Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2020-70-RC1, 2020

Earth Surface Dynamics Discussions
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Interactive comment on "Stability assessment of degrading permafrost rock slopes based on a coupled thermo-mechanical model" *by* Philipp Mamot et al.

Anonymous Referee #1

Received and published: 3 December 2020

The manuscript by Marmot et al. presents a failure model for degrading permafrost rock slopes, which couple thermal and mechanical properties of the slope. They use the Zugspitze crest (Germany) as an example, from which they draw general conclusion about the thermo-dynamical behaviour of steep rock slopes in permafrost environments.

In general, the manuscript is mostly well written and addresses a topic of wide scientific interest, and therefore deserves publishing in an international journal. They demonstrate the stability in steep rock faces is influenced of ground temperatures, and stability is reduced with increasing temperatures toward the melting point. I am not

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Discussion paper

expert in some of the details of the mechanical modelling used, so I do not have any comments of the parametrisation and mechanical equations. This should be addressed by a reviewer with proper competences within this field. It is obvious, that the authors present innovative results by combining the ground thermal regime and mechanical behaviour in a real slope setting, at least I am not aware of many similar studies. It has to be mentioned here that this topic is of outmost interest in the light of passed and predicted atmospheric warming. However, before possible publishing I would suggest some issues to be solved:

- I struggle a bit with the structure of the manuscript. The authors want to show the result of a rock mechanical model, where mechanical parameters change with changing ground temperatures. This is in principle fine. However, chapter 2 is not only the mechanical model, but also a lot of results which serve as important input to the model, and to a large degree documented as supplemental. I would suggest to re-structure this part, distinguishing the site description, rock joints and kinematics, lab work and permafrost distribution from the rock mechanical set up and modelling. Here I assume that the first topics I mentioned are derived in this manuscript, as many of these points are more explained in the supplemental. The authors want to present a large material, from the present state of permafrost and stability of the Zugspitze crest, to the development of a thermo-mechanical model, resulting in for me interesting conclusions.

- The ground temperature distribution and temporal change is a crucial part of the manuscript. The authors start with a thermal setting derived from ERT measurements, which were calibrated in the laboratory in terms of temperature and associated resistivity. Much of the underlying assumption are presented in the supplemental, on has to jump back and forth to find the relevant information. Maybe it is wise to include some of it in the main document. It is positive that the authors discuss the possible inclusion of a heat-flow model to assess the geometry of the permafrost body in the Zugspitze crest.

- The manuscript is lengthy and partly full of redundancies/summaries and can be

shortened substantially and with this make space for inclusion of some of the supplementary information. E.g. the conclusions are too long, and partly either a summary or even a discussion (see below). Make a list of conclusions of your work and avoid lengthy summaries.

The following minor comments apply:

l. 22: last sentence abstract, is this so? Only to check. . ..

l.79: Randa rock slope (Gischig et al) – no permafrost there?

l. 103: Chapter 2, see comment above. This is a mix of methods and results. I would suggest you first evaluate the setting (rock joints, kinematics, thermal regime) and then make a model based on the settings.

l. 116: Do not understand the sentence, velocity are reduced 84% during summer? Please clarify. Fig. 2: Show first the map (setting), then the images. Scale bar is missing. Maybe use colors for elevation, or use a normal topographic-type map. DEM is of no interest here.

l. 161: You give "results" in the setting chapter. . ...

l. 177: all 2.4. is a result of investigations done for this manuscript (?)

l. 225: 2.5. is a new part, and should probably be handled as such.

l. 339: Why is this an own chapter? This is part of the modelling?

l. 454: Avoid all sentences starting "as mentioned above. . .".

Fig. 7: Consider to give these displacements in mm or so.

l. 557, discussion: This all start is a totally uncecessary summary. You can delete the whole page and start with 5.1.

652: The discussion should probably start with the limitations etc. It destroys a bit the flow of the discussion,

l. 725: The conclusions are far too long. 50% of the conclusions is a summary, in addition to some discussion points (e.g. l. 767). You can avoid repeating stuff and citing literature in the conclusion. You should show what your study has come up with.

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