

***Interactive comment on* “Brief Communication:
Evaluation and comparisons of permafrost map
over Qinghai-Tibet Plateau based on inventory of
in-situ evidence” by Bin Cao et al.**

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Response to Anonymous Referee #2

Anonymous Referee #2

Received and published: 18 October 2018

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

The manuscript presents a useful contribution for understanding performance of different permafrost maps at QTP. The aim of the study, methods and presented results are relatively clear, however, several parts of the text need to be clarified and part of the methods needs to be slightly extended. The manuscript has to be proofread for language and use of several terms in the manuscript can be improved. I have listed a number of specific comments below, which should improve the clarity of the text.

Response: The language of revised manuscript will be carefully checked.

Authors should find the comments straightforward to implement.

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Specific comments:

- Page 1, line 4: change “overall accuracy of about” to “overall accuracy between”
Response: Done.
- Page 1, line 5: omit “extremely large”. The areas are matter of scale and don’t need to be evaluated in this case. It is also not clear how this part of the sentence relates to the beginning where comparison to in-situ measurements is discussed.
Response: Yes, they are compared in the manuscript rather than evaluated. In the revised manuscript, we will reformulate this part to

“Many maps have been produced to estimate permafrost distribution over the Qinghai-Tibet Plateau, however, the estimated permafrost region ($1.42\text{--}1.84 \times 10^6 \text{ km}^2$) and area ($0.76\text{--}1.25 \times 10^6 \text{ km}^2$) are extremely large. The evaluation and inter-comparisons of them are poorly understood due to limited evidence.”

- Page 1, line 6: How do you define “fragile landscapes”?
Response: “fragile landscapes” means the areas where topography (mountains or valleys), surface conditions (e.g., vegetation cover, soil proxies, and river distribution) are spatial variable. The “fragile landscape” will be replaced by “*spatially highly variable landscape*” to clarify.
- Page 2, lines 4-5: What is a large enough dataset? I assume that the evaluation datasets were large enough for the publications to be published. In the next sentence, “This would weaken their applications” sounds as the datasets were inappropriate. I would change the formulations of the both sentence to more positive. For instance: “The new larger dataset can be used to improve evaluations of the existing datasets, which would further improve their applications. . .”

Response: In the revised manuscript, this part will be changed to

“Despite the increasing efforts made on permafrost mapping, existing maps over the QTP so far have not been evaluated and inter-compared with large data sets. A large amount of permafrost presence/absence evidence has been collected using a wide variety of methods (e.g., ground temperature, soil pits, and geophysics) on the QTP since the 2000s. The new larger dataset can be used to improve evaluations of the existing datasets, which would further improve their applications in permafrost and related studies, e.g., as a boundary condition for eco-hydrological model simulations.”

- Page 2, line 16: The word evidence is used at many places in the manuscript. I'm not sure that its use is correct. It could be replaced by “information” in this case and maybe just a “validation site” elsewhere in the manuscript.

Response: “Evidence” has been widely used for describing permafrost presence or absence “validation site”. I listed several published literatures using “evidence” below.

*Cremonese, E., Gruber, S., Phillips, M., Pogliotti, P., Boeckli, L., Noetzli, J., ... Zischg, A. (2011). Brief Communication: “An inventory of permafrost evidence for the European Alps.” *The Cryosphere*, 5(3), 651–657. <https://doi.org/10.5194/tc-5-651-2011>*

*Boeckli, L., Brenning, A., Gruber, S., & Noetzli, J. (2012). A statistical approach to modelling permafrost distribution in the European Alps or similar mountain ranges. *The Cryosphere*, 6(1), 125–140. <https://doi.org/10.5194/tc-6-125-2012>*

Schmid, M.-O., Baral, P., Gruber, S., Shahi, S., Shrestha, T., Stumm, D., &

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Wester, P. (2015). *Assessment of permafrost distribution maps in the Hindu Kush Himalayan region using rock glaciers mapped in Google Earth. The Cryosphere, 9(6), 2089–2099. <https://doi.org/10.5194/tc-9-2089-2015>*

We would keep the evidence in the revised manuscript, and hope you agree.

