Responses to the Reviewer's comments:

TO REVIEWER#2

General comments

This paper presents a new rock glacier inventory in the Guokalariju region of the Tibetan Plateau, then estimate the hydrological water stores and the permafrost index based on the distribution of rock glaciers. This is a good contribution as new inventories are needed globally, hence the work is relevant to the community. However, I find that the paper needs significant improvement both in terms of methodology writing and in the way that results are presented. There are some concerns about the terminology used, which have already been addressed by a previous review, so I will not comment of these here but I agree with them. My additional concerns relate to:

We feel great thanks for your professional review work on our manuscript. We have provided point-by-point answers to your comments below, and we will revise the manuscript according to your valuable suggestions. The comments are listed in italics font, and our answers are given in blue text.

Methods:

RG delineation: these are not detailed or specific enough, particularly with respect to the mapping. This is covered only in one or two sentences, and there is no information about how exactly RGs were delineated with respect to RGIK updated guidelines. Without this, it is hard to assess if this is a significant contribution as we now need to ensure that inventories are constructed using standardized methodology following existing guidelines.

Thank you for your suggestion. Our work started before the RGI_PCv2.0 updated (RGIK, 2022), we mainly applied the methods used in previous studies (Scotti *et al.*, 2013; Jones *et*

al., 2021). Details are as follows: the outline of the entire rock glacier surface was delineated, extending from the rooting zone (i.e. uppermost extent) to the foot of the front slope (i.e. lowermost extent). When the frontal lobes of two (or more) rock glaciers originating from distinct source basins join downslope, they are considered the two components as separate bodies. Where the limits between lobes are unclear and the lobes share other morphological characteristics, the whole system is classified as a unique rock glacier (Scotti *et al*, 2013). In occurrences where rock glaciers grade into upslope landforms, a clear distinction between the two landforms cannot be set and they are delineated as the whole body (Scotti *et al.*, 2013; Jones *et al.*, 2021).

In addition, following the update of the guidelines, the rock glacier outline in the study area was re-examined and adjusted to better comply with the guidelines in accordance with the latest standards. And we will add more details in the revised manuscript.

Section is lacking Data sources which makes is hard to follow which data were used and their characteristics and accuracy. Please consider adding one.

Thank you for pointing out this problem. In the reply to the next question, we list the relevant information of topo-climatic data. And we will also give a more comprehensive explanation of each data in the revised manuscript.

Topo-climatic factors: there is limited information given about this, and it is mostly vague. Authors need to be more specific and carefully describe each factor.

Thank you for your suggestion. We have listed the information of relevant variables (see Table 1), which is obtained by extracting and calculating the mean value of the topo-climatic data of the range of rock glaciers in ArcGIS 10.7. We will also rewrite this part in the revised manuscript.

Factor	Year	Data source	Resolution	Software
Latitude/Longitude	/	Google Earth Pro	/	ArcGIS 10.7
Altitude	2000-2013	ASTER GDEM V3	30 m	ArcGIS 10.7
Slope/Aspect	2000-2013	ASTER GDEM V3	30 m	ArcGIS 10.7
MAAT	2015	Du and Yi, 2019	1 km	ArcGIS 10.7
MAGT	2005-2015	Ran et al., 2019	1 km	ArcGIS 10.7
MAP	2015	Du and Yi, 2019	1 km	ArcGIS 10.7
PISR	2015	ASTER GDEM V3	30 m	SAGA GIS 8

Table 1: Topo-climatic data information.

MAAT: mean annual air temperature

MAGT: mean annual ground temperature

MAP: mean annual precipitation

PISR: potential incoming solar radiation

The link with climatic conditions: similar to what was suggested before, this needs to be much more thought of; for example, the question of special resolution is not even mentioned, while most climatic data come at coarse spatial resolution.

Thanks. You have raised an important point. However, due to the limitation of the difficult field environment and observation conditions, less meteorological data can be obtained in the study area, and it is still difficult to obtain high-resolution climate data in our study area. In the next study, we will further explore available data and try to improve the resolution of the data through relevant methods.

Uncertainty section is spread throughout the paper, it would be much more convenient to have an uncertainty assessment as a separate section.

