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External and internal origins of ENSO modulation revealed by Holocene corals and climate model simulations

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El Niño-Southern Oscillation (ENSO) is the main driver of Earth's interannual climate variability. Palaeoclimate records indicate reduced ENSO variance during the middle Holocene; however, the extent to which external forcing has driven past changes in the magnitude and characteristics of ENSO are matters of considerable debate. Here, we combine coral oxygen isotope (δ^{18}O) data from central Pacific corals, with a suite of forced and unforced simulations conducted using the CSIRO Mk3L and GFDL CM2.1 climate system models. On millennial timescales, the coral data reveal a statistically significant increase in ENSO variance over the past 6,000 years. This trend is not reproduced by the unforced model simulations, but can be reproduced once orbital forcing is taken into account. Analysis of the forced simulations reveals that increasing NINO3.4 SST variance arises from a weakening of the Asian summer monsoon circulation, and an associated weakening of the Pacific Walker Circulation, in response to decreasing boreal summer insolation. The picture is less clear on shorter time scales, and we explore further ENSO multi-decadal variations focusing on the apparent ENSO amplitude minimum at 3,000-5,000 years ago. We combine a 175-year-long coral δ^{18}O ENSO record from a 4,300-year-old coral with new δ^{18}O results from a ~300-year-long *Porites* coral microatoll. Both corals were discovered on Kiritimati (Christmas) Island, an optimal ENSO 'centre of action' in the equatorial Pacific, and radiometric dating indicates that the corals have a 25-year overlap. Together, the unprecedented contiguous ~450 year-length of the combined results shows interdecadal modulation of ENSO amplitude. The results provide a robust baseline of intrinsically generated ENSO modulation, against which to quantify the response of ENSO to past and future external forcings.