Review

An-empirically-derived hydraulic head model controlling water storage and out flow over a decade in degraded permafrost rock slopes (Zugspitze, D/A)

By Riccardo Scandroglio et al.

General Comments:

This paper evaluates the ground water dynamics in two rock fractures in a tunnel by deriving an empirical model using decades of discharge and weather measurements and snow simulations. The authors analyzed and compared long terms and short terms trends by combining data records at over three stations in the study region. The authors used water collecting systems to estimate discharges, which were later used to generate fluid flow models beneath the study region. The results are summarized in **7. Conclusion:**

Here we quantitatively demonstrate the relevance of water flow in deep fractures and prove its relevance for slope stability of degraded bedrock permafrost. The estimated hydrostatic pressures can destabilize and/or trigger unstable rock slopes.

The technical quality of the paper is good although there are considerable grammar/writing mistakes that should be corrected before publishing. Authors have clearly analyzed and interpreted the results. The novelty of the research is also acceptable. However, I have some suggestions for authors to improve the quality of the manuscript before publishing it. Therefore, I recommend accepting this article with major revisions. My suggestions are as below:

The authors assembled a large data set and rigorously processed it to generate models and get meaningful findings. However, it is somewhat disappointing that the presentation and writing are on a low scale. It is not clear to me why you did this study, what are key findings and how those results will enhance our current understanding of the problems. Please clearly summarize key questions, findings and major impact in both abstract and conclusion sections. There is lot of information and repetitions on intro and method sections that you do not need to interpret your results. You can remove those and that will help to reduce the length of the method section. I would suggest re-structuring the manuscript in the following way: (1) intro (2) Geological or hydrological background and previous work in the region (3) method (4) results including modeling part (5) discussion (6) conclusion. This will follow the general structure that most of the journals follow, and it will be easy to go over the info on the manuscript for both authors and readers.

Specific comments:

Title: What is D/A?

1. Line 8: We analyze input (i.e., snowmelt …) and outputs (i.e.,…, base flow(partially saturated), no-flow(unsaturated)).

2. Line 14: Remove sentence starting "E.g.,".

3. Line 15: Sentence starts on "Here we show", Not clear you put this on right place. I feel like you are referring to the method within the few sentences that you summarized your results. Either Re-write the sentence or put it into the place where you refer your methodology in the abstract.

4. Line 24-26: Sentence starts on "Logistically challenging terrain ….", Not clear what is your point in this sentence. Please re-phrase it.

5. Line 30: "Developments suggest that", Not clear, what development? Bedrock or basin or hillslopes or what?

6. Line 53: Remove "of rock-rock contacts" and add "between rock contacts"

7. Line 61-65: As I understand, authors try to list the methods and their limitations in this paragraph, but it is not clearly state that. So please re-write the entire paragraph.

8. Line 78: remove "and visited by thousands of tourists daily"
9. Line 79: remove all sentence starting " A disused…"

10. Line 101: Replace "thanks to a" with ", equipped with". I noted similar types of wording at many places (e.g., line 154, 175) in the manuscript and I would recommend either removing or fixing those places with appropriate scientific words. You can give credits to all in the acknowledgement section.

11. Line 120: title should be like "4. Data and method"

12. Line 125: Add "snowmelt prediction or calculated snowmelt"

13. Line 136: Add citation for software package.

14. Line 234: replace "yq" with "q"

Figures:
Fig 1: add description about little inset map on figure (a) to caption. shift small table beneath figure (d).

Fig 6: fig (d & g-i) and Fig 8a: Not sure why there are color lines outside from the axis and what is referring to? Never seen manuscript figure like that before.