Authors reply to the comments by Jan Beutel of the manuscript essd-2020-106

"An integrated observation dataset of the hydrological-thermal-deformation dynamics in the permafrost slopes and engineering infrastructure in the Qinghai-Tibet Engineering Corridor"

by Lihui Luo et al.

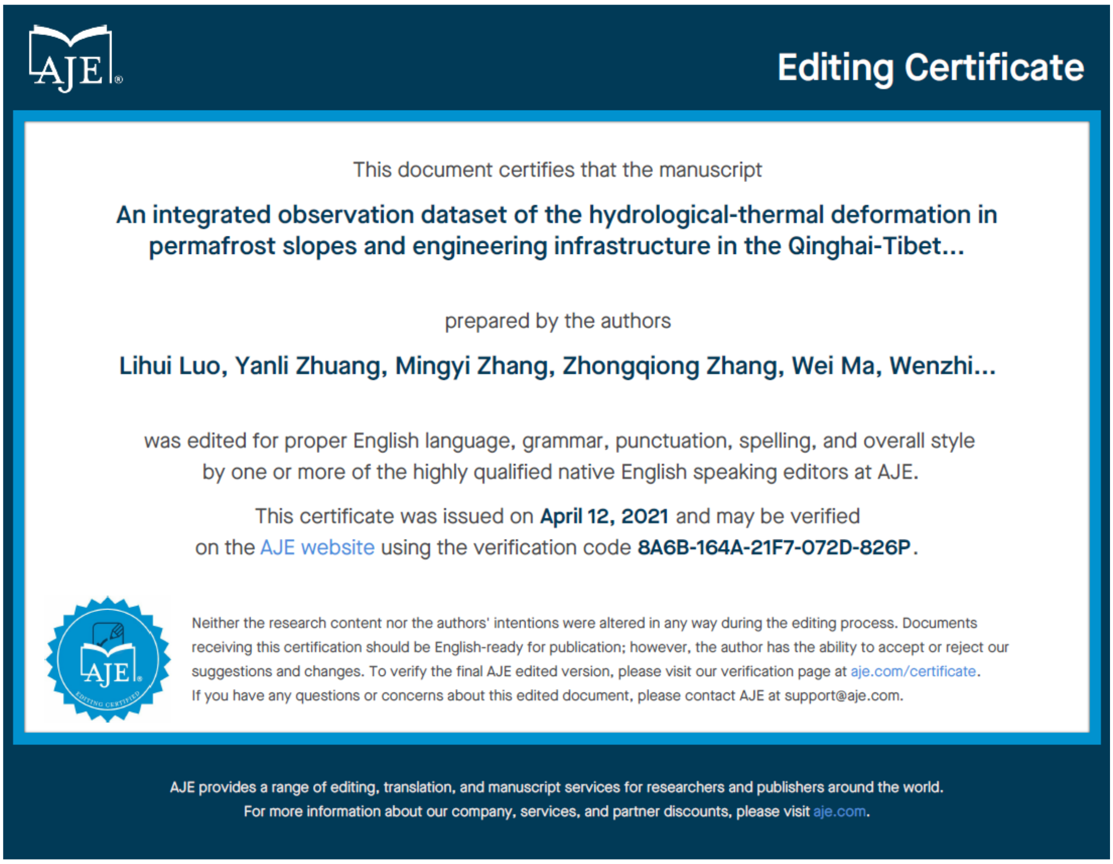
We thank Dr. Jan Beutel for valuable feedback, which helped us improve the manuscript. Please find below the Referee comments in black, Author responses in green, and Changes to the manuscript in blue.

Response to referee comment 1:

Dear authors,

This paper gives an overview of measurement data derived from permafrost study sites in the Kunlun Mountain Pass area of the Qinghai-Tibet Plateau, China. The paper describes the locality with focus on the collocated engineered structures of the Qinghai-Tibet highway, railway and power lines. The paper is a companion to data and processing code published on zenodo.org (Meteo/ground measurements, TLS, UAV images). This paper supersedes further publications by the authors that are based in part of this data. It is highly appreciated that the authors take the extra effort to collate and describe multiple datasets into one common format and data publication. However, in the present form, the paper is incomplete w.r.t. to a number of details, the metadata describing the data as well as the processing code provided. Two datasets mentioned (Xidatan weather, ground observations, sentinel InSAR data) are not provided. Apart from textual issues I will elaborate below and in the attached commented manuscript pdf file the main issue is that I was not able to run the code in conjunction with the datasets provided. Furthermore some references are missing/misleading. Some of the figures in this paper have already appeared elsewhere (other papers by the authors). Therefore they should be clearly marked as references.

