

Response to the Editors (O. Peyron) comments:

Many thanks to the editor for taking the time to go through so thoroughly what is now quite a long and involved paper. It is again much improved following her suggestions and comments. Almost all of the 29 changes suggested have been made to the manuscript, with only 19 and 20 being declined for the reasons outlined below.

1. Abstract, line 28 “The reconstructions are based on the modern analogue technique (MAT) with a modern calibration pollen dataset taken from the latest Eurasian Modern Pollen Database (~8000 samples).” **You don’t use the standard MAT (Guiot et al papers) as the MAT is based on pollen counts; if you calculate a dissimilarity index not on raw counts but on PFTs scores as you did in Davis et al 2003, you need to clarify it. I suggest “ The reconstructions are based on the modern analogue technique (MAT) adapted with PFT scores...”**.

Response: Ok

Action: Text changed to “*The reconstructions are based on the modern analogue technique (MAT) adapted using PFT scores, and with a modern pollen dataset taken from the latest Eurasian Modern Pollen Database (~8000 samples).*”

2. - Abstract, lines 36-37 “Differences between our latest MAT reconstruction and those in earlier studies can be largely attributed to bias in the small modern calibration dataset previously used”. **I agree but differences can also be explained by the method itself (see Brewer et al 2008 or Salonen et al 2019 for multi-method approaches). I suggest “... to bias in the small modern calibration dataset previously used and also to the method itself (Brewer et al 2008, Salonen et al 2019)”**.

Response: Ok

Action: Text changed to: “*Differences between our latest MAT reconstruction and those in earlier studies can be largely attributed to bias in the small modern calibration dataset previously used, and differences in the method itself (Brewer et al. 2008, Salonen et al. 2019).*”

3. - Introduction, line 70, **a key reference is missing, please add it. Braconnot, P., Harrison, S.P., Kageyama, M., Bartlein, P.J., Masson-Delmotte, V., Abe-Ouchi, A., Otto-Bliesner, B., and Zhao, Y.: Evaluation of climate models using palaeoclimatic data, Nat. Clim. Change, 2, 417–424, <https://doi.org/10.1038/nclimate1456>, 2012.**

Response: Ok

Action: Braconnot et al has been added

4 - Introduction, line 88 “through the use of a correction algorithm (Prentice et al. 2017)” **Here, the recent papers by Cleator et al 2020 is missing, please add it.**

Response: Ok

Action: Cleator et al 2020 has been added

5 - Introduction, line 91 “Pollen-climate reconstructions based on inverse modelling that account for these low CO2 effects show less cooling and drying and consequently greater agreement with climate models (Ramstein et al., 2007; Wu et al., 2007).” **Key recent papers using the INV for the LGM are missing, please add it.**

- Izumi and Bartlein, 2016: North American paleoclimate reconstructions for the Last Glacial Maximum using an inverse modeling through iterative forward modeling approach applied to pollen data, <https://doi.org/10.1002/2016GL070152>

- Wu et al 2019. Quantitative climatic reconstruction of the Last Glacial Maximum in China. *Sci. China Earth Sci.* 62, 1269–1278 (2019). <https://doi.org/10.1007/s11430-018-9338-3>

Response: Ok

Action: Izumi & Bartlein 2016 & Wu et al 2019 have been added

6 - Introduction, line 161 “In addition, ... using the Modern Analogue Technique (MAT)...” and Methods lines 277-279 “We reconstructed climate from pollen data based on a standard Modern Analogue Technique (MAT) that used PFT scores to match fossil samples with modern pollen samples (as used by Davis et al., 2003).” **same as in the abstract: you don’t use the standard version of the MAT, so avoid the term standard and replace it by “a modified version of the standard MAT (Guiot et al 1989)...”**

Response: Ok

Action: The text has been changed at the two places identified “*In addition, quantitative reconstructions of forest cover as well as winter, summer and annual temperatures and precipitation were undertaken using a modified version of the standard Modern Analogue Technique (MAT) (Guiot et al. 1989), “ and also “We reconstructed climate from pollen data based on a modified Modern Analogue Technique (MAT) (Guiot et al. 1989).*”

7 - Methods 2.6 Marine pollen records: **thanks so much for this new part! You provide very interesting new results which have never been discussed before. I just suggest to put it in 2.4 before the part on the vegetation cover**

Response: Ok

Action: Section 2.6 has been moved to 2.4

8 - Results line 576 ***Pinus* in italic**

Response: Ok

Action: *Pinus* has been italicized

9 - Results line 607-610 “comparisons between studies can only be made with caution because results are often heavily dependent on the nature of the modern pollen dataset used as the training set, which is not the same in all studies (Juggins, 2013).” **I agree with you; the choice of the method is also very important, so I suggest to add “and results also largely depend on the method used (Salonen et al., 2019; Brewer et al., 2008; Peyron et al., 2013)”**

Response: Ok

Action: the references and text has been added: “*..can only be made with caution because results are often heavily dependent on the nature of the modern pollen dataset used as the training set (Juggins, 2013), as well as the method used (Salonen et al. 2019, Brewer et al. 2008, Peyron et al., 2013).*”

10 - Discussion line 690 : **tundra not Tundra** , and line 821 **boreal not Boreal**

