Dear Yan Bai,

On behalf of all co-authors, I would like to warmly thank you for your thorough review and constructive feedback. Below, I address your main concern.

Major concern 1 :

The preprint was submitted to the EGU discussion platform for peer-review consideration in *Biogeosciences* on 28 July 2025, while the second article published in *Paleoceanography and Paleoclimatology* (https://doi.org/10.1029/2025PA005214) appeared later, on 6 October 2025. Initially, this preprint was intended as the first part of the project, focusing on the description of 162 new samples and the comparison of GDGT distributions across Arid Central Asia. The *Paleoceanography and Paleoclimatology* paper (*Dugerdil et al., 2025*) was conceived as the second part, dedicated to comparing traditional and machine learning-based calibration methods.

However, due to differences in the peer-review timelines between *Biogeosciences* (which includes a public discussion phase) and *Paleoceanography and Paleoclimatology* (which follows a classical closed review process), the second part was published before the first.

Although both manuscripts rely on the same dataset (162 new samples combined with 599 previously published ones), the current preprint presents, for the first time, a detailed description and analysis of the fractional abundances and major GDGT indices for these new samples. In contrast, Dugerdil et al. (2025, Paleo) uses the ACADB dataset solely to train machine learning models, without providing the complete data characterization presented here.

However, we agree that, in the current state of publication, it appears more accurate to remove the term "new" in the current study. This word has been removed along the manuscript and a reference to Dugerdil et al., (2025, Paleo) has been added in line 93-104 within the introduction with : "*This study relies on the first regional database of surface brGDGT samples for drylands, aiming to identify the key climate and environmental parameters influencing their distribution. This dataset, referred to as the Arid Central Asian brGDGT Surface Database (ACADB), includes brGDGT assemblages from various sites across the region, totalling 761 sites. This dataset was compiled by Dugerdil et al., (2025) to train machine learning models for climate reconstructions. The dataset combines 162 new samples collected across four ACA countries with 599 previously published records (Fig. 1). In Dugerdil et al. (2025), machine learning calibrations outperformed traditional linear models, suggesting that confounding factors weaken linear brGDGT–temperature relationships. The present study tests this hypothesis by analysing modern brGDGT distributions against key climate parameters, mainly aridity, temperature, and precipitation, as well as chemical characteristics such as pH, salinity, and sample type (soil or lacustrine). The results are then compared with the global Worldwide brGDGT Surface Database (WDB; modified from Raberg et al., 2022b) to assess whether similar brGDGT patterns are observed at both regional and global scales.*". Also the Materials and Method section have been modified as follow (l. 211-213) "*Two databases are compared in this study (Figs. 1 and 2, steps 4 and 5). The Arid Central Asian Data Base (ACADB, n = 761) gathers samples from Dugerdil et al. (2025) used to train machine learning calibrations, as well as samples collected from previously published studies, listed in Table 1 and Table S.2.*".

Major concern 2 :

We agree that previous studies have shown that linear regressions (i.e., MBT-based calibrations) and multiple linear regressions perform less effectively in drylands than in more humid environments. In the present study, we build upon these findings by testing a broader range of indices, environmental parameters, and an expanded dataset, the ACADB.

To further enhance palaeoclimate reconstructions in drylands, we propose two methodological improvements: (1) a salinity-specific set of MBT-based calibrations, and (2) a new index based on the difference between MBT'$_{5Me}$ and MBT'$_{6Me}$ to track aridity changes. These improvements directly result of the analyse of the modern brGDGT response to environmental gradients.

The detailed evaluation of quantitative reconstructions derived from modern brGDGT samples (i.e., proper climate calibration process) constitutes the primary focus of *Dugerdil et al. (2025, Paleo)*. We therefore consider the two publications to be distinct yet complementary, each addressing a different aspect of the overarching research objective: (1) the brGDGT distribution response against climate and soil properties, and (2) the quantitative climate calibration process.

However, to make this articles distinction and complementarity more clear we modified the present manuscript by adding a section *Temperature calibration errors* in section 4.3.1 from the Discussion. This section is supported by a new figure (Fig. 10) and the following text (l. 648-656): "*As a result of the multiple confounding factors influencing the response of brGDGTs to climate, and their complex combined effects, traditional temperature calibrations exhibit substantial errors when cross-validated using the ACADB dataset (Fig. 10). This is true for both the Mean Annual Air Temperature (Fig. 10A) and the mean air temperature of Months Above Freezing (Fig. 10B). At the ACADB scale, local calibrations show a significant average bias, producing either overly warm (Yang et al., 2014; Sun et al., 2011; Thomas et al., 2017) or overly cold estimates (Wang et al., 2016). Although global calibrations reduce this offset, they still display wide dispersion (ranging from –20 to 35 °C). These large errors persist across various statistical approaches, including quadratic and multiple linear regressions, MBT'$_{5Me}$-based, and Bayesian calibrations. Altogether, these findings highlight the need for developing dedicated calibrations for dryland environments, particularly focusing on temperature and precipitation reconstructions tailored to specific sample types (e.g., freshwater vs. hypersaline systems).*".

Minor comments :

Line 34: We changed "air" by replacing it with "ambient temperature".

Line 45: We changed "CBT'" to "CBT$_{5Me}$".

Line 55: The word "thus" have been changed by "For instance"

Table 2 and Line 192: The "CBT'$_{5Me}$" indication have been corrected to "CBT$_{5Me}$" all along the manuscript and in the figures as well.