Response to Referee 2

The authors would like to thank the reviewer for the constructive feedback and kind advice, and the thorough assessment of the manuscript. Below, we are providing a point-to-point response to each comment: Reviewer comments are given in black, and our responses are given in blue. Additionally, we have included details of how we address these changes in the revised submission.

The authors provided a valuable dataset of GST observations at various spatial scales in the Headwater Area of the Yellow River (HAYR). GST datasets were collected at 39 sites between 2019 and 2020. The authors showed how the measurements could be used for permafrost research.

Thank you for your kind summary! We have tried our best to address the raised issues as follows.

General Comments

(1) Overall picture

While the authors provide a very detailed comparison of GST at different scales, this study generally lacks an overall picture. An easy way to do this would be to examine the lapse rate of MAGST. There should be a new figure with the x-axis representing elevation and the y-axis representing MAGST. You could even use different colors to represent vegetation cover.

Indeed, as suggested by Referee 1, the influence of elevation on GST spatial variability has been detailed and assessed, including a graphical representation of the decrease of GST with elevation (please see Figure 4 from Șerban et al., 2023). In that figure, the elevation is exactly represented on the x-axis, MAGST on the y-axis, and landcover with different colors. Additionally, the regression lines are added to indicate that the more significant decrease of MAGST is visible in bare ground than in vegetated sites. The lapse rate has been calculated as well:

"The MAGST in the study area declines with a vertical lapse rate of –3.9 °C/km for alpine meadows, –7.3 °C/km for bare grounds, and –9.4 °C/km for alpine swamp meadows. Considering all landcover types together, MAGST lowers at a vertical lapse rate of –6.8 °C/km." (Șerban et al., 2023).

In this data paper, we avoided repeating the same analysis and we focused more on the intra-plot variability of GST. We only briefly mentioned:

L83-84: "The variability of MAGST at other scales and their environmental controls have been assessed in detail by Serban et al. (2023)."

L306-308: “The intra-site MAGST variability has been mainly controlled by elevation and landcover types (Șerban et al., 2023), similar to observation from the Swiss Alps (Gubler et al., 2011).” has been replaced with “The intra-site MAGST variability has been mainly controlled by elevation and landcover types (as is shown in Fig. 4 of Șerban et al., 2023), similar to observation from the Swiss Alps (Gubler et al., 2011). Slope and aspect do not play a relevant role because the monitoring plots are located mostly in flat areas (Șerban et al., 2023).”

(2) Permafrost borehole temperature datasets

A borehole temperature measurement from Luo et al., 2018 was used to determine whether permafrost was present. As an additional dataset, I suggest authors make the borehole temperature measurements public open.

That dataset of borehole temperature is not openly available at this moment but is planned to be published in the near future. However, in our comparisons, we only used the average values from Table 1 from Luo et al., 2018 and not the full dataset. Therefore, we only cite the respective paper.

(3) Review of GST measurements

In the CMA monitoring network, GST has been measured since the 1950s on the QTP and even the entire country. In spite of this, the measurement algorithm is inconsistent, making direct use of the dataset problematic (see Cui et al., 2020, Cao et al., 2023). Therefore, the datasets here are valuable. It would be helpful if you reviewed the measurement algorithms and clarified your significance.

Although this work is not focused on reviewing older measurements of GST from other networks, we further emphasized the importance of this dataset recorded through automatic measurements as suggested. The following changes have been made:

L62-65: “Although the GST started to be manually measured since the 1950s through the network of the China Meteorological Administration, these earlier measurements were inconsistent with the recent automatic measurements. Furthermore, the manual protocol of historical measurements was highly biased by the presence of snow cover (Cao et al., 2023; Cui et al., 2020).” has been added.

Specific Comments

L37: ...approximate or about 55%.

L39: "because 55%" has been replaced with "because about 55%"

L39: Cao et al., 2019 PPP reported the permafrost zonation index map based on a statistical model and various measurements. Please consider citing here.

L40: "and 41% by permafrost (Zou et al., 2017; Cao et al., 2022)" has been replaced with "and 40 to 46% by permafrost (Zou et al., 2017; Cao et al., 2019b, 2022)."

L44: Cao et al., 2018, JGR-Atmospheres reported the permafrost changes over the Northeastern QTP.

