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Climate of the Past
Discussions

Interactive comment on "Climate reconstructions based on GDGT and pollen surface datasets from Mongolia and Siberia: calibrations and applicability to extremely cold-dry environments over the Late Holocene" *by* Lucas Dugerdil et al.

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1 Responses to the comments of Reviewer 2 (Anonymous Referee)

1.1 General comments:

This study focuses on the calibration of proxy-climate relationships for pollen and GDGTs by comparing large published Eurasian calibrations with a set of 49 new surface samples. These calibrations are cross-validated by an independent dataset of top-core samples and then applied to two Late Holocene paleosequences from the Mongolian Altai and the Qaidam basin. GDGTs are relatively new proxies for reconstructing environmental conditions and any studies on calibrating modern datasets relative to climate data is very important. Along those lines, this work is interesting from a methodological point of view.

However, the choice of paleodata for the application of the results obtained in the calibration is not correct: none of the paleo records does belong to the territory of the Mongolian Plateau described in the paper.

Response: The paleo-validation of a calibration study is always difficult in an area where there are still a few paleo studies. This is the case for the Mongolian plateau. More over, the definition of the Mongolian Plateau (MP) borders is changing from a study to another (Windley et al., 1993; Meng et al., 1998; Wang et al., 2013; Sha et al., 2015; Chen et al., 2015a). However for the majority among them, the MMNT5C03 top-core and the D3L6 core are within the Mongolian Plateau. For the GDGT sequence, the only available lake dataset was collected on the Loess Plateau which is the closest geographical plateau to the MP. Therefore, the environmental conditions on the Loess Plateau (elevation, climate parameters, vegetation...) are similar to the ones prevailing on the MP.

Applied changes: We do agree that the paleo-validation is more accurate when the paleo-sequence is close to the surface sample transect. That is why we have applied our calibration on an other pollen sequence from Dulikha Bog (Bezrukova et al., 2005; Binney 2017) which is very close to the Lake Baikal in the Buriakya Republic (Rebuttal Figs. 2 and 3).

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Another disadvantage is that the data on pollen and on GDGTs were obtained from different paleosequences. Of course, not much data is currently available on GDGTs from Mongolia. Therefore, we will not consider this a shortcoming of the study, but we will consider it a consequence of the little research of the territory. However, pollen data from Mongolia are abundant.

Response: We fully agree with this comment. The multi-proxy validation approach should be conducted on the same core. But there is, to our knowledge, no multi-proxy study available to date in Arid Central Asian (ACA) area. Such a comparative multi-proxy calibration study have to be conducted in the next years.

Applied changes: For the time being, we found a recently brGDGT paleosequence (NRX) with open access data from (Rao et al., 2020). This sequence is perfect for our calibration validation test : the peat core come from Altai mountains, with an elevation (around 1700 m a.s.l) close to the NMSDB average elevation and with same range of climate parameters, is only 200 km away from the D3L6 sequence as the crow flies. Therefore in the revised manuscript, we were able to compare the brGDGT calibration on two paleo-sequences (NRX and XRD) and to compare the brGDGT and the pollen signal for Altai mountains (NRX and D3L6). The location of the new paleo-sequences have been added to Rebuttal Figs. 2 and 3 and the results are displayed in Rebuttal Fig. 1.

The next point is the definition of the study area. The map shows the entirety of Mongolia, with the Mongolian Plateau not highlighted.

Applied changes: We have changed the figure 2 or Rebuttal Fig. 2 to highlight the MP following the geological definition (Windley et al., 1993; Sha et al., 2015) and the political borders (Meng et al., 1998, Chen et al., 2015a) including the whole Inner and Outter Mongolia plus northern part of the Xinjiang and Gansu provinces and the Buriakya and Tuva Republic, the Zabaykalsky Krai and the Amur Oblast.

Part of the locations is near Lake Baikal (the authors call it the Siberian Basin). First of all, there is no Siberian Basin and there are mountains around Baikal. According to the map, samples were taken only along the Angara River, where the height is about 700 m asl. This location is only a minor point in the huge territory of Siberia. I propose to work out the geography of the study.

