Reply to Reviewer #1 (RC1):
Lucas Bittner et al.

We thank Reviewer #1 for his effort and help improving the manuscript. In the following, we provide a point-by-point reply to all comments:

Branched glycerol dialkyl glycerol tetraethers are bacterial membrane-spanning lipids whose distribution has been shown to correlate with temperature. This correlation has made the lipids a valuable paleotemperature proxy in a variety of archives, including lake sediments. Here, Bittner et al. contribute to both the refinement of this paleotemperature proxy through a regional study of modern lake surface sediments and to our understanding of East African paleoclimate through an application of the refined proxy downcore. The authors find that a brGDGT isomer that is usually excluded from proxy applications is important in their study region. They also reconstruct the paleotemperature history of a high-altitude lake in a region where such data are lacking and put the results in a broader climatic context. The work is well thought out, well written, and makes a significant contribution to the study of brGDGTs and their application. It is well suited for publication in Biogeosciences. I recommend it for publication with one major revision and some minor revisions.

Many thanks for your kind and encouraging feedback.

An important contribution of this work is the inclusion of the 6-methyl brGDGT IIIa’ into a regional temperature calibration. This compound is normally excluded from such calibrations, but here the authors show that it is important for maximising r2 in the modern dataset. This compound also shows substantial variation downcore: Figure 4 shows sediments from the AHP have a higher proportion of 5-methyl compounds while those from the Meghalayan have more 6-methyl. The authors note that this shift coincides with prolonged drought conditions and hypothesise that two factors – lake water conductivity/salinity and/or microbial community shifts – could be driving these changes in IIIa’ downcore. While the latter would require much additional analysis beyond the scope of the work, the former hypothesis is easily testable.

In theory, regional drying could lead to an increase in lake water conductivity/salinity, especially for this seasonally closed lake (which could perhaps become permanently closed if lake level dropped?). Calibrations exist for reconstructing such conductivity/salinity changes (Raberg et al., 2021; Wang et al., 2021). I recommend the authors apply...
calibrations from one or both of these publications to the Garba Guracha record and discuss the results, specifically Equation 12 or S5-7 from Raberg et al. (2021) and/or Equation 10 or 11 from Wang et al. (2021).

- We are very grateful for this valuable feedback. We used Equation 12 from Raberg et al. (2021) and also added the surface water pH calculation from Russell et al. (2018). Referee #1 is right, Garba Guracha becomes a closed lake during dry intervals. The reconstructed conductivity as well the pH point to changing lake conditions at the time when the isomerisation changes. We added both reconstructions to Fig.5 and included both in the discussion and conclusion.

Minor Revisions:

Does temperature go below freezing for these lakes? If not, it would be nice to mention that MAT = MAF for these lakes.

- Garba Guracha does usually not freeze. Occasionally, a thin layer of ice forms along the shore during very cold nights. We added the sentence in line 302: “In the tropical Bale Mountains, especially due to the intense insolation, freezing of lakes is extremely rare, and MAT is equal to MAF.”

Does salinity, conductivity, or pH data exist for these lakes? I wonder if that could help explain their deviation from the East African Lakes dataset.

- Unfortunately, there is no data on salinity or conductivity. However, the dataset published by Baxter et al. (2019) includes pH values, which we have put into the supplement material. The modern pH values of Bale Mountain lakes are moderate to high compared to other similar East African lakes.

L68: "Northern” is capitalised while “eastern” is not.

- Done

L82: Morrissey et al. (2018) use isoprenoidal rather than branched GDGTs, I believe...

- Thank you. We deleted the citation.

L85-87: A few additional citations that may be of interest are (Weber et al., 2018) and (Van Bree et al., 2020), both of which examined microbial communities and brGDGTs in lacustrine settings. (I see these publications are cited later in the manuscript, but I think they would be relevant here as well.) Halamka et al. (2021) also cultured a brGDGT-producing acidobacterium. Depending on timing, two recent pre-prints (Chen et al., 2022; Toby A Halamka et al., 2022) may also be relevant.

- We included Weber et al., 2018; Van Bree et al., 2020; Halamka et al., 2021.

L89: Sentence should end, "...pH values, respectively”

- Done

L120: Remove period after "sea level”

- Done
L176: Put “(III)” after “hexamethylated” for consistency
- Done

L177: Change to “a and/or ω C5…”
- Done

L191: Fractional abundance is defined here, but the authors use mostly percentages rather than fractions throughout the text. Would be good to standardise for clarity.
- Done

Fig. 2: Inset has “East African Lakes” while caption has “eastern African lakes”. Is there a difference? Colors in caption don’t match those in plot. State whether the PCA uses fractional or absolute abundances.
- Thank you very much. It has been changed to eastern Africa. Actually, the dataset Russell et al. (2018) published was named “East African Lake Dataset”, so we refer to it by that name. In all other cases, since we are working on a joint European-Ethiopian project, we have been asked to replace the politically tainted term “East Africa” with the more geographic term “eastern Africa”.

L218-219: The nomenclature of this sentence is a bit confusing and inconsistent.
- Changed

Fig. 3: Again, clarify that plots B and C are using % rather than absolute abundance. Check that colors match.
- Done

L229: Again, specify that this is %IIIa or f(IIIa)
- Done

L230-231: Raberg et al. (2021) and Wang et al. (2021) both show that conductivity/salinity can control isomerisation in lake sediments.

- We readily follow the valuable suggestion of referee #1 and rephrased the sentence to “It has been shown that the isomerisation of brGDGTs can be affected by the conductivity and salinity of the lake water (Raberg et al., 2021; Wang et al., 2021) and therefore, the observed production of IIIa’ at the expense of IIIa could have the potential to influence MBT’$_{SME}$.”

Table 1: Define EAL and EALBM in caption
- Done

L281: R2 for EALBM doesn’t match that in Table 1
- Done

L283-287: Is “Table 6; Eq. 7” in L285 supposed to be “Table 1; Eq. 7”? And are you referring to the calibration using the MIa Set in Table S3 of Raberg et al. (2021) here? They’re not completely comparable as that calibration uses multiple fractional abundances
(fIA2, fIIa'MI, fIIIaMI, and fIIIIaMI2) calculated in the Meth-Isom Set while your Equation 7 in Table 1 would just be the fractional abundance of Ia in the Meth-Isom Set (fIAI). I calculated the correlation between fIAI (= your Equation 7) and MAF in the dataset from Raberg et al. (2021) and it has $r^2 = 0.75$ and RMSE = 3.45°C ($p$-value $<< 0.01$), so you can make a direct comparison between Eq. 7 in Table 1 and those values if you’d like.

- Thanks a lot for pointing us to this issue. We misinterpreted the calibrations in Raberg et al. (2021) and therefore deleted the invalid argument.

**Fig. 6:** Caption should start with “Correlations of the EALBM datasets”? Colors don’t match.

- Thank you. We adjusted the colours to suit colour blindness during the submission process and forgot to change the captions. Has been done now.

*L298-301: Consider rephrasing this. Also, it was unclear to me where the $r^2 = 0.97$ came from.*

- Thank you very much. We tried to clarify this by changing the sentence to “The results of the calibrations $Ia/(Ia+IIa+IIIa+IIIa')$ (MAT= -0.773 + 35.646 x $Ia/(Ia+IIa+IIIa+IIIa')$) and MBT'SME + IIIa' (MAT= -1.4734 + 35.777 x MBT'SME + IIIa') applied to the Garba Guracha sediment core are very similar and correlate well ($r^2=0.97$) (Fig. 7, purple and green curves, respectively). “