavia. More recently, Sweden suffered from water shortages in 2016/2017 and 2018, and many regions had to issue local water use restrictions.

In all cases, there was large spatial variability in hydro-climatic patterns across the country, which highlights the complex interplay of meteorological, topographic and anthropogenic features and the resulting hydrological impacts at the catchment scale. Given the large observed temperature increase in Northern Europe over the last century, accompanied by changes in precipitation patterns and dramatic increases in human activities, we hypothesize that streamflow droughts in Sweden have become more common and that not all regions are affected by streamflow droughts to the same extend. We also argue that increasing temperatures have led to an extended duration of the summer period (following the meteorological definition based on temperature) and a longer vegetation period, which might have triggered more drought days during summer. To assess these hypotheses, we examined the spatial and temporal development of streamflow droughts in 90 Swedish catchments over a period of 56 years (from October 1961 to September 2017). Streamflow droughts were identified and characterized with help of the standardized streamflow index (SSI) and the threshold-level method. Temporal trends were analyzed using the non-parametric Mann-Kendall test and the Sen's slope estimate. Spatial patterns in streamflow drought characteristics were identified using a cluster analysis.