Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2019-500-AC1, 2020

Interactive comment on "Assessing branched tetraether lipids as tracers of soil organic carbon transport through the Carminowe Creek catchment (southwest England)" *by* Jingjing Guo et al.

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Received and published: 6 May 2020

We would like to thank this reviewer for their feedback on our manuscript. Below we indicate how we will address their comments in our revised version.

Anonymous Referee #3

The following comments should help in improving the manuscript: Line 13: Here, the authors mention the fact some tracers are required to quantify the fluxes of soil OC. Nevertheless, brGDGTs would be more qualitative than quantitative tracers. Therefore,

this sentence should be modified.

Reply: We agree with the reviewer, and we will change this.

Lines 52-53: Here, I would directly say that brGDGTs are ubiquitous lipids, present in terrestrial and aquatic environments, and thus not necessarily specific soil tracers.

Reply: We chose to follow a chronological order for our introduction, and thus first introduce the discovery of brGDGTs, followed by the development of brGDGT-based proxies, additional production in different aquatic environments (i.e. coastal marine area, rivers and lakes), and the implications of mixed sources for their use as proxies. We prefer to leave this as is.

Line 54-55: This sentence should be rephrased, as only some of the brGDGT producers may belong to the phylum Acidobacteria. As brGDGTs were detected in various settings, it seems unlikely that they are produced by the same microorganisms everywhere.

Reply: We will clarify this.

Lines 77-93: It should be clearly mentioned somewhere that BIT index can be largely biased by in situ production of brGDGTs in aquatic settings (which was not taken into account in the initial hypothesis by Hopmans et al. 2004) and therefore should be applied with caution in coastal and lacustrine settings.

Reply: We will emphasize this directly after introducing aquatic brGDGT production.

Lines 82-90: These two studies are restrictive and specific. Other examples of studies dealing with brGDGT in situ production should be mentioned here (Miller et al., 2018, Climate of the Past; Loomis et al., 2014, GCA; Buckles et al., 2014; Biogeosciences etc.). Please also mention that in situ production of more cyclized but also more methylated brGDGTs is generally observed in aquatic vs. terrestrial settings.

Reply: We agree that there are many more studies that show aquatic brGDGT production than the two that are mentioned in this comment. Please note that we already listed a large number of studies on aquatic brGDGT production in lines 77-79. Our selection includes those studies that were either first in suggesting that in situ production takes place in a certain aquatic environment, provided direct evidence for in situ production, or propose (quantitative) ways to identify the aquatic contribution. We do note, however, that in situ production in lakes is not further clarified in our manuscript. One reason for this is that there is no consistent trend among lakes that enables the identification of in situ brGDGT production, in contrast to production in rivers (more 6-methyl brGDGTs) or in coastal marine environments (higher degree of cyclisation). We will add this information to the introduction of our revised manuscript and add the appropriate references.

Lines 100-102: In order to trace soil OC with brGDGTs, these lipids should be mainly derived from soils, with only reduced in situ production. Such an assumption should be clearly specified.

Reply: We will add this.

Lines 160: Were some samples analysed in replicates?

Reply: No, we did not analyze samples in replicates.

Lines 172-181: IsoGDGT-0 concentrations are only reported for the lacustrine sediments. What about the soils and the riverine sediments?

Reply: We only reported the concentration of isoprenoid GDGTs for the lacustrine sediments as we only discuss them for this environment as part of the GDGT-0/crenarchaeol ratio (section 4.4). Concentration data for GDGT-0 in the other environments will be added to the supplementary table.

Line 227: principal component analysis instead of principle component analysis

Reply: Thanks. We will correct this.

Line 236: In Fig. 4b, a lot of samples are outside the circles (the 3 groups of soils) and do not overlap. This should be acknowledged.

Reply: There are several ways to display these results. We here followed the approach of Glendell et al. (2018), who previously studied the same set of samples. The circles in Fig. 4b represent the 95% confidence interval around the mean point of the group (the enlarged symbol inside the ellipse), which is the reason why there are multiple points that plot outside the ellipse. We will clarify this in the figure caption.

Line 251: Regarding the turnover of brGDGTs in soils, please also refer to the publication by Huguet et al. (2017, GCA), with turnover times between 8 and 41 years in the same range as Weijers et al. (2010).

Reply: We will add this reference.

