Author's response：

Dear Dr. Tobias Bolch:

Thank you very much for once again reviewing the manuscript we submitted and for your helpful suggestions! We have revised the manuscript again according to your suggestions. Please find the point-by-point responses to the two reviewers listed below this letter. We sincerely hope that the revised manuscript now meets the requirements of the journal.

Sincerely, thank you again for your ongoing series of efforts to enhance this manuscript!

Looking forward to hearing from you.

Best regards.

Yours sincerely,

Mengzhen Li

Corresponding author:

Yanmin Yang
Zhaoyu Peng
Gengnian Liu

27 Oct. 2023

Responses to the comments:

Specific comment

You map active, transitional and relict rock glaciers. You need to better distinguish between the activity status as the fronts of relict rock glaciers are typically located at lower elevations than the active ones (as mentioned in the text and also visible in Fig. 4). e.g. distinguish also in table 2. Also you need to clarify this issue when calculating the water storage. Relict rock glaciers do not contain ice anymore per definition and the ice content of transitional rock glaciers may be lower. You should also better clarify how you classified the activity and would also be good to show an example of a relict rock, transitional one and an active one in a figure.

Thanks to your suggestion, we have repopulated Table 2 with a description of the classification criteria for different activity types of rock glaciers in the Method section, and the corresponding figure legends have been added in Fig. 2.

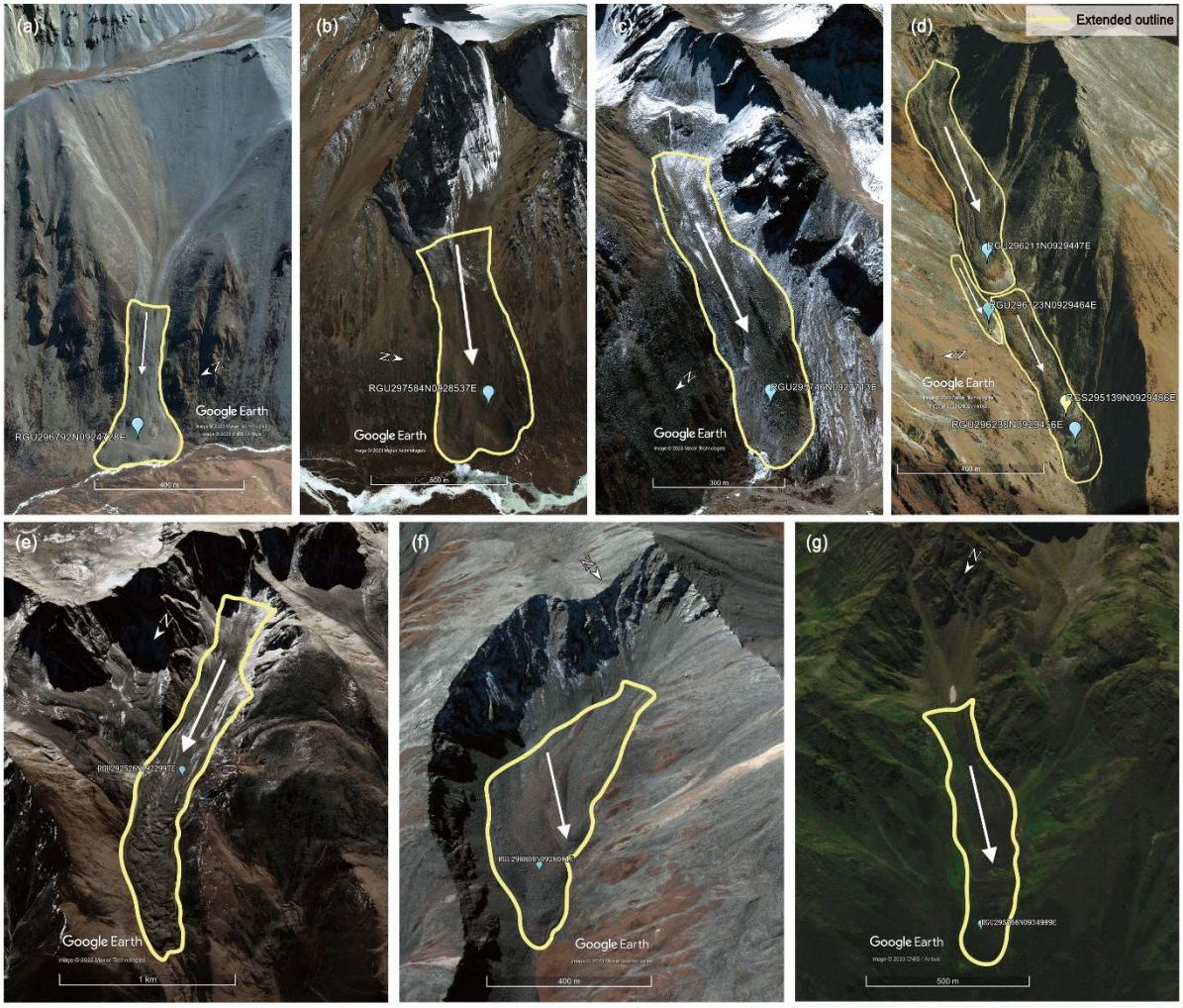

Figure 2: Example images of different upslope boundary types of rock glaciers in Guokalariju. (a) a debris-mantled slope-connected rock glacier; (b) a talus-connected rock glacier; (c) a glacier forefield-connected rock glacier; (d) a rock glacier system; (e) an active rock glacier; (f) a transitional rock glacier; (g) a relict rock glacier. Images from ©Google Earth.

