Review 2:

This study presents magnetostratigraphic results from the Büyükteflek section in the Balkanatolia Basin and reconstructs a quantitative paleotemperature record using carbonate clumped isotope (Δ47) thermometry. The results provide the first quantitative terrestrial record of late Eocene warming and indicate an approximately 7 °C decline in summer surface temperatures during the Eocene–Oligocene Glacial Maximum (EOGM). The manuscript also explores the potential influence of regional climate changes on terrestrial mammal evolution. Overall, this is an interesting and valuable contribution. However, several issues need to be addressed, particularly regarding the geochronological framework. My specific comments are outlined below.

1. Structure, Formatting, and Presentation. Some aspects of the manuscript structure and formatting require improvement. For example, Paragraph 1 would benefit from being split at the sentence:

“While the EOT and the EOGM are well documented in marine records, their impact on land remains poorly understood.” A new paragraph should begin here to introduce the discussion of terrestrial records, which would improve readability and reduce the density of information.

Done

In addition, minor typographical errors should be corrected (e.g., “Eastern Asiaby theParatethys” should read “Eastern Asia by the Paratethys”). A thorough proofreading of the manuscript is recommended to eliminate similar issues.

Finally, I suggest including one or two summary tables: One summarizing climate and biotic changes across the EOT in different regions; Another outlining the regional geological setting.

We tried to polish and fluidify the introduction. However, we do not think that adding these tables would be a great improvement. First, we only explore the link between one Eurasian biotic event (the Grande Coupure) and the EOT; adding details about other biotic events would take unnecessary space in an already long article. However, we added a table that synthesizes all other terrestrial paleotemperature records of the EOT, in order to fluidify the discussion of our data. This table has been added in the discussion.

Moreover, the regional geological setting includes multiple angles (tectonic and paleogeographic evolution of the region, sedimentation in the broad Cankiri Basin and in the area of study) and we do not see how this would fit in a table with columns and rows. Such a composite table would not be self-explanatory and would thus require a long text.

We thus think that leaving the geological context under text format is better, as made in most paleoclimatic studies.

These additions would improve clarity and accessibility for readers.

2. Figure Presentation. The paleomagnetic correlation scheme shown in Figure 7 could be merged with that in Figure 4 to streamline presentation and facilitate comparison. It would also be helpful to include data from Licht et al. (2022) for direct comparison, allowing readers to better evaluate similarities and discrepancies between studies.

This comment is similar to Reviewer 1's regarding the distinction between our data and that of Licht et al. (2022). The data points have now been clearly distinguished and specified in the figure legend.
Regarding the addition of the correlation to Figure 4, we chose to keep the figure in its current form to avoid making it overly complex and difficult to read, especially since Figure 4 also focuses on sedimentary facies.

Since the Δ47 analyses were conducted on pure calcite, the authors should present corresponding XRD data to verify sample purity.

Done, XRD patterns are now given as a new supplementary material. The patterns are already mentioned in the main text.

Additionally, several published EOT paleotemperature records are mentioned but not directly compared. These should be compiled into a single figure alongside the new data presented here, enabling readers to assess spatial variability in the EOT climate response on a broader, potentially global scale.

As mentioned previously, we have now added a synthetic table with all other terrestrial paleotemperature records of the EOT from geochemical proxies, to directly compare our data with previous studies. We tried to display these other studies in a single figure for comparison, but they all have different sampling resolutions, age range and uncertainties, making their display on a single figure very tricky. A table seemed easier to read.

Site/location	**Proxy**	**Age range (Ma)**	**T° change**	**References**
Ebro basin (Spain)	Mean annual temperature (MAT) estimated from the "clayeyness" ratio C = mAl/mSi of paleosol B horizons	35-33.2	No significant changes reported during the EOT	Sheldon et al. (2012)

	using the climofunction of Sheldon (2006): T(°C) = 46.9C + 4			
Isle of Wight (UK)	Mean annual temperature (MAT) estimated from the salinization ratio $S = (mK_2O + mNa_2O)/mAl_2O_3$ of paleosol Bt and Bw horizons using the climofunction of Sheldon et al. (2002): MAT (°C) = −18.5S + 17.3	33.2-35.4	MAT remains unchanged across the EOT	Sheldon et al. (2009)
Hampshire Basin (UK)	Clumped isotopes from freshwater gastropods shells	35-32.4	Decrease in MAT during the EOT of ~4-6°C	Hren et al. (2013)
Xining Basin (Tibet/China)	Clumped isotopes from carbonate-bearing mudstones	43-25	~20°C drop across the EOT. Interpreted as resulting from both a shift in the seasonality of carbonate formation and a decrease in surface temperatures, estimated at ~9°C.	Page et al. (2019)
Oregon (US)	MAT estimated using: MAT (°C) = −18.5S + 17.3 from Sheldon et al., 2002), where $S = (mK_2O + mNa_2O)/mAl_2O_3$.	37-29	Gradual cooling across the EOT: from ~15-18°C at ~36 Ma to ~8-10°C at ~27 Ma	Sheldon and Retallack (2004)
Eastern Wyoming (US)	Clumped isotopes on pedogenic carbonates	35-32	Drop of 7°C across the Eocene Oligocene Boundary	Fan et al. (2017)
SW Montana (US)	Clumped isotopes on pedogenic carbonates	34-27	No major changes across the EOT. Gradual cooling of 10°C after the EOT, during the early oligocene	Meijer et al. (2025)
Wyoming, South Dakota, Nebraska (US)	MAT estimated from mammals fossil bone and tooth enamel d18O	36-31.7	Decrease in MAT during the EOT of 8.2 +/- 3.1 °C	Zanazzi et al. (2007)

