

Response to RC2 (Andrew Wickert)

We thank Andrew Wickert for his time and effort as a referee. We appreciate his thoroughness, comments and suggestions and think we were able to improve our manuscript by acting on those. In this communication, we highlight our responses in blue.

16, 21, etc. I think that there should be emdashes instead of hyphens between PI and MH, LGM, and PLIO

This has been corrected throughout the entire manuscript.

24. explained → described.

We use the term “explain” in a statistical sense, as is consistent with the language used to describe the results of the discriminant analysis. The LMD is an explanatory tool. However, we acknowledge that this may create some confusion in the abstract. We therefore now explicitly state in the abstract that this explanation is a statistical one.

48–49. Modern climate is not always assumed, though. As an example with which I am quite familiar, we (Wickert et al., 2019) actually used plausible river discharges based on glacial-stage conditions including ice-sheet melt and precipitation minus evapotranspiration (Wickert, 2016) to understand incision of the Mississippi River. I strongly agree that using the appropriate past climate is important! But I am wondering if “often have to be interpreted” is a bit too strong in general – from paleo-proxy data, we generally do know something about how climate varied. But perhaps what you mean to say is that there is not a globally-spanning resource to do this and ingest it into models, which could in fact be closer to your aim (?) and a stronger way to state this. p.2 and 3 overall: Consider ways to split this 1.5-page single paragraph – perhaps between background and what you do. (Even if it is supposed to be split at the list and I just don’t see it, the p. 2 single paragraph definitely could benefit from being broken up into its sub-topics.

We thank Andrew Wickert for this comment. Indeed, we could have been clearer in this regard. The advantages of GCM’s are (1) having a globally-spanning resource, and (2) a way to relate observations of palaeoclimate back to processes and drivers, since GCM’s are based on our physical understanding of the climate system, (3) they are a tool suitable for sensitivity experiments, (4) they complement proxy-based reconstructions with regional averages and additional climate variables to offer a more complete picture of climate. We agree that our original phrasing is a little strong. We adjusted this and offer a clearer motivation for using GCM’s for these purposes. Additionally, we split the paragraph into three parts: (1) General motivation for the work and using GCM output, (2) previous palaeoclimate modelling work, and (3) what we do here. (L54-64)

79. “lies on” seems awkward to me. Why not, “We focus on 4 regions...”
Many thanks for the suggestion. We changed this in our text.

93, 95. Earth-surface here is a compound noun, and so should be hyphenated.
This has been corrected.

It also seems that 93-95 is an accidental self-standing one-sentence paragraph
This has been corrected.

99. surface-process-relevant (compound noun)
This has been corrected.

112. Consider updating the PMIP reference, as new PMIP projects have run since 2012 – we are now on PMIP4! The following reference is an experiment overview. But in addition to just citing, I think that their science and model outputs could be quite useful to you and your future work. Kageyama, M., Braconnot, P., Harrison, S. P., Haywood, A. M., Jungclaus, J. H., Otto-Bliesner, B. L., ... Zhou, T. (2018). The PMIP4 contribution to CMIP6 – Part 1: Overview

and over-arching analysis plan. *Geoscientific Model Development*, 11(3), 1033–1057.
<https://doi.org/10.5194/gmd-11-1033-2018>

We updated the reference in the text, but still included the Bracannot reference since our simulations were based on simulations and protocols from the third phase. We agree that PMIP4 will be very relevant to us and certainly plan to take advantage of PMIP4 in future work.

119. Consider starting a new paragraph at “Mutz”

We agree that this gives the text more structure and followed the suggestion.

142. “of interest to the Earth surface”: rephrase. I know what you mean, but Earth’s surface doesn’t have the mental capacity for interests.

We added a hyphen to clarify that we speak of the Earth-surface communities (and palaeoaltimetry communities).

143. communities (plural)

This has been corrected.

144-145. hyphens to emdashes (indicating range)

This has been corrected.

163-170. In your place, I would have added evapotranspiration (or P-ET) to this list, as the sum of latter across watershed is what should control river discharge. Could you explain your decision not to include this?

We refrained from using several potentially relevant variables due to their poor representation in GCM’s on the scale we are working on. GCM’s don’t represent the regional hydrology well due to the parameterisations in their land surface schemes. Routing GCM’s through more sophisticated hydrological models or regional climate models would allow the inclusion of such variables. We changed the text to be clearer about our choice of variables (in “Data and Methods”), and added those limitations (and suggestions) to the “Comments on methodical implications” section.