Thank you for the insightful comments. In revising the paper, we have carefully considered your comments and suggestions. We agree with your comments regarding the metadata, code execution, and data description, among others. To address these concerns, we have made the following modifications to the manuscript: (1) we have added README.md files for the entire dataset of the manuscript and for each data set, such as meteorological and ground observations, TLS measurements, UAV RGB and TIR images, and R code of permafrost indices and visualization, and generated the corresponding README pdf and html files; (2) we have checked the integrity of the data file and added the missing data, including InSAR data and the study area boundary shapefile data in the TLS measurement dataset; (3) we have added vector and raster data of the boundary, DSM (digital surface model), and mosaic of the study area processed by UAV monitoring data; (4) we have renamed some data files because it was difficult for data users to obtain certain data due to naming reasons, and reorganized the file directory, (5) we have modified many inappropriate expressions, including the title; (6) we have updated the data DOI; (7) we have deleted some references with little relevance and added some related references; and (8) we have improved the flow of the language throughout the manuscript (Figure R1). We have tried our best to address each of your points in detail. We feel the revision represents an improvement, and we hope that you agree. For more details, please see our replies below.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An integrated observation dataset of the hydrological-thermal deformation in permafrost slopes and engineering infrastructure in the Qinghai-Tibet...

prepared by the authors

Lihui Luo, Yanli Zhuang, Mingyi Zhang, Zhongqiong Zhang, Wei Ma, Wenzhi...

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Figure R1. Editorial Certificate.

Specific comments:

You are using the term “hydrological-thermal deformation dynamics” and “hydrological thermal deformation” interchangeably. I understand the first term with dynamics, but am not sure the second is correct. What exactly is a hydrological deformation? I understand thermal deformation (contracting/expansion of a material under thermal stress) and I think I know what you want to say. I would rather talk about permafrost or ground dynamics or ground deformation in the context of landslides or precursor patterns rather than combining process origin (thermal/hydrological) with the observed effect (deformation) in one long term.

The water, heat, and deformation of the permafrost slopes and their surroundings are monitored. We mainly want to describe the three main monitoring factors of water, heat, and deformation. For a clearer description, we have revised the title of the manuscript to "An integrated observation dataset of the hydrological-thermal deformation in permafrost slopes and engineering infrastructure in the Qinghai-Tibet Engineering Corridor". Simultaneously, for consistency of expression, the term "hydrological-thermal deformation" is used throughout the manuscript.

Much of your intro argumentation centers around the impact of engineering structures (man made interference through the immediate built environment) on permafrost in QTP and resulting hazards. While this is clearly an important issue a number of references given do not relate to this or should be explained in a different context (see annotations). Also in your data description it is not clear what data are influenced by engineering (and possibly how much) and what data are not influenced by QTH/QTR etc.

Roads, railways, and electric towers stand beside or on these two slopes. The operation of these projects affects the water, heat, and deformation of these two slopes. Therefore, the slope-related data we observe are all affected by the project operations. We have checked all the references and explained the data. For updates on some references, please see the answers below.

The data should be described concisely with correct metadata. Your data packages and references to the data in the paper do not match, file/directory naming is not explanatory. Please provide a global inventory of the data provided and exact file descriptors. Also it seems your dataset covers data from 1955-2020 (in some parts) but your paper mentions the period 2014-2019. Please clarify. Most importantly the files for ground observations are missing.

We have added metadata files README.md for all data sets and generated the corresponding html and pdf format files. The study area embeds Google Maps in the README.md file. Meteorological and ground observations, as well as the R code of permafrost indices and visualization, include the period from 1955 to 2019. TLS measurements and UAV RGB and TIR images are from 2014 to 2017. We have added a description of the time period in the main text and README.md.

You are using a time-domain reflectometer (TDR) probe (model CS615-L, Campbell Scientific) for assessing the soil volumetric content. The probe is specified by the vendor (followup product CS616) for operation in 0-70℃ only. However you present data in figure 4 down to -16℃. https://www.campbellsci.com/cs616-reflectometer Operating Temperature Range 0℃ to +70℃. Furthermore Or, Dani, and Jon M Wraith. 1999. "Temperature Effects on Soil Bulk Dielectric Permittivity Measured by Time Domain Reflectometry: A Physical Model." Water Resources Research

35 (2): 371–83. https://doi.org/10.1029/1998WR900008. P. Overduin, Pier & Yoshikawa, Kenji & Kane, D. & Harden, J. (2005). Comparing electronic probes for volumetric water content of low-density feathermoss. Sensor Review. 25. 215-221. 10.1108/02602280510606507. Detail that it is not at all straightforward to measure these quantities in the frozen state. Therefore I suggest to (1) remove moisture data below T = 0 °C or (2) at least mention that this data must be treated with utmost care as it is outside the spec of the instrument you are using.