Thank you for your suggestion. We will add a separate chapter in the revised manuscript to account for the uncertainty associated with the rock glacier inventory, water volume content estimation, and permafrost probability distribution estimation.

The logistic regression is presented too briefly, it needs to be clearer how variables were selected; besides, many of them were correlated- how was this dealt with?

Thank you for your suggestion, we will add this part of the explanation in the revised manuscript. In order to reduce the influence of multicollinearity, we adopt a stepwise regression method (Forward Selection (Likelihood Ratio)) to solve this problem. The method

is a process of starting from the model with no independent variables, and then gradually increasing and screening the independent variables. Through this method, we can gradually build a robust and reliable regression model under the condition of multicollinearity of variables in the equation.

We calculated the regression model in SPSS 27, and 7 climate-topographic factors were included by the Forward Selection (Likelihood Ratio), *i*.e. longitude, latitude, mean altitude (ASTER GDEM V3), mean annual precipitation in 2015 (Du and Yi, 2019), mean annual ground temperature in 2015 (Du and Yi, 2019), mean slope and area (calculated in ArcGIS 10.7 based on ASTER GDEM V3). The regression model's total fitting and all coefficient estimates are highly significant (p < 0.05, Table.2), and the Hosmer–Lemeshow test also means the model is a good fit (p = 0.709, p > 0.05). The area under the ROC curve (AUC) was calculated to be 0.85.

	D	SE		$\mathbf{E}_{\mathbf{v}}(\mathbf{D})$	BCa 95% CI(B)	
	D	SE	р	Ехр(Б)	Lower	Upper
Mean altitude	0.007	0.000	0.000	1.008	1.007	1.008
Mean annual precipitation	-0.021	0.002	0.000	0.979	0.976	0.982
Mean slope	-0.041	0.009	0.000	0.960	0.943	0.977
Mean annual ground temperature	-0.145	0.073	0.047	0.865	0.750	0.998
Area	0.000	0.000	0.016	1.000	1.000	1.000
Longitude	4.327	0.215	0.000	75.742	49.659	115.524
Latitude	-2.320	0.275	0.000	0.098	0.057	0.168
Constant	-359.428	22.036	0.000	0.000		

Table 2: Logistic regression output.

Results/discussion:

The main issue here is that the language is vague in many places, and not quantitative. I have marked these in the specific comments. The way the results are presented, it is hard to pick out what is important from these results. For example, R2 stands out as an anomaly compared to R1 and R3 in terms of estimated water storage- this could be interesting to make a more detailed

analysis/comparison among the regions, doing some statistical tests to see if the difference is significant. This is at present not presented.

Thank you for providing the suggestions. We restate the vague places in the manuscripts, and the response is made in the specific comments below. Our results emphasize the control of temperature, precipitation, and other environmental factors to the distribution of the rock glacier and give the key factors for the distribution of the rock glacier in the region of GKLRJ. We give the evaluation of the water resources in the region and the hot spots of the permafrost distribution.

To the water storage of R1, R2 and R3, we conducted an analysis of variance (ANOVA) on the WVEQ of the three groups of rock glaciers in R1, R2, and R3, and the results showed that all of the different groups showed significance (p < 0.05) for the WVEQ (see Table 3), implying that the WVEQ of rock glaciers in R1, R2 and R3 were all different. We will also continue to explore potential possibilities in the results based on this and add them to the revised manuscript.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.435	2	17.217	58.263	0.000
Within Groups	1.773	6	0.296		
Total	36.208	8			

Table 3: The statistic result for ANOVA.

Also, the authors average the WEQ over the 3 regions then compare to Jones et al, which is not ideal. A weighted analysis would be needed

We agree with that. We calculated a ratio of intact rock glaciers to clean ice glaciers' water volume equivalence (WVEQ) by using the weighted average method from the following equation. We also add it to our revised manuscript.

