

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2021-285

Anonymous Referee #1

Referee comment on "Explicitly modelling microtopography in permafrost landscapes in a land surface model (JULES vn5.4_microtopography)" by Noah D. Smith et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-285-RC1>, 2022

Smith et al. present a study in which: 1) JULES, the land component of the UK Earth System Model, is updated to represent microtopographic relief in permafrost settings using a two-tile approach, allowing for redistribution of snow, soil moisture, heat between tiles, and surface water accumulation in the lower tile; and 2) the new model is validated against observations from two ice wedge polygon field sites in Siberia and two palsa field sites in Scandinavia. Similar approaches have been used in the past to study these same land forms in other land surface models, but this study is the first to implement these changes in JULES. The authors clearly define the scope of their study and its limitations, while suggesting next steps to build on their approach in the future. In its current iteration, the implementation of microtopography in JULES allows for reasonable snow redistribution and temperature splitting between high and low tiles. It also allows for the simulation of perennially saturated soils in the lower tile of one of the palsa sites, which meaningfully impacts simulated methane emissions.

Overall the paper is a meaningful step forward in representing permafrost environments within Earth system models and worthy of publication in GMD. However, I recommend that the authors address the following concerns:

1) The abstract as written is quite long and detail-oriented, especially with regards to the summary of results. Please shorten it with the aim of describing only the main points of the study and its significance.

2) I would like to see the authors include a bit more information about some aspects of JULES which currently are not described, as they were not updated for the present study. In particular, how does JULES handle freeze and thaw in a soil column? Do liquid water and ice ever co-exist in the pore space? Is the expansion of liquid water upon freezing accounted for?

3) The authors state in line 302 that "Currently, no thermal effects of the pond are included, and the pond cannot freeze..." This seems like a major simplification, particularly as delayed freeze-up beneath ponds is one of the mechanisms which raises mean annual ground temperatures and drives positive feedbacks on permafrost thaw in cold environments. Please discuss this limitation in more detail in your discussion section. Also, please clarify how the presence of a pond that cannot freeze affects simulations in winter. For example, can snow accumulate atop the pond when air temperatures are below freezing?

Minor Comments:

Line 116 - Please describe the "top-down" approach of Turetsky and Schneider von Deimling a bit, instead of simply referencing it.

Line 240 - What is the "sloped area" of polygonal tundra?

Line 416 - This definition of Δx is vague. Please clarify it and describe how you justified your choice of distance.

Line 488 - Please elaborate on what q_{base} is mathematically. Is this water which is extracted from the soil and leaves the model domain completely?

Figure 9 - Please describe the symbology of your box and whisker plots (e.g., meaning of center line, box height, and whisker extent).

Line 653 - I am unsure what "liquid water content as a fraction of saturation" means. Is this averaged among all the layers in a tile? Also, since you use the word "reduce", I think the negative signs in in line 354 are unnecessary and confusing.

Line 658 - It is very interesting that turning off heat fluxes between tiles seems to have more impact on tile saturation than turning off water fluxes. Please explain in more detail why this is the case, as it is not intuitive.

Line 715 - Again, I think the negative signs should be eliminated from this sentence.

Line 823 - How did you estimate the parameter uncertainties in Table 4?

Line 887 - Please check whether GMD allows for citation of submitted manuscripts which have not yet been published.