3. Age Model and Magnetostratigraphy. While I agree that the Büyükteflek section likely spans the EOT interval, I have concerns regarding the precision of the age model. The presence of two hiatuses introduces uncertainty, and without independent high-precision dating methods, their durations cannot be tightly constrained.

This uncertainty is further compounded by the relatively low quality of the paleomagnetic data, which shows a poor correlation with the GPTS 2020, particularly between 150 and 300 m (as seen in Figure 7).

We have now significantly improved this part of the text following the comments of reviewer#1 and we provide a more nuanced correlation for the base of the section. Our new age model takes into account the uncertainty of our correlation for the Priabonian part of our section.

Therefore, I recommend that the authors adopt a more cautious interpretation and avoid overstating the precision of the age model unless stronger supporting evidence can be provided. This also reinforces the need to compare the paleomagnetic results with those of Licht et al. (2022).

Done. We have also ensured that the figures distinctly separate the data from our study and the one from Licht et al. (2022).

4. Diagenetic and Secondary Controls on Carbonate Geochemistry. Although the authors selected pure calcite for Δ47-based paleotemperature reconstruction, the manuscript does not sufficiently address potential post-depositional alterations. These may include burial diagenesis, reworking, detrital contamination, changes in moisture source, and possible hydrothermal influences.

Such processes can modify the oxygen isotope composition of calcite and potentially bias paleotemperature estimates. I strongly recommend adding a dedicated discussion evaluating these potential effects and their implications for the robustness of the results.

We have now expanded the discussion on this topic.
Thin section observations (Supplementary Figure S2) show well-preserved micritic to microsparitic textures in all analyzed pedogenic carbonates. Calcite and dolomite occur as diffuse cements between detrital grains (e.g., samples BTCARB08, BTCARB13, BTCARB15, BTCARB19), with no evidence of coarse sparite recrystallization, blocky calcite cement, or hydrothermal mineral assemblages. Such features would typically accompany significant burial diagenesis or hydrothermal overprinting (Henkes et al., 2014; Stolper and Eiler, 2015). The analyzed carbonates occur as in situ nodules and caliche horizons within paleosols (facies Smp), or as diffuse cements in floodplain deposits (facies Fmp, Gmm). Their stratigraphic position and micritic textures strongly argue against significant reworking or detrital carbonate contamination. The Δ47-derived temperatures are coherent with formation in the vadose zone, where temperature variations reflect near-surface soil conditions (Quade et al., 2013). Importantly, the

reconstructed temperatures fall well below the threshold required for solid-state reordering of clumped isotopes (>100-150°C over geological timescales; Henkes et al., 2014; Stolper and Eiler, 2015), further supporting preservation of the primary isotopic signal. Variations in $\delta^{18}O$ values likely reflect changes in soil water $\delta^{18}O$ under evolving aridity, consistent with sedimentological evidence such as increased caliche development. Given the proximity to the Neotethys and the Paratethys of the study area, major shifts in moisture source beyond these proximal moisture sources would require substantial paleogeographic changes (Kaiseri-Özer et al., 2013). Calculated soil water $\delta^{18}O$ values (after Kim and O'Neil, 1997) are consistent with progressive evaporative enrichment rather than abrupt changes in moisture source. Replicate Δ_{47} analyses show high reproducibility (±4,6°C, 2SE), and our temperature trends are consistent with other Eurasian clumped isotope records (e.g., Page et al., 2019; Semmani et al., 2024). Overall, the convergence of petrographic, stratigraphic, and geochemical evidence supports the primary nature of the Δ_{47} signal and the robustness of the reconstructed paleotemperatures.

5. Interpretation of Aridification. While the general temperature trend appears reasonable, the interpretation of aridification requires further support.

The authors state (Lines 479–481): "Interestingly, the peak of lake retreat starts during the latest Priabonian and covers the EOT, and thus predates the EOGM and the global low of eustatic level (Miller et al., 2008); lake levels increase again during the EOGM." It is unclear what proxy evidence supports this inference. Reliance solely on sedimentary facies may not be sufficient to robustly reconstruct lake-level changes. Furthermore, the use of $\delta^{18}O_{water}$ as an indicator of aridification assumes a stable moisture source and constant precipitation isotopic composition through time. This assumption needs to be justified with additional evidence. Without such support, attributing $\delta^{18}O_{water}$ variations primarily to evaporation remains insufficiently constrained.

