Review of Sluijs et al.

In this work, Sluijs et al. revisit the early Paleogene sedimentary records recovered from the central Arctic Ocean (2004 ACEX Expedition) to better examine the past sea surface temperature (SST) estimates from their earlier studies (Sluijs et al., 2006; 2009). In their previous study which lead to major scientific discoveries of hyperthermal events and climatic/ecological changes in the Arctic region during the late Paleocene – early Eocene, the biomarker records revealed unusual GDGT (glycerol dialkyl glycerol tetraether) assemblage (i.e. high GDGT-3) and high terrestrial organic input, leaving some concerns in the application of GDGT-based paleothermometry in the Arctic (e.g. TEX_{86}). Here, the study re-evaluates the previous record/samples with new analyses, including glycerol monoalkyl glycerol tetraethers (GMGTs) for recently developed temperature proxy.

First of all, TEX_{86} is a charming proxy that could help us learn the past ocean temperature, especially in the greenhouse climate. The study provides an excellent and thorough reassessment of the TEX86, especially describing the current status of understanding/limitation of the TEX_{86}-SST calibration and testing the potential bias from other GDGT sources/factors with the range of indices in their actual samples. In addition, the fractional calculation of terrestrial-derived isoprenoid GDGTs provides valuable insight into TEX_{86} application and I appreciate the authors for adding the example calculation in the spreadsheet. TEX_{86}-H (Kim et al., 2010) and BAYSPAR (Tierney & Tingley, 2014) has been used after screening the bias and I also agree with the authors (in their Author's Response) for excluding the OPTiMAL (Eley et al., 2019) method which is yet subject to significant revisions.

Secondly, the study provides the several other independent temperature proxies (e.g. pollen, terrestrial vegetation indicators) along with the GDGT-base proxies and suggests that the SST estimate of ~20-25 °C is skewed toward the summer-end. Importantly, I find this study as an open question study on how the current paleothermometry (i.e. TEX_{86}, MBT) should be applied, what are the limitations, and what should be considered, especially when studying the Arctic region during past greenhouse climate condition. This study would be a broad interest to geochemists, paleoceanographers and climate modelers.

Lastly, I find the MS greatly improved after the first revision. The abstract, main text, the load of citations and figures all have become concise and clear. Here, I only have few minor comments which are mostly technical corrections (see below).

Overall, I recommend this work to be accepted in *Climates of the Past* for providing the next stepping stone of temperature reconstruction based on our current understanding of the proxy application and the importance of studying the nature of past Arctic Ocean, which is an critical end-member in assessing the past polar warmth and latitudinal temperature gradient of the Earth climate system for both proxy and climate model studies.

Some minor comments are below:

Line 223: I suggest to remove the word "assumed" since these diagnostic GDGT distributions (predominantly GDGT-1 to -3) have been observed in many studies from methane-impacted environments (e.g. Pancost et al., 2001) and based on this rationale, MI was developed. Rather add "which preferentially produce GDGT-1, 2 and 3 (refs)";

Line 286: calculate from TEX_{86} using;

Line 289: limits of the TEX_{86}-RI relationship;

Line 304: brGDGT-IIa';

Line 306: brGMGT-H1048;

Line 329: duplicate parenthesis;

Line 350: does this mean that the original BIT is slightly higher than the newly measured BIT? Then I assume "0.05" higher rather "0.5" which this will be a huge difference;

Line 398-399: interval 371-369 "also" stands out;

Line 416-417: "cyclization" same as line 416. Also is the degree of cyclization interpreted using RI (Figure 6e, red)?

Line 421: section 2.2.6;

Line 460: seen in GDGT-2 and;

Line 610: H-MBT (H1020c, H1034b);

Fig.3

Based on provided supplement data, I find that the two regression lines of TEX86 and BIT are both somewhat different from Figure 3.