$$WVEQ \text{ ratio}_{\text{Rg: Glacier}} = \frac{WVEQ \text{ R1}_{\text{Rg}} \times \frac{\text{R1}_{\text{Rg}}}{\text{All}_{\text{Rg}}} + WVEQ \text{ R2}_{\text{Rg}} \times \frac{\text{R2}_{\text{Rg}}}{\text{All}_{\text{Rg}}} + WVEQ \text{ R3}_{\text{Rg}} \times \frac{\text{R3}_{\text{Rg}}}{\text{All}_{\text{Rg}}}}{WVEQ \text{ R1}_{\text{Glacier}} \times \frac{\text{R1}_{\text{Glacier}}}{\text{All}_{\text{Glacier}}} + WVEQ \text{ R2}_{\text{Glacier}} \times \frac{\text{R2}_{\text{Glacier}}}{\text{All}_{\text{Glacier}}} + WVEQ \text{ R3}_{\text{Glacier}} \times \frac{\text{R3}_{\text{Glacier}}}{\text{All}_{\text{Glacier}}} + WVEQ \text{ R3}_{\text{Glacier}} \times \frac{\text{R3}_{\text{R3}}}{\text{All}_{\text{Glacier}}} + WVEQ \text{ R3}_{\text{R3}} \times \frac{\text{R3}_{\text{R3}}}{\text{All}_{\text{Glacier}}} + WVEQ \text{ R3}_{\text{R3}} \times \frac{\text{R3}_{\text{R3}}}{\text{All}_{\text{R3}}} \times \frac{\text{$$

where WVEQ ratio_{Rg: Glacier} is the ratio of intact rock glaciers to clean ice glaciers' WEVQ; WVEQ Rn_{Rg} (n=1,2,3) respectively are the WVEQ for rock glaciers in R1, R2 and R3; Rn_{Rg} (n=1,2,3) respectively are the number of rock glaciers in R1, R2 and R3; All_{Rg} is the number of rock glaciers in the whole GKLRJ; WVEQ $Rn_{Glacier}$ (n=1,2,3) respectively are the WVEQ for clean ice glaciers in R1, R2 and R3; $Rn_{Glacier}$ (n=1,2,3) respectively are the number of clean ice glaciers in R1, R2 and R3; $All_{Glacier}$ is the number of clean ice glaciers in the whole GKLRJ.

After recalculation, the ratio changed from 1:1.63 to 1:1.81 (see Table 4), which is still relatively high compared with most of the study areas in the world.

Region Glaci		F	RG - WVEQ (km ³)			
	Glacier - w VEQ (km ²)	40%	50%	60%	WVEQ ratio	
All	9.29	4.55	5.69	6.82	1:1.81	
1	0.19	0.34	0.43	0.51	2.26:1	
2	6.6	3.73	4.66	5.59	1:1.42	
3	2.51	0.48	0.60	0.72	1:4.18	

 Table 4: Ice volume (km3) and corresponding WVEQ (km3) regionally and GKLRJ-wide (All).

Conclusions are brief and some are I find they tend to be speculative, and contradictory to some of the results (for ex the role of precipitation in the formation of RG). The authors present the possible links between climate and RG development but these are not on the same time scale! This needs to be addressed, or the analysis should be revised to present this as a climate" index" rather than temperature and precipitation values.

We think this is a helpful suggestion. We will focus on using more quantitative language instead of speculative words to illustrate the relationship between the regional occurrence characteristics of rock glaciers and the climate.

Figures are small and hard to see. Also, these need more extensive presentation Thank you for pointing out this problem. We will redraw the figures with this problem in the revised manuscript.

Reference list is adequate

Thanks. We will further check and update.

The language needs much improvement both in terms of the English language and in terms of scientific language, I am providing below very thorough edits to help with this, but it should again be checked by a language editor. Thank you for your careful reading and helpful suggestions concerning our manuscript. In the later revision, we will pay more attention to the use of scientific language and invite professionals to help us further improve our language.

Specific comments

Abstract

L8 remove "more" because there is nothing given as comparison

Corrected.

L 9 specify on what basis (manual delineation etc).

We delineated rock glacier boundaries by the manual method.

L 11 what does the altitude refer to? mean altitude of RG? Please specify

Yes. The altitude is the mean altitude of RG.

L 12 "distributed. . " - > a word seems to be missing here, distributed in what way? Thank you for pointing this out. What we want to express originally is that most of the rock glaciers are located in the semi-arid region of the study area.

L 13 remove "which are more" for conciseness

Corrected.

L 14- 15 "A huge potential . . .was found. . " ï rephrase as it reads awkward The potential is estimated not found, and "huge" is qualitative Corrected. We have changed 'huge' to 'considerable'.

