

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-4

Anonymous Referee #1

Referee comment on "Post-Little Ice Age rock wall permafrost evolution in Norway" by Justyna Czekirda et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-4-RC1>, 2022

General Comments

Czekirda et al. present an interesting analysis to describe the evolution of permafrost in rock walls over the last 100+ years. The analysis is based on 2-D thermal modelling and measurements from rock wall temperature loggers along 9 profiles in Norway. The authors consider the various factors influencing the permafrost distribution and its evolution in the simulations and also assess their relative importance. The results of the simulations indicate an increase in ground temperatures since the 1980s and that the rate of change increases with elevation within a single rockwall section. Overall the analysis, interpretation of results and conclusion appear to be sound. The paper is for the most part, well written but some editorial revisions are required. The paper would be of interest to the general permafrost research community and especially those interested in mountain permafrost distribution and the stability of rockwalls. The paper is therefore worthy of publication following minor revision. I have a number of comments for the authors' consideration.

It is good that field measurements such as the rock wall temperature measurements have been utilized in model calibration. However, there is not much comparison of the simulated results with observations. There is some comparison of the data (near-surface temperatures) derived from the rock wall loggers with the simulated temperatures but as the authors point out, these data were used for the calibration of the forcing input and only qualitative comparisons are done. There is not much comparison to observations of deeper temperatures, although a comparison to one borehole is mentioned. There appears from the information in section 2 and the references cited there are a number of boreholes with temperature cables (e.g. Christiansen et al. 2010) in the study area and also geophysical surveys have been done (e.g. Etzelmuller et al. 2021). It is not clear whether any of the boreholes or geophysical surveys are located on or close to the study transects. It would be good if the paper could include a comparison of these observational data with the simulated results. This could help strengthen discussion with respect to the relative importance of forcing factors (and limitations of the model) and other modes of heat transfer such as convection or advection along the various profiles.

Specific Comments

L17-18 – revision suggested: "...show the distribution of permafrost is sporadic to continuous along..."

L22 – It makes more sense to mention rock wall temperature before permafrost distribution since it is the ground temperature that determines occurrence of permafrost.

L33-35 – You could be clearer here that this was due to an extreme event rather than long-term change.

L38 – "permafrost-affected cliffs" or "cliffs underlain by permafrost" might be a better way of writing this.

L40-45 – Could you refer to the 3D (or multi-dimensional?) nature of heat flow and the higher thermal conductivity of the rock (compared to soil, unconsolidated sediments) here.

L53-56 – Aren't freeze-thaw cycles important to this process (thermal contraction/expansion)? Would the frequency of these cycles change with climate warming?

L76-78 – Are you referring to the BTS approach here (e.g. Hoelzle 1992 <https://doi.org/10.1002/ppp.3430030212>; Gruber and Hoelzle 2001 <https://doi.org/10.1002/ppp.374>; Bonnaventure and Lewkowicz 2008 <https://doi.org/10.1139/E08-013>)

L85-86 – revision suggested: "...to simulate the thermal evolution since 1900 of mountain permafrost...." (I think you mean that you simulate thermal state since 1900 rather than rock walls being instrumented since 1900).

L89 – Why not just refer to limits of permafrost occurrence rather than near-surface permafrost.

L91-93 – How were the transects chosen – are they representative of the geological and climate conditions in the region?

L96 – Here and throughout text – just refer to “Western Norway” (delete “the”)

L98 – revise to “annual total precipitation” (revise elsewhere in text also)

L99 – revise to “mean air temperature” – is this “mean daily air temperature”? (note: important to be clear that this is air temperature since surface and ground temperatures are also mentioned in text). It would be useful to give the normal mean annual air temperature as well as the range, here and in description for the other study areas.

L102 – Do you mean “insulates” rather than “isolates”?

L103 – Revision suggested: “...2015-2017 nine loggers have been installed at selected rock walls to measure surface temperature in western Norway”. Since the data from these loggers appears to be used in your study, you should probably mention the type of logger and its accuracy and precision.

L 127 – Revision suggested: “ ...areas in Norway, including its highest peak.”

L132-133 – Revision suggested: “..than western Norway with normal (1961-1990) mean precipitation typically less than 1000 mm per year (Lussana, 2018)...”

L135 – delete “the” before Central

L136-144 – Are these boreholes and geophysical surveys on or near the study profile?

L140-143 – Do you mean that permafrost occurs at least at elevation as low as 1559 m and that frozen conditions exist at all the boreholes down to this elevation? OR is it present at some boreholes but not others? Some clarification and revision of text required.