Response: OK

Action: Tundra has been changed to tundra, Boreal to boreal

11 - Discussion line 835: (see figure 6 in Velasquez et al., 2021); **just cite the ref Velasquez et al., 2021);**

Response: OK

Action: ‘see figure 6’ has been removed

12 - Discussion line 848: (Kageyama et al., 2021, Bartlein et al., 2011; Harrison et al., 2015; Kageyama et al., 2006). **References are missing : Braconnot et al 2007 ; Braconnot et al 2012, Cleator et al 2020**

Response: OK

Action: The references have been added

13 - Discussion line 855: « but instead uses a process-based vegetation model run in inverse mode.” **The ref Guiot et al 2000 is missing, please add it**

Response: OK

Action: Guiot et al 2000 has been added

14 - Discussion line 857 : « but in inverse mode the model is reconfigured to generate climate as an output given a particular vegetation (pollen) assemblage as an input.” **not true: in the inverse modelling developed by Guiot and updated by Wu et al, 2007, 2019 input data are climate data (and CO2) and output data are PFTs scores simulated by the vegetation model; these PFTs scores are compared to the pollen-inferred PFT scores following an iterative process: the climate value is selected as the most probable (when the error between the simulated and pollen-based PFTs score is the lowest). Please correct**

Response: OK

Action: The text has been changed accordingly: “..but in inverse mode the model is reconfigured so that the input climate (and CO2) can be varied iteratively until the closest match is found between the vegetation simulated by the model (represented by PFT scores) and the fossil pollen assemblage (also represented by PFT scores).”

15 - Discussion line 981 : **Lago della Costa just after in the text, please check**

Response: OK

Action: Text has been changed

16 - Discussion line 1011 : “A number of additional proxies have also been used to reconstruct LGM mean annual temperature”. **a recent ref is missing for your comparison: Last glacial maximum cooling of 9 °C in continental Europe from a 40 kyr-long noble gas paleothermometry record Bekaert, D.V .et al 2023 Quaternary Science Reviews, 310, 108123**

Response: OK

Action: The reference has been added as well as the following text: *“Mean annual temperatures have also been reconstructed from the Paris basin area in Eastern France by Bekaert et al. (2023) using the Noble gas proxy. The authors suggest an LGM temperature anomaly of -9.1 ± 0.9 °C although this is actually dated to 25.6 ± 0.5 k, which is earlier than our 21 ± 2.0 k time window that we adopt here. The sample closest to 21k is at 21.9 ± 0.5 k and suggests slightly warmer temperatures at -7.77 °C, which compares well with our pollen reconstructions nearby at [Bergsee site #29] -8.2 ± 3.3 °C and [La Grotte Walou site #28] -6.6 ± 3.1 °C.”*

17 - Discussion line 1014 : **correct to the Vosges Mountains**

Response: OK

Action: Corrected

18 - Discussion line 1027 : “This compares with -7.2 C for our 63 pollen 1028 sites.”: **not sure to understand which is compared**

Response: OK

Action: Text has been changed from *“This compares with -7.2 °C for our 63 pollen sites.”* to *“These average anomalies across all sites calculated by Allen et al (2008a) compare with an average temperature anomaly of -7.2 °C across all 63 of our pollen sites.”*

19 - Discussion line 1046: “Further south and west...” **A reference is missing for your comparison : Rodrigo-Gamiz et al 2022 : Padul new record, lipids biomarkers, temperature close to the current ones.**

Response: This reference was also suggested earlier in the review process by one of the reviewers. This was our response: “We are reluctant to include this study by Rodrigo-Gámiz et al. 2022 because this record looks quite odd. In particular, it appears warmer than the present day for much of the glacial period and has a long-term trend very similar to pH. This is important because the brGDDT proxy has been criticised for being influenced by pH as well as temperature, although this potential

bias does not appear to be mentioned in the paper. We do not think that excluding the study would make any significant difference to the conclusions of the paper.”

Action: None

20 - Discussion line 1085: “Few proxies apart from pollen provide quantitative reconstructions of precipitation during the LGM.” **A comparison with the paper by García-Alix et al 2021 is missing García-Alix et al 2021. Paleohydrological dynamics in the Western Mediterranean during the last glacial cycle, Global and Planetary Change, 202, 2021,103527, <https://doi.org/10.1016/j.gloplacha.2021.103527>.**

Response: This is an interesting paper, but it provides only qualitative estimates of precipitation change and is partly based on pollen data which also undermines it as an independent proxy. We deliberately didn't want to include qualitative reconstructions in the discussion (eg all the lake level studies) because it would make it too broad and the paper is long enough as it is.

Action: None

21 - Conclusion lines 1196 and 1200: **boreal not Boreal**; line 1221: **comparison not comparsons**

Response: OK

Action: Boreal has been changed to boreal. Comparsons has been changed to comparisons.

22 -Figure3: **in the figure correct arboreal pollen**

Response: OK

Action: The figure has been corrected

23 -Figure 5 and 7, **the name of the sites is too small, the title of each curve also, please correct it**

Response: OK

Action: The text in the figures has been increased from 16 point to 18 point

24 - figure A3: **this figure`s panels are included separately with their own captions. This will be unacceptable in the final paper**

Response: OK

Action: Figures A3a-A3-f have been relabelled A3-A8.