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The Cryosphere Discussions

Interactive comment on "Fracture dynamics in an unstable, deglaciating headwall, Kitzsteinhorn, Austria" *by* A. Ewald et al.

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We thank Jan Beutel for his insightful and constructive comments. The expressed criticism is substantial and points to a lack of novelty and originality in the submitted manuscript. We therefore consider a complete revision of our manuscript. The intended new manuscript will no longer focus on recent deglaciation, instead we will explore the relation between fracture kinematics and active layer dynamics in steep, frozen rockwalls. For this purpose we will now concentrate on regression analyses between data from the described crackmeter station and an adjacent permafrost borehole. We consider the immediate vicinity of a deep borehole and a crackmeter station a novel measurement setup that has the potential to advance the current knowledge on kinematics in steep bedrock permafrost. To increase the significance of the new

analysis we will expand the time series to four years (2016-2019) as opposed to 2.5 years in the current manuscript. To model thermo-elastic deformation we will resort to the linear regression model published by Weber et al. (2017), and will no longer derive the thermo-elastic deformation component from cracktop temperatures below -10 °C, which has been criticized by all reviewers. To identify potential discrepancies between measured and modeled fracture kinematics we intend to implement state-of-the-art ice segregation models driven by borehole temperature data.

COMMENT: The manuscript by Andreas Ewald et al. discusses experiments and their respective results regarding kinematic observations made in a steep, high-alpine rockwall (permafrost) in the European Alps. In general this is interesting and timely work. Research in this area is appreciated by many although similar work exists/is performed only by a (very) small community. As a result the body of knowledge and related work is compact and many open questions exist. And exactly in this respect I feel that the present manuscript lacks focus and tries to solve (elude to) too many problems at once. Many of the claims made are not substantiated by evidence (observation/models) and in parts are contradicting. As such i suggest to limit the manuscript to relate only to processes that are either known and defined in related work or are clearly visible in the data and analysis provided.

REPLY: Thank you for this constructive comment. We will consider a more thorough focus of our analysis and discussion for the revised manuscript version.

COMMENT: The title suggests that an "unstable, deglaciating headwall" is discussed in this paper. While i have no doubts that (significant) glacier retreat also takes place at Kitzsteinhorn, no evidence (retreat rates, references, differential DEM, photos) are given to back up the "deglaciating". W.r.t. to the term "unstable" the paper later states that "irreversible fracture opening was not observed". Additionally there is no further evidence given (rockfall observations, large-scale kinematic observations, debris) that back up the term "unstable". Similarly the term "headwall retreat" should be backed up as well. How much? What is known here? What is observed? Given the collocation

with infrastructure (cable car, ski resort) long term evidence should be available apart from regional spatial data and references.

REPLY: We decided to shift the focus away from the deglaciation aspect towards fracture kinematics and active layer dynamics. Nevertheless the comment reveals that the site description requires improvement. We will provide more information on the rockwall-glacier interaction and the site conditions in the study site description. We will no longer refer to headwall rates here, since this is beyond the scope of the data.

COMMENT: With respect to the data presented there are some issues that should be fixed: The temperature "Crack Top" is not properly described ("Crack top temperatures may not represent the entire fracture"). Where is it measured and what does this represent exactly? The air temperature and snow height that is in large parts used for process analysis is measured on the glacier, yet your rock wall is north facing above the glacier (up to 100m altitide). How do you correct this air temperature/snow height to reflect conditions inside the steep north-facing rock wall? Your precipitation measurement is from a station 500-600m lower in altitude and 2km away. This gives you an impression of the regional precipitation (sum), but in an alpine setting it is doubtful if it really captures event-by-event details w.r.t. precipitation, especially for the steep rockwall environment and strong (warm) summer liquid precipitation you are targeting. A co-located precipitation sensor would be highly beneficial here. The model developed here (section 4.3) lacks detail. In it's current state, the model cannot be reproduced.

REPLY: We will revise our measurement setup description to better illustrate our measurement. Concerning the climate data, we did not perform any corrections to cover distance and altitudinal variability. Air temperature and snow height of the climate stations are only part of the site description and not used in the analysis. We referred to precipitation events of the mentioned station 2 km away. We are not aware of any technique to correct these data, but we consider this distance relatively small compared to similar studies. For the purpose of our analysis, we focus on the timing of the events and not on the amount of rainfall. We gratefully acknowledge further comments on

ways to correct for these distance changes, but it remains to be proven how local variability of slope, sheltering or aspect, can be reproduced by a correction. Concerning the modelling approach, we will change to a different modelling approach (Weber et al. 2017) and therefore generate a new model description.

COMMENT: Last I want to comment that you regularly relate to "randkluft systems" and to people knowing your project (history) it is known that you are actively exploring/instrumenting also the perimeter of the Kitzsteinhorn rock walls below the glacier surface but this paper does not show any evidence from below the glacier surface. Therefore any connect to processes specific to this "randkluft" regime, e.g. last sentence of the abstract, middle section of section 5.3 are highly speculative at the best. Similarly, speculative statements ("other mechanisms may affect fracture dynamics" "may lead to...") do not offer any sound interpretation of what is/can be observed in this case study. The general impression that this manuscript is not quite mature yet is further exacerbated by the fact that figure captions and figures are not located together, which makes the manuscript rather hard to decipher.

REPLY: In the revised version of the manuscript we will shift the focus away from the randkluft and deglaciation. Therefore this comment will no longer apply. We will produce a more mature version of the manuscript. Dislocation of figures and captures will be avoided in a revised version. This was mainly caused by the template used.

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