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Observing the human influence on hydrological drought

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Human activities have a large influence on the hydrological system. This influence needs to be studied from observations to improve the understanding of human-water systems, especially under drought conditions. Here we present a database of 30 case studies from around the world for which we quantified the human influence on hydrological drought, with the focus here on streamflow drought, using observation data. We used a methodological framework which allowed for consistent quantification of the human influence whilst using a variety of approaches depending on data availability: i) paired-catchment approach; ii) upstream-downstream approach; and iii) observed-naturalised approach. For each case study, we compared the natural conditions with the human-influenced situation for the same time period. Streamflow drought events were detected for both time series using the variable threshold level method, with the natural time series being used as the benchmark to allow for the quantification of the human influence. Through a comparison of drought events, the impact of different human activities (e.g. water abstraction, reservoir building, and urbanization) on streamflow drought durations and deficits has been calculated.

Our groundwater abstraction case studies show a clear aggravation of streamflow drought events due to the human water abstraction. This is especially seen in the deficit volumes, with many showing increases between 100 and 400% due to the human influence. Reservoirs are seen to have varying impacts on downstream droughts depending on the reservoir purpose, with both the aggravation and alleviation of drought events observed in our global case studies. These case study results could help to identify how different reservoir purpose and management strategies impact droughts, which can help to inform future water management during drought conditions. Through our urbanization case studies we have discovered how complex the effect of urbanization on hydrological droughts is. We expected the land use change effect to be dominant, but found that streamflow droughts in the urbanised catchments were also governed by unknown anthropogenic in-and outflows. Therefore we reclassified urbanisation to the term mixed influences, to incorporate these simultaneous changes.

The quantification of the human influence was not always possible, with appropriate data availability often being the limiting factor. It can be difficult to obtain data of the natural situation for the correct time period because of issues identifying a monitored paired catchment or upstream location, or obtaining existing modelled natural data. Therefore we have also used a number of case studies with soft data (e.g. case studies investigating the human influence on drought but without numerical data to quantify it) to compliment the quantified case studies, and to start extrapolating knowledge into regions where we are lacking necessary data. We find that our soft data case study results are in agreement with our more detailed quantitative results.

Overall, this work helps to build a better picture of patterns of human influence on drought across different human activities and regions. The results have potential to help shape more efficient drought policies and drought management practices.