In lines 44 and 45, we speak about the models that predict the spatial distribution and the future evolution of the permafrost at the regional level of the entire QTP. The suggested paper analyzed in-situ observations from boreholes in a small area from northeastern QTP and it does not match with the context of this paragraph.

L45-46: "Earth system models predicted that permafrost thicker than 10 m covers 36% of the QTP and permafrost thickness will continue to decrease at rates of up to 21 cm per year under various climate change scenarios (Zhao et al., 2022)".

However, the suggested paper also reports values of MAGST observations from another mountain range from the northeastern QTP and is more suitable for comparison in the results and discussions section. The following changes have been made:

L322-323: "MAGST variations of up to 3 °C were also reported from the Qilian Mountains on the northeastern QTP (Cao et al., 2018)." has been added.

L56: Cao et al., 2020 TC (Table 1) reported how the MAGST combined with thermal offset can be used as an indicator for permafrost presence/absence.

Thank you very much for this suggestion. Indeed, very useful thresholding was determined for the QTP. The following changes have been made:

L57-58: "… delineate the distribution of SFG and permafrost (Rödder and Kneisel, 2012; Vieira et al., 2017; Luo et al., 2019; Wani et al., 2020; Serban et al., 2021; Jiao et al., 2023)(Cao et al., 2019; Jiao et al., 2023; Luo et al., 2019; Rödder and Kneisel, 2012; Serban et al., 2021; Vieira et al., 2017; Wani et al., 2020).” has been replaced with “… delineate the distribution of SFG and permafrost (Rödder and Kneisel, 2012; Vieira et al., 2017; Luo et al., 2019; Cao et al., 2019a; Wani et al., 2020; Serban et al., 2021; Jiao et al., 2023).”

L369-370: “On the QTP, a MAGST (including the maximum thermal offset of 0.79 °C) that is below or equal to 0 °C indicates the permafrost presence (Cao et al., 2019a).” has been added.

L104: Please clrify the landcover and microtopography information here.

L111-115: “Therefore, GST has been monitored in different landcover types, such as the alpine steppe, meadow, swamp meadows, and bare grounds. In terms of microtopography, GST is monitored mostly on flat terrains but also in disturbed grounds by highway construction, thermokarst depressions, between thermokarst ponds, earth hummocks, and near gullies..” has been added.

L121-122: “Sites are placed in the proximity of both sides of the highway in different landcover types, such as the alpine steppe, meadow, swamp meadow, and bare ground.” has been replaced with “Sites are placed in the proximity of both sides of the highway in different landcover types.”

L132-133: “Differentiation is caused by micro-topography and landcover variety because sites are placed in alpine meadows, swamp meadows, bare grounds, disturbed grounds by highway construction, thermokarst depressions, between thermokarst ponds, and near gullies. The linear distance between sites is ranging from 70 to 465 m, with an average of 275 m.” has been replaced with “Differentiation is caused by micro-topography and landcover variety, while the linear distance between sites ranges from 70 to 465 m, with an average of 275 m.”

L135: *“…for some sites…”*, please give the number of sites which have similar landcover.

L142-143: “For some sites, …” has been replaced with “For 26 sites, ….”

L170: change *larger* to greater

L178: “An FN larger than 0.5” has been replaced with “An FN greater than 0.5”

L173: The principle behind SO and TO is the effects of vegetation cover, and soil properties (soil organic content, soil moisture). Please clarify here.

L182-185: “The surface offset is driven by snow cover and solar radiation and controlled by topography and vegetation. Thermal offset is mainly controlled by heat transfer and influenced by different soil thermal conductivities in the frozen and thawed states determined by soil properties, such as soil texture and soil moisture, and organic contents (Smith and Riseborough, 2002; Wani et al., 2020)." has been added.

L193: change "*delete*" to remove

L204: "to detect measurement errors" has been replaced with "to detect and remove measurement errors"

L231: "*Differences larger than 2.5 ºC were observed mainly at the sites at elevations above 4600 m a. s. l., regardless of the landcover types in the plots." why?*

These larger differences at higher elevations could be related to the temperature inversion observed on the elevational transect (Șerban et al., 2023). While these temperature inversions showed seasonality, being more visible in spring and especially in winter, they could also indicate a diurnal variability as these high daily differences appear predominantly in autumn, winter, and spring. The following changes have been made:

L248-252: "The larger intra-plot difference in daily GST at higher elevations may be related to the temperature inversion observed on the elevational transect. These temperature inversions showed seasonality, being more visible in spring and especially in winter (Șerban et al., 2023). However, they could also indicate a diurnal variability caused by the strong radiation cooling under dry conditions and the local air circulation. The spatial differences in the reduction of plant species and root biomass could also increase the GST due to the decrease of evapotranspiration (Du et al., 2007)." has been added.