Introduction

L32 "then causing" -- > I suggest "with possible consequences on" since this is not a certainty

Corrected as suggested.

I 42 Add "The" before Tibetan Plateau

Corrected.

I 44 "mapped" -- > "constructed" or "created" (an inventory is not mapped)

Corrected.

I 45 add "the" after "Nepalese"

Corrected.

I 48 I suggest not using the acronym of the region in the intro, but rather introduce

it in the study area. Also what is meant by "is a typical region"?

Corrected. (A large number of rock glaciers distributed in Guokalariju (GKLRJ) provide good materials for the study of rock glaciers in the Tibetan Plateau.)

I 51 "study... has mapped" is not correct, need a subject (author or personl). Also specify what method was used previously

Corrected. (The previous study has identified partial rock glaciers in the Yarlung Zangbo River watershed by manual interpretation (Guo, 2019).)

I 54 "Thus" is not appropriate, replace ("To fill this gap" or "To address this. . ") Corrected. We have modified it to "To address this...".

158 remove "the"

Corrected.

Study area

L 60 see my previous comment, I suggest introducing the acronym here and first spell out the region name. Also refer to the figure here

Corrected. Thanks for your suggestion.

L 64 "In the division of the tectonic unit" is ambiguous, rewrite

Corrected. We have rewritten this part according to the Reviewer's suggestion.

L 70 spell out ISM

Indian summer Monsoon (ISM).

L 70 is this R2 and R1? Then why not introduce them here directly?

Thank you for your suggestion, we have not used R1 and R2 directly here because the boundaries of the climatic zones do not exactly correspond to those of R1 and R2, with parts of the northeastern part of R2 belonging to the temperate humid region.

L 72 073 reference?

The mean annual temperature and mean annual precipitation datasets were provided by Du and Yi (2019).

L 73 is this across the region? please specify

Yes. The mean annual precipitation of the entire study area is about 400 mm. We have

referred to your suggestions and provided the table below for more detailed information.

L 78 "can be further divided" ï we divided"; also rephrase to clarify, "3 regions referred to as R1 (east) and so on"

Corrected. Thanks for your suggestion.

L 80 split the phrase "The mean altitude" and specify this is about R1 Corrected.

L 80 -88 needs re-writing to be more compact. I suggest making a small table with the 3 regions, the MAGT, altitude, etc. . in each, as the text is heavy. Some things are vague, for ex I83 "significantly greater" ï there is no statistical text so this cannot be used

Thanks for your suggestion. We have reorganized the information in this section and summarized it in the below table.

Table 5: Mean altitude, mean annual precipitation, and mean annual ground temperature in the study area.

	Mean altitude	Mean annual precipitation	Mean annual ground
	(m a.s.l)	(mm)	temperature (°C)
All	3472	349	2.71
R1	4580	284	1.60
R2	4893	386	-0.07
R3	4398	534	0.00

Materials and methods

This section needs work as the mapping methods are not clear, they are only described in a short paragraph from I 95 - 100. Based on what criteria, exactly? How many analysists? What auxiliary data were used? Along the same lines, there is no data sources section so it is hard to know what was used. Please revise this section accordingly

Thanks for your kind suggestion. We have tried our best to revise the manuscript according to your kind construction comments and suggestions. The details will be presented later in the revised manuscript.

L 90 remove "s" from glaciers Corrected. L 95 "Firstly. . " I100 "secondly" and I109 "Thirdly" are not needed for each step,

suggest removing

We agree and have moved them.

L 95 add "from" after images and remove parenthesis

Corrected.

L 102 add Jones et al papers

Corrected.

L 104 reference (RGIK group?)

The conceptual categorization of rock glacier activity refers to the previous works (Scotti *et al.*, 2013; Baral *et al.*, 2019) and RGIK (2022).

L 107 – 109 I suggest removing the acronyms; it makes the paper harder to read and it is not particularly needed

Corrected. Thanks for your suggestion.

L 109 "them" ï "the shapefiles"

Corrected.

L 110 not sure how these can be calculated in Excel since these are spatial data! We are sorry that we didn't express this clearly. We extracted the corresponding information of each rock glacier in ArcGIS 10.7, and then carried out further statistical calculations in Excel.

