IS SOLAR FORCING A CONTROLLING FACTOR OF ENSO VARIABILITY?

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Whereas the physical links between solar irradiance and terrestrial climate are still poorly understood, an increasing number of proxy climate records provide circumstantial evidence suggesting solar inputs as a dominant controlling factor of global climate changes. Here we report the results of an investigation of stalagmites from a mid-ocean island in the South Pacific located at the epicenter of oceanic ENSO that contains a detailed and continuous millennial record of rainfall and ENSO variability. Spectral analysis of the proxy records suggests a strong linkage between solar cycles and ENSO variability during the first millennium AD.

Century-long instrumental records on Niue Island (19° 00'S; 169° 50'W) provide a frame of reference and indicate that the interannual and interdecadal air temperature variability is negligible but the rainfall is fully engaged in the wheels of ENSO such that El-Niño and La-Niña events correspond with droughts and abundant rainfall, respectively. Seasonal monsoon and trade rainfalls exhibit a significant contrast in their oxygen isotope compositions. Rainfall amount also governs microbial soil activities resulting in convergent ^{18}O and ^{13}C depletions and enrichments in the drips that are transferred to the calcite stalagmites in the Niuean caves. A detailed study of four actively growing stalagmites overlapping with the instrumental records (see paper by M. Rasbury et al, this meeting) confirms that continuous layered stalagmites on Niue Island archive interannual ENSO and interdecadal IPO histories in their annual couplets widths and stable oxygen and carbon isotope time-series records.

The low U concentration in the range of 44.2 to 97.5 ppb renders dating by $^{230}Th/^{234}U$ method impractical considering the youthfulness of the stalagmite and the amount of available material. Three alternative dating techniques were used to derive a robust chronology: (i) $^{226}Ra/^{234}U$ by TIMS; (ii) radiocarbon by AMS, and (iii) couplets counting. In conjunction the three dating methods indicate that the 160 mm stalagmite section spans a time interval from 490 to 1354 years AD. Whereas interannual and interdecadal-scale variability are the largest components of variance in the millennial-long oxygen and carbon isotope time series, century-long phase transitions are prominent in the records. Global climate shifts during the 7th and 8th centuries AD (Cold Dark Age) and during the 12th and 13th centuries AD (Medieval Climate Anomaly) correspond to prolonged El-Niño-like dry phases manifested by distinct ^{18}O and ^{13}C enrichments amounting to several per mil in the stalagmite records. These implicit dry phases are corroborated by contemporaneous reductions in ice accumulation on the Quelccaya Ice Cap on the high Peruvian Andes whose link to ENSO-driven precipitation has been amply demonstrated.

Processed in the frequency domain to quantify the variance, the proxy stable isotope data yield high frequency cycles at 2.6 to 7 years matching modern interannual ENSO periodicity bands. Importantly, frequency peaks at 11, 22, 72 and 108 years exceeding the 90% confidence level and matching precisely known solar periodicities (Schwabe, Hale, Gleissberg and deVries cycles) are clearly discerned in the oxygen isotope spectral power. The low frequency cycles exhibit phase alternations between prolong ENSO events manifested in severe droughts that are succeeded by “normal” ENSO events and abundant rainfall. The new mid-ocean stalagmite record offers compelling evidence bearing on the coupling between solar cycles and ENSO variability through time.