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Spatial and temporal variability of past rainfall in western Australia inferred from tree rings

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For much of the Southern Hemisphere, the ability to identify spatial and temporal patterns of past climatic variability is constrained by the short length of instrumental records and the sparse spatial distribution of proxy records. This is particularly true for continental Australia, where instrumental records are generally <100 years long and where there are also few proxy records.

We have developed two high-resolution chronologies using growth rings of cypress pines (Callitris columellaris) from northwest and southwest Australia. These chronologies are currently the only multi-century tree-ring records for mainland Australia. Both chronologies are strongly correlated with hydroclimate and allow robust reconstructions of past hydroclimatic variability over spatially broad areas (i.e. > 3° x 3°) of inland western Australia. These reconstructions represent significant extensions of the instrumental rainfall records and reveal inter-annual to multidecadal-scale variation in past hydroclimate over the last two centuries for northwest Australia and four centuries for southwest Australia.

In both the northwest and southwest regions, periods of prolonged drought (typically extending between one and three decades) have been interspersed with shorter periods of above-average rainfall (typically less than a decade). Of particular note our northwest record reveals that the last two decades (1995–2012) have been unusually wet in inland northwest Australia compared to the previous two centuries. This period of unusually high rainfall coincided with both an anomalously high frequency and intensity of tropical cyclones in northwest Australia and the dominance of the positive phase of the Southern Annular Mode, both of which are major mechanisms of rainfall delivery to inland northwest Australia.

Our tree-ring records also reveal the occurrence of several prolonged drought periods as well as extreme wet events in the last two centuries that were synchronous between northwest and southwest Australia, suggesting possible teleconnections between the two regions. In addition, there appears to have been a generally anti-phase relationship between the hydroclimate of inland western Australia and that of southeast Australia over the last two centuries, with the exception of a prolonged drought period in the 1830s that is evident in proxy and historical records from both western and eastern Australia.

The spatially-broad hydroclimatic signal contained in these two existing tree-ring records as well as the widespread occurrence of Callitris columellaris suggests that a coarse-scale spatial reconstruction (or 'atlas') of past hydroclimatic variability could be developed for the entire western Australian region with the addition of relatively few new proxy records from key locations.