L 112 present tense used here while past was used in previous phrase. Please check all manuscript for consistency

Thanks for your careful checks. We are sorry for them. Based on your comments, we have made corrections to harmonize the consistency in the whole manuscript.

L 115 – 120 the uncertainty section is too brief and it is not clear, please address. Same with the Table on I125. A separate section on uncertainty would be needed Thank you for your suggestion. We will add a separate chapter in the revised manuscript to account for the uncertainty associated with the rock glacier inventory, water volume content estimation, and permafrost probability distribution estimation.

L 118 "In addition, we used..." ï rewrite, for ex "All shapefiles were in XX projection" or move to the end, This is not an "addition".

We have made the change as "All shapefiles were in 1984 UTM Zone 46N projection system".

L 119 – 124 this section as well is short and vague. How were the attributes derived, I assume mean of each glacier? What about lat long? Center of the glacier

The attributes derived from each rock glacier. The 'lat' and 'long' from the location of the point we mapped by manual method, nearly the center of each rock glacier.

Please put this in a new paragraph and add the necessary detail

Thank you for your suggestion. We will add this part to the revised manuscript.

L 120 ASTGMT2 DEM- there is no mention of the spatial resolution, no reference and no justification on why this was chosen. Please address.

Thank you for pointing this out. In the revised manuscript we have updated the latest version of DEM data (ASTER GDEM V3) for the study area to better capture topographic information.

The Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) Version 3 (V3) provides a global digital elevation model (DEM) of land areas on Earth at a spatial resolution of 1 arc second (approximately 30-meter horizontal posting at the equator). It was generated using 1,880,306 Level-1A scenes acquired between March 1, 2000, and November 30, 2013. And it was created by stacking all individual cloud-masked scene DEMs and non-cloud-masked scene DEMs, then applying various algorithms to remove abnormal data (Abrams *et al.*, 2015). We chose this data because of its high spatial resolution and ease of access, which serves as an effective way to meet the basic requirements of our study.

Section 3 .2 does not follow the order in the objectives on 155

Thank you for pointing this out. We will revise the objectives order in the Introduction

L 128 – 133 this is background, please re-write

Thanks for your suggestion. We will move this part to the "Introduction" part.

L 133 remove "that has been" for more conciseness

Corrected.

I 135 remove "a calculation by" so it reads "requires multiplying". Also, the

equation is needed here upfront (eq 2 but for RGs). The detail each part of that equation into Eg1.

Thanks for your suggestion. We will reorganize this part in the revised manuscript.

Also, remove "estimated" as the method in the ideal case requires the known thickness and ice content. Then in the following phase state that these were estimated as follows etc ...

Thanks for your suggestion. We will correct it here in the revised manuscript.

L 142 "lower, etc" is unclear- you mean the volume ranges?

Yes. For example, "lower" means that the ice volume accounts for 40% of the volume of the rock glacier.

L 147 this is confusing as it is not mentioned in the beginning of the section anything about clean ice volume, should be clarified on I 127. Also, same comment as before, there is no section on data sources and so there is not enough detail on The Second Inventory Glacier dataset (what year, what source?) and GlabTop2. I strongly suggest adding a data sources section to detail all these data.

Thanks for your suggestion, we did neglect to introduce the detail of the calculating method of clean ice volume in this section. We mainly refer to the approach used by Jones *et al.* (2018b) in the Himalaya-Karakoram region, and the ice volumes of clean ice glaciers also were calculated from Eq (2) in the manuscript. The area of each clean ice glacier is derived from the second glacier inventory dataset of China (version 1.0) (2006-2011) (Liu *et al.*, 2012), and the thickness is calculated by the GlabTop2 in Python 3.10 (Linsbauer *et al.*, 2009).

L 151 "ice glacier" – revise, "clean ice glaciers"

Corrected.

L 153 "has been found" -- > "has been used" Corrected.

L 154 "has been applied" -idem

Corrected.

L 156 use past tense for consistency

Corrected.

L 160 - 161 rephrase for English language; and move "using SPSS software at the end" explain what is the progressive forward method

Corrected. We have modified the "progressive forward method" to Forward Selection (Likelihood Ratio). This method with entry testing is based on the significance of the score statistic, and removal testing is based on the probability of a likelihood-ratio statistic based on the maximum partial likelihood estimates.

