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Going subsurface: Reconciling proxy and model estimates of early Eocene marine temperatures

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The early Eocene (50-55 million years ago) is a time interval characterized by elevated surface temperatures and atmospheric CO_2, and a flatter than-present latitudinal surface temperature gradient. The multi-proxy derived flat temperature gradient has been a challenging feature to reproduce in model simulations, especially the subtropical warmth inferred from the archaeal lipid-based palaeothermometry, namely TEX86H, for both poles. Although widely applied on marine and lacustrine sediments, archaeal lipid paleothermometry is not without uncertainties, especially in the water depth origin of the lipids. Here we take an alternative approach to constrain this uncertainty, by comparing the temperature variability inferred from multiple proxies over a broad range of time-scales (millennial to multi-million years). Our analysis shows that the widely used TEX86H overestimates the amplitude of past temperature changes and suggests that the archaeal temperature signals originate from greater depths. A recalibration of the TEX86H thermometry, using the independent estimates of past temperature variability as a constraint, strongly improves the model-proxy comparison of Eocene warming at water depths corresponding to the calibration. This finding implies that the subtropical Eocene warmth inferred from TEX86H for both poles, which is not reproducible in climate models, are likely an artefact due to the fundamental bias in the applied calibration. This study emphasizes that learning from model-data comparisons needs an in-depth understanding of the proxy as well as the model uncertainty.