To show this, I simply plotted the TEX86 relationship (new vs. original) from the data spreadsheet – column BQ (for newly measured TEX86 data, excluding five outliers mentioned in the author's response) and column DC (for original TEX86 data) – which gives regression of y=0.836x+0.077 (R^2=0.83; see figure below). Slightly lower slope than 1 indicates that the newly TEX86 is slightly higher the original TEX86, which is also shown in the TEX86 vs. depth plot (MS Figure 3 left; red generally higher than blue). For BIT, regression gives y=1.055x+0.021 (R^2=0.97) – column BR (new BIT) vs. column DB (original BIT).

Please verify if the regression curve needed to be corrected.

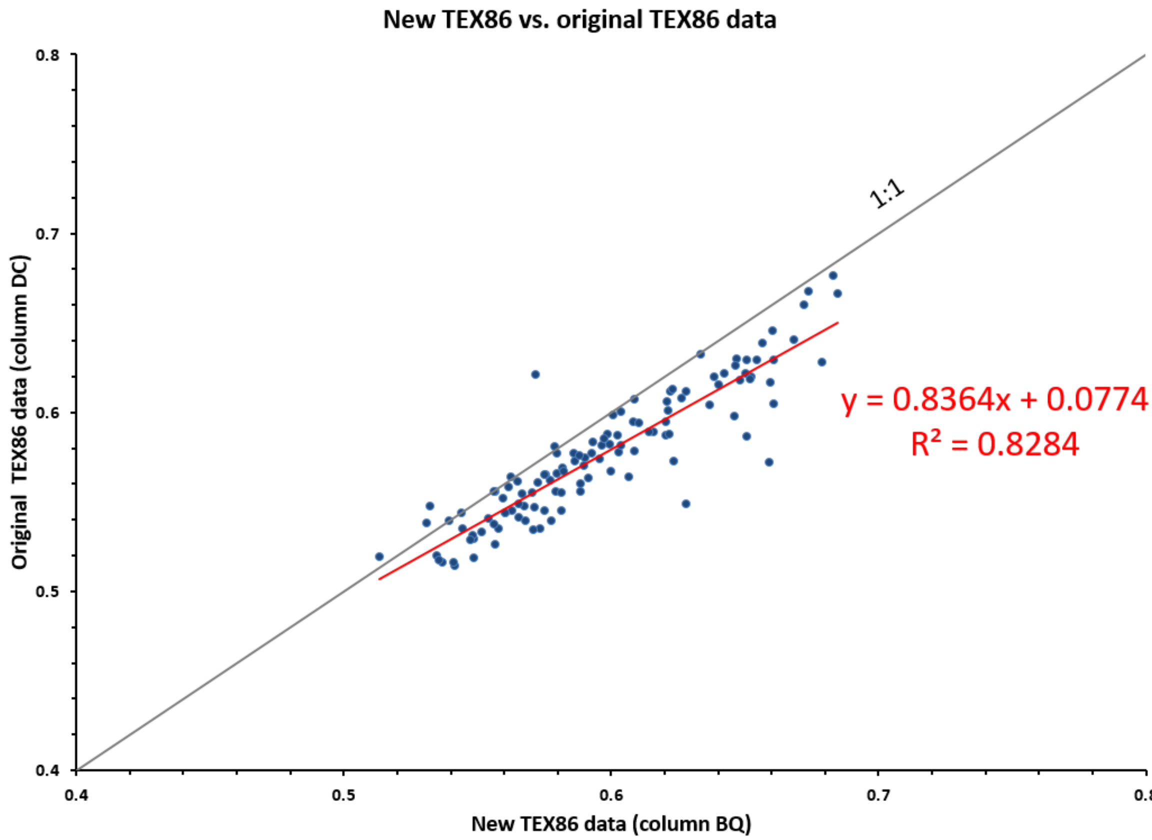

Fig. 1. TEX_{86} relationship (new vs. original data) plotted from the supplementary data spreadsheet. Regression shown in red line and 1:1 line in gray.