Response: We definitely acknowledge that the word Siberia is not precise enough to describe the possible range of application of our calibration dataset. Indeed, our surface samples were collected from the wide definition of the Mongolian Plateau, that is to say the Baikal area, the Khentii and Khangai mountains, the central Mongolian steppes and the Gobi desert.

Applied changes: We have changed Siberia by Baikal Area in the text. Also, the location of Baikal and Angara have been added on the map Rebuttal Fig. 3.

Try to prove that the results of the calibration of your samples taken from the Angara and then the transect to the south can really be applied to the sites located in the Mongolian Altai and Qaidam. The ideal would have been to choose paleo-sites within your transect. At least try to explain why this is not being done.

Applied changes: Two new past records within the transect have been added and discussed into the 5.2.4 paragraph. The reconstructed climate parameter trend follows the previously used paleo-sequence reconstruction (from D3L6 and XRD) trend.

I also suggest adding South Siberia or Baikal area in the title instead of Siberia.

Applied changes: The title has been changed into *Climate reconstructions based on GDGT and pollen surface datasets from Mongolia and Baikal area: calibrations and applicability to extremely cold-dry environments over the Late Holocene.*

1.2 Specific comments:

Lines 14-15: "(3) even if local calibrations suffer from reduced amplitude of climatic parameter due to local homogeneity, they better reflect actual climate than the global ones by reducing the limits for saturation impact," This statement is pretty obvious without many pages of statistics.

Response: The saturation impact is a tricky question currently discussed in brGDGT studies associated to extreme climate reconstruction, that is why it appears mandatory to insist on it.

Lines 65-66: "Environmental drivers are linked to climate parameters (Weijers et al., 2007b), soil typology and vegetation cover (Davtian et al., 2016), which in turn imply land cover and land use" I don't understand to what link this statement. To BrGDGT?

Response: This sentence summarizes the major environmental factors than can drive the brGDGT assemblages.

Applied changes: The sentence (L. 68) has been changed into BrGDGT environ-

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mental drivers are linked to (...) land cover and land use.

Line 75: “CBT and MBT indexes”. What is this? Abbreviations appear for the first time, they must be deciphered.

Applied changes: The line 78 has been changed into To monitor these changes, Cyclisation ratio of Branched Tetraethers (CBT) and Methylation index of Branched Tetraethers (MBT) indexes linked to environmental factors such as climate and soil parameters have been proposed (Weijers et al., 2007b; Huguet et al., 2013a)

Lines 76-78: “the 5-methyl correlates mainly with temperature (Naafs et al., 2017a), while 6 and 7-methyl seem to react to moisture and pH” What do you mean, "correlate," "react"? Is there something happening to them that is quantified?

Response: These two propositions have indeed been mathematically shown but the actual ecophysiological process behind these correlations are still not well understood.

Applied changes: The sentence has been modified to underline the mathematical aspect of the relations and the R-squared values of the studies have been added. We have (L. 80-84) the 5-methyl mathematically correlates mainly with temperature ($R^2 = 0.76$, Naafs et al., 2017), while 6 ($R^2 = 0.69$) and 7-methyl ($R^2 = 0.44$) seem to moderately correlates with moisture and pH (Yang et al., 2015; Ding et al., 2016).

Lines 80-84: “MBT05Me, Index1, Ri/b” Are you sure that all readers of your paper know what is this? I don’t know, for example.

Response: We do agree that this indexes are very technical and precise. But, within the brGDGT research communities the question of the accuracy of these indexes is determinant. To make this part more fluid and digestible, we try to deciphered each acronym.

Applied changes: The sentence L. 83-86 has been changed in More specific indexes have been proposed by DeJonge et al., (2014b) to limit the multi-correlation systems with the withdrawal of 5-methyl compounds such as MBT'_{5Me} which is independent of the pH and CBT_{5Me} which is more representative of the soil pH than the former version of the index (index formula in Supplementary Table S1). . The sentence L. 91 has been changed in The Ratio of isoGDGT on brGDGT ($R_{i/b}$) has been proposed as a reliable aridity proxy (Yang et al., 2014; Xie et al., 2012) .