Table 2: Mean characteristics for rock glaciers in three sub-regions.

	RG type	Number	Total area (km^3)	Mean altitude (m asl)	Mean MEF (m asl)	Mean area (km^3)	Mean slope range (°)	Mean MAGT (ºC)	Mean MAAT (ºC)	Mean MAP (mm)
Western Region	Active	296	18.89	5166	5118	0.06	20.11	-0.1	-1.87	341
	Transitional	78	6.54	5127	5069	0.08	19.85	-0.04	-1.64	350
	Relict	150	8.69	5067	5021	0.06	19.33	0.12	-1.34	341
	Talus-connected	354	19.42	5152	5109	0.05	19.83	-0.06	-1.8	345
	Debris mantled slope-connected	127	6.66	5101	5050	0.05	20.79	0.14	-1.36	338
	Glacier forefield -connected	43	8.05	5064	4968	0.19	17.23	-0.22	-1.7	337
	All	524	34.13	5132	5083	0.06	19.85	-0.02	-1.68	343
Central Region	Active	1,941	155.14	5160	5102	0.08	19.31	-0.59	-2.1	389
	Transitional	856	78.78	5090	5026	0.09	19.07	-0.67	-1.84	394
	Relict	650	57.57	4995	4929	0.09	19.23	-0.58	-1.62	400
	Talus-connected	2,123	181.58	5096	5037	0.09	19.22	-0.61	-1.89	395
	Debris mantled slope-connected	890	59.84	5104	5046	0.07	19.99	-0.47	-1.76	386
	Glacier forefield -connected	434	50.07	5201	5128	0.12	17.73	-0.87	-2.54	393
	All	3,447	291.49	5117	5051	0.08	19.23	-0.6	-1.94	392
Eastern Region	Active	248	13.85	4965	4906	0.06	23.79	-0.96	-1.31	496
	Transitional	255	18.41	4964	4897	0.07	21.99	-0.96	-1.69	495
	Relict	583	46.82	4861	4796	0.08	20.19	-0.86	-1.57	495
	Talus-connected	762	58.81	4930	4867	0.08	20.63	-0.92	-1.75	489
	Debris mantled slope-connected	310	18.58	4850	4785	0.06	23.49	-0.86	-0.99	511
	Glacier forefield -connected	14	1.69	5047	4971	0.12	19.86	-1.15	-2.45	503
	All	1,086	79.08	4909	4845	0.07	21.43	-0.9	-1.54	495

MEF: minimum altitude at the rock glacier front

MAGT: mean annual ground temperature

MAAT: mean annual air temperature

MAP: mean annual precipitation

Since previous studies have mostly treated active and inactive rock glaciers as intact rock glaciers collectively with the same ice content, we have applied the same method in our present study in order to compare the results with previous studies. Meanwhile, we also re-estimated the range of water storage in the three states of rock glaciers, active, transitional, and relict, following the method of Janke *et al.* (2015), and the results are provided in the supplement

(Table S2).

Table S2: Ice volumes (km^3) and corresponding WVEQs (km^3) referred to Janke *et al.* (2015) and calculated using the perfectly plastic model (Cicoira *et al.*, 2021) for sub-regions and Guokalariju-wide (All).

Region	Glacier WVEQ (km3)	Min RG WVEQ (km^3)	Max RG WVEQ (km^3)	Mean RG WVEQ (km^3)	RG : Glacier WVER ratio
All	3.95	1.83	0.87	1.35	1:2.92
Western	0.06	0.08	0.17	0.13	2.08:1
Central	2.65	0.71	1.46	1.09	1:2.44
Eastern	1.24	0.06	0.21	0.14	1:9.19

*Min RG WVEQ = Active RG (25% ice content) + transitional RG (10% ice content) + relict RG (0 ice content)

*Max RG WVEQ = Active RG (45% ice content) + transitional RG (25% ice content) + relict RG (10% ice content)

*Mean RG WVEQ is the mean value of the min and max, and it used to be compared to the WVEQ of glaciers.

- Avoid abbreviations in the abstract, in particular in case you do not use them further in the abstract. You can also write also "the study region" when mention the second time Guokalariju or write in full. Make sure you introduce the abbreviations in the main text.

