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Comment on tc-2022-178

Wilfried Haeberli (Referee)

Referee comment on "Assessment of rock glaciers, water storage, and permafrost distribution in Guokalariju, Tibetan Plateau" by Mengzhen Li et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-178-RC1, 2022

Comments by Wilfried Haeberli

on

Assessment of rock glaciers, water storage, and permafrost distribution in Guokalariju, Tibetan Plateau

Paper submitted to The Cryosphere by

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General

The authors present and discuss the results of a rock glacier inventory in southeastern Tibet. Their work follows a number of other recent studies in the larger region, is at present-day level of knowledge and understanding, and represents an important contribution to the internationally coordinated efforts to map and monitor mountain permafrost as part of global climate observation (IPA-RGIK, GTN-P). The text is mostly clear, well-structured and accompanied by a good number of adequate references. Further improvements are mainly possible with respect to (1) the physical background and technical terminology of the treated phenomena, (2) more precise information about climatic conditions as key factors of permafrost existence and evolution, and (3) adequate treatment of related environmental aspects.

- Physical background and technical terminology

Mapping the landform “rock glaciers” for inventory work is perfectly adequate. It would, however be important to more precisely and explicitly mention the physical conditions and processes behind such landforms. The striking flow features used to define the landform “rock glacier” are expressions of coherent (or cohesive) viscous flow (or creep) taking place in perennially frozen materials (talus, debris) rich in ice. The term “perennially frozen” implies two fundamentally important physical aspects: the subsurface material remains below 0°C throughout the year and contains ice (in whatever form). The volumetric ice content of about 40-60% as applied in the paper is based on core drillings and numerous geophysical soundings worldwide and hence realistic. Such high ice contents exceed the pore volume of the involved talus or morainic material in unfrozen conditions by roughly a factor of two or even more. It is this "ice-supersaturation" or "excess ice" which not only induces cohesion by relating individual rock particles with each other but at the same time also reduces internal friction by separating them from each other. The resulting viscous flow through steady-state (or secondary) creep enables the formation of the recognizable landform "rock glacier" as a result of cumulative deformation over time scales of millennia (typically Holocene). The "thickness" value very roughly estimated by the authors using the "Brenning approach" most likely represents a characteristic thickness of the moving body as defined in many cases by internal stress-related shear horizons or by bedrock occurrence at depth. Perennially frozen materials can, however, exist far beyond this depth as well as in the surroundings of striking creep features. As a consequence, the water volume calculated from moving frozen materials only represents a lower limit of the totally existing subsurface ice in the permafrost of a region. Cicoira et al. (2020) and Krainer et al. (2014) with their literature references can be consulted concerning such aspects.

- Climatic conditions

Permafrost is a specific geothermal condition (negative subsurface temperature throughout the year) directly related to climatic conditions at regional scale (especially air temperature) and to microclimatic conditions (mainly snow cover, radiation, surface characteristics) at local scales. Instead of giving a "mean temperature" for an entire region, mean annual air temperatures (MAAT) should be defined as a function of altitude and time. This then makes it possible to define MAAT at sites where creeping permafrost occurs. An advanced calculation of mean annual ground temperatures (MAGT) after Ran et al. is used in the present study, enabling definition of corresponding values for the documented permafrost landforms. From the mean altitudes and the mean MAGT provided in the paper for the region(s), most likely values for active rock glaciers there are likely to be between about 0 and -5°C. Such quantitative information should be provided in the paper and discussed with respect of ongoing warming trends (which must also be more precisely defined). A brief explanation of the applied MAGT model should be given and a more detailed discussion with respect to the involved variables of the quantitative approach used concerning probabilities of permafrost occurrence is also needed.

- Related environmental aspects

General environmental aspects potentially related to the completed work are only briefly mentioned. Such aspects as water quality, slope instability, or global climate-related permafrost monitoring are serious matters, needing at least a minimum of specific formulations (e.g. heavy metals in water from thawing rock glacier permafrost, large rock- and rock/ice avalanches from steep icy peaks, RGIK-GTN-P, GCOS) and up-to-date literature referencing. Examples could be: Thies et al. (2013: chmistry of water from rock glaciers), Deline et al. (2021: slope stability), Etzelmüller et al. (2020: evolution of borehole temperatures in European mountain permafrost), RGIK/IPA.

Minor remarks

The English needs smoothing in places. Write "rock glacier inventory" (instead of rock glaciers inventory; check throughout the paper). Use present tense when describing results concerning present-day conditions.

Detailed technical remarks are contained in the annotated PDF.

References:

Cicoira, A., Marcer, M., Gärtner-Roer, I., Bodin, X., Arenson, L.U., and Vieli, A.: A general theory of rock glacier creep based on in situ and remote sensing observations. Permafrost and Periglacial Processes, 32(1): 139-153, 2021.

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Krainer, K., Bressan, D., Dietre, B. Haas, J.N., Hajdas, I., Lang, K., Mair, V., Nickus, U., Reidl, D., Thies, H., and Tonidandel, D.: A 10,300-year-old permafrost core from the active rock glacier Lazaun, southern Ötztal Alps (South Tyrol, northern Italy). Quaternary Research 83 (2), 324–335. doi.org/10.1016/j.yqres.2014.12.005, 2014.

RGIK/IPA: see reference list in paper

Thies, H., Nickus, U., Tolotti, M., Tessadri, R. and Krainer, K.: Evidence of rock glacier melt impacts on water chemistry and diatoms in high mountain streams. Cold Regions Science and Technology 96, 77-85, 2013.

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2022-178/tc-2022-178-RC1-supplement.pdf