Line 115: “Fig. 1.A).” I don’t see Siberia on this map.

Applied changes: Siberia has been changed to Baikal area on lines 33, 105, 123, 130, 269, 287, 307, 412, 415, 416, 505, 530 and added on the map.

Lines 120-121: “from the Siberian Oblast of Irkoustsk, Russia” No such administrative or geographical district in Russia.

Response: We thought the eastern edge of the Lake Baikal was under the Irkutsk Oblast district.

Applied changes: The sentence (L. 130) has been modified into a fifth transect has been done in the Sayan range along the Angara valley, Russia (*MRUT1, n = 12*, on

Fig. 1.G).

Line 129: cyperaceae should be Cyperaceae

Applied changes: Modified accordingly.

Lines 136-138: Strange choice of locations: both do not belong to the Mongolian plateau

Applied changes: The sentence (L. 149) has been modified into For the pollen analysis, the cores D3L6 from Unkelbach et al. (2019) located in the Mongolian Altai range and the Dulikha bog located in the Sayan range, Baikal area (Fig. 1, Bezrukova et al., 2005; Binney, 2017) are compared to the Xiangride section (XRD) used for brGDGT sequence from Sun et al. (2019), sampled in the Chinese Qaidam Basin and the NRX peat bog (Chinese Altai, Fig. 2, Rao et al., 2020).

Line 147: “the geography is characterized by the Baikal lake basin” What do you mean?

Applied changes: The sentence (L. 160-162) has been changed into In the northernmost part of the MP, the Baikal lake area is characterized by a basin at a lower altitude (around 600 m a.s.l, Fig. 3.G, Demske et al., 2005).

Line 153: The dark-taiga cannot be dominated by larches (Larix sibirica). Larch is dominant of light taiga.

Response: Indeed, we tried to apply these sub-taiga vegetation community to MP vegetation communities which is not right. We corrected this confusion using the description of both Demske et al., (2005) and Schlutz et al., (2008). Finally, they describe a Light taiga-riparian forest community in the Angara valley and a Mixed light/dark taiga–birches sub-taiga on the MP.

Applied changes: Finally, these vegetation communities have been described as following (L.164-166) The distribution of vegetation and biomes follows a latitudinal belt organization: in the North, the boreal forest presents a mosaic of light-taiga dominated by *Pinus sylvestris* mixed with riparian forest dominated by birches (*Betula* spp.), alders (*Alnus* spp.) and willows (*Salix* spp., Demske et al., 2005). On the MP, the light-taiga dominated by larches (*Larix sibirica*) and few birches is mixed with dark-taiga composed of Siberian pines (*Pinus sibirica*) and spruces (*Picea obovata*, Schlütz et al., 2008). Moreover, the Figs. 3 and 5 as well as the result paragraph 4.1.1 have been actualized following these new community definitions.

Line 164: Here should be references concerning vegetation description.

Applied changes: We used Demske et al., (2005), Dulamsuren et al., (2005b), Schlutz et al., (2008) and Klinge et al., (2018) as reference for the actual vegetation.

Line 165: “2.3 Bioclimate Systems” Do you mean ‘climate’?

Response: The use of the *Bioclimate* term allows to discuss the influence of climate systems on the vegetation communities of the MP.

Lines 174-175: “Mongolian summer precipitations are controlled by the East Asian

Summer Monsoon system (EASM) instead of the Westerlies'. Please provide references that in Northern Mongolia and the Altai Mountains are the summer precipitation controlled by EASM. I think it is not correct and even your Fig. 2 supports this.

