

Dear Moritz Langer and colleagues,

Thank you for your submission to The Cryosphere (TC). We noted that you asked to submit an updated version of your manuscript before starting the review process – but unfortunately this is not possible at this stage, given that you uploaded your manuscript as a preprint on EGU sphere (we double checked with the editor-in-chief and the Copernicus team). If you think the changes you performed are important to mention at this stage, I invite you to provide information on the changes as a comment in the discussion. Otherwise, you are invited to just include these when sending your revised manuscript addressing the reviewer comments. I am sorry for this inconvenience caused by the new setup with preprints being available on egu sphere. Similarly, I was not able to provide comments before the start of the discussion phase ('the quick access review'). I nevertheless provide them here, and invite you to incorporate these when addressing the reviewer comments.

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#### 1. Originality (Novelty):

In this manuscript, the authors present a new model, CryoGridLite, which they extensively evaluate and utilize to simulate the evolution of Arctic permafrost over the past three centuries. The long-term focus of the study is interesting and is made possible through the fact that CryoGridLite relies on some simplifications and parameterizations that make it faster to run than more complex permafrost models. This allows the authors to make some claims on the long-term evolution of permafrost, thereby highlighting some clear regional differences that may in part not yet be (well) known.

#### 2. Scientific Quality (Rigour):

CryoGridLite seems to find the weak spot between complex permafrost models and (very) strongly simplified parameterizations. The approximations described in the manuscript seem relevant, and will be further judged by reviewers. The elaborate model evaluation (section 3.1) is really helpful and provides confidence in the shown results, while at the same time acknowledging some of the limitations (highlighted in section 3.6).

#### 3. Significance (Impact):

The impact of this study may be two-fold. First, the new insights on the long-term evolution seem to be quite important for the community. Second, the newly presented model (including the data needed to represent the results as presented here – excellent) is likely to be used for many other applications in the future.

#### 4. Presentation Quality:

The manuscript is very well written and easy to follow – also for someone without any background in permafrost science. The figures are also very clear, visually appealing, and support the story well.

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List of (mostly very minor) comments that I noted when going through your manuscript:

- At first it was not clear to me that your new model is CryoGridLite. To highlight this, and for this manuscript to also serve as the reference for this model in the future, I suggest:
  - mentioning the name of the model in your abstract. You could even consider adding it in the title, although this entirely up to you.
  - Explicitly mention that it is your new model in the methods section. Now, the model is never named, and you immediately start with 'CryoGridLite largely...'. Maybe something along the lines of 'Our newly developed CryoGridLite model largely...'?
- l.66: add a space between the two sentences + 'permafrost' instead of 'permarost'
- l.71: To avoid having two subsequent sentences starting with 'In addition', suggest removing this from previous sentence (in l.69)
- l.109-110: when mentioning the stability of the models. Does the fully implicit model approach require such a small time step as well? And if so, is the requirement for the others even more constraining (e.g. (sub-)hourly)? Just a question out of interest – that could potentially be answered by providing slightly more info here
- l.141: "simultaneously with the ground": at the same time as the calculations performed for the ground? Maybe reword to make this clearer.
- l.158-159: the lowest grid cells: at which depth are these occurring?
- l.160: when reading this sentence, I wondered if this means that you can maximally model a snow-depth of 2 m (which was later confirmed when seeing the values in Table 1). What is the reason for this – and is this a limitation? Most likely not, but maybe good to mention why.
- Caption of figure 1: "This way a wide..." → "Through this approach, a wide"
- Table 1 caption: 'which were varied' → "which are varied"? to be consistent with the text? Same comment applies to the second sentence.
- l.221: "which are drawn"?
- l.239: why do you rely on ERA-Interim and not ERA-5? Not suggesting this needs to be changed, but would be good to clarify, since the latter is by now in most cases the reference (or is this not the case in the permafrost community)?
- Figure 2 and 3 caption: replace '5' by 'five' (generally, it is recommended to write out the numbers smaller than ten)
- l. 305: using the term 'evaluate' is definitely correct here, but may be a bit confusing, since you have just done what you refer to as the evaluation in the previous section (3.1). Maybe you want to make this distinction clearer and refer to 'analyze' here?
- l.311-312: "which is found more than" → "which is found to be more than..."
- l.341: "...indicates southern boundary..." → "...indicates the southern boundary..."
- l.343-344: "the simulation shows a substantial increase in ALT of more than..."
- Figure 5 caption: here you refer to the active layer thickness (ALT), while in the figure itself this is referred to as the that depth. Any reason for using two different terminologies? If not, would suggest having this consistent here (also for other occurrences in text)

- l.353: did I understand it correctly that if the ALT is more than 3 m, this is not considered to be permafrost then?
- l.370: introduce VEI here? Only done in caption of Figure 6 now
- l.372: remove the double brackets for the reference
- l.377: “begin” to be consistent with the rest of the sentence?
- Caption figure 6:
  - $VEI \geq 6$ , right?
  - Suggest rewording the last sentence to: “The maps show permafrost occurrence at specific time...”
- l.472: suggest rewording to: “...capable of estimating the thermal...”
- Author contribution:
  - What is “the web-map”? Something online or shown here?
  - And similarly, not sure I understand what “out visualization” is?
- l.522: replace the ‘&sim;’ in title of paper
- l.573: ‘B ayesian’ → ‘Bayesian’ (two occurrences)

Best regards,  
Harry