Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC2
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Comment on esurf-2022-39

Anonymous Referee #2

Referee comment on "Simulating the effect of subsurface drainage on the thermal regime and ground ice in blocky terrain in Norway" by Cas Renette et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2022-39-RC2, 2022

General comments:

The authors have used CryoGrid simulator to perform three synthetic experiments based on soil stratigraphies with/without drained soil conditions to investigate whether well-drained blocky soil conditions (referred to as blocks only, drained in the manuscript) can lead to colder soil thermal conditions in permafrost regions. One-dimensional simulations with dynamic water/ice were carried out using an empirical subsurface lateral flow representation. The results showed significant sensitivity to wind-driven snow distribution and soil moisture conditions (lateral flow). While the effects of snow, soil stratigraphy, and soil moisture on permafrost thermal regimes are well-known, I still believe the study, once revised, will make a nice manuscript for permafrost researchers, especially mountainous permafrost audience. However, I have some concerns with the manuscript in its current form.

Major comments:

- Describe in more detail the rationale for each scenario.
- The effects of drainage, snow, soil moisture, etc. have been studied for other permafrost sites, but may not be particularly for mountainous regions, the physics does not change from low- and moderate-relief regions to mountainous regions. How does this study connect with existing literature that studied the effect of snow, soil moisture, etc. on permafrost thermal regime? A better referencing is needed.
- I would strongly suggest rewriting/reorganizing the Introduction (also Methods) section. The authors have done a good job in providing detailed background; however, it needs to be organized so the reader can follow it. Especially, I found a disconnect between the driving mechanisms and how this work is going to address those. The last two paragraphs in the Introduction section provide a slight background but that needs to be expanded.
- There are lots of short (4-5 lines) paragraphs throughout the manuscript, and probably

not needed and can easily be merged.

- The example of CryoGrid processes provided (lines 134-135) is highly abstract. I am not expecting to provide all the details, but at least some details for a quick reference.
- Paragraphs in the abstract? does the journal allow it, usually not seen/recommended?
- There are many places where authors need to be specific. for example, L135: "Likewise, different process representations for the seasonal snow cover can be chosen." this needs to be expanded to mention specific snow processes rather than "different processes"
- Sensitivity to computational domain depth and bottom boundary condition is needed. Provide details that why the domain depth of 5 m and the prescribed geothermal flux were chosen. Describe if the results are sensitive, they will be, to the domain depth and bottom boundary conditions. I understand this can get complicated but at least mention it in the text.
- A schematic of the model domain with boundary conditions, soil discretization, soil layers, etc. can help better follow the results.
- Figure 7 shows results for transient runs (1951-2019). What is the air temperature gradient (or increase in the mean annual air temperature) over this period? and did the authors try to run detrended data to isolate the effect of temperature increase? Otherwise, this effect is not due to soil stratigraphy and drainage only. And since the porosity in the "Blocks with sediment" case is 25% (half of the two other cases), more degradation is not unexpected. Also, what caused the patchy low ice content in some of the subplots in Figure 7 (for example, top/bottom right)?
- The authors kept referring to "at depth 5 m". Please draw/highlight surface elevation (datum) in the figures. For instance, what elevation would be "5 m depth" in Figure 7? It is not clear.
- The study is performed on an idealized column domain with a fixed surface datum. So, it would be easy for the reader to have the vertical scale in "depth" [0,5], instead of elevation, which I don't think is needed unless I am missing something.
- The focus of this work is to study the effect of soil stratigraphy (with drained/undrained conditions) on the soil thermal regime; however, no sensitivity study is performed on "soil stratigraphy". For instance, how the *blocks only* scenario with porosities of 0.6 and 0.4 will affect permafrost conditions?
- I would also suggest some of the sensitivity-related results, for example, section 4.2, to be moved to a supplemental document, and focus more on what is new here.
- Also, in section 4.1 (line 307) authors mentioned all simulations used a single snowfall factor, however, later in section 4.3 they use different snowfall factors. This needs more explanation. Providing a table (which may not be in the main manuscript) listing all scenarios (other than the three listed in Table 1) will help the reader better understand it otherwise it is hard to untangle.
- What type of soil retention curve is used in the study? Moreover, how sensitive are the results to hydraulic conductivity? I didn't find any mention of the role of spatial gradient (steepness). All these factors significantly impact drainage. Discuss.

Minor comments:

Please see the annotated manuscript (attached as a supplement) for more comments.

Please also note the supplement to this comment:
https://esurf.copernicus.org/preprints/esurf-2022-39/esurf-2022-39-RC2-supplement.pdf