Comments on "**Projecting circum-Arctic excess ground ice melt with a sub-grid representation in the Community Land Model"** by Lei Cai et al submitted to The Cryosphere.

General

Permafrost soils usually contain large amount of ground ice. Its melting has significant impacts on infrastructure, landscape and hydrology. Ground ice also affects the timing and speed of permafrost thaw. This paper modelled the effects of ground ice on permafrost thaw using a sub-grid representation in the Community Land Model. They first test the implementation in Lena River delta. It shows that using three land units of different ground ice provides more realistic results than using one average ice land unit. The modelled thawing depths also very different among the three land units and from using the average ice content. Then they implemented the representation across the circum- arctic region using four land units (no ice, low, mid and high ice) and compared with the results using average ice content. The results shows more realistic pathways of permafrost degradation and a different total area with permafrost comparing to using average ice. The circum-arctic excess ice data are rough, the CAPS dataset is a very broad generalization of the complex ground ice conditions and how to use the dataset is not straightforward. However, this study does show some progress to include ground ice in a more realist way than previous studies (no excess ice, or using average for an entire grid) and it provides a general range of the large-scale impacts of such sub-grid differences. The paper is well prepared in language and figures.

Major points

The test study shows very different active-layer thicknesses among the three land units and from the one-unit with average-ice (Figure 4). The paper did not provide much about the results of active-layer thickness for the circum-arctic modelling. It would be important to add this part in the results and analysis. Observations on ground subsidence is sparse and highly depend on the local conditions. An improved modelling of active-layer thickness would provide some support evidence about the usefulness of including excess ice in sub-grids.

"Compared to the grid average ice case, even more permafrost areas are sustained in the sub-grid ice case" (Line 313-314). However, Figure 9 shows the permafrost area difference between sub-grid case and no ice case is similar to the difference between the average ice case and no ice case before the 2050, after that the latter reached about 1 million km2. That means the permafrost areas under average ice case and sub-grid ice case are similar before the 2050s. After that, the modelled permafrost area under average ice case is larger than under sub-grid ice case. In the last two panels in Figure 7, the shaded area in the second panel seems larger than the second panel. That is not consistent with the results in Figure 9. Not sure whether my understanding is correct. Any way, it would be useful and interesting to provide more explanation and analysis about the differences among these three cases (no ice, average ice and sub grid ice).

The data about ground ice is rough and how to use the current data is based on some assumptions or artificial choices. It would important to indicate that uncertainties more clearly in the text (the paper already indicated that at different places).

Minor points

Line 28-29: delete “enhance” or “improve”.

Lines 42-44, “The existence of excess ice and its distribution in permafrost can significantly affect the rate of permafrost thawing”. It would be useful to add some references here.

Line 58: “over generations”. It seems strange to say model versions as “generations”. It would be clearer to say “in recent years” or so.

Line 67: “Separate from this”, revised to “In addition”

Line 71-74. Check the grammar for this long sentence.

Line 74-95: “the depth distribution of ground ice can vary substantially on the order to 10-50 meters horizontally 75 and 10 meters vertically”. Is the depth to the top of ground ice or also including the thickness of ground ice? Probably you want to say both. Check and consider revising the sentence.

