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ENSO variability and tropical Pacific mean-state changes in glacial climates

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The El Niño-Southern Oscillation (ENSO) phenomenon and ENSO-related global climate anomalies provide a challenge for a more thorough understanding of ENSO dynamics. Much progress has been made during recent decades in this respect. The picture is less clear, however, for different background climatic states. For instance, the nature of the ENSO response to modified boundary conditions, such as during paleoclimatic episodes, has not been clarified in detail, both from a modelling point of view and from paleo data evidence. Here we use the comprehensive Community Climate System Model (version 3) to investigate changes in ENSO variability for selected time intervals of the last glacial period. Our study focusses on the Last Glacial Maximum (centered on 21 ka BP) and Marine Isotope Stage 3 (centered on 35 ka BP). Glacial boundary conditions and freshwater hosing at high latitudes of the North Atlantic are imposed to mimic Heinrich Stadial 1 and Dansgaard-Oeschger stadials and interstadials.

Our simulations suggest that glacial ENSO variability in the eastern tropical Pacific is enhanced by about 57 % in response to a slowdown of the Atlantic Meridional Overturning Circulation by 63 %. We relate these changes in ENSO variability to glacial changes in the tropical Pacific mean state identified from (sub-)surface meridional and zonal asymmetries of the tropical Pacific ocean. In contrast to idealized modelling studies, an overall deepening of the tropical Pacific thermocline by a few meters is found in the experiment with enhanced ENSO variability. Furthermore, it is demonstrated that the enhancement of ENSO variability appears to be associated with a weakening of the annual cycle of sea surface temperature in the eastern tropical Pacific.