Supplementary Material: Bayesian multi-proxy reconstruction of early Eocene latitudinal temperature gradients

—

Kilian Eichenseer[1] and Lewis A. Jones[2]

—

[1]Department of Earth Sciences, Durham University, South Road, DH1 3LE, Durham, United Kingdom

[2]Centro de Investigación Mariña, Grupo de Ecoloxía Animal, Departamento de Ecoloxía e Bioloxía Animal, Universidade de Vigo, 36310 Vigo, Spain.

—

Corresponding author: kilian.eichenseer@durham.ac.uk

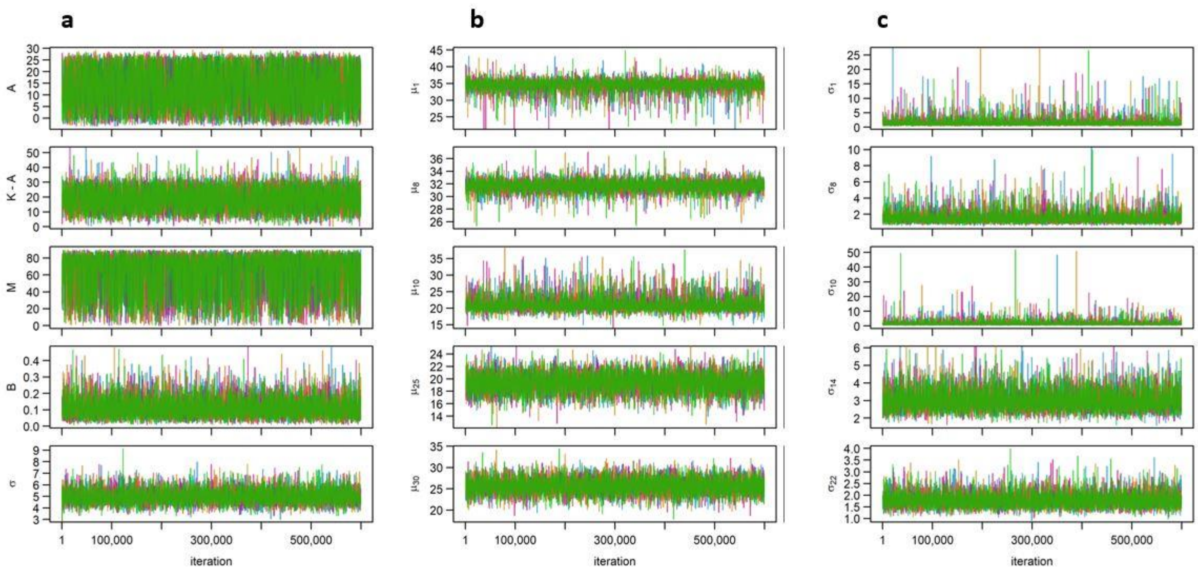

Figure S1: Traceplots of a subset of the unknown model parameters. The four colours correspond to the four independent model runs. a) Traceplot of A, K-A, M, B and σ; b) Traceplot of five selected μ_j; c) Traceplot of five selected σ_j. All traceplots display mixing of the chains, and relatively quick convergence.

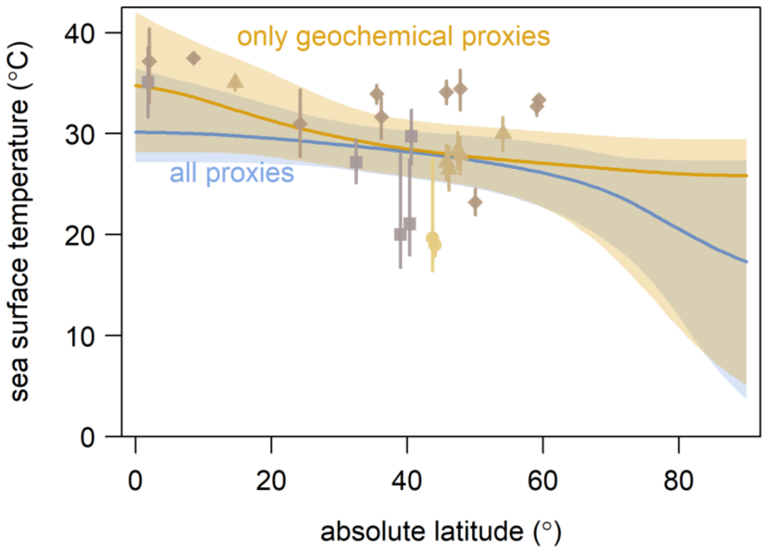

Figure S2: Estimated latitudinal temperature gradient using only the geochemical proxy data (yellow), showing the median (line) and 95% credible interval (shading). Symbols with vertical lines show the median and 95% credible intervals of the location mean temperatures μ_j. The blue line and shading in the background show the latitudinal temperature gradient with the geochemical and ecological proxy data, as in Figure 4.