(We used the Forward Selection (Likelihood Ratio) method in SPSS 27.0 to stepwise select the topo-climatic variables for the logistic regression model.)

"Was used to conduct correlation analysis" check English; vague, please be specific, correlation of what to what? Which variables exactly?

Thank you for pointing this out. The variables we used for factor analysis include mean altitude, mean slope, mean aspect, area, mean annual precipitation, mean annual ground temperature and potential incoming solar radiation.

L 168 same comment as before, these data would be listed in a data sources section. What was the resolution of the climate data? Resampling it does not add any detail and this should be discussed (differences on resolution)

Thanks for your suggestion. The main reason for resampling is to keep the resolution of the climatic data consistent with the resolution of the DEM data. And we have listed the data sources and resolution information for the relevant climate variables in the previous section.

L 170 "by" -- > "using". What method? Nearest neighbor? Bilinear? Also note that this is not a suitable method, as proper downscaling would be needed

Corrected. We used the Nearest Neighbor method to resample data and will also try to find better ways to downscale.

Results

L 176 not clear: "categorized as visual uncertainty". Again, I suggest adding these separately in an uncertainty section which should be expanded

Thanks for your suggestion, we will add a new section on uncertainty to illustrate relevant

content.

L 177 Certainty should not be in caps

Corrected.

L 179 see comment before, acronym can be removed

Corrected.

L 179 do you mean their mean altitude? Please be specific

Yes. It refers to the mean altitude of rock glaciers, which will be corrected

L 181 vague, please quantify and remove acronyms

Corrected.

L 188 how is this different than previous paragraph? Seems to be the same topic (altitude) so please merge and re-write

Thanks for your suggestion. We will merge the altitude related content with the previous paragraph.

L 189 "gradually" is vague, Is there a significant trend?

Thanks for your comment. We will remove "gradually" from the sentence. The mean altitude of rock glaciers from R1 to R2 decreased from 5116 m a.s.l. to 5060 m a.s.l, and finally decreased to 4845 m a.s.l. in R3.

To further validate the relationship between the mean altitude of rock glaciers and changes in longitude, we conducted a linear regression analysis of the variables in SPSS software, and the results showed that the linear regression model was statistically significant (F=1779.51, p<0.001), indicating a linear relationship between the mean altitude of rock glaciers and longitude (see fig.1). This also illustrates a gradual decrease in the altitude of rock glaciers from R1 to R3.



Figure 1: The scatter plot and fit line for altitude and longitude.

L 188 – 207 this entire section is vague and a lot needs quantification (eg "longer length, "higher altitude") and cluttered with acronyms so it is hard to pull out the important bits, please revise.

L 215- 222 same comment here.

We apologize for the confusion caused by the acronyms used in the manuscript. To illustrate the result in this part more clearly, we will reorganize the content of this paragraph in the revised version and no longer use acronyms.

L 221 "geometry classification" – check English. Not so sure of the utility of the geometry classification with the two sets of aspect figure, I suggest reflecting and picking the most interesting to show

We sincerely appreciate the valuable comments. In our results, rock glaciers with two different planar geometric features did not show much difference in aspect distribution. We will re-write this part according to your suggestion.

L 225 there is no mention of PCA in the methods, please revisit and the methods accordingly

Thanks for your kind suggestion. We will add the suggested content to the method part of the manuscript. We will reconsider the value of this part of the research and revise it in the manuscript.

L 226 here and elsewhere, avoid starting the phrases with "As shown in Fig xx.

Rather, add it in parenthesis at the end eg (see Fig xx)

Corrected.

Not clear which environmental factors you refer too precisely

I'm sorry we didn't make that clear. By this we mean all the variables in Table 3, including mean altitude, mean slope, mean aspect, area, mean manual precipitation (MAP), mean manual ground temperature (MAGT), and potential incoming solar radiation (PISR) of each rock glacier.

L 227 please use standard term correlation "coefficient" ï "Pearsons' r" and mention the confidence interval

Thanks for your suggestion, we will revise this part in the manuscript.

L 227 which altitude? Mean? Also. Should be plural

Corrected. It is the mean altitude of each rock glacier.