Response: The question of the climate system influencing the MP is a tricky point still under debate (Piao et al., 2018). It seems that the westerlies dominate the surrounding areas but it is still paradoxical that almost all the precipitation occurs in summertime almost on the whole MP (Dulamsuren et al., 2005b) which is more associated with the EASM system. The northern part of this EASM front explain the precipitation amount up to the Baikal area (Shukurov et al., 2017 and periodic phenomenon (weak EASM involves anticyclone on the MP) could also explain the northwest set up of this front onto ACA and MP (Zhang et al., 2021). In any case, Piao et al., (2018) insist on the impact of the local water evaporation on the recycling moisture in MP and Siberia.

Applied changes: The sentence L. 191-193, has been changed and enriched as follows An unknown amount of precipitation occurs in winter as snowfall (Rudaya et al., 2020) which it is not always measured into the weather station MAP. The main part of the MP MAP occurs during the summer (climate diagrams from Dulamsuren et al., 2005). However, the precipitation origin for Mongolia is still under debate (Piao et al., 2018). Mongolian summer precipitations up to the Baikal area (Shukurov and Mokhov, 2017) seem to be controlled by the East Asian Summer Monsoon system (EASM) instead of the Westerlies' winter precipitation stocked onto the Sayan and Altai range (Fig. 2; An et al., 2008). The alternating Westerlies / EASM domination on the MP climate system appears to fluctuate throughout the Holocene depending on the monsoon strength (Zhang, 2021): the weakest is the monsoon, the furthest the EASM bring precipitation up to the ACA hyper-continental area. The EASM force may variate in function of the MP snow cover (albedo effect on sun radiance impact, Liu and Yanai, 2002) and/or the Pacific surface temperature (Yang and Lau, 1998). Finally,

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Piao et al. (2018) insist on the locally evaporated water recycling importance within the Mongolian MAP amount.

Line 206: “3.2 SIG Bioclimatic Data”. What is SIG?

Response and applied changes: SIG is the french version of a GIS. We have corrected this translation mistake.

Line 245: “Statistical Analyses”, but in lines 227-244 was also statistical analysis.

Response and applied changes: The part 3.3 is about GDGT analysis and the way we can connect brGDGT abundances with climate parameters. The part 3.4 is more about the general tools used in the study to describe the variance of the different data sets. To make it clearer the part 3.3 has been changed into GDGT Analysis and Calibrations .

Line 260, 279: “Siberian basin” is absent on the geographical map.

Response and applied changes: Siberian basin has been changed into Baikal area (L. 33, 105, 123, 130, 269, 287, 307, 412, 415, 416, 505, 530).

Lines 263-264: Fig 5 appears before Fig 4.

Response: The Fig. 4 is called line 245 for the fist time, the Fig. 5 appears after it, in line 280.

Lines 313-314: This information about isoGDGTs you can move to the part when you describe the brGDGTs in the introduction

Response and applied changes: The sentence has been moved to the introduction (L. 87).

Line 350: What is NSSM? This paper is going to publish in a journal with a wide readership. You have to explain specific terms.

Response and applied changes: The N_{SSM} value is the number of different Stepwise Selection Model (SSM) possible to calculate. We have reminded on the previous sentence (L. 375) the meaning of the SSM acronym.

Line 367: Fig. 8, appears before Fig. 7

Response and applied changes: The two figures have been interchanged to follow the text development.

Line 403: "the Siberian-Mongolian system seems to be mainly controlled by precipitation". I just want to emphasize that Siberia has a huge size and varied landscapes.

Response and applied changes: Here too, we changed the sentence in Baikal area-Mongolian Plateau . In the paragraph, we add also Southern to the Siberian-Mongolian system. The labels in the former Fig. 8 (newly Fig. 7) have also been modified from Siberian to Baikal .

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Lines 480: There is not Baikal basin on the geographical map. Baikal is divided into three basins, but it is about the lake.

Response and applied changes: Each Baikal basin have been replaced by Baikal area .

Lines 498, Fig. 9: NSMDB – wrong name

Response and applied changes: Modified accordingly, as well as in the Fig. 9 label.

Fig. 9: Negative values of MAP should be explained.

Response and applied changes: This point was addressed in the Referee 1 comments responses and we applied changes in the text.

Fig. 10. The chronological curve is filled only up to 5000 yr BP. Remove the blank part up to 6000 yr BP.

