25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

KEYNOTE

Bridging the data gap: A spatially resolved reconstruction of drought in the South Pacific Islands

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Abstract: Droughts are a natural occurrence in many small Pacific Islands and can have severe impacts on local populations and environments. The El Niño-Southern Oscillation (ENSO) is a well-known driver of drought in the South Pacific, and much research effort has been expended to understand its mechanisms and impacts. However, the South Pacific is a data sparse environment in both space and time, and our understanding of extreme ENSO events and their influence on island hydroclimate is limited by the geographical distance between stations, the short instrumental record, and the infrequency of ENSO extremes.

To address this gap, we present the South Pacific Drought Atlas (SPaDA), a multi-proxy, spatially resolved reconstruction of the November-April Standardised Precipitation Evapotranspiration Index for the southwest Pacific islands. The reconstruction integrates coral proxies, which provide local information on the South Pacific hydroclimate but are limited in number and length, with a network of continental tree-ring chronologies targeting Pacific climate variability through remote teleconnections. To validate the SPaDA, we look to non-quantitative sources of climate information, derived from compilations of documentary records. These records, while uncertain, provide an entirely independent means to corroborate the results of the paleo-reconstruction.

The SPaDA provides a 350-year, continuous dataset of climate information, which can be used to explore the occurrence of extreme events in the pre-instrumental period. The SPaDA closes the gap between existing paleo-reconstructions of point ENSO indices, and a spatially resolved drought atlas, allowing both the hydroclimate of individual islands and regional patterns of drought to be assessed. The benefit of a spatially resolved dataset to assess climate extremes in small Pacific islands is highlighted in the case of extreme El Niño events, which can have substantially different hydroclimatic impacts than more moderate events.

We used an Isolation Forest, an unsupervised machine learning algorithm, to identify anomalous hydroclimatic states in the SPaDA that may indicate the occurrence of an extreme event. Extreme El Niño events characterised by very strong southwest Pacific drought anomalies and a zonal SPCZ orientation are shown to have occurred semi-regularly throughout the reconstruction interval, providing a valuable baseline to compare to climate model projections. By identifying the spatial patterns of drought resulting from extreme events, we can better understand the impacts these events may have on individual Pacific Islands in the future.

In creating the SPaDA, we thought broadly about what it means to 'observe' an environment. This project shows how multiple sources of climate information can be combined to provide a more complete picture of past hydro-climatological change in data sparse environments.

Keywords: *South Pacific, paleoclimate, tree rings, machine learning*