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A Multi-Proxy Perspective on Climate Variability in the Tropical Pacific over the Last Millennium

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The southwest Pacific is a major source of tropical climate variability through heat and moisture exchanges associated with the Western Pacific Warm Pool (WPWP) and the South Pacific Convergence Zone (SPCZ). These variations are especially significant at the annual, ENSO, and multi-decadal timescales. Climate proxy records from the tropical Pacific must be used to extend records of SST, SSS, and rainfall variations into the pre-instrumental period. We highlight our recent efforts to quantitatively understand tropical climate variability over the last millennium using numerical simulations and climate proxy records (corals and stalagmites), the latter of which overlap with, and extend beyond the instrumental period.

We investigate the use of individual foraminiferal analyses (IFA) in assessing past ENSO variability using numerical simulations. The simulation quantifies the sensitivity of IFA to ENSO amplitude and seasonal cycle amplitude (or a combination of both) at different locations in the tropical Pacific. Results indicate that IFA sensitivity towards ENSO is highest at the central equatorial Pacific surface ocean and the eastern equatorial Pacific (EEP) thermocline, whereas sensitivity towards the seasonal cycle is highest at the EEP surface ocean.

We investigate tropical surface ocean variability using two recent coral-based climate reconstructions: a 233 yr record from Misima Island, Papua New Guinea (10.6˚ S, 152.8˚ E) and a 293 yr record from Olasana Island, Western Province, Solomon Islands (8.2˚ S, 157.2˚ E). The PNG coral record of monthly resolved δ^{18}O and Sr/Ca variations spans the interval ∼1414-1645. This record indicates that the surface ocean in this region experienced a small change in hydrologic balance with no change in temperature, extended periods of quiescence in El Niño activity, and no change in average amplitudes of El Niño events relative to signals captured in regional modern records. The Solomon coral δ^{18}O record (1716-2009) documents early 19^{th} century El Niño events that rival and exceed the largest instrumentally documented ENSO events at this site. In addition, the Solomon record contains evidence of decadal and longer period hydroclimate variability. Both of these coral proxy records from the WPWP suggest that internal variability is responsible for the observed wide range of ENSO event magnitudes.

We investigate tropical Pacific rainfall variability using two recent stalagmite-based rainfall reconstructions: a 445 yr δ^{18}O record from Espiritu Santo, Vanuatu (15.5˚S, 167˚E) and a 595 yr δ^{18}O record from Guadalcanal, Solomon Islands (9.4˚S, 160˚E). The Vanuatu proxy rainfall record (1557-2003) is dominated by changes in stalagmite δ^{18}O that are large (∼1‰, quasi-periodic (∼50 yr period), and generally abrupt (within 5–10 yr), which are not correlated with solar forcing. The Solomon proxy rainfall record (1416-2011) displays similar patterns of variability: stalagmite δ^{18}O changes are large (∼1.5‰, quasi-periodic (∼12-60 yr period), and generally abrupt (<10 yr). Both of these rainfall proxy records suggest decadal-scale variability in rainfall is a persistent feature of SPCZ that arises from internal variability.