Dear Editor and Reviewer#1:

On behalf of the co-authors, we are very grateful to you for giving us an opportunity to revise our manuscript. We really appreciate your positive and constructive comments together with suggestions on our manuscript entitled 'BrGDGTs-based seasonal paleotemperature reconstruction for the last 15,000 years from a shallow lake on the eastern Tibetan Plateau' (MS No.: cp-2023-32). We have therefore studied reviewer' comments carefully and tried our best to revise our manuscript accordingly. Notably, the changes are highlighted in red in the revised manuscript. Please see below for a point-by-point response to the reviewers' comments and concerns.

Responds to the comment of Reviewer#1:

The potential seasonal bias produced by terrestrial archives are important to better understand the so-called "Holocene Temperature Conundrum", the difference between simulated global Holocene warming and proxy-reconstructed global Holocene cooling. In this manuscript, Hou et al analyze down-core brGDGTs from a sediment core collected from Gahai Lake on the eastern Tibetan Plateau. Based on brGDGTs, they reconstruct an ice-free season (May to September) temperature over the past 15 ka. They also compare the new record with a previously published pollen-based July temperature record from the same core, and find that Holocene Thermal Maximum in the ice-free season record lags that in the July temperature record. They also review other published brGDGT-based temperature records, and evaluate differences among them. They emphasize the importance of considering lake conditions and modern-process investigations when using brGDGTs to reconstruct past climate changes.

Overall, I think this study provide some valuable data to better understanding the seasonal bias in Holocene temperature reconstruction. In particular, difference records from the same sediment core from the same lake add the credibility of the results. Moreover, the systematic modern process analyzes for brGDGTs sources in lake catchment basin significantly improve the quality of the reconstructed record. Therefore, I would recommend a minor revision.

One main issue the authors should be considered is the chronology. They author simply cited the age-model results from a published paper, without any detailed explanation. For my understanding, as an independent paper, the author should necessarily and concisely explain how they reconstructed the age model and how they evaluate the potential "old carbon" effect. Although these potential age uncertainties won't affect the main finding for Holocene climate changes, they seem do affect the timing of the deglacial BA and YD events.
Response: We are very grateful to you for your meaningful comments. As you said, as an independent article, it should indeed have a detailed introduction to the chronology. We have included this part in the text, please see line 187-213.

“The chronology of the upper 20 cm of the sediment core is based on measurements of ^{210}Pb and ^{137}Cs, at a 1-cm interval. The chronology for the deeper part of the core is provided by accelerator mass spectrometry (AMS) ^{14}C measurements of 13 bulk sediment samples, which were conducted by Beta Analytic Inc. (Miami, USA) (Fig. 2) (Wang et al., 2022).

The ^{210}Pb age model was constructed using the constant rate of supply (CRS) model and the ^{137}Cs peak was used as supplement (Appleby, 2002). The calculated age of ^{210}Pb using CRS model aligned well with the ^{137}Cs peak at 6 cm. Overall, the CRS model was deemed suitable for determining the age of Gahai lake.

Reservoir age, as highlighted by Hou et al. (2012), is a crucial factor affecting the age determination of lake sediment cores on the TP. Therefore, it was necessary to establish the reservoir age of Gahai lake before undertaking paleoclimate reconstruction. The linear extrapolation relationship between the ^{14}C ages and depth to the sediment-water interface is often used to estimate the reservoir age. The ^{14}C age of 13 samples exhibits a good linear relationship with sediments depth in Gahai lake. Extrapolation of this 13 ^{14}C ages down to the depth of 6 cm yielded a ^{14}C age of 461 yr BP, while the reliable ^{210}Pb age at 6 cm is -27 yr BP. Consequently, the difference between the two ages, which amounts to 488 yr, was taken as the reservoir age. Additionally, it’s worth noting that independent estimations of the ^{14}C calibration age and ^{210}Pb age around 10 cm in Gahai lake was obtained, resulting in values of 497 yr BP and 18 yr BP, respectively. The difference of 479 yr between these two ages can also be considered as the reservoir age. These two methods of estimating reservoir age of Gahai lake show very close, which are mutually supportive. So, the average of 483 yr was adopted as the reservoir age. All original ^{14}C dates were corrected by subtracting the reservoir age (483 yr) and calibrating them to calendar ages using Calib 8.1. The age-depth model (Fig. 2) was constructed using the Bacon program with the ^{14}C ages and ^{210}Pb ages (Blaauw and Andres Christen, 2011) and was reported by Wang et al. (2022).”