Thank you for the insightful comments. Calibrations of TDR derived from unfrozen soil may not apply to frozen soil, where water is replaced by ice (Spaans and Baker, 1995). Indeed, soil moisture below 0% is difficult to measure, and there are many uncertainties for measuring data below 0 °C. Because there are too many soil moisture data for soil temperatures below 0 °C, we have retained these data, but we have added an explanation in the text.

Soil moisture with a soil temperature below 0 °C is beyond the scope of instrument monitoring. Monitoring soil moisture under frozen conditions has always been a technical difficulty. Therefore, soil moisture data below 0 °C are not available.

Figure 4 should be labeled correctly.

The Figure has been labeled correctly. Please refer to the new Figure 4 as follows:

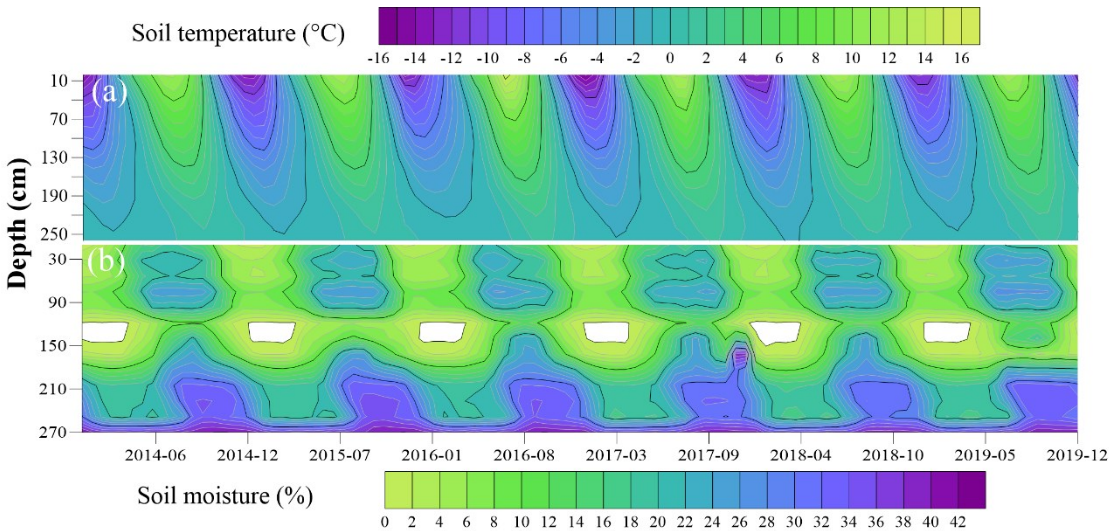

Figure 4. Soil temperature and volumetric water content from 2014 to 2019. (a) Soil temperature (°C); (b) soil moisture (%).

You mention: “This study analyzes the thermal impact of engineering operations 240 on permafrost slopes. The results show that the QTH has the greatest thermal impact on permafrost slopes, followed by the QTR and finally the power/communication towers.” I can see one figure. But where is the analysis, how is it performed and what is the quantitative outcome?

This was due to the lack of clarity of our expression. Based on these data, the thermal impact of different project operations on permafrost slopes was analyzed, using mostly the inflection point analysis method of regional analysis.

This study analyzes the thermal impact of engineering operations on permafrost slopes. The projects and the slope were divided according to a width of 2 m, and then the surface temperature of the project and the temperature between different zones of the surrounding slope were compared. When these temperature differences appear at the first break point, this is the largest thermal impact of the project on the slope. The distance between the slope zone and the project is the maximum range of thermal influence (Luo et al., 2018a). The results show that the QTH has the greatest thermal impact on permafrost slopes, followed by the QTR and finally the power/communication towers.

The R code provided cannot be used. Please provide comments/readme and explain the filenames used/origin of the input files. E.g. this file referenced in the code is not available: xdt <- read.csv("PLOT/XDTMS2014-2018_PLOT.csv", header = TRUE)

Thank you for the insightful comments. We have reorganized the code, added the required comments and instructions to the code, added a new instruction document on how to use the code, and added the README.md markdown file for operation of the code, including the corresponding html and pdf files. We have also recorded an operation video and provided it in README.md and README.html.