Response and applied changes: Modified accordingly.

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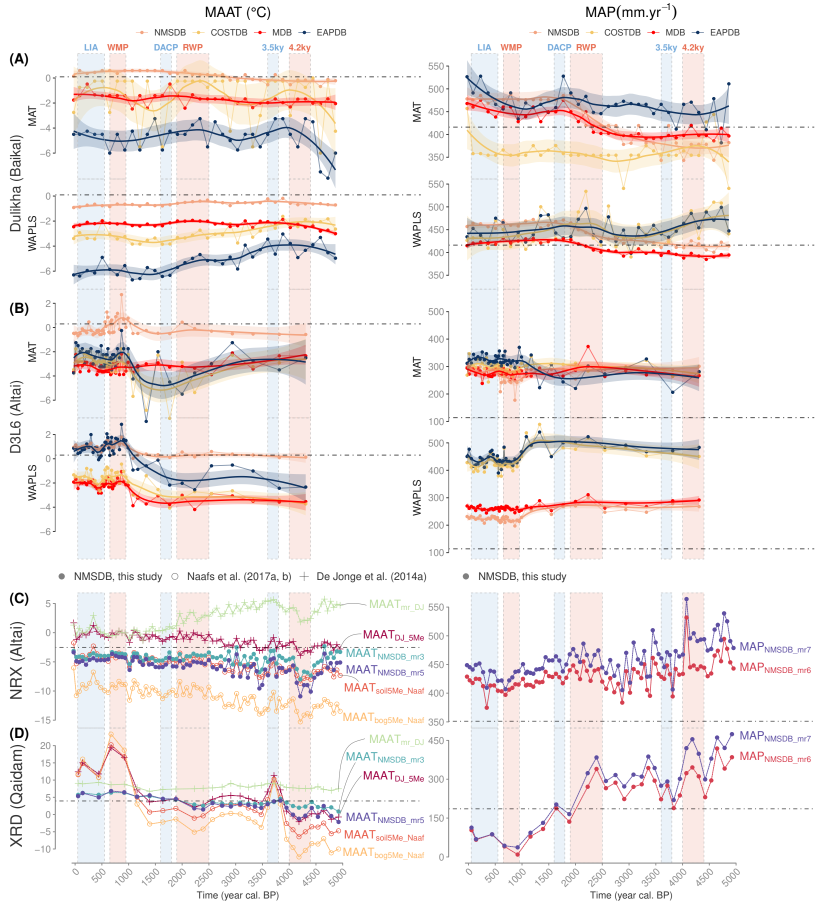

Fig. 1. ACA climate reconstruction for the 5000 year cal BP. A: climate–pollen inferred for the Dulikha and Lake D3L6. B: climate–brGDGT inferred MAAT and MAP.

