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The Cryosphere Discussions

Interactive comment on "Thaw processes in ice-rich permafrost landscapes represented with laterally coupled tiles in a Land Surface Model" *by* Kjetil S. Aas et al.

Anonymous Referee #2

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In this paper, the authors take steps towards an ability to represent in a large-scale model the important lateral snow redistribution, water, and heat processes that impact the trajectory of permafrost thaw and related processes in different permafrost landscapes. The approach is parsimonious, which I like. The authors propose to represent these systems with just two 'tiles' (rim and center for polygonal tundra), rather than explicitly modeling the full complexity of the heterogeneous landscape. I like this approach as it does lend itself to potential inclusion across the pan-Arctic. A significant limitation is that the model is not explicitly modeling the formation of these permafrost landscape features. Instead, the goal is simply to be able to simulate the transition from a low-centered to a high-centered polygon. This is a reasonable first step and the

authors acknowledge this limitation. Clearly, to have 'full' confidence in the model, one would want it to be able to simulate the full set of physical processes that drive both the formation and the decay of low-centered polygons. Nonetheless, this is a practical first step that is clearly an improvement over the current 1-tile assumption that cannot at all account for the real spatial heterogeneity of the system.

Overall, I enjoyed reading this paper and I find it suitable for publication with a few relatively minor revisions and clarifications.

Specific comments

1. When the Noah-MP model is introduced, it would be good to explain why Noah-MP is being used instead of any other model. I believe that it is because of the lateral flow capabilities in WRF-hydro, but that capability isn't introduced until section 2.2.4.

2. P. 8, line 2 typo: "only elevated only"

3. I wonder if the "coupled" is the best way to reference the multiple tile simulations. Coupled can mean a lot of things in different contexts. Perhaps you could rename as Reference and Tiled or Single column and Two column or something else that is more descriptive.

4. Figure 5: Why is the ref simulation at depth so much warmer than either the RIM or CENTER simulation?

5. P.9, Line 16: "The simulated maximum snow depths in 2008 compares quite well with observations for both RIM (0.23 m compared to 0.16 m), and centers (0.39 m compared to 0.46) although the observations show considerable spread (see Nitzbon et al., 2018)." Statements like this are a bit misleading. Should make it clear that the simulated snow depths matching observations is probably mostly good fortune. You are using large-scale forcing from CRU-NCEP. It would be completely unsurprising if the snow depths didn't match up with the observations at the local site when using large-scale forcing. It would be more appropriate to note that due to this good fortune,

it is easier to make direct comparisons to observations.

6. P. 10, line 1: Similar to above, the discrepancy in temperature between model and obs is likely substantially a result of using the large-scale CRUNCEP data to force the model. You wouldn't really expect the soil temperatures to match the observed site level soil temperatures in this circumstance.

7. P. 13, line 4: Same again as above. The stability of the peat plateau is at least partly related to what you are getting from the large-scale forcing. You can't go as far as to make the argument that you have to have certain couplings to maintain the peat plateau permafrost, which is what is implied. What you are finding, which is interesting and important, is just that soil conditions are colder on the peat plateau when snow and water coupling is included.

8. The Discussion section brings up a lot of good points. One thing that isn't clear in the discussion of how one could potentially employ this method at pan-arctic scale is the question of how one would specify the tile structure for each grid cell (is it a polygonal system or a peat plateau, something else, or a mixture of several permafrost landscapes within each large-scale grid cell). Along same lines, how would you know how to initialize the amount and depth of excess ice across the pan-Arctic domain? Based on the information provided in the paper, it seems like this took some trial and error to get it 'right'.

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