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Comment on bg-2022-95

Jonathan Raberg (Referee)

Referee comment on "A Holocene temperature (brGDGT) record from Garba Guracha, a high-altitude lake in Ethiopia" by Lucas Bittner et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-95-RC1, 2022

Review of: "A Holocene temperature (brGDGT) record from Garba Guracha, a high-altitude lake in Ethiopia" by Lucas Bittner et al.

Reviewed by: Jonathan Raberg

Overview and recommendation:

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.

Major Revision:

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 maximizing r^2 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 hypothesize 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).

Minor Revisions:

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

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.

L68: “Northern” is capitalized while “eastern” is not.

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

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.

L89: Sentence should end, "…pH values, respectively"

L120: Remove period after "sea level"

L176: Put "(III)" after "hexamethylated" for consistency

L177: Change to "α and/or ω C5…"

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

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.

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

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

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

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

Table 1: Define EAL and EAL_{BM} in caption

L281: R^2 for EAL_{BM} doesn't match that in Table 1

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 MI_a Set in Table S3 of Raberg et al. (2021) here? They're not completely comparable as that calibration uses multiple fractional abundances

(fIa_{MI}^2, $fIIa'_{MI}$, $fIIIa_{MI}$, and $fIIIa_{MI}^2$) 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 (fIa_{MI}). I calculated the correlation between fIa_{MI} (= 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.

Fig. 6: Caption should start with "Correlations of the EAL_{BM} datasets"? Colors don't match.

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

Reference:

Van Bree, L. G. J., Peterse, F., Baxter, A. J., De Crop, W., Van Grinsven, S., Villanueva, L., et al. (2020). Seasonal variability and sources of in situ brGDGT production in a permanently stratified African crater lake. *Biogeosciences*, *17*(21), 5443–5463. https://doi.org/10.5194/bg-17-5443-2020

Chen, Y., Zheng, F., Yang, H., Yang, W., Wu, R., Liu, X., et al. (2022). The production of diverse brGDGTs by an Acidobacterium allows a direct test of temperature and pH controls on their distribution. *BioRxiv [Preprint]*. https://doi.org/10.1101/2022.04.07.487437

Halamka, T.A., McFarlin, J. M., Younkin, A. D., Depoy, J., Dildar, N., & Kopf, S. H. (2021). Oxygen limitation can trigger the production of branched GDGTs in culture. *Geochemical Perspectives Letters*, 36–39. https://doi.org/10.7185/geochemlet.2132

Halamka, Toby A, Raberg, J. H., Mcfarlin, J. M., Younkin, A. D., Liu, X., & Kopf, S. H. (2022). Production of diverse brGDGTs by Acidobacterium Solibacter usitatus in response to temperature , pH , and O 2 provides a culturing perspective on brGDGT paleoproxies and biosynthesis. *EarthArXiv [Preprint]*.

Raberg, J. H., Harning, D. J., Crump, S. E., De Wet, G., Blumm, A., Kopf, S., et al. (2021). Revised fractional abundances and warm-season temperatures substantially improve brGDGT calibrations in lake sediments. *Biogeosciences*, *18*, 3579–3603. https://doi.org/10.5194/bg-18-3579-2021

Wang, H., Liu, W., He, Y., Zhou, A., Zhao, H., Liu, H., et al. (2021). Salinity-controlled isomerization of lacustrine brGDGTs impacts the associated MBT5ME’ terrestrial temperature index. *Geochimica et Cosmochimica Acta*, *305*, 33–48. https://doi.org/10.1016/j.gca.2021.05.004

Weber, Y., Damsté, J. S. S., Zopfi, J., De Jonge, C., Gilli, A., Schubert, C. J., et al. (2018). Redox-dependent niche differentiation provides evidence for multiple bacterial sources of glycerol tetraether lipids in lakes. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(43), 10926–10931. https://doi.org/10.1073/pnas.1805186115