Fig.1: Please add the specific distance for each scale in the legend.

The specific distance for each scale has been added in the legend.

References

Cao, B., Zhang, T., Peng, X., Mu, C., Wang, Q., Zheng, L., Wang, K., & Zhong, X. (2018). Thermal Characteristics and Recent Changes of Permafrost in the Upper Reaches of the Heihe River Basin, Western China. *Journal of Geophysical Research: Atmospheres*, *123*(15), 7935–7949. https://doi.org/10.1029/2018JD028442

Cao, B., Zhang, T., Wu, Q., Sheng, Y., Zhao, L., & Zou, D. (2019). Permafrost zonation index map and statistics over the Qinghai-Tibet Plateau based on field evidence. Permafrost and Periglacial Processes, 30(3), 178–194. https://doi.org/10.1002/ppp.2006

Cao, B., Zhang, T., Wu, Q., Sheng, Y., Zhao, L., & Zou, D. (2019). Brief communication: Evaluation and inter-comparisons of Qinghai–Tibet Plateau permafrost maps based on a new inventory of field evidence. *The Cryosphere*, *13*(2), 511–519. https://doi.org/10.5194/tc-13-511-2019

Cao, B., Wang, S., Hao, J., Sun, W., & Zhang, K. (2023). Inconsistency and correction of manually observed ground surface temperatures over snow-covered regions. *Agricultural and Forest Meteorology*, *338*(November 2022), 109518. https://doi.org/10.1016/j.agrformet.2023.109518

Cui, Y., Xu, W., Zhou, Z., Zhao, C., Ding, Y., Ao, X., & Zhou, X. (2020). Bias Analysis and Correction of Ground Surface Temperature Observations across China. Journal of Meteorological Research, 34(6), 1324–1334. https://doi.org/10.1007/s13351-020-0031-9

Luo, D., Jin, H., Jin, X., He, R., Li, X., Muskett, R. R., Marchenko, S. S., & Romanovsky, V. E. (2018). Elevation-dependent thermal regime and dynamics of frozen ground in the Bayan Har Mountains, northeastern Qinghai-Tibet Plateau, southwest China. Permafrost and Periglacial Processes, 29(4), 257–270. https://doi.org/10.1002/ppp.1988

Du, M., Kawashima, S., Yonemura, S., Yamada, T., Zhang, X., Liu, J., Li, Y., Gu, S., and Tang, Y.: Temperature distribution in the high mountain regions on the Tibetan Plateau - Measurement and simulation, in: MODSIM07 - Land, Water and Environmental Management: Integrated Systems for Sustainability, Proceedings, 2146–2152, 2007.

Luo, D., Jin, H., Jin, X., He, R., Li, X., Muskett, R. R., Marchenko, S. S., and Romanovsky, V. E.: Elevation-dependent thermal regime and dynamics of frozen ground in the Bayan Har Mountains, northeastern Qinghai-Tibet Plateau, southwest China, Permafr. Periglac. Process., 29, 257–270, https://doi.org/10.1002/ppp.1988, 2018b.

Șerban, R. D., Bertoldi, G., Jin, H., Șerban, M., Luo, D., and Li, X.: Spatial variations in ground surface temperature at various scales on the northeastern Qinghai-Tibet Plateau, China, Catena, 222, 106811, https://doi.org/10.1016/j.catena.2022.106811, 2023.

Smith, M. W. and Riseborough, D. W.: Climate and the limits of permafrost: a zonal analysis, Permafr. Periglac. Process., 13, 1–15, https://doi.org/10.1002/ppp.410, 2002.

Wani, J. M., Thayyen, R. J., Gruber, S., Ojha, C. S. P., and Stumm, D.: Single-year thermal regime and inferred permafrost occurrence in the upper Ganglass catchment of the cold-arid Himalaya, Ladakh, India, Sci. Total Environ., 703, 134631, https://doi.org/10.1016/j.scitotenv.2019.134631, 2020.