

Enhanced frequency of multi-year El Niño-Southern Oscillation across the Holocene

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By : Lu, Zhengyao ; Schultze, Anna ; Carré, Matthieu ; Brierley, Christopher ; Hopcroft, Peter ; **Yin, Qiuzhen** [\[UCL\]](#)  ; Zhang, Qiong **et al.**

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The El Niño-Southern Oscillation (ENSO) events that persist and develop for a second year or beyond (multi-year) are relatively rare. Compared to single-year events they create higher cumulative impacts and are linked to extended periods of extreme weather events worldwide. Past ENSO variations help us to better understand and anticipate how multi-year ENSO may change in the future. Here we combine proxy data reconstructions with a multi-model ensemble of climate simulations to investigate the evolution of multi-year ENSO during the Holocene (about 11,700 years ago to the present day), when the global annual mean climate was relatively stable and mainly driven by seasonal distribution of insolation. We find that the ratio of multi-year El Niño and La Niña to single-year events increased by a factor of 5, associated with a longer ENSO period (from 3.5 to 4.1 years) over the past ~7,000 years in monthly-resolved fossil coral oxygen isotope reconstructions from the equatorial central Pacific. This change is verified qualitatively by comparison with a subset of transient Holocene model simulations with a more realistic representation of ENSO periodicity. More frequent multi-year ENSO and prolonged ENSO period are caused by a shallower thermocline and stronger upper ocean stratification in the tropical Eastern Pacific towards the present day. The sensitivity of ENSO duration to orbital forcing provides a warning signal highlighting the urgency of minimising anthropogenic influence which could accelerate the long-term trend towards more persistent ENSO damages.