Response to review from Maria Fernanda Sanchez Goñi

This manuscript provides a continuous record from 60 ka to the present of brGDGT temperature reconstruction for the Eifel region (Central Europe). This record is relevant and deserves to be published in Climate of the Past. So far, there is a lack of regional quantitative climate reconstructions for the last glacial period in Central Europe and very few for other European regions. However, before accepting this manuscript for publication, the authors should address some chronological issues and discuss the ELSA record in more detail, taking into account the other quantitative climate reconstructions for Europe. I am not an expert in geochemistry and my review is mainly focused on section 3 of the manuscript "Results and discussion".

We appreciate the constructive comments, and our responses and planned edits are in red below.

Lines 35-40 and lines 450-453: In the Introduction and in Section 3.4, it would be relevant to cite the papers that, based on pollen analysis of deep-sea sediment sequences, have detected for the first time, without chronological ambiguity, the European millennial scale climatic variability in response to the D-O warming and cooling events, including the Heinrich events (e.g. Sanchez Goñi et al. 2000, 2008). The only works cited in the manuscript are the terrestrial pollen records and speleothem sequences, which, even if relatively well dated, cannot be directly compared with the North Atlantic millennial-scale climate variability.

I agree the mentioned papers are important to cite as they established a definitive link between European terrestrial environment changes and N. Atlantic millennial-scale events.

Figure 7: How is it possible to have 50%-100% of tree pollen in the 60-30 ka interval? These values are found during interglacial periods, as shown during the Holocene of the same sequence.

The pollen data are published in Sirocko et al. (2022) and the chronology is well described in Sirocko et al. (2021). At this site, evidence suggests that MIS 3 climate was relatively mild, allowing for the growth of temperate forests from 58-48 kyr BP. After 41 kyr BP pollen suggest a steppe or woodland-steppe environment. The temperate forest in early MIS 3 fits with our GDGT data which suggest that early MIS 3 growing season temperatures were not significantly different from present day. It is always possible that tree pollen data are somewhat inflated due to long distance transport of pollen.

Lines 394-401 in section 3.3 and lines 453-471 in section 3.4: I do not know to what extent the temperature of months above freezing (TMAF) in the Eifel region can be compared with the sea surface temperatures (SST) of the Iberian margin but if the authors do so, I think it is more appropriate to discuss the TMAF in the Eifel region in the light of the surface air temperatures estimated from the pollen records of the Iberian margin, the Alboran Sea (Sanchez Goñi et al., 2002) and the Gulf of Lyon (Sanchez Goñi et al., 2021), which cover the period 50-27 ka, i.e. HS 5 to HS 3 and the associated D-O cycles. Although the latter correspond to winter temperatures, the authors should compare their estimates of summer temperatures with them, especially in the light of the question of seasonality they discuss in Section 3.4, which is the main contribution of this work. For HS 5, pollen-based winter surface air temperatures show pronounced decreases, averaging 5-10°C relative to present, in southern Iberia and south-eastern France, consistent with the severe SST low in the eastern North Atlantic. HS 3 is also marked by cooling in southern Iberia, although less so than HS 5 and HS 4. Furthermore, why are HS 5 and HS 3 marked by warm summers in the Eifel region and HS 4 by cold summers? Are these seasonal changes linked, for example, to orbital parameters?Figure 10 should be implemented with the pollen-based surface air temperatures from western Europe.

This is a good point. We will incorporate discussion of the pollen-based temperature estimates.

Lines 409-422: The authors discuss the mean temperature of the 29-24 kyr b2k interval in the Eifel and compare it with other reconstructions for the LGM without defining their respective chronologies. This interval extends from 29 to 19 ka according to Hughes et al. (2022) but from 23 to 19 ka according to Mix et al. (2001, EPILOG). The problem is that the LGM according to Hughes et al. encompasses three D-O warming events (D-O 4, D-O 3 and D-O 2), HS 2 and the LGM defined by EPILOG. Do they compare the same period in the different reconstructions (Paris Basin and Auel Maar, "...considering the significant age uncertainty in the Auel Maar data", line 372, for example), the assimilation of global palaeoclimatic data and the output of the HadCM3 model? In terms of vegetation in north-western and southern Iberia, the HS and LGM are markedly different (Naughton et al., 2007; Fletcher et al., 2008; Turon et al., 2003), with more Ericaceae and less Amaranthaceae-Chenopodiaceae during the LGM compared with the HS that flank it, indicating drier and colder conditions during the HS, associated with greater seasonality.

In lines 409-422 and Figure 11 we compare maximum LGM cooling relative to present for several datasets. We aim to use the same time window for comparison based on the coldest period in the GDGT data (29-24 kyr BP). This interval was used to estimate the LGM temperature from the HADCM3 simulation. The Paris Basin noble gas data (Bekaert et al., 2023) shows a temperature minimum around 26 kyr BP (low-resolution data). The Tierney et al. (2020) data assimilation uses 23-19 kyr BP, so this dataset comes from a slightly different time period. However, it should be noted that the emphasis here is on comparing a sustained period of minimum temperatures, and the datasets we compare with do not resolve millennial-scale variability. We will edit the text to note the ages of the temperature estimates from (Bekaert et al., 2023; Tierney et al., 2020).

Lines 468-471 : It is interesting to add that the 17°C of warming of the coldest month between stadial and interstadial yielded by the LOVECLIM model simulations (Van Vermeerck et al., 2011) is higher compared to the pollen-based estimations of 10°C on average for SW and SE Iberia and 5°C for SE France.

Agreed that this particular climate model simulation yields a rather large stadial-interstadial amplitude.

The last part of section 3.4, devoted to the examination of changes in seasonality during the last glacial period, should be improved and strengthened by taking into account the pollen-based reconstructions of winter temperatures available for Western Europe.

Agreed, we will implement this suggestion and include mention of winter temperature reconstructions based on pollen, which strengthen the argument that stadial-interstadial changes were dominated by winter temperature changes.

Minor comments

Line 212 : Specify in the text the meaning of the abbreviation SM = Schalkenmehrener Maar

Line 214 : Replace Schalkenmehrener Maar with « SM »

Lines 245-247 : Rephrase. A dot is lacking after Figure 5b.

Line 391 : Replace « prescence » with « presence ».

Line 445 : the subject of the sentece is lacking.

All minor comments will be corrected in the revised manuscript

References

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We thank the reviewer for the suggestions, which will be implemented in a revised manuscript.

On behalf of all authors, Paul Zander

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