Please also note the supplement to this comment:
https://essd.copernicus.org/preprints/essd-2020-106/essd-2020-106-RC1-supplement.pdf

We have moved the reviewer's comments here from the manuscript edits.

L23 & 27 are the sensors "between the slopes and engineering projects" or "on and around the slopse" ?

To describe the deployment of the instrument more clearly, we have deleted the sentence “and the aforementioned sensors are densely located on and around the permafrost slopes". The soil moisture sensor is deployed on the slope, the GNSS is deployed around the slope and 30 km away from the slope, the TLS performs mobile monitoring on the slope, and the drone flies on the slope according to the planned route. The slope here also includes the projects surrounding and standing on the slope.

L37-39 yes. but is this general sentence really necessary?

This has been deleted. Thank you.

L50 these references do not talk about statistical evidence for "permafrost disasters". i am sure there are better ones.

We have updated the relevant references (Huggel et al., 2010;Streletskiy et al., 2019;Bessette-Kirton and Coe, 2020;Patton et al., 2019).

L51 this reference shows some nice landslide features in QTP but none of them are documented w.r.t. direct impact on engineering structures (they are somewhat close to QTH)

We have updated the relevant references (Ma et al., 2006;Guo and Sun, 2015;Yu et al., 2020).

L54 see above

We have updated the relevant references (Niu et al., 2015;Wirz et al., 2015).

L56 this reference is just about climate change and warming. not about man-made impact due to engineering in permafrost regions

Thank you for the insightful comments. We apologize for the inappropriate references. We have updated the references (Zhang et al., 2020;Liu et al., 2020;Zhao et al., 2020).

L62 MAAT is air temperature, not soil temperature. please correct this sentence. later in the sentence it is correct

We apologize for the unclear expression in the previous text. In fact, we want to express the changes in MAAT in seasonal frozen soil areas, island permafrost areas, and continuous permafrost areas, so we have rewritten this sentence.

In the past 60 years, the MAAT of the seasonal and island permafrost areas along the QTEC has increased 0.3 to 0.5 °C, and the MAAT in the continuous permafrost area has increased 0.1 to 0.3 °C (Obu et al., 2019;Luo et al., 2018b;Wu et al., 2007).

L68 this paper does not talk about deformation/destruction of engineering facilities. just about deformation of part of your data.

We have updated the relevant references (Streletskiy et al., 2019;Yu et al., 2020;Ma et al., 2017).

L68-74 this section should be rewritten for clarity

For clarity, we have rewritten the sentence as follows:

Warming of the climate and operation of permafrost projects around slopes have caused the ground temperature to rise. On ice-rich slopes, melting underground ice due to rising temperatures reduces the cohesion and angle of internal friction between the active layer and underground ice and becomes extremely unstable under the influence of gravity (Yuan et al., 2017). The locations of these slopes near permafrost engineering projects, such as railways and highways, thaw slumps, frost heaves, landslides, rockfalls, etc., may cause serious damage to permafrost engineering (Niu et al., 2015;Luo et al., 2018a).

L80-84 yes indeed, but can you also give some data/evidence/reference of engineered structures that are monitored and/or their susceptibility?

Most of them focus on the interaction between a single project and the slope, and few studies have addressed the interaction of water-heat and deformation between multiple projects, such as highways, railways, and electric towers and slopes. In addition, the capacity of the Qinghai-Tibet Engineering Corridor (QTEC) to accommodate several infrastructure projects, such as the Qinghai-Tibet Highway, Railway, the Golmud–Lhasa Oil Pipeline, the Qinghai–Tibet Power Transmission Line, and the future Qinghai-Tibet Express Highway, must be considered. Due to severe topographical, geographical, and geological restrictions, the width of the QTEC varies from 100 m to 10 km. As a result, the mutual thermal influence of these infrastructures within the narrow corridor cannot be ignored. We have added some references (Wang et al., 2020;Ma et al., 2019).

L85 how do you do TLS _WITH_GNSS? TLS is laser reflection that is sent out by an instrument. this is often georeferenced by GNSS. please be precise.

We have added the following sentence:

GNSS can be used as the datum point and control point of TLS, helping TLS point cloud data establish a georeferenced coordinate system and improving the accuracy of comparative analysis of multiple TLS data.

L88-90 you mention "visible light images" and ground surface temperature? how does this fit together?

