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Radiative forcing of El Niño-Southern Oscillation over the Holocene : a model perspective

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Using a model of intermediate complexity, we simulate the response of the El Niño-Southerm Oscillation system (ENSO) over the last ˜10, 000 years of the Earth's history (the Holocene). Solar forcing is reconstructed from radiocarbon production rate data (Bond et al, 2001), using various scaling factors to account for the conflicting estimates of solar irradiance variability since the Maunder Minimum (1645 to 1715 AD) as reviewed in Frölich and Lean (2004). As estimates of the difference range from 0.05 % to 0.5 % of the solar "constant" , we consider these two extreme cases, along with the intermediate case of 0.2%, corresponding to peak-to-peak differences of, respectively, 0.17, 0.68 and 1.7 Wm? 2, in terms of surface insolation. We show that for a large forcing (the 0.5% case), the 40-year low-passed filtered east-west SST gradient along the equator responds remarkably linearly to irradiance forcing, with a phase lag less than a year. In contrast, the 0.05%-case shows no significant variability above that inherent to the model's chaotic behavior. Wavelet analysis suggest a statistically-significant enhancement of the century-to-millenial scale ENSO variability for moderate-to-strong irradiance forcing, but not in the weak forcing case. Orbitally-driven insolation forcing is found to temperate the large excursions in solar irradiance in the early Holocene. Finally, variations associated with the eleven-year solar cycle are found too short-lived to generate any low-frequency variability in the model, despite their relatively large amplitude. Given the central importance of ENSO in the climate system, the results suggest a potentially significant role for long-term solar irradiance variability as a driver of natural climate change.