Reference:

Appleby, P.G., 2002. Chronostratigraphic techniques in recent sediments. In: Tracking Environmental Change Using Lake Sediments. Springer, pp. 171–203.

Blaauw, M., Andres Christen, J., 2011. Flexible Paleoclimate Age-Depth Models Using an Autoregressive Gamma Process. Bayesian Analysis 6, 457-474.

Hou, J.Z., D'Andrea, W.J., Liu, Z.H., 2012. The influence of 14C reservoir age on interpretation of paleolimnological records from the Tibetan Plateau. Quaternary Science Reviews 48, 67-79.

Wang, N., Liu, L., Hou, X., Zhang, Y., Wei, H., Cao, X., 2022. Palynological evidence reveals an arid early Holocene for the northeast Tibetan Plateau. Climate of the Past 18, 2381-2399.

Comment: L39, on "the" TP;
Response: Thanks for the suggestion, we have added "the".

Comment: L47, add "a more" before "rapid warming";
Response: Thanks for the suggestion, we have added "a more".

Comment: L60, I think there are "many" rather than "several" records being published, as you listed in the following sentences.
Response: Thanks for your reminder, we have changed "several" into "many".

Comment: L63, "ice cores" rather than "ice deposits";
Response: Thanks for the suggestion, we have corrected it.

Comment: L92-94, this sentence is a bit confuse, consider to rewrite;
Response: Thanks for the suggestion, we have rephrased this sentence as follows: "Extensive research has been conducted in lakes, employing a single proxy to reconstruct past temperature fluctuations. However, there have been scarce studies that employ various proxies within the same core to reconstruct paleotemperature variations. Furthermore, the limited number of studies primarily concentrate on reconstructing summer temperature and annual average temperature". Please see line 94-99.

Comment: L114, I think the reference "Zhao et al., 2013" is based on alkenones rather than brGDGTs, right?
Response: Thank you very much for your reminder, we have deleted this reference here.

Comment: L117-120, write this sentence, it a bit confuse now;
Response: Thanks for the suggestion, we have rephrased this sentence as follows: "Lake sediments, characterized by their organic matter-rich composition, exhibit continuous and rapid accumulation rates. As a result, they offer high-resolution records of environmental changes, making them highly valued as a primary terrestrial climate archive". Please see line 122-125.

Comment: L143, delete "and it", and replace "which" with "and"; also note Tao "River" and Yellow "River";
Response: Thanks for your suggestion, we have corrected it.

Comment: L148, what is the time/year coverage of the meteorological data? From 1981 to the present, or something else?
Response: Thanks for your meaningful comments. The meteorological data coverage at Langmu Temple station spans from 1957 to 1988. We have added this in the manuscript.

Comment: L149, be specific on how many soil samples, rather than using “several”;
Response: Thanks for your reminder. Four catchment soil samples were collected from around the lake. As per your suggestion, we have explicitly mentioned this number (four catchment soils) in the manuscript.

Comment: L175, the more information for chronology should be briefly summarized here as an independent paper;
Response: Thanks for your meaningful comment. We have modified this section, please see line 187-213.
“The chronology of the upper 20 cm of the sediment core is based on measurements of ^{210}Pb and ^{137}Cs, at a 1-cm interval. The chronology for the deeper part of the core is provided by accelerator mass spectrometry (AMS) ^{14}C measurements of 13 bulk sediment samples, which were conducted by Beta Analytic Inc. (Miami, USA) (Fig. 2) (Wang et al., 2022).