L 228 this does not mean much, as PPT and T are often correlated. Table 3 needs to be presented in more detail, this section is too succinct

Thanks for your suggestion.

- We agree that precipitation and temperature are often correlated, and we have considered the impact of the correlation between temperature and precipitation in the stepwise regression method (Forward Selection (Likelihood Ratio)). And we didn't discuss this relationship in the following part but focused more on the relationship between precipitation and altitude. Because the KMO value is 0.443 which indicates that the original variables are not suitable for PCA (KMO < 0.5, see Table.6), and most correlations here are weak, so we will reconsider how to better illustrate this result in the revised manuscript.
- The more detailed information for Table 3 in the manuscript is below:

Table 6: KMO and Bartlett's test.

Kaiser–Meyer–Olkin measure	0.443		
Bartlett's test of sphericity Approx. χ^2		3913.967	
Degree of freedom		21	
	Significant level	0.000	

Table 7: Correlation matrix of rock glacier variables.

		A #20	Mean	Mean	Mean	MAD	MACT	DICD
		Alca	altitude	slope	aspect	MAP	MAUI	FISK
	Area	1.000	-0.057	-0.269	-0.062	0.057	-0.096	0.052
	Mean altitude	-0.057	1.000	-0.036	-0.026	-0.462	-0.065	0.213
	Mean slope	-0.269	-0.036	1.000	0.076	-0.042	0.096	-0.217
Correlation	Mean aspect	-0.062	-0.026	0.076	1.000	0.024	-0.090	0.030
	MAP	0.057	-0.462	-0.042	0.024	1.000	-0.413	-0.067
	MAGT	-0.096	-0.065	0.096	-0.090	-0.413	1.000	-0.184
	PISR	0.052	0.213	-0.217	0.030	-0.067	-0.184	1.000
	Area		0.000	0.000	0.000	0.000	0.000	0.000
	Mean altitude	0.000		0.006	0.034	0.000	0.000	0.000
C:	Mean slope	0.000	0.006		0.000	0.001	0.000	0.000
level	Mean aspect	0.000	0.034	0.000		0.044	0.000	0.016
	MAP	0.000	0.000	0.001	0.044		0.000	0.000
	MAGT	0.000	0.000	0.000	0.000	0.000		0.000
	PISR	0.000	0.000	0.000	0.016	0.000	0.000	

L 232 same comment as above "As illustrated in table. . " in the beginning of the phrase

Corrected.

L 234 give these in percent

Corrected. (R1 stores 0.34 - 0.51 km³ of water which accounts for 8% of the whole GKLRJ.

And R3 stores about 11% of the water about 0.48 - 0.72 km³.).

L 236 what is meant by regional area? Please check formulation

Regional area means the area of rock glaciers in R1, R2, and R3.

L237 "According to" is not correct, can only be used for a person, revise

Corrected. (Base on...)

L 238 confusion here, as it is not GlabTop2 model that estimates the WVEQ ratio, please revise and use active voice

Corrected. (GlabTop2 provides estimated clean ice glacier thicknesses ranging between ~ 1 and ~ 263 m (mean = ~ 18 m). Based on this result, we estimated the total WVEQ of the clean ice glaciers to be ~ 9.29 km³.)

L 243 name the topo-climatic factors and please be more detailed, re-state the dependent variable. How was the accuracy calculated, on the basis of which data? I do not think this is in the methods

We have listed some topo-climatic factors and variables information in the 'General Comments-Method' part. And the accuracy is the percentage accuracy in classification that is calculated by the SPSS 27.0 software.

L 248 "previous study results" ï "previous work"

Corrected.

L 257 – 260 this should be in methods, not introduced here. please explain ROC

A receiver operating characteristics (ROC) graph is a technique for visualizing, organizing and selecting classifiers based on their performance (Fawcett, 2006). The accuracies of the models and consensus methods could be calculated using spatially independent test data by the area under the curve (AUC) of the ROC plot. The area under the ROC curve (AUC) is a measure of accuracy, in the sense of the ability of an algorithm to distinguish between two classes or groups. The range of AUC values is from 0.0 to 1.0. A model providing excellent prediction has an AUC higher than 0.9, a fair model has an AUC between 0.7 and 0.9, and a model is considered poor if it has an AUC lower than 0.7 (Swets, 1988, Marmion *et al.*, 2009).