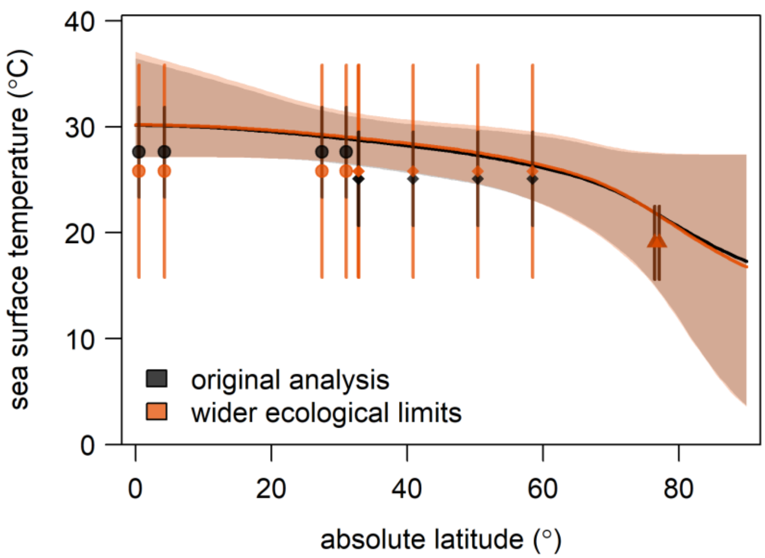

Figure S3: Estimated latitudinal temperature gradient using only wider ecological limits for the coral data and for the *Avicennia*-Rhizophoraceae mangrove assemblage (orange), showing the median (line) and 95% credible interval (shading). The ecological limits were expanded to include 95% of the probability density in the interval of 16.0 to 35.6°C, using the minimal monthly temperature experienced by coral reefs (Kleypas et al., 1999), and a modelled maximum derived by Jones et al. (2022). Symbols with vertical lines show the mean and 95% interquantile range of the ecological proxy probability distributions. The black line and shading in the background show the latitudinal temperature gradient with the narrower ecological limits, as in Figure 4.

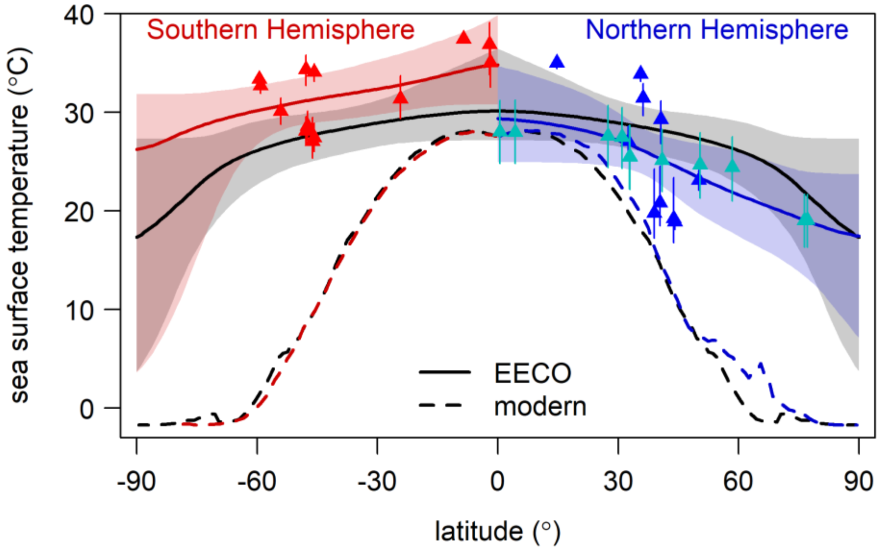

Figure S4: Estimated latitudinal temperature gradients for each hemisphere, showing the medians (lines) and 95% credible intervals (shadings) in the Southern (red) and Northern Hemisphere (blue). Symbols with vertical lines show the median and 95% credible intervals of the location mean temperatures μ_j. Turquoise symbols in the Northern Hemisphere highlight the ecological proxy data. The grey line and shading in the background show the latitudinal temperature gradient with the data from both hemispheres combined, plotted in both hemispheres. The dotted lines show the empirical, modern gradient, averaged across bins of 1°, for both hemispheres combined (black), and for the Northern hemisphere (blue) and Southern hemisphere (red), separately.

EECO gradient with uncertainty on proxy observations

Most of the geochemical proxy data used in the EECO analysis (300 of 308) come with uncertainties around their temperature estimates. Due to their negligible influence on the model results, we have not included them in the main analysis, but we show a comparison between the main EECO model output (see Fig. 4) and an the results of an expanded model, including uncertainties, below.