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Reservoir age, as highlighted by Hou et al. (2012), is a crucial factor affecting the age determination of lake sediment cores on the TP. Therefore, it was necessary to establish the reservoir age of Gahai lake before undertaking paleoclimate reconstruction. The linear extrapolation relationship between the ^{14}C ages and depth to the sediment-water interface is often used to estimate the reservoir age. The ^{14}C age of 13 samples exhibits a good linear relationship with sediments depth in Gahai lake. Extrapolation of this 13 ^{14}C ages down to the depth of 6 cm yielded a ^{14}C age of 461 yr BP, while the reliable ^{210}Pb age at 6 cm is -27 yr BP. Consequently, the difference between the two ages, which amounts to 488 yr, was taken as the reservoir age. Additionally, it’s worth noting that independent estimations of the ^{14}C calibration age and ^{210}Pb age around 10 cm in Gahai lake was obtained, resulting in values of 497 yr BP and 18 yr BP, respectively. The difference of 479 yr between these two ages can also be considered as the reservoir age. These two methods of estimating reservoir age of Gahai lake show very close, which are mutually supportive. So, the average of 483 yr was adopted as the reservoir age. All original ^{14}C dates were corrected by subtracting the reservoir age (483 yr) and calibrating them to calendar ages using Calib 8.1. The age-depth model (Fig. 2) was constructed using the Bacon program with the ^{14}C ages and ^{210}Pb ages (Blaauw and Andres Christen, 2011) and was reported by Wang et al. (2022).”

Reference:

Appleby, P.G., 2002. Chronostratigraphic techniques in recent sediments. In: Tracking Environmental Change Using Lake Sediments. Springer, pp. 171–203.
Blaauw, M., Andres Christen, J., 2011. Flexible Paleoclimate Age-Depth Models

Using an Autoregressive Gamma Process. Bayesian Analysis 6, 457-474.
Hou, J.Z., D'Andrea, W.J., Liu, Z.H., 2012. The influence of ^{14}C reservoir age on interpretation of paleolimnological records from the Tibetan Plateau. Quaternary Science Reviews 48, 67-79.
Wang, N., Liu, L., Hou, X., Zhang, Y., Wei, H., Cao, X., 2022. Palynological evidence reveals an arid early Holocene for the northeast Tibetan Plateau. Climate of the Past 18, 2381-2399.

Comment: L215-216, significantly “higher”? double check;
Response: Thank you very much for your reminder, we have corrected it here, it should be “lower”.

Comment: L224, replace “abundant” with “abundance”;
Response: Thanks for the suggestion, we have corrected this.

Comment: L276, replace “like” with “close to”;
Response: Thanks for the suggestion, we have replaced “like” with “close to”.

Comment: L285, replace “a” before “new Bayesian” with “the”;
Response: Thanks for the reminder, we have replaced “a” with “the” here.

Comment: L298-306, some references here (if there are) would be more helpful. Another possible reason is that the frozen lake surface in winter would insulate the lake water to the atmosphere. Even if there are brGDGTs produced within lake water, they were no longer able to track atmospheric temperature changes during the frozen season (as discussed Sun et al., 2021 and Zhang et al., 2022b as you cited);
Response: Thank you for your suggestion. We have updated the references and modified this section with your meaning suggestion. Below is what we updated, which can also be seen on lines 292-295 and lines 318-323.

Lines 292-295: “Gahai is a shallow lake that is usually completely frozen during winter and spring, and the local meteorological data show that the average snowfall period is 269 days, and that the snowfall period lasts for ~50 days (Luqu County Local Chronicles Compilation Committee, 2006).”

