

Rebuttal to the comments of referee #2

We thank the referee for the positive assessment of our manuscript. Although the referee finds the presented data on the salinity impact on the distribution of OH-GDGTs interesting, he/she raises some concerns. We agree with the referee that the slightly deviating values of the OH-GDGT-derived SST indices in the surface sediments of the northern Baltic alone cannot be considered to be solid evidence for the influence of salinity on the values of RI-OH' index. The observed deviation may also be caused by an increased lateral sediment influx, as is clearly stated in the abstract and main text of the manuscript. The predominant argument for a potential effect of changing salinity on OH-GDGT-derived SST indices is the huge change that occurs in the values of e.g. the RI-OH' index during the freshwater (Ancyclus) phase (i.e. from 0.18 to ca. 0.75). With the existing global core top calibrations such a high value would translate into an SST of 17°C, which is entirely unrealistic. This is corroborated by the fact that TEX_L' values remain constant or are even slightly lower (see Figure 5). Our observation made at two different locations in the Baltic Sea is entirely consistent with recent observations in a large Swiss freshwater lake (Lake Lugano; Sinninghe Damste et al., 2022). This strongly suggests that when salinity drops below a certain threshold value (which is assumed to be relatively low, e.g. 4 g kg⁻¹ or even lower) thaumarchaea adjust the distribution of their (OH)-GDGTs differently as thaumarchaeota growing in brackish or marine waters. We agree with the referee that our dataset does not provide 100% evidence for a causal relationship, but we would like to emphasize that we do not claim this (e.g., “the record of the RI-OH' index, thus, most likely reflects both changes in temperature and salinity”, line 31).

The referee remarks that the salinity “effect” could have been further examined with our thaumarchaeotal enrichment culture. We agree with the referee that additional culture experiments with thaumarchaeotal cultures and enrichments grown at various salinities and temperatures would be a useful topic for future studies. However, this type of work is extremely laborious, and we consider this beyond the scope of this already “data-rich” study. For our experiment with the enrichment culture just the two temperature “extremes” that the organisms are faced with in the Baltic Sea water column were chosen to see if a significant effect occurs on the (OH)-GDGT distribution. An increase of the number of data point along this temperature gradient, as suggested by the referee, would indeed be of interest and is a promising topic for future studies. Our enrichment culture was grown at a salinity of 12 g kg⁻¹. Reduction of the salinity by 70% or more would have very likely led to ceasing of the culture. The growth rate of the enrichment culture was already very low at the low temperatures, characteristic for this environment. So, therefore, it is hardly possible to obtain information on the salinity response within this experimental set-up. Furthermore, we analyzed previously a “natural” enrichment culture in the deeper waters of Lake Lugano growing at 6°C. In this setting, 93-100% of all archaeal 16S rRNA sequences were derived from a single freshwater thaumarchaeon and the (OH)-GDGT distribution was also characterized by an anomalously high values of the RI-OH' index (Sinninghe Damste et al., 2022). It is hard to come up with a better equivalent for the Ancyclus Lake phase of the Baltic Sea than this natural setting, so we feel confident about our suggestion that salinity may have a substantial effect on temperature proxies based on OH-GDGTs.

Another suggestion of the referee was to examine the core-top dataset on the potential effect of salinity on the distribution of OH-GDGTs. Unfortunately, these data are not from areas with a low salinity (<4 g kg⁻¹), which would be required to do so.

We have chosen to plot the sediment data versus depth instead of time because the age models are not well constrained for the other phases than the brackish phase. We will add in the figures the estimated age of the boundaries between the various phases (stippled lines in Figures 2 and 3).

In the revised version we will adjust our manuscript according to the other remaining useful minor remarks on the text and figures of the referee. We performed base and not acid hydrolysis because the OH-GDGTs partially lose their hydroxy group upon acid treatment (see Sinninghe Damsté et al., 2022 for details). This would possibly alter their distribution.

References

Sinninghe Damsté, J. S., Weber, Y., Zopfi, J., Lehmann, M. F., Niemann, H. (2022) Distributions and sources of isoprenoidal GDGTs in Lake Lugano and other central European (peri-)alpine lakes: Lessons for their use as paleotemperature proxies. *Quatern. Sci. Rev.* 277, 107352, <http://dx.doi.org/10.1016/j.quascirev.2021.107352>.