Lines 269-270: please specify the 2 transects along which large spatial variations in BIT are observed. T1 and T2? All the discussion about spatial variations in BIT and soil moisture remains very speculative. How can you explain that these variations occur only along 2 transects? What about the other transects? Are they any in situ measurements of soil moisture available to strengthen the argumentation? Or measurements in the lab (after having dried the soil samples)?

Reply: The BIT index values gradually increase from the hilltop downwards along Transect-1 and Transect-8. As can be seen in the table attached in supplement, Transect-1 and Transect-8 show the largest change in BIT index vales (>0.3). Transect-2, Transect-3 and Transect-7 also show an increase from hilltop downslope, albeit to a smaller degree (0.17, 0.19 and 0.04 increase, respectively). The other three transects (Transect-4, Transect-5 and Transect-6) in north catchment have stable BIT values, and the BIT values in south catchment do not show an obvious trend at all. Also based on the comments of Dr. Sparkes, we will clarify our discussion on the BIT index in a revised version. Unfortunately, the soil water content was not analyzed.

Line 277: similarly, please specify the 4 transects along which large spatial variations in IR index are observed.

Reply: We will add the specifications.

Lines 281: Is the relationship between the relative abundance of 6-methyl brGDGTs and pH given for all the soils of the catchments or only those of the 4 transects previously mentioned?

Reply: The reported relationship between the relative abundance of 6-methyl brGDGTs and pH is for all the soils in the study catchment. We will specify this in the manuscript.

Lines 281-283: similarly, please specify to which soils correspond the different pH values (those of the 4 transects, the total dataset etc).

Reply: We will further specify this.

Lines 321-322: In addition to Congo, brGDGTs are also mainly derived from soils in other large riverine systems such as the Amazon (Kim et al., 2012, GCA) or RhoÌĆne river (Kim et al., 2015, Frontiers in Earth Science).

Reply: We will add these studies.

Line 326: why would brGDGTs would be degraded more rapidly in soils than in aquatic settings? This sentence should be removed as it appears too speculative.

Reply: The line that the reviewer refers to is on purpose phrased as a potential explanation for our results, and thus meant to be speculative Note that we do not compare brGDGT degradation in soils vs an aquatic setting, but the degradation of soil-derived vs aquatic brGDGTs in the same aquatic environment. One process that could explain this process is priming. We will add this explanation and appropriate references (e.g. Bianchi, 2011) to the revised version.

Line 348-349: as said above, the identity of the brGDGT producers remains elusive in soils as well.

Reply: Yes, we agree with the referee, although so far there are more clues on the producer(s) of brGDGTs in soils than there are for aquatic systems.

Lines 352-358: I do not see the interest of this part of this discussion on the ecological niches of brGDGTs producers in Loe Pool as it is totally speculative and has no direct link with the main aim of the paper (using brGDGTs as soil OC tracers).

Reply: In this section it becomes clear that the brGDGTs in the lake sediment are not derived from soils, but are most likely produced in the lake itself. Since we can, therefore, not use the brGDGTs as tracer for soil OC, we instead use this section to further explore the environmental significance of their signature stored in the lake sediments. For this, it is important to understand the depth and season of brGDGT production in Lake Loe Pool, for which we compare our dataset with the latest insights on brGDGT production in lakes in general, i.e. the ecological niches identified in Lake Lugano (Weber et al., 2018).

Lines 359-389: in this section about local environmental changes, what about reconstruction of past temperature/pH variations with brGDGT-based indices? It would be complementary to the discussion about the lake eutrophication.

Reply: We agree with the reviewer that records of past temperature and pH variations would be a valuable addition to the discussion. However, the aquatic source of the brGDGTs in the lake sediments disqualifies the use of the transfer functions from e.g. De Jonge et al., 2014 or Naafs et al., 2017, that are based on soils. We did apply the transfer functions in the latest lake calibration (Russell et al., 2018), however, the calibration dataset only includes lake sediments from tropical east Africa, and results in reconstructed temperatures that are too high (13.7 ± 0.1 °C vs the locally historical recorded temperature of 10.9 ± 0.6 °C (average of 1978 to 2018, UK metoffice)). It thus seems that both the global soil calibration and the tropical lake calibration are not appropriate for the brGDGTs in this temperate lake, and therefore decided to not include these records in our manuscript.

Lines 385-387: The authors should also mention the in situ production of isoGDGTs in deep lacustrine sediments, as it could bias the signal recorded in the sediments.

