

Interactive comment on “Review article: Inferring permafrost and permafrost thaw in the mountains of the Hindu Kush Himalaya region” by S. Gruber et al.

Anonymous Referee #2

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In this manuscript the authors aim to provide a review of the state of knowledge of permafrost in the Hindu-Kush Himalaya (HKH) region. The paper is motivated by the fact that there is likely a large areal abundance of permafrost in the HKH and therefore widespread impacts are expected under thawing conditions and although research on permafrost in the HKH dates back to the 1970's there are still vast gaps in knowledge. Therefore this review is an important and timely contribution to the topic.

The paper is clear and well written/ structured and does a good job of providing the science basis to the problem as well as referencing existing works in the region. However, I have several comments to put forward for consideration.

MAIN COMMENTS

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1. As reviewer#1 already pointed out there are large parts of textbook style text. I would say that the content on P.2 in the chapter "Principles governing...." is useful and important. Physical principles can and should be exchanged between regions while acknowledging that relative importance of processes may change. However, I think that particularly the chapter "Persistence and impacts of permafrost thaw in the HKH" draws too heavily on general permafrost research. The current text is a really nice summary of what can be expected based on known experience/knowledge but could be given more context by rooting in known events/ examples from the HKH in perhaps a more detailed case study style approach. Important topics/events could be GLOFS, landslides/rockfalls, engineering issues. The authors touch on all these topics but in a rather 'high level' manner. These more detailed "case-studies" could also be an opportunity for more figures in the manuscript, which I found quite sparse. I realize the challenge of providing a review over such a diverse area (as you state p7 l1-2) but still feel some more detailed examples would give the manuscript good grounding.

2. I think the chapter on "climate and climate change..." could be expanded as there is certainly a reasonable amount of work in this field in the HKH (as compared permafrost research) and several high elevation initiatives. Climate in the end plays a large part in controlling the distribution and evolution of permafrost and an expanded section would serve as a good starting point for "inferring permafrost". Here it could also be mentioned that the northerly side of the Hindu Kush (Afghanistan) experiences a unimodal precipitation pattern (winter, as shown in Fig1D) dominated by westerlies as effect of monsoon is largely blocked by southern edge of the Hindu-Kush in Pakistan. In this section there could also be an opportunity to discuss snowcover in more detail due to both a good observational record and its important controlling effect on ground temperatures.

3. The climate change part of the the climate chapter could be stronger as there is a good deal of literature on this topic that could be given coverage as this is central to inferring evolution of permafrost in different regions. Example being a discussion of

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the diverse effects expected in such a heterogeneous region as the HKH - how could relative changes in precip and temp play out with respect to permafrost in different regions?

4. Although a lot of research questions are presented in the final chapter "Perspectives", I think a useful contribution this paper could make would be to clearly identify and focus on key current knowledge gaps on this topic in the HKH and possible strategies to addressing them. In this context the authors mention simulation and remote sensing (c.f. "Perspectives") but a section on what's needed in terms of ground-based measurements/ networks would be good and how this compliments remote methods by assessing model performance or calibrating RS algorithms.

5. As authors from ICIMOD are present on this paper it might be a good opportunity to see what scope for regional initiatives there are. What's going on currently in this topic (if anything) and what are the possibilities in the future?

TECHNICAL COMMENTS

1. p.3 l.6: "In combination, these effects can cause differences in mean annual ground temperature of more than 10 °C within a distance of less than one kilometer.": reference would be useful here.

2. I think some references from Bodo Bookhagen's precipitation work could be included in the climate section.

3. p.6 l.30 additional measurements references - Ishikawa 2001, Regmi 2008 (you already have these elsewhere).

4. p.9 l21-23 - awkward sentence, perhaps review.

5. p.12 l15-16; "or noticed" sounds odd, perhaps reconsider this sentence.

6. I'm missing Kaab et al 2005 - as an important mountain permafrost hazards reference.

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7. Figure 1: Hopefully this can be full page in final publication and perhaps consider adding country outlines (even if these are complex in places) in a subtle way to aid orientation. Glacier outlines are plotted on each subplot but only on legend of 1E I think - I found this slightly confusing at first. Perhaps this legend item should relate to the entire figure.

8. I think figure 2 would be enhanced if you could pairwise match the Google earth/model overlays to existing photos of each example you give, even if its just a small sample of the landscape you show. This would give informative local context.

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