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Detecting seasonal signals in Holocene sea surface temperature trends by satellite-model-proxy integration

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Past sea surface temperatures (SSTs) are routinely estimated from organic and inorganic remains of fossil phytoplankton or zooplankton organisms, recovered from sea floor sediments. These paleo proxies are usually interpreted to represent annual mean climate conditions, although potential seasonal biases have often been acknowledged, for example when systematic deviations among different types of proxies occur. However, such discrepancies are unresolvable from the data perspective, alone. In the present study we combine Holocene SST trends from the two most commonly used paleo proxies for SST, Uk'37 and Mg/Ca ratios, with results from idealized state-of-the-art climate model simulations forced by changes in the orbital configuration, which represent the major climate driver over the last 10 kyrs. Such changes cause a spatio-temporal redistribution of incoming solar radiation resulting in a modulation of amplitude and phasing of the seasonal cycle. The climate signal received by a plankton-based paleo proxy will be influenced by the non-linear response of the dynamic systems (1) atmosphere and (2) ocean, as well as (3) the seasonal productivity cycle of the respective proxy organism. While the sensitivity to factors (1) and (2) is covered by the climate model, we use the modern relationship between SST and marine net primary production (NPP), both obtained from satellite observations, as independent constraint to link modeled SST trends with proxy data. Our results demonstrate that temperatures recorded by Uk'37 are preferentially recording the warm (cold) season in high (low) latitudes, rather than annual mean. Based on our findings, multi-proxy approaches can actually go beyond the reconstruction of average climate trends, specifically allowing to resolve the evolution of internal climate variability, such as seasonality.