Therefore, we calculated the AUC to measure the performance of the logistic regression model of the permafrost probability distribution.

L260 "some accuracy" and "closely related" is vague. Not sure what the purpose of I 260 -I 262 is, it does not bring much

Thank you for your suggestions. The original intention of these contents is to prove the reliability of the permafrost prediction model through the results of AUC. We will adjust this part of the content in the revised manuscript and make supplementary explanations in the method part.

Reference

Abrams, M., Tsu, H., Hulley, G., Iwao, K., Pieri, D., Cudahy, T., and Kargel, J.: The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) after fifteen years: Review of global products, International Journal of Applied Earth Observation and Geoinformation, 38, 292–301, https://doi.org/10.1016/j.jag.2015.01.013, 2015.

Baral, P., Haq, M. A., and Yaragal, S.: Assessment of rock glaciers and permafrost distribution in Uttarakhand, India, Permafrost and Periglacial Processes, 31, 31-56, 10.1002/ppp.2008, 2019.

Du, Y., Yi, J.: Data of climatic factors of annual average temperature in the Xizang (1990-2015). National Tibetan Plateau/Third Pole Environment Data Center, 2019.

Du, Y., Yi, J.: Data set of annual rainfall and climate factors in Tibet (1990-2015). National Tibetan Plateau/Third Pole Environment Data Center, 2019.

Fawcett, T.: An introduction to ROC analysis, Pattern Recognition Letters, 27, 861–874, https://doi.org/10.1016/j.patrec.2005.10.010, 2006.

Guo Z: Inventorying and spatial distribution of rock glaciers in the Yarlung Zangbo River Basin, Ph.D. thesis, Institute of International Rivers and Eco-Security, Yunnan University, China, 77pp., 2019.

Jones, D. B., Harrison, S., Anderson, K., Selley, H. L., Wood, J. L., and Betts, R. A.: The distribution and hydrological significance of rock glaciers in the Nepalese Himalaya, Global and Planetary Change, 160, 123-142, 10.1016/j.gloplacha.2017.11.005, 2018b.

Jones, D. B., Harrison, S., Anderson, K., Shannon, S., and Betts, R. A.: Rock glaciers

represent hidden water stores in the Himalaya, Sci Total Environ, 793, 145368, 10.1016/j.scitotenv.2021.145368, 2021.

Linsbauer, A., Paul, F., Hoelzle, M., Frey, H., and Haeberli, W.: The Swiss Alps Without Glaciers - A GIS-based Modelling Approach for Reconstruction of Glacier Beds, https://doi.org/10.5167/uzh-27834, 2009.

Liu, S., Guo, W., Xu, J.: The second glacier inventory dataset of China (version 1.0) (2006-2011). National Tibetan Plateau/Third Pole Environment Data Center, DOI:10.3972/glacier.001.2013.db. CSTR:18406.11.glacier.001.2013.db, 2012.

Marmion, M., Hjort, J., Thuiller, W., and Luoto, M.: Statistical consensus methods for improving predictive geomorphology maps, Computers & Geosciences, 35, 615–625, https://doi.org/10.1016/j.cageo.2008.02.024, 2009.

Ran, Y., Li, X.: The mean annual ground temperature (MAGT) and permafrost thermalstability dataset over Tibetan Plateau for 2005-2015. National Tibetan Plateau/Third PoleEnvironmentDataCenter,DOI:10.11888/Geogra.tpdc.270672.CSTR:18406.11.Geogra.tpdc.270672., 2019.

RGIK.: Towards standard guidelines for inventorying rock glaciers: practical concepts (version 2.0). IPA Action Group Rock glacier inventories and kinematics, 10 pp., 2022.

Scotti, R., Brardinoni, F., Alberti, S., Frattini, P., and Crosta, G. B.: A regional inventory of rock glaciers and protalus ramparts in the central Italian Alps, Geomorphology, 186, 136-149, 10.1016/j.geomorph.2012.12.028, 2013.

Swets, J. A.: Measuring the Accuracy of Diagnostic Systems, Science, 240, 1285-1293, doi:10.1126/science.3287615, 1988.