Specifically, we took the 95 or 90% confidence intervals of the temperature estimates to calculate the standard deviation representative of this uncertainty ($t_{\sigma,i,j}$), which we used for the analysis. Instead of using fixed mean proxy temperature observations $t_{i,j}$ directly in Equation 3, we let $t_{i,j}$ be the function of a normal distribution with mean $t_{\mu,i,j}$ and standard deviation $t_{\sigma,i,j}$, where $t_{\mu,i,j}$ and $t_{\sigma,i,j}$ are provided by the proxy data set:

$$t_{\mu,i,j} \sim N(t_{i,j}, t_{\sigma,i,j}), \quad i = 1, \dots, m, \quad j = 1, \dots, n, \qquad (1)$$

where m is the number of observations at each location, and n denotes the number of locations.

The resulting gradient estimated with this expanded model is very similar to that estimated with the original model (Fig. S5). The uncertainty around the proxy temperatures allows the estimated location mean temperatures to be drawn closer to the gradient line, resulting in a slightly lower median residual standard deviation (4.7 as opposed to 4.9 in the original model).

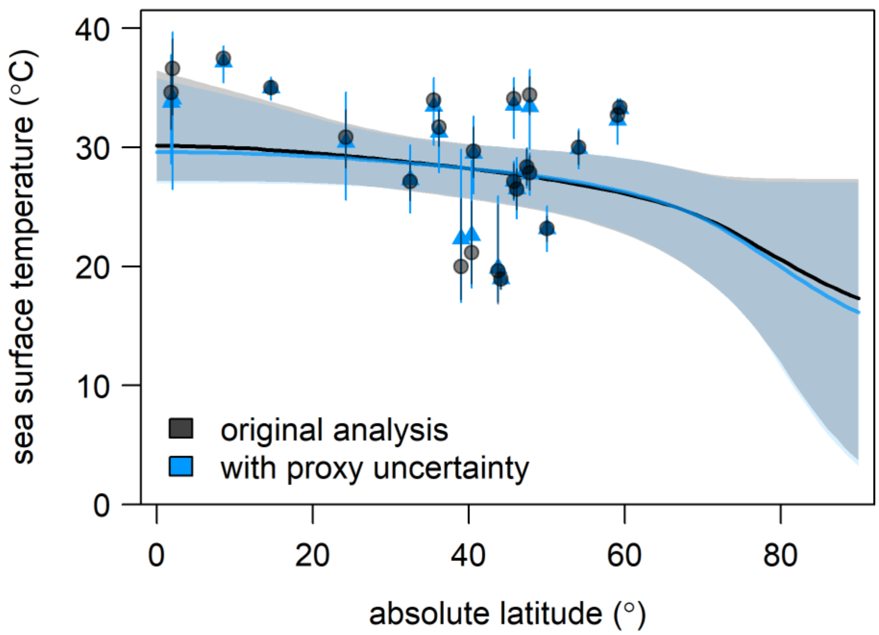

Figure S5: Estimated latitudinal temperature gradient with uncertainty on proxy observations (blue), compared to the original model result (black, as in Fig. 4). Gradients are depicted as medians (lines) and 95% credible intervals (shadings). Symbols with vertical lines show the median and 95% credible intervals of the location mean temperatures μ_j for the geochemical data, with (blue) and without (black)including uncertainty.

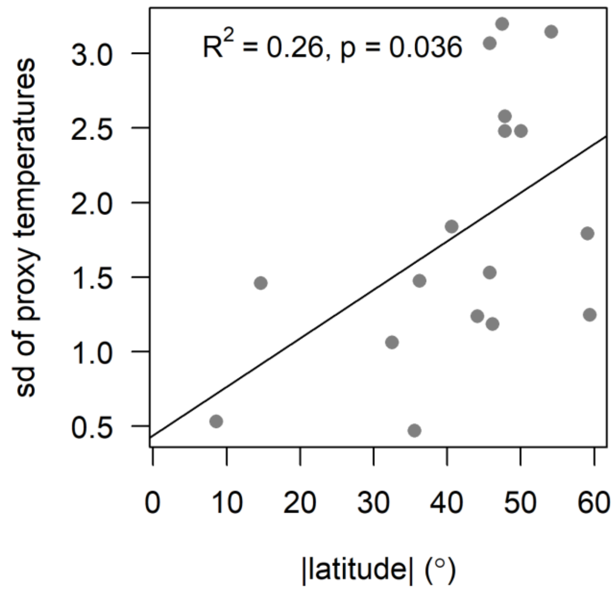

Figure S6: Standard deviation of temperature estimates from individual localities of the EECO geochemical proxy data from Hollis et al. (2019) with more than one sample, against the absolute latitude of the locality (n = 17). The line shows a linear regression, suggesting a moderate effect of absolute latitude on proxy data variability, with mid- and high-latitude data being more variable than low-latitude data.