The coordinated use of multiple sensors is to obtain information from multiple angles of the two permafrost slopes from topography and landform to temperature changes. For clarity, we have rewritten the sentence as follows:

Unmanned aerial vehicles (UAVs) can be equipped with visible digital, thermal infrared (TIR), and multispectral sensors. In addition to obtaining the topographic and landform features of the two frozen soil slopes, it can also estimate the spatial distribution of the ground surface temperature on permafrost slopes and evaluate the thermal influence of nearby engineering infrastructure (Luo et al., 2018a).

L93-94 i only see data on slopes that are adjacent to engineering structures. but the data are not truly specific to the engineering structures. please reword.

We have rewritten this sentence.

We provide an integrated dataset of the hydrological-thermal deformation covering permafrost engineering and slope areas in the QTEC from 2014 to 2019.

L108-109 can you please comment on the presence of permafrost? is it all permafrost? is it continuous/discontinuous? if yes/ where/how?

The area around the Kunlun Mountain Pass on the Qinghai-Tibet Plateau is characterized by continuous permafrost (Figure R2). The data come from the Map of Geocryological Regionalization and

Classification in China (Qiu et al., 2000).

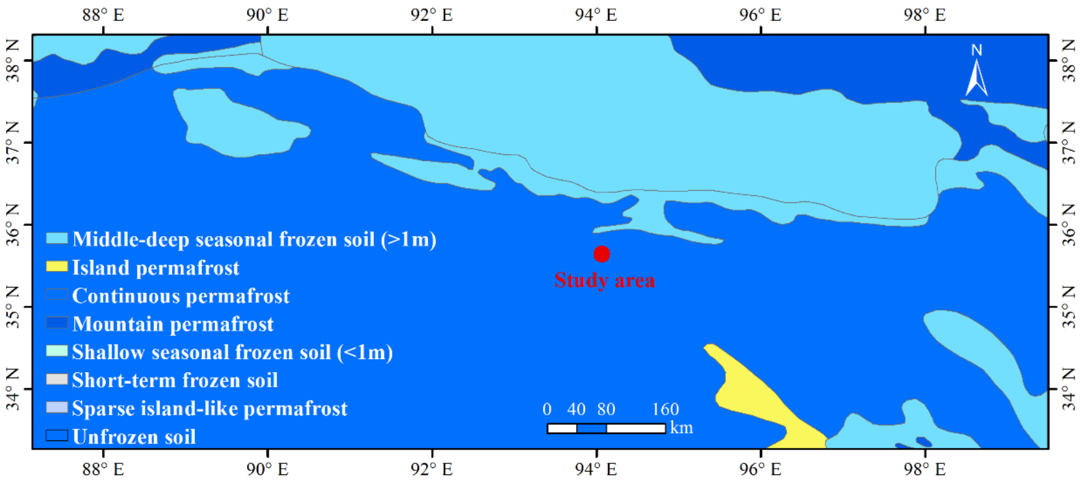

Figure R2 The frozen soil distribution in the study area.

L115 if permafrost is only above 4200 masl, then where is it 92m? is that the maximum on QTP? or a mean? please be precise.

The development of permafrost is different from that of the permafrost thickness. Permafrost is well developed at the Kunlun Mountain Pass. The permafrost thickness is the thickness of the frozen soil layer, which is derived from data from boreholes. Data from boreholes in this area show that the thickness of permafrost ranges from 46 to 112 m. The borehole data closest to the study area show that the permafrost thickness is 92 meters. To avoid misunderstanding, we have changed “92 meters” to “from 46 to 112 m”.

L123 drilling or pit? where was the drilling performed? location?

In 2010, two deep boreholes (please see Figure R3) were created by our institute around two slopes, which were 200 and 300 m deep (Yang et al., 2011;Yang et al., 2017;Wu and Zhang, 2008). The “depth of underground ice” is the mean depth of underground ice in the study area. "Top of permafrost" is the temperature at the top of permafrost or the temperature at the bottom of the active layer (TTOP), which differ from year to year. The warming of permafrost has become common in this region, so we have added references. We have rewritten the sentence.

