Streamflow regime shifts in a changing climate: A case study from Victoria, Australia

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Abstract: Multi-year droughts are projected to increase in a future warming climate. These prolonged dry conditions have been shown to cause changes in streamflow regime patterns over time. These changes are referred to as streamflow regime shifts. Understanding a resultanting shift from perennial to non-perennial regimes as well as the intensification of non-perennial flows is crucial for example for environmental water management, and in particular, when planning for environmental releases. Insight into these shifts is necessary to combat the impacts from water scarcity in light of environmental degradation, such as a reduction in aquatic plant and animal biodiversity. In the past several metrics/signatures have been developed to classify streamflow characteristics. These signatures are quantitative metrics describing statistical and dynamical streamflow properties, that also allow to infer meaningful processes of catchment processes. They can be grouped to characterise ecological important features representing categories of flow regime in terms of magnitude, timing, frequency, duration and the rate of change as well as characterising flow intermittence and variability, e.g. flood regime (McKillan, 2020).

In this study, we investigate streamflow regime shifts for catchments in response to one of Australia's worst multi-year droughts, known as millennium drought (1997–2009). The millennium drought is characterised by the longest un-interruped rainfall decline since the start of the rainfall recordings in 1900 The drought led to disproptional changes to rainfall-runoff relationships (Saft et al., 2015). Research indicates that some catchment might not be able recover from this period even after returning to pre-drought rainfall levels (Peterson et al, 2021). Building on the research and to investigate the influence on streamflow shifts, we combine metrics that incorporate both climatic and hydrologic indices. A case study from south-east Australia is presented by applying these indices to pre-drought (1970–1996), millennium drought (1997–2009), and post-drought (2010–2018) conditions and 116 hydrological reference stations (HRS). These are catchments that have a long record of high-quality data and that are unimpacted by human activities, such as water management or major environmental disturbances. As a result, we identified rivers that remained in the non-perennial flow regime post drought. Using changes to water balance components derived from the Bureau of Meteorology's operational Australian Water Resources Assessment model (AWRA-L) as well as prevailing weather systems and associated rainfall (Pepler et al., 2021), we discuss reasons for the persistent shifts in streamflow regime and implications for water management.

REFERENCES

McKillan, H. A review of hydrological signature and their applications, 2020. Wires Water, 1499, https://doi.org/10.1002/wat2.1499.

Pepler, A., A.J. Dowdy, P. Hope, 2021. The different role of weather type systems in southern Australian rainfall between 1979–1996 and 1997–2015. Climate Dynamics, 56, 2289–2302. https://doi.org/10.1007/s00382-020-05588-6.

Peterson, T., M. Saft, M. C. Peel, A. John, 2021. Watersheds may not recover from drought. Science, 372, 745–749, DOI: 10.1126/science.abd5085.

Saft, M., A. W. Western, L. Zhang, M. C. Peel, N. J. Potter, 2015. The influence of multiyear drought on the annual rainfall-runoff relationship: An A ustralian perspective. Water Resour. Res. 51, 2444–2463. https://doi.org/10.1002/2014WR015348.

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