Our interpretation of lake-level fluctuations is based on stratigraphic, facies, and unconformity evidence. Lake levels in ancient lacustrine deposits are commonly reconstructed based on such sedimentary proxies (e.g. Shaban et al., 2021; Zavala et al., 2024)

The appearance of well-developed caliches and cemented carbonate horizons within the Smp facies indicates phases of subaerial exposure, reflecting lake-level fluctuations associated with increased aridity. As mentioned in the text, local climate is not the only factor controlling sedimentary activity: tectonics also plays a role in reorganizing paleodrainages. The first unconformity (Hiatus 1) is associated with a shift from fine-grained to coarser deposits, which we attribute primarily to tectonic reorganization (uplift of the Cicekdagi anticline and establishment of a new drainage network; See Gülyüz et al., 2013). However, the second unconformity (Hiatus 2) is marked not only by a sedimentological change but also by a dramatic increase in cemented carbonate facies and the development of exceptionally thick paleosols. The paleosol associated with hiatus 2 exceeds 2 meters in thickness and displays well-developed caliche horizons,

indicating prolonged subaerial exposure under arid conditions. Such thick caliche development requires an abrupt and sustained arid episode, likely involving significant lake-level retreat.
We interpret the significant increase of $\delta^{18}O_{water}$ values between hiatus 1 and hiatus 2 reflect increasing aridity, likely driven by enhanced evaporative enrichment, as it is commonly seen in pedogenic carbonates(e.g. Kelson et al., 2018; Broz et al., 2021; Kelson et al., 2023) . As mentioned previously, the context does not support a change in moisture source during this interval: the Paratethys/Neotethys is inferred to have remained the dominant regional moisture source for Balkanatolia throughout the latest Eocene (Kayseri-Öser, 2013), with no documented major reorganization of atmospheric circulation patterns until later in the Oligocene. Under such stable moisture-source conditions, the development of an exceptionally thick caliche requires an abrupt climatic event as specifically a drastic arid episode coupled with lake-level lowering. This interpretation is further supported by the occurrence of Oligocene evaporites elsewhere in the Çankırı Basin (Kaymakcı et al., 2003), indicating a basin-wide shift toward hypersaline conditions during the early Oligocene.
Above hiatus 2, the presence of well-developed cemented carbonates, caliches, and dolomite-dominated facies supports continued lake-level fluctuations within a persistently arid and hypersaline system. Lake-level recovery and subsequent fluctuations are inferred to have initiated during the EOGM, as evidenced by the resumption of sedimentation immediately above hiatus 2. In contrast to the lower part of the section (below hiatus 1), which is dominated by fine-grained floodplain deposits of the Fmp facies association, the upper part (above hiatus 1) is characterized by coarser Smp facies interpreted as distal fan-delta to lake-margin deposits. This transitional setting made these deposits highly sensitive to lake-level changes: the widespread occurrence of diffuse and cemented carbonates in the Smp facies is diagnostic of lake-influenced deposition, with repeated phases of subaerial exposure allowing pedogenic processes and carbonate cementation to occur.

We have added additional details to the text to improve clarity.

6. Linkages to Regional Biotic Evolution. Although the introduction highlights the importance of the EOT for terrestrial mammal evolution, this aspect is not fully developed in the results and discussion sections.

I recommend that the authors expand this component by synthesizing and, where possible, quantifying changes in mammalian assemblages (e.g., taxonomic composition, diversity, and body size) across the study interval. Integrating these data into Figure 8 would provide a more comprehensive and compelling synthesis, rather than relying solely on qualitative discussion.

We have now included more context on the grande coupure and expanded this paragraph (5.5) by providing more explicit detail on the Grande Coupure and its potential climatic context. Specifically, we added quantitative information on the decline in endemic artiodactyl diversity in Western Europe (Weppe et al., 2023), clarified the temporal relationship between mammalian biohorizons (MP18–MP20) and the two aridification steps identified in our record, and further discussed the possible role of increasing aridity and cooling in shaping faunal turnover in Balkanatolia and Western Europe. Quantitative data on the Grande coupure exist in areas where there are multiple sites (see, for example, Weppe et al., 2022, *PNAS* for western Europe) and they are now mentioned in the text. Yet, we do not think that adding quantitative paleontological data from our study area (or for all Balkanatolia) and comparing them with our paleoclimatic data is adequate. There are less than 10 Priabonian paleontological sites on Balkanatolia, and even less Rupelian sites, and most of them have yielded 1 or 2 taxa only (see, e.g., Licht et al., 2022, *ESR* for a review). It is, at this point, impossible to provide a quantitative and statistically robust view of the evolution of body size or taxon diversity before and at the Grande Coupure during this time interval.