Lines 318-323: “Additionally, the presence of the frozen lake surface during winter creates a thermal barrier, impeding the exchange of heat between the lake water and the atmosphere. Consequently, any brGDGTs generated within the lake water during this period lose their ability to accurately reflect atmospheric temperature variations (Sun et al., 2021; Zhang et al., 2022a). Thus, they were no longer able to track atmospheric temperature changes during the frozen season. So, we prefer to use Gahai brGDGTs to reconstruct temperatures during the summer and ice-free seasons.”

Reference:

Luqu County Local Chronicles Compilation Committee., 2006. Luqu County Chronicles. Gansu Cultural Publishing House, Lanzhou. pp. 71.

Sun, X., Zhao, C., Zhang, C., Feng, X., Yan, T., Yang, X., Shen, J., 2021. Seasonality in Holocene Temperature Reconstructions in Southwestern China. Paleoceanography and Paleoclimatology 36.

Zhang, C., Zhao, C., Yu, S.-Y., Yang, X., Cheng, J., Zhang, X., Xue, B., Shen, J., Chen, F., 2022a. Seasonal imprint of Holocene temperature reconstruction on the Tibetan Plateau. Earth-Science Reviews 226, 103927.

Comment: L312-314, note the time intervals for BA and YD are different with our current knowledge, this should be briefly discussed;

Response: Your suggestion is very helpful to us. In summary, our records indicate a slight temperature increase during 14.8-11.8 ka, followed by a period of temperature decrease from 11.8-10.5 ka. We propose that these temperature fluctuations may correspond, within the range of dating uncertainties, to the Bølling-Allerød (B/A, 14.8–12.8 ka) and Younger Dryas (YD, 12.8–11.7 ka) events, respectively. Due to the potential presence of age uncertainties, we did not provide detailed elaboration on this aspect in the original text. Additionally, as observed in the Fig. 5a, there is a scarcity of test samples during the 11.8-10.5 ka period. This is attributed to GDGT concentrations falling below the detection limit in these samples. Consequently, we directly connected the reconstructed temperatures at the two points, 11.8 ka and 10.5 ka, resulting in the lowest temperature occurring around 10.5 ka. This deviation in timing introduces a discrepancy with the occurrence of the YD event. We also speculate that climate changes prior to 11.8 ka might have influenced the samples, leading to exceptionally low GDGT concentrations, while the YD event was occurring circa 12.9 ka to 11.7 ka BP. Furthermore, the description provided in our original text may not be accurate, and it is necessary to tone down the assertion of a direct relationship between these two temperature fluctuations and the B/A and YD events. Therefore, we have made the following modifications to this section.

"Within the range of age uncertainties, weak warming occurred during 14.8–11.8 ka, likely corresponding to the Bølling–Allerød (B/A) interstadial. A minor cold reversal occurred during 11.8–10.5 ka, potentially corresponding to the Younger Dryas (YD) event. Notably, the samples collected between 11.8 ka and 10.5 ka exhibited GDGT concentrations below the detection limit. Therefore, we directly linked the temperature reconstructions at the two aforementioned time points, ~11.8 ka and ~10.5 ka, resulting in the lowest temperature of this time period appearing around 10.5 ka. This may cause a time lag with the occurrence of the YD event." Please see lines 378-385.

Comment: L330-333, should mention here you will discuss this in the later section.

Response: Thanks for your suggestion. We have appended a sentence after this statement, indicating that we will conduct a detailed discussion in the following section. Please see line 415.

Comment: L396-398, why jump to Indian monsoon here? Anything related with your discussion on temperature changes? In particular, the monsoon changes shown by oxygen isotopes from Dongge Cave (as you cited in Figure 6h) do not show a weakened monsoon during the early Holocene. Suggest to delete this sentence.
Response: Thanks for your meaningful comments. We have deleted this sentence.

Comment: L453-456, this statement is not true. In Zhao et al., 2021b (as you cited), they have compared both data using the same calibration, and found a quite similar result.
Response: Your suggestion is very important to us and thanks for your reminder. We have deleted this sentence.