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A 4500 year Southern Hemisphere record of ENSO activity from kauri tree rings

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Kauri (Agathis australis (D. Don) Lindl.) is a long-lived closed-canopy emergent conifer endemic to northern New Zealand. Its clear annual rings carry a regional-scale climate signal which is amplified by pooling data across the modern growth range. Annual rings are predominantly laid down in September through December, coincident with El Niño and La Niña events peaking and with the strongest El Niño – Southern Oscillation (ENSO) teleconnection to New Zealand. Statistical analyses indicate that ENSO was the dominant 20th century driver of inter-annual variability of kauri growth with El Niño and La Niña events usually associated with wide and narrow tree rings respectively. A consequence is that the waxing and waning of ENSO activity through time is registered in kauri master tree-ring chronologies as evolving time series variance (variance increases during ENSO active periods).

A multi-millennial master kauri tree-ring chronology has been built from samples extracted from living trees, historic building timbers, logging relics, and wood preserved in swamps. Recent work has extended the chronology to 2489 BCE and has increased sample depth to a minimum of nine trees from 1589 BCE (to 2002 CE). We describe this chronology and critically evaluate the utility of its running variance as a proxy for ENSO activity and/or regional teleconnection changes. Issues related to signal contamination, associated with complex evolving sample mix and depth, are highlighted. Inferred changes in past ENSO activity and/or teleconnections are related to plausible climate drivers (solar activity, volcanism, and global warming).

In line with multi-proxy ENSO studies, our results indicate increasing ENSO activity as the world has warmed over the last 500 years or so, with superimposed quasi-periodic multi-decadal oscillations. We also find evidence of decadal-scale spectral features emerging at times of high chronology variance, consistent with the results of wavelet analysis of 20th century instrumental records. However, although 20th century ENSO activity was high relative to the last 500 years, no such claim can be made at the multi-millennial scale. Multi-centennial and multi-millennial trends in variance, with superimposed quasi-periodic multidecadal features, are present throughout the record, although the latter are highly variable in both amplitude and periodicity. Several interesting relationships between chronology variance and potential forcings are apparent over the 2nd millennium CE, but these do not appear to be consistent over longer time periods.