- R1, R2, R3. These are unclear in the abstract. You may write Eastern, Central and Western region and then also write in full, e.g. "Central Region" when mention "R2" later in the abstract.

- In general, I recommend to write GKLRJ always in full as the abbreviation is not much shorter than "Guokalariju" and other mountain ranges such as the "Himalaya" are also not abbreviated. However, I leave the decision to you.

Corrected.

- Include in the abstract not only the maximum water storge but the range and include here to comparison to the glaciers.

Corrected.

"The possible water storage in the subsurface ice of rock glacier permafrost was 1.31-3.04 km^3, which is at a ratio of 1:1.86 to the surface ice in local glacier storage."

- Change the heading of 3.2. to "Estimating the Hydrological Storage"

Corrected.

- L 216 (of the track changes version): If I calculated the total area of all rock glaciers incl. the relict ones from table 2, the total area would be about 383,22 km². Probably because the rounding issues. Anyway, please come up with some uncertainty estimates or write about 404 km². This would be more than the glacier area and would mean a very high density. This is worth mentioning more prominently (but also mention the ratio for the active ones vs. glaciers). Provide the total area of relict, transitional and active.

Thank you for pointing this out, this may have been caused by rounding in the calculations, we have added mean characteristics statistics for each type of rock glacier in Table 2.

Also, we have added the following description to the manuscript:

"In Guokalariju, the total area of rock glaciers is 404.69 km^2, with active rock glaciers covering 187.88 km^2, transitional rock glaciers covering 103.73 km^2, and relict rock glaciers covering 113.09 km^2, respectively."

"In the Guokalariju, along with the continuous melting of glaciers in the study area, the area of active rock glaciers now exceeds the glacier area, and the estimated water storage of rock glaciers is about 54% of the glacier water storage, which shows the indispensable hydrological significance of rock glaciers in the study area."

- There are different estimates of glacier volumes. I ask you to compare to those ot at least the most commonly used one (e.g. Farinotti et al. 2019). The comparison should be straight forward as the data is freely available.

Thank you for your suggestions. We have added to the supplement the statistical results of ice thickness in the study area measured using the three models Glabtop2 (Frey *et al*., 2014), OGGM (Maussion *et al.*, 2018), and the data provided by Farinotti *et al.* (2019) (Table S1). It can be noticed that the results of Glabtop2 lie between the other results. Previous results have shown that GlabTop2 is more sensitive to the accuracy of both DEM elevation and slope of the Tibetan Plateau compared to other models. Therefore, we chose the ice thickness results measured by GlobTop2 for water storage estimation of the surface ice contained in the glaciers in the study area.

Table S1: Ice thickness of glaciers in Guokalariju calculated by different models.

Model	Min ice thickness (m)	Max ice thickness (m)	Mean ice thickness (m)
Open Global Glacier Model (OGGM; Maussion *et al*., 2018)	1	176	24.05
GlabTop2 (Frey *et al*., 2014)	1	208	23.87
Farinotti *et al*. (2019)	4	147	28.82

- L340ff. Include the uncertainty ranges of the total water storage of rock glaciers. Please also check the numbers carefully, e.g. Jones et al. (2018), Sci Rep. write "We provide the first approximation of near-global RG water volume equivalent and this is 83.72 ± 16.74 Gt.". Use cad cite the most up to date number and reference only.

Thanks for the reminder. We have rechecked and updated this data. Because Jones *et al*. updated the results of this article in December 2021, the first approximation of near-global RG water volume equivalent from "83.72 ± 16.74 Gt " has been changed to "62.02 ± 12.40 Gt." The near-global RG to glacier water volume equivalent ratio changes from "1:456" to " 1:618." (Jones *et al*., 2021b). Since the Rock Glacier Database (RGDB) contains data up to 2017, we add to this the results of studies published after this date on rock glacier water storage calculations (Millar and Westfall., 2019; Wagner *et al*., 2021). At the same time, Jones *et al*. recalculated hidden water stores in the Himalayas in their article published in Science of the Total Environment in 2021. As a result, we also removed the Jones *et al*. (2018b) included in their RGDB and used the new results (50.83 ± 10.17 Gt) for the calculations. Finally, we obtain an updated global rock glacier water reserve of approximately "95.49 ± 12.40 Gt".

- L345ff: I recommend also to cite the number of Bolch and Marchenko (2009), because it is located also in High Mountain Asia).

Thanks to your reminder, we realised that the results contained in this article had previously been included in the RGDB (Jones *et al*., 2018b), so we did not make a separate citation, but the results were in fact included.

- Add an uncertainly rage to the area of rock glaciers in the conclusions or write "about …" Provide also the area of the active ones.

Corrected.

"The results show that there are 5,057 rock glaciers in the study area, covering an area of about

404.69 km^2 in total. Among them, the area of active rock glaciers is about 187.88 km^2, which exceeds the area of glaciers in the study area. "

Reference

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