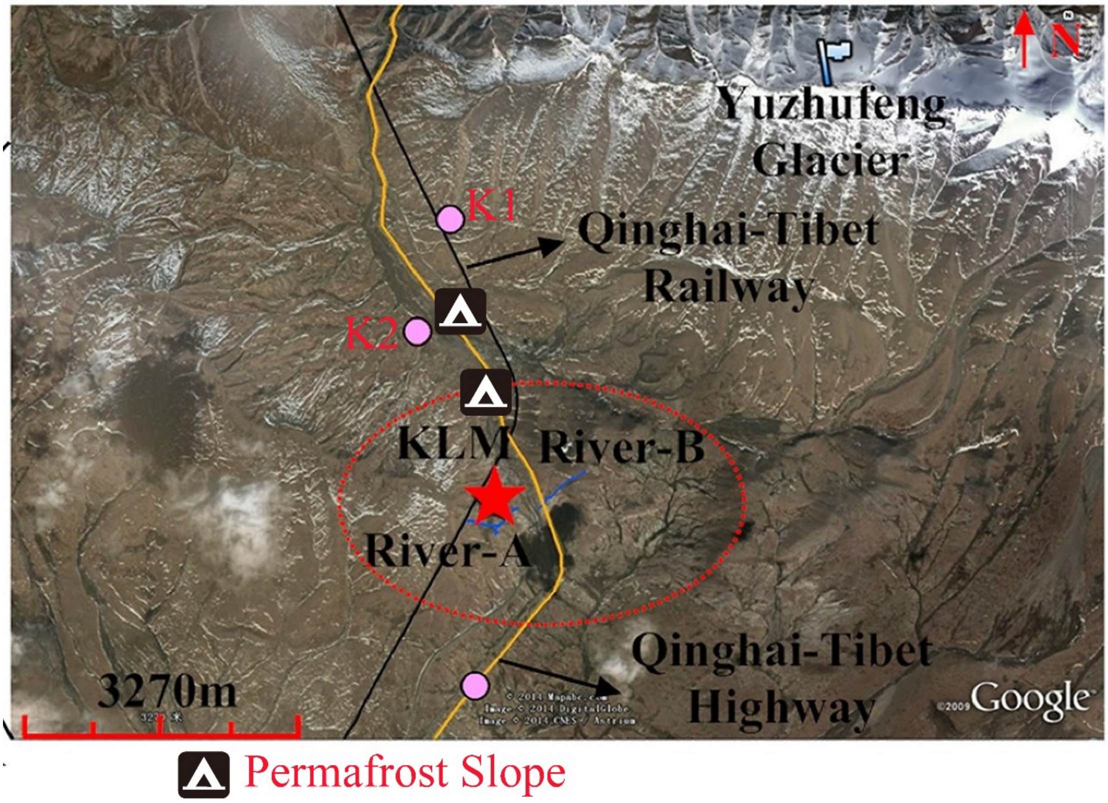

Figure R3. The location of two boreholes (K1 & K2). Base map came from Yang et al. (2017).

L130-131 the data supplements cite 2014-2020 for TLS and ground data is 2014-2018.

We have added a reference.

L175 cannot be used safely below 0℃

Please see our responses “2” in the Specific comments section (above).

Figure 4 no labels in the figure

We have added the labels in Figure 4.

L208-209 where is this sentinel data?

We have added Sentinel data to the TLS measurement data depository at http://doi.org/10.5281/zenodo.3764502

L236-237 some flights are not "from moring to afternoon". please be more specific here. also list which files are form which flight/times/area

We have revised this sentence.

The TIR flight experiments lasted from morning to afternoon, with intervals of 1 to 2 hours (Table 2)

L240-242 this is no surprise. but where is the analysis and how much is the impact? please add details.

Please refer to our responses “2” in the Specific comments section (above).

L256-257 how?

The data were first checked manually to identify suspicious and incorrect data. Quality control codes for the meteorological station data were adopted to examine and correct the suspicious and incorrect data.

The meteorological data have undergone quality control. First, all suspicious and incorrect data were manually re-examined and corrected. For example, a new column of “Corrected_P” has been added to the precipitation data based on the original data, and this column of data is the result of manual revision.

L277-278 how? why?

Trampling by wild animals may affect the deformation.

Figure B3 I cannot see any value in this figure

We have deleted Figure B3.

References:

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Luo, L., Ma, W., Zhao, W., Zhuang, Y., Zhang, Z., Zhang, M., Ma, D., and Zhou, Q.: UAV-based spatiotemporal thermal patterns of permafrost slopes along the Qinghai–Tibet Engineering Corridor, Landslides, 15, 2161–2172, https://doi.org/10.1007/s10346-018-1028-7, 2018a.

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Wirz, V., Geertsema, M., Gruber, S., and Purves, R. S.: Temporal variability of diverse mountain permafrost slope movements derived from multi-year daily GPS data, Mattertal, Switzerland, Landslides, 13, 67-83, https://doi.org/10.1007/s10346-014-0544-3, 2015.

