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A multi-archive, multi-tiered reconstruction of southeastern Australian hydroclimate variability over the past 1200 years

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Hydroclimate variability has profound socioeconomic and environmental impacts in Australia. Therefore, it is of vital importance to understand the drivers and range of variability through time. Existing hydroclimate reconstructions for the continent are predominantly based on short (<500 year), annually-resolved tree ring, coral, and ice-core records, most of which are geographically removed from the mainland continent. Recent efforts by the PAGES Aus2k working group have identified a limited number (n=22) of high quality, non-annually resolved palaeoclimate records covering the Australasian region over the Common Era, the majority of which are hydroclimatically sensitive. Nine of these records are situated in southeast Australia (SE Australia), which is the most populated and agriculturally intensive area of the country. This region has also experienced a decline in cool season rainfall in recent decades. The small number of records, in addition to the diversity of archives, measured proxies, resolution, and robustness of age model, emphasizes the need to characterise and incorporate uncertainty estimates in any data synthesis effort.

This study combines multiple novel techniques to examine the inter- and intra-site coherency of climate signals within the nine records from SE Australia. First, new Bayesian age-depth models are constructed to provide a consistent approach to age modeling and quantification of uncertainty. As with many palaeoclimate records generally, many of the SE Australian records have multiple proxies measured from one site. Differing sensitivities of proxies to regional versus local conditions can be overcome by data reduction techniques. Here, dominant modes of variability are extracted using data-appropriate Monte Carlo Empirical Orthogonal Functions (MCEOF), and then combined with time series of single-proxy records into regional MCEOFs. Resulting regional modes minimise local effects and highlight regional climate variability. Identified modes show moderate agreement with a published single-archive multi-tiered regional MCEOF synthesis for the same region, as well as El Niño-Southern Oscillation and regional temperature reconstructions. This approach demonstrates the importance of incorporating age uncertainty in a consistent manner, and the utility of data reduction methods. It highlights the potential for acquiring coherent regional climate signals from a sparse network of non-annually resolved palaeoclimate archives from the Australian mainland.