- Page 2, line 18: The use of word “confidence” shall be used instead of “certainty” also further in the manuscript.

Response: Yes, we agree. In the revised manuscript, the “certainty” will be changed to “confidence”.

- Page2, line 25: What are your criteria to define confidence (certainty) classes medium and low? How are these classes used further in the manuscript?

Response: The confidence degree was described in the manuscript and available in the inventory as supplement, however, it was not further used for map evaluation. Since the inventory may be used for other related studies (e.g., permafrost simulation evaluation), and the confidence information would be useful for further selecting the data based on research aims, we would keep the classification in the inventory and move the classification description into the Appendix A (See below).

The classification algorithm of confidence degree largely follows Cremonese et al. (2011) and could be summarized as

“For board use of the permafrost presence or absence inventory, the data confidence degree was provided (Table A1). BH and SP provide direct evidence of permafrost presence or absence based on MAGT and/or ground ice observations, and hence have high confidence (Cremonese et al., 2011). The data confidence derived from MAGST is classified based on temperature and the length

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Table A1. Classification algorithm of in-situ permafrost presence or absence evidence from various methods

Method	Indicator	Survey depth	Permafrost	Confidence degree
BH	$MAGT \leq 0 \text{ } ^\circ\text{C}$	meters to about 20 m	presence	high
SP	ground ice presence	about 1.0–2.5 m	presence	high
GST	$MAGST \leq -2 \text{ } ^\circ\text{C}$ & observations ≥ 3	0.05 or 0.1 m	presence	medium
	$MAGST \leq -2 \text{ } ^\circ\text{C}$ & observations < 3		presence	low
	$MAGST > -2 \text{ } ^\circ\text{C}$ & $MAGST + TO_{max} \leq 0 \text{ } ^\circ\text{C}$		presence	low
	$MAGST < 0 \text{ } ^\circ\text{C}$ & $MAGST + TO_{max} > 0 \text{ } ^\circ\text{C}$		ambiguous	–
GPR	$MAGST > 0 \text{ } ^\circ\text{C}$		absence	medium
	clear permafrost reflection	about 0.80–5.0 m	presence	medium

BH = borehole temperature, SP = soil pit, GST = ground surface temperature, and GPR = ground-penetrating radar. TO_{max} , the maximum thermal offset under natural conditions reported for the QTP, is $0.79 \text{ } ^\circ\text{C}$.

of the observation period. The evaluated GPR survey result was considered as medium confidence."

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- Page 3, lines 4-5: How do you define a clear permafrost reflection? The exact criteria for selection of GPR sites should be presented.

Response: Cao et al. (2017) presented detailed description of GPR data acquisition and processing, here we used the data which active layer depth was identified, and could summarized as

“Here, GPR data from Cao et al. (2017) are measured using 100 and 200 MHz antennas depending on the active layer thickness. The GPR survey depth is from about 0.8 to near 5 m, and the data are considered as indicating the presence of permafrost only if an active layer thickness (or a clear permafrost reflection) could be established.”

to clarify.

- Page 3, line 9: The IPA map shows extent of four permafrost zones and is therefore not a binary map. Present here how did you convert it in to binary map showing permafrost presence and absence.

Response: Yes, the IPA map is categorical map rather than binary. Additionally, the QTP_{TTOP} and QTP_{Noah} maps are also categorical maps. The binary map was changed to categorical map throughout the manuscript. In the revised manuscript, we will change this part to

“In general, permafrost maps over the QTP could be classified as (i) categorical, using categorical classification with different permafrost types (e.g., continuous, discontinuous, sporadic, and island permafrost), seasonally frozen ground, and unfrozen ground, and (ii) continuous, using continuous probability or indices [0–1] to represent proportion of an area that is underlain by permafrost.”

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to clarify.

In Section 2.4, we will also add

“For map evaluation, the categorical map was aggregated to binary map by merging different permafrost types to permafrost presence [1] and by merging the others to permafrost absence [0].”

- Page 3, line 16: Please explain here how PZCold, PZIwarm and PZI_{norm} were derived by Gruber (2012) and what is difference between them.