175. New paragraph at “clustering”.

This has been corrected.

178-180. I think that the writing would be clearer if you focus on this criterion before the preceding sentence, in which you give the appropriate values. So, methods ! results.

We re-arranged these sentences, so that the order of information makes more sense.

203. I’m a bit confused here by the mention of the number of cluster members. I had thought that the clusters themselves were not yet defined. Or by this, do you mean “grid boxes”? Or “groups selected and then tested”?

We thank Andrew Wickert for pointing out the confusing nature of this sentence. As summed up in Fig. 1, we carry out the clustering (and find the optimal cluster number k) before we conduct the LMD. However, we refer here to the number of cluster members, i.e. the number of elements or grid boxes in each cluster. We realise now that we have not used the term “cluster members” before and replaced it by “elements in each cluster” to avoid any such confusion.

Equation 4 seems unnecessary – perhaps you can just write that you maximized.

We acknowledge the redundancy and overlap between equation 3 and 4. However, we think equation 4 nicely summarises the whole problem in a way that you also may find it summarised in text books, thus making it easier to recognise the same thing again when reading up on LMD. We therefore decided to leave out equation 3 and keep equation 4 (now 3).

Equation 6 seems strange for multiple reasons. But now I realize that what looks like strange matrix multiplication is actually really several separate matrices. Please also ensure that you have reasonable formats, including consistent positioning and orientation of ellipses, brackets that look like brackets

long brackets (this is more for typesetting, but these look like you just stretched short brackets, thus ending up with long knobs on the ends), etc. The latter comments are for style, but the former are for content.

6 (now 5 in the revised manuscript) merely expands and explains the terms of the previous equation, which is a common notation to shorten the notation for multiple regressions (cf. next comment response). It may not be necessary to include this to expand on what is already stated before, but we hope that this will look more familiar to some of the readers. We reworked the formatting.

224. Could you describe your solution technique in more detail? I do not understand why you needed to partially differentiate the equation (or with respect to what) in order to solve it.

It would involve partial differentiation with respect to discriminant coefficients, which can be seen as regression coefficients if we think of it as a multiple regression for the elements on the discrimination axis. We clarified this and inserted a reference for more details, since this is a well-established method.

224. Could you explain mathematically what you mean by “standardized”? This is the point at which I no longer have enough information to understand or reproduce your approach. In addition, I quite dislike two-letter variables: it is then quite difficult to know if they represent two variables that should be multiplied together, or a single variable.

We thank Andrew Wickert for these comments. We use the term “standardised” in a statistical sense, i.e. we put the value in relation to the standard deviation of the respective variable. We clarified this. We agree that using two-letter variables can lead to confusion. We changed the variable names to one-letter variables and updated them throughout the manuscript and on our figures.

253. Please read this paragraph and split it at the point at which “Erosion rates...” is no longer a good topic sentence. I suggest at, “The anomaly cluster”.

We agree that this gives the text more structure and followed the suggestion.

262-263. The “Late Pliocene” sentence seems a bit unnecessary – if you want to add an example, consider using something with a reference to demonstrate that this would be the case.

We decided to remove this sentence as it is somewhat distracting and unnecessary.

316. Argentina, AND THE central and...

This has been corrected.

364. endashes

This has been corrected.

364. “decreases in 2m air temperature AND freeze-thaw days, and”: separate decreases and increases. In general, I suggest that you use the Oxford comma; it can disambiguate your complex lists.

We appreciate the suggestion and made changes accordingly.

366. These cells are covered by more than just the Scandinavian ice sheet.

We updated the text to make sure we include the British Ice Sheet.

399. PLIO!MH?

Yes, this should read “MH”. We corrected it.

423. incl. The!including the

This has been corrected.

424. temperature, and WITH (required to split lists)

This has been corrected.

458-459. large-scale
This has been corrected.

462. and→as well as to (required to split lists)
This has been corrected.

490-494. Consider noting something about changes in evapotranspiration vs. changes in erosion rate due to the physical presence of vegetation (e.g., roots)
We have included a note on vegetation's modification of the hydrological cycle, and modifying hillslope stability by changing root characteristics.

525. erosion-relevant
This has been corrected.

525. By “high” do you mean small spatial, short temporal, both, neither?
We mean both and clarify this now in the text.

Data availability: I suggest that you obtain a DOI for your model outputs.
As we understand, it is not possible to obtain a doi for self-hosted data, and the size of the original model output is currently still too large for hosting services.