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| Durham University – Logos Download | Dr Kilian Eichenseer  Department of Earth Sciences  Durham University  South Road, DH1 3LE, Durham, UK  Email: [kilian.eichenseer@durham.ac.uk](mailto:kilian.eichenseer@durham.ac.uk) |

**01 June 2023**

Dear Editors,

Please consider our manuscript “Bayesian multi-proxy reconstruction of early Eocene latitudinal temperature gradients” by Kilian Eichenseer and Lewis A. Jones for publication as a research article in *Climate of the Past*.

Accurately reconstructing Earth’s deep climatic past on a global scale has been a major goal of geological research for many decades. Despite great improvements in the quality, quantity and accessibility of palaeoclimate proxy data, proxy-based palaeoclimate reconstructions are still commonly created in ways that invite biases and error.

We introduce a novel, Bayesian method that directly models the full equatorial-polar thermal gradient from sparse geological and ecological proxy data. The structure of our model ensures unbiased estimation of latitudinal temperature gradients even if the sampling of the underlying data is spatially biased and incomplete. By placing informative priors on key model parameters, we are able to include physical constraints and other prior knowledge, ensuring realistic estimates already at very low sample sizes. Ultimately, this model allows for the elimination of spatial and sampling bias in global temperature reconstructions.

As a case study, we apply this new method to the proxy record of the early Eocene climatic optimum, a time of particular relevance for assessing the potential climatic futures of Earth, in the face of climate change. Our modeling of the early Eocene sea surface temperature gradient reconciles the geochemical and ecological proxy record, and confirms a shallow thermal gradient that was more different from the modern climate than predicted by most earlier reconstructions.

This is, to our knowledge, the first Bayesian method developed to explicitly model the latitudinal temperature gradient, and the first fully quantitative study combining the early Eocene geochemical and ecological proxy records.

We believe that our manuscript is a perfect fit for *Climate of the Past*, being at the forefront of methodological advances in palaeoclimate research. Potential reviewers for this manuscript include:

[Jessica Tierney (University of Arizona)](https://www.geo.arizona.edu/~jesst/), email: jesst@arizona.edu

[Gordon N. Inglis (University of Southampton)](https://www.southampton.ac.uk/people/5y5nn7/doctor-gordon-inglis), email: gordon.inglis@soton.ac.uk

[Ethan L. Grossman (Texas A&M University)](https://envp.tamu.edu/people/profiles/faculty/grossmanethan.html), email: e-grossman@tamu.edu

Thank you for considering our manuscript. We hope that it meets the high standard expected for review at *Climate of the Past*.

Sincerely,

Dr Kilian Eichenseer (on behalf of all co-authors)