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Discussion paper

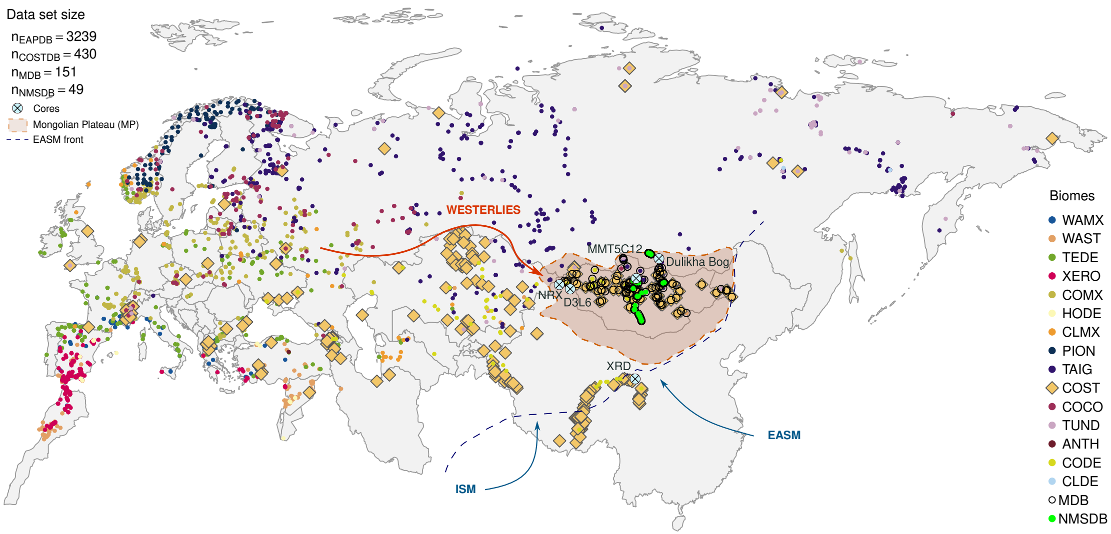

Fig. 2. Eurasian map of all the pollen surface samples included in the database. The color code refers to the biome pollen inferred for each site.

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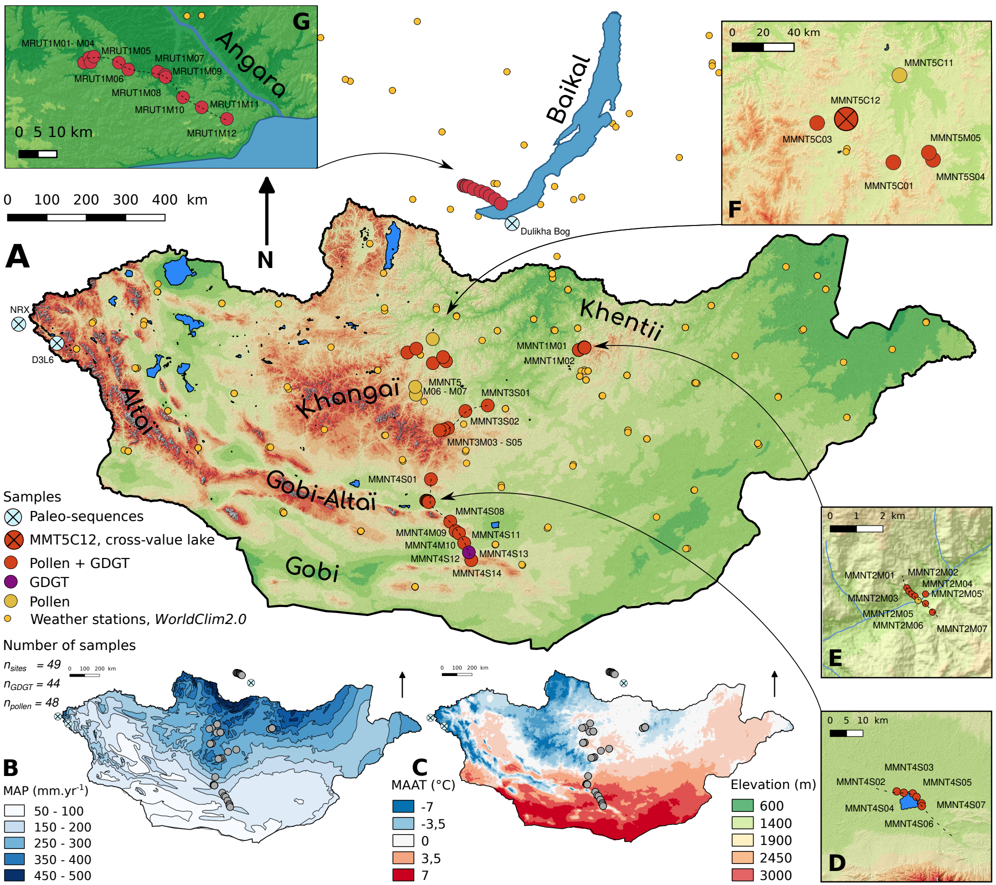

Fig. 3. A: Topographic map of Mongolia (from ASTER data) with the location of surface samples and weather stations considered in the present study; B: MAP; C: MAAT; D: Gobi desert focus; E: Khentii focus