Reply: We will add that isoGDGTs may potentially be produced in deeper sediments, although we are not aware of a study that has shown this and we can add as a reference. Given the resemblance of the trends in GDGT proxies with that of the eutrophication history of the lake, we also assume that the contribution of a deep-sediment-producer will be minor.

Lines 395-397: I would rephrase this sentence. There is no direct evidence that soil moisture exerts a control on brGDGT distribution here and the variations in BIT were observed along 2 transects only.

Reply: As we mentioned above, the trend in BIT values is evident in five out of eight transects in the north catchment, although the increase is relatively small in three of them. Based on the influence of soil water content reported in the literature (e.g. Dirghangi et al., 2013; Menges et al., 2014), and the supposedly lower ground water table at the hilltop compared to the soils downslope, we will leave this interpretation as is.

Line 401: Please replace "replaced" by "mixed", as the soil brGDGT signal is not replaced by the aquatic brGDGT signal, the two signals are mixed in the sediment.

Reply: We will change this sentence.

Lines 407-410: please be more moderate here, as the interpretation based on brGDGTs is purely qualitative and complementary to previous data. I would rather say that the trends derived from GDGT data are roughly consistent with the historical record of lake eutrophication.

Reply: We will change this accordingly.

Lines 411: this sentence should be modified, as in the case of the Carminowe Creek catchment, this study clearly showed that brGDGTs do not record land management

change and that in situ production dominates in the riverine system.

Reply: Note that we here refer to GDGTs in general, not just the brGDGTs. The land management that we mention refers to the increased use of manure and septic tanks and intensified agriculture that caused the eutrophication of the lake, and the subsequent restoration efforts that are reflected in the GDGT proxy records from the lake core (Fig. 6). The conclusion that brGDGTs in the lake sediments are produced within the lake is already clearly mentioned in line 402-403.

References: Bianchi, T. S.: The role of terrestrially derived organic carbon in the coastal ocean: A changing paradigm and the priming effect, Proc. Natl. Acad. Sci., 108(49), 19473–19481, doi:10.1073/pnas.1017982108, 2011. Dirghangi, S. S., Pagani, M., Hren, M. T. and Tipple, B. J.: Distribution of glycerol dialkyl glycerol tetraethers in soils from two environmental transects in the USA, Org. Geochem., 59, 49–60, doi:10.1016/j.orggeochem.2013.03.009, 2013. De Jonge, C., Hopmans, E. C., Zell, C. I., Kim, J.-H., Schouten, S. and Sinninghe Damsté, J. S.: Occurrence and abundance of 6-methyl branched glycerol dialkyl glycerol tetraethers in soils: Implications for palaeoclimate reconstruction, Geochim. Cosmochim. Acta, 141, 97–112, doi:10.1016/j.gca.2014.06.013, 2014. Menges, J., Huguet, C., Alcañiz, J. M., Fietz, S., Sachse, D. and Rosell-Melé, A.: Influence of water availability in the distributions of branched glycerol dialkyl glycerol tetraether in soils of the Iberian Peninsula, Biogeosciences, 11(10), 2571–2581, doi:10.5194/bg-11-2571-2014, 2014. Naafs, B. D. A., Gallego-Sala, A. V., Inglis, G. N. and Pancost, R. D.: Refining the global branched glycerol dialkyl glycerol tetraether (brGDGT) soil temperature calibration, Org. Geochem., 106, 48–56, doi:10.1016/j.orggeochem.2017.01.009, 2017. Russell, J. M., Hopmans, E. C., Loomis, S. E., Liang, J. and Sinninghe Damsté, J. S.: Distributions of 5- and 6-methyl branched glycerol dialkyl glycerol tetraethers (brGDGTs) in East African lake sediment: Effects of temperature, pH, and new lacustrine paleotemperature calibrations, Org. Geochem., 117, 56–69, doi:10.1016/j.orggeochem.2017.12.003, 2018. Weber, Y., Sinninghe Damsté, J. S., Zopfi, J., De Jonge, C., Gilli, A., Schubert, C. J., Lepori, F., Lehmann, M. F. and Niemann, H.: Redox-dependent niche differentiation provides evidence for multiple bacterial sources of glycerol tetraether lipids in lakes, Proc. Natl. Acad. Sci., 115(43), 10926–10931, doi:10.1073/pnas.1805186115, 2018.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2019-500/bg-2019-500-AC1-supplement.pdf

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Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2019-500, 2020.