L145 – replace “whole” with “entire”

L155 – Here and elsewhere in text, delete “the” before “Northern”

L156 – revise to: “...with the highest annual total precipitation in..... where annual total precipitation was less than...”

L159-160 – Were these boreholes on or near the study profiles?

L195 – Define “GST”

L197 – Revision suggested – “Note that since CryoGrid 2D is a conductive mode, convective...”

L216 – Do you mean “surficial deposits”? also “all of” might be better than “the entire”

L239 – “positive trends” rather than “increasing”?

L249-251 – How far back before 1900 do you reconstruct SAT?

L259 – revise to “GST determined from rock wall loggers”. It isn’t clear what you mean by giving more reliability as SAT and GST are not the same thing and there are offsets which you mention later in the paper.

L268 – Be clear that freezing n-factors are used. Revise to “.....accounted for by using freezing n-factors (nF) that....”

L270 – revise to: “...assign various nF values along the....”

L288-289 – revise to: “...case of rock walls thawing n-factors (nT)....might not be able to....”

L301 – Revision suggested: “Model runs start around..”

L334 – What depth for GT are you referring to?

L339 – Although the video shows the evolution of the thermal regime over the entire 120 years it would be useful to include 1900 in Figure 4 so that the reader can easily compare current conditions to those at the start of the time period. This could also be done for the figures for the other two regions.

L357 – Do you mean permafrost degrades almost completely by 2020?

L381 – Revision suggested: "...blockfields, simulated GT is between -6 and -4°C."

L382 – Here and elsewhere in text – It might be better to refer to range in GT rather than span.

L383 – Deep GTs – how deep? Revision also suggested "...glaciers has the smallest range in GT.."

L387-388 – Revision suggested: "GTs are simulated to be higher beneath warm-based glaciers with no permafrost beneath the thickest parts of the glaciers" – is this what you mean?

L408 – "lower" rather than "colder"

L441 – "The colder zones move rapidly" – not clear. It would be better to refer to rate of warming or cooling.

L455-458 – I may have missed this, but do you mention why you chose these time periods? I assume it is because they coincide with periods of warming and cooling in the SAT record. Also, be clear that you are referring to simulated GT.

L459 – revise to "GT at 20 m remained..."

L464 – "negative trend" might be better than "decreasing trend"

L465 – revise to: “At 20 m, GT....”

L469 – replace “raised” with “increased”

L481 – replace “larger” with “higher”

L484 – replace “coldest” with “lowest”

L545 – Shouldn’t you mention that the ice content is important?

L641 – Something else to consider in this section. Surface temperature in winter and therefore nF will not just be a function of the snow depth but will also depend on active layer thickness and substrate conditions (especially moisture content) as these will influence the latent heat effect (see for example Riseborough and Smith 1998, 7th Int. Permafrost Conf. Proc.; Throop et al. 2012 doi:10.1139/E11-075).

L663-665 – Late-lying snow cover would delay or reduce the spring warming of the ground. Also, latent heat required to melt snow reduces amount of heat available to heat the ground.

L675-672 – Effect of thin or late onset of snow accumulation is also shown by Palmer et al. (2012 doi:10.1139/E2012-002). The temporary ground cooling related to low snow cover is also reported for the European Alps by PERMOS (2019) and Noetzli et al. (2020 <https://doi.org/10.1175/BAMS-D-20-0104.1>)

L705-707 – Are you referring to the thermal offset here which is related to the difference between frozen and unfrozen thermal conductivity (as well as the lag effects that mean that permafrost can still be present at depth when surface temperatures are above 0°C).

L709 – Are you referring to annual mean temperature here? Also revise to “..measured by the....”

L733- 735 – It would be useful to show this comparison, maybe in an appendix or supplementary information.

L737 – Has “RW” been defined earlier in paper?

L788-789 – Are these rates determined for the same time period?

L793 – Revision suggested – “Permafrost is likely discontinuous along most of the modelled profiles...” Do you really mean that for 2 of the profiles (Mannen and Ramanosi) permafrost is likely absent while 7 of the profiles are likely underlain by permafrost although it may be discontinuous in distribution.

L800 – Revision suggested: “..are warming by $0.2^{\circ}\text{C decade}^{-1}$...”

L803 – Replace “leaded” with “led”

L805 – revision suggested “...size appear to be important...”

L828 – revise to: “...colder than the rock wall...”

L840 – “positive trend” rather than “increasing trend”. Also, note the increase has largely occurred in the last 40 years.

L855 – You might also want to indicate the source of the data in the caption.

L1203-1208 – References out of order