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Detecting changes in marine responses to ENSO from 850-2100 CE: insights from the ocean carbon cycle

Kathrin Keller (1), Fortunat Joos (1), Flavio Lehner (1,2), and Christoph C. Raible (1)

(1) Climate and Environmental Physics, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland, (2) now at National Center for Atmospheric Research, Boulder, USA

El Niño–Southern Oscillation (ENSO) is the most important mode of natural variability in the climate system on global scales. It is open whether ENSO varies under climate change, and how potential changes are best detectable. We investigate ENSO and its influence on biogeochemical tracers, pH, productivity, and ocean temperature utilizing a continuous 850-2100 CE simulation with the Community Earth System Model. ENSO is represented by the Niño3.4 index, i.e., the spatial average of SST anomalies in the equatorial Pacific (5 °S-5 °N, 170-120 °W). The response of variables is investigated by applying composite analysis, thereby accounting for nonlinearity of positive and negative phases of ENSO. The modeled variance in ENSO amplitude is significantly higher during the Maunder Minimum cold than during the 21^{st} century warm period. ENSO-driven anomalies in global air-sea CO_2 flux and marine productivity are two to three times lower and ocean tracer anomalies are generally weaker in the 21^{st} century. Significant changes are detectable in both surface and subsurface waters and are earlier verifiable and more widespread for carbon cycle tracers than for temperature. The results suggest that multi-tracer data of both physical and biogeochemical variables might allow an earlier detection of potential changes in ENSO characteristics than physics-only approaches. This in turn could benefit the planning and cost-efficient implementation of adaptation and mitigation measures.