Response: As we mentioned in the previous manuscript, the PZI_{global} map is derived largely based on the heuristic-empirical relationship between PZI and mean annual air temperature (MAAT) based on generalized linear models. The model parameters are established largely based on the boundaries of continuous (PZI = 0.9 for MAAT = -8.0 °C) and isolated (PZI = 0.1 for MAAT = -1.5 °C) permafrost in the IPA map and do not use field observations. The cold and warm cases were introduced into the map to allow the propagation of uncertainty caused by input dataset and model suitability, and they differ in the parameters used. Comparing the normal case, the cold and warm variants are derived by shifting PZI and MAAT at the respective limit by $\pm 5\%$ and ± 0.5 °C, respectively. We will change this part to

“The model parameters are established largely based on the boundaries of continuous (PZI = 0.9 for MAAT = -8.0 °C) and isolated (PZI = 0.1 for MAAT = -1.5 °C) permafrost in the IPA map and do not use field observations. Additionally, two cases, including cold (conservative or more permafrost) and warm (anti-conservative or less permafrost), were introduced into the map to allow the propagation of uncertainty caused by input dataset and model suitability. The three cases, and hence the PZI_{norm}, PZI_{warm}, and PZI_{cold} maps, differ in the

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parameters used. Comparing the normal case, the cold and warm variants are derived by shifting PZI and MAAT at the respective limit by $\pm 5\%$ and $\pm 0.5\text{ }^{\circ}\text{C}$, respectively."

- Page 3, consider moving 2.3 section before 2.2 because it is in my opinion logical continuation of the inventory of permafrost validation sites. Also consider changing the section title to "Topographical and climatological properties of the inventory (or permafrost validation) sites"

Response: In the revised manuscript, the section 2.3 will be moved before 2.2, and the title will be changed to

"Topographical and climatological properties of the inventory sites".

- Page 3, line 32: What are you referring to with "(about 500m)"?

Response: It is the spatial resolution. In the revised manuscript, the sentence will be changed to

"The MASCD with a spatial resolution of about 500 m was. . ."

- Page 4, line 9: Please consider extending the explanation about the difference between permafrost area and permafrost region. This concept is difficult to understand by broader permafrost community. Maybe introduce the concept of scale and ground coverage by permafrost.

Response: This part will be changed to

"Permafrost region is the exposed land surface below which permafrost is likely present, however, the permafrost may not be everywhere. It is an arbitrary definition, and usually 10% permafrost coverage is used as the threshold (Gruber , 2012). Permafrost area is where actually underlain by permafrost (Zhang et al., 2000)."

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- Page 4, lines 26-27: Restructure the sentences. It sounds as because of your permafrost absence/absence classification, you have 1475 sites. I assume that this is because of your site selection criteria.

Response: In the revised manuscript, the sentence will be change to

“In the inventory, there are in total 1475 permafrost presence or absence sites/plots acquired from BH, SP, GST, and GPR methods (Figure 1).”

- Page 5, line 3: “were aggregated based on their major value”. Maybe replace with “the majority value was assigned to aggregated sites.

Response: Done.

- Page 5, line 15: More appropriate term for “band” would be “range”. What exactly does the word “sensitive” refer to?

Response: “band” will be replaced by “range” throughout the revised manuscript. The sentence will be deleted as it does not give us too much useful information.

- Page 5, line 31: Did you mean QTP_{TTOP} instead of PZI_{TTOP} ?

Response: Yes, it will be corrected.

- Page6, line 10: Again, how exactly is fragile landscape defined?

Response: The “fragile landscape” will be replaced by *“spatially highly variable landscape”*.

References

Cao, B., Gruber, S., Zhang, T., Li, L., Peng, X., Wang, K., Zheng, L., Shao, W., Guo, H. (2017). Spatial variability of active layer thickness detected by ground-penetrating radar in the Qilian Mountains, Western China. *Journal of Geophysical Research: Earth Surface*.

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<https://doi.org/10.1002/2016JF004018>

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Zhang, T., Heginbottom, J. A., Barry, R. G., and Brown, J.: Further statistics on the distribution of permafrost and ground ice in the Northern Hemisphere, *Polar Geography*, 24, 126–131, <https://doi.org/10.1080/10889370009377692>, 2000.

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