The early Eocene equable climate problem: Exaggerated by a proxy calibration bias?

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Characterized by elevated surface temperatures and atmospheric CO_2, the early Eocene epoch is regarded as a potential analog for future warm climates. A long-standing conundrum in our understanding of the early Eocene climate is its flatter-than-present latitudinal surface temperature gradient reconstructed from geological proxies. This feature has been challenging to reproduce in model simulations, especially the subtropical warmth inferred for both poles using the archaeal lipid-based TEX_{86} paleothermometer. Although widely applied across realms and time-scales, this proxy is associated with uncertainty in the water depth origin of the lipids, which is difficult to constrain via the spatial proxy-temperature relationship in globally distributed marine surface sediments due to the strong correlation of seawater temperatures at different depths in the water column. Here we take an alternative approach to constrain this uncertainty, by comparing temperature variability inferred from multiple proxies over a broad range of time-scales, spanning millennial to multi-million years. Our analysis shows that TEX_{86} systematically overestimates the magnitude of temperature variability across all time-scales. The most parsimonious explanation is that the calibration is fundamentally biased, likely as the archaeal temperature signals originate from greater water depths. Using the independent estimate of past temperature variability, we constrain the range of possible recording depths of TEX_{86}. Our reinterpretation of TEX_{86} reconciles the proxy-model mismatch in early Eocene without having to force the Eocene simulation with an unrealistic CO_2 level or to invoke missing physics in the climate models. Further, this finding has implications for the large body of TEX_{86}-based reconstructions, especially those of past warm climates, which rely heavily on this proxy.