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Tropical Pacific response to the LGM/Holocene transition: a millennial-scale climate record from the Gulf of California

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Within the modern climate system, the interannual variability in the tropical Pacific ocean-atmosphere circulation intensity, defined as the El Niño/Southern Oscillation (ENSO), has significant impacts both within and beyond the tropics. Despite evidence for past "ENSO-like" climate variability at a variety of timescales, the behaviour of the ENSO system under different climate boundary conditions continues to be debated. Here, we investigate the millennial-scale signature of ENSO-like variability across the transition from the Last Glacial Maximum to the early Holocene, testing the ENSO system response to changes in insolation, atmospheric CO2 and global ice volume. We have analysed a remarkable high resolution sediment core from the Gulf of California, MD02-2515 (IMAGES MONA expedition). The mm-scale (annually) laminated diatomaceous muds reflect seasonal variations in ocean and atmospheric circulation, driven in part by a monsoon climate, and interannual variability driven by ENSO. We address both the marine and terrestrial records of past ENSO-like variability using a variety of geochemical proxies. The UK37' and TEX86 indices for sea-surface temperature are combined with accumulation rates of chlorins, alkenones and diatom-specific sterols, alongside opal and organic carbon contents, to investigate the intensity of the upwelling system. We show that the transition from the LGM to the Holocene is marked by a slight warming ($\sim$2°C) and a reduction in the amplitude of millennial-scale SST variability (from $\sim$5°C to $\sim$3°C). Absolute SSTs differ between the UK37' and TEX86 proxies, reflecting production by different source organisms in different seasons and/or water depths. Alkenone and chlorin concentrations detail highly variable coccolithophore and total primary production, but suggest reduced productivity and a weakened upwelling system during the Younger Dryas event that punctuates the transition. Terrigenous inputs (e.g. n-alkanes) are dominated by aeolian sources, given very low (<0.1) BIT index values that are most likely derived from fluvial sources. Both the concentrations and average chain lengths of the n-alkanes indicate weaker wind systems and/or cool conditions during the Younger Dryas. Thus, whilst SSTs reveal a smooth transition from the glacial to interglacial, events during the transition itself appear more significant for marine production and conditions onshore.