Geophysical Research Abstracts
Vol. 19, EGU2017-13874, 2017
EGU General Assembly 2017

Lessons learned for applying a paired-catchment approach in drought analysis

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Ongoing research is looking to quantify the human impact on hydrological drought using observed data. One potentially suitable method is the paired-catchment approach. Paired catchments have been successfully used for quantifying the impact of human actions (e.g. forest treatment and wildfires) on various components of a catchment's water balance. However, it is unclear whether this method could successfully be applied to drought. In this study, we used a paired-catchment approach to quantify the effects of reservoirs, groundwater abstraction and urbanisation on hydrological drought in the UK, Mexico, and Australia.

Following recommendations in literature, we undertook a thorough catchment selection and identified catchments of similar size, climate, geology, and topography. One catchment of the pair was affected by either reservoirs, groundwater abstraction or urbanisation. For the selected catchment pairs, we standardised streamflow time series to catchment area, calculated a drought threshold from the natural catchment and applied it to the human-influenced catchment. The underlying assumption being that the differences in drought severity between catchments can then be attributed to the anthropogenic activity. In some catchments we had local knowledge about human influences, and therefore we could compare our paired-catchment results with hydrological model scenarios. However, we experienced that detailed data on human influences usually are not well recorded.

The results showed us that it is important to account for variation in average annual precipitation between the paired catchments to be able to transfer the drought threshold of the natural catchment to the human-influenced catchment. This can be achieved by scaling the discharge by the difference in annual average precipitation. We also found that the temporal distribution of precipitation is important, because if meteorological droughts differ between the paired catchments, this may mask changes caused by human activities. This issue can generally be overcome by selecting adjacent or nearby catchments. Finally, we found that geology is much more important for paired-catchment analysis of drought than we anticipated based upon the experiences in flood research. For example, in two of the UK pairs, we could not use the results due to differences in geology overruling the human influence. We learned that in the selection of catchments for drought analysis, (hydro)geology should be considered in even more detail.

Taking these aspects into account, we concluded that the paired-catchment approach works for evaluating the effects of reservoirs and groundwater abstraction on streamflow drought, but is more challenging for urbanisation. The reasons are more problems in catchment selection, lack of results, and complexity of processes making attribution more difficult. Urbanisation is not a simple land cover change influencing only infiltration and runoff, but it involves all kinds of indirect effects, such as artificial inputs (drainage, sewage return flows) that are very important during low flow periods. For this we would suggest starting in small, well-measured urban catchments, of which all artificial inputs are known. We believe that with the careful selection criteria and accounting for variations in climate and landscape, there is scope for using a paired-catchment approach in hydrological drought research.