Wu, Q., Dong, X., Liu, Y., and Jin, H.: Responses of Permafrost on the Qinghai-Tibet Plateau, China, to Climate Change and Engineering Construction, Arctic, Antarctic, and Alpine Research, 39, 682-687, https://doi.org/10.1657/1523-0430(07-508)[wu]2.0.Co;2, 2007.

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Yang, Y.-z., Wu, Q.-b., Deng, Y.-s., Jiang, G.-l., and Zhang, P.: Chemical Composition of Borehole Gas in Kunlun Pass Basin in Permafrost Regions in Qinghai-Tibet Plateau, Natural Gas Geoscience, 6, 2011.

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Zhang, Z., Yu, Q., You, Y., Guo, L., Wang, X., Liu, G., and Wu, G.: Cooling effect analysis of temperature-controlled ventilated embankment in Qinghai-Tibet testing expressway, Cold Regions Science and Technology, 173, https://doi.org/10.1016/j.coldregions.2020.103012, 2020.

Zhao, L., Zou, D., Hu, G., Du, E., Pang, Q., Xiao, Y., Li, R., Sheng, Y., Wu, X., Sun, Z., Wang, L., Wang, C., Ma, L., Zhou, H., and Liu, S.: Changing climate and the permafrost environment on the Qinghai–Tibet (Xizang) plateau, Permafrost and Periglacial Processes, 31, 396-405, https://doi.org/10.1002/ppp.2056, 2020.

Authors reply to the comments by Anonymous Referee of the manuscript essd-2020-106

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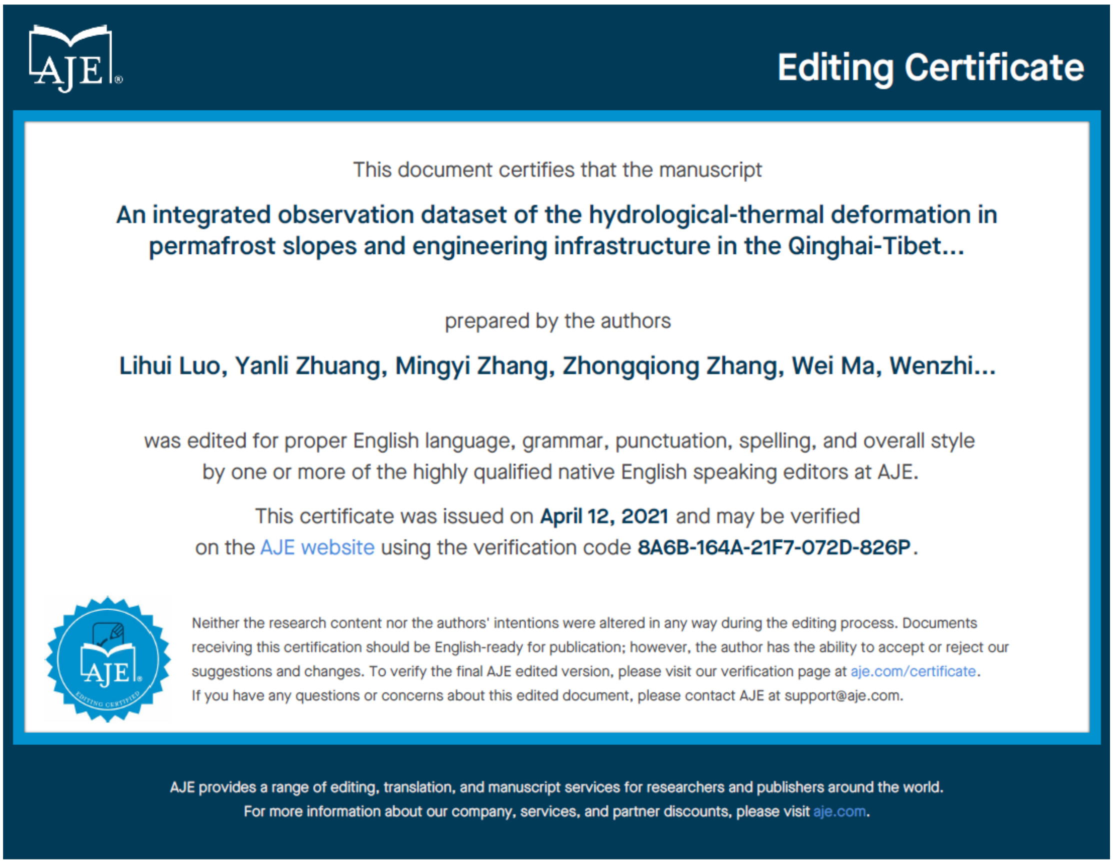
We thank Anonymous Referee #2 for valuable feedback, which helped us improve our manuscript. Please find below the Reviewer comments in black, Author responses in green, and Changes to the manuscript in blue.

Response to referee comment 2:

The manuscript by Luo et al. described multiple observation data sets in the Qinghai-Tibet Engineering Corridor (QTEC). I agree with the previous reviewer's comments about the hard-won data in this manuscript. What is particularly commendable is that the author chose a study area where railway, highway and electrical towers are all distributed on a frozen soil slope. Temperature, air and ground temperature, is the most important indicator of changes in frozen soil. The author uses drones equipped with thermal infrared sensors to monitor spatial changes in surface ground temperature. This data should be relatively rare. This set of data is of great significance for studying the interaction between frozen soil engineering and slopes. Overall, this is a well-prepared manuscript with useful data. The study area is very typical and distinctive.

Thank you for the insightful comments. In revising the paper, we have carefully considered your comments and suggestions. We agree with your comments regarding the metadata, code execution, and data description, among others. To address these concerns, we have made the following modifications to the manuscript: (1) we have added README.md files for the entire dataset of the manuscript and for each data set, such as meteorological and ground observations, TLS measurements, UAV RGB and TIR images, and R code of permafrost indices and visualization, and generated the corresponding README pdf and html files; (2) we have checked the integrity of the data file and added the missing data, including InSAR data and the study area boundary shapefile data in the TLS measurement dataset; (3) we have added vector and raster data of the boundary, DSM (digital surface model), and mosaic of the study area processed by UAV monitoring data; (4) we have renamed some data files because it was difficult for data users to obtain certain data due to naming reasons, and reorganized the file directory, (5) we have modified many inappropriate expressions, including the title; (6) we have updated the data DOI; (7) we have deleted some references with little relevance and added some related references; and (8) we have improved the flow of the language throughout the manuscript (Figure R1). We have tried our best to address each of your points in detail. We feel the revision represents an improvement, and we hope that you agree. For more details, please see our replies below.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An integrated observation dataset of the hydrological-thermal deformation in permafrost slopes and engineering infrastructure in the Qinghai-Tibet...

prepared by the authors

Lihui Luo, Yanli Zhuang, Mingyi Zhang, Zhongqiong Zhang, Wei Ma, Wenzhi...

was edited for proper English language, grammar, punctuation, spelling, and overall style by one or more of the highly qualified native English speaking editors at AJE.

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Figure R1. Editorial Certificate.

Therefore, I don’t have any major suggestions on how to improve the manuscript. Please see some minor comments below.

Minor comments:

1. Please provide a more detailed metadata description of the data set.

We have added metadata files README.md for all datasets and generated the corresponding html and pdf format files. The study area embeds Google Maps in the README.md file. Meteorological and ground observations, as well as the R code of permafrost indices and visualization, include the period from 1955 to 2019. TLS measurements and UAV RGB and TIR images are from 2014 to 2017. We have added a description of the time period in the main text and README.md.

2. It is recommended to add the running notes in the code, and increase the readability of the code, so that users can not only execute, but also modify and improve.

Thank you for the insightful comments. We have reorganized the code, added the required comments and instructions to the code, added a new instruction document on how to use the code, and added the README.md markdown file for operation of the code, including the corresponding html and pdf files. We have also recorded an operation video and provided it in README.md and README.html.

3. Please delete Figure B3. If possible, just describe it in the text.

We have deleted Figure B3.

4. The latest references need to be cited, and some references need to be added. As in the following article:

Wu, Q., Sheng, Y., Yu, Q., Chen, J., and Ma, W.: Engineering in the rugged permafrost terrain on the roof of the world under a warming climate, Permafrost and Periglacial Processes, 31, 417-428, https://doi.org/10.1002/ppp.2059, 2020.

We have added the indicated reference and updated some references in the manuscript.

5. This manuscript focuses on ground and drone monitoring data, so it is recommended to delete InSAR data.

As a supplement to the TLS point cloud data, we have prepared Sentinel-1 deformation data for the freeze-thaw stage in the study area from 2014 to 2020 using interferometric synthetic aperture radar (InSAR) technology. These are the InSAR data for the entire study area. These data are a good supplement and comparison to the TLS point cloud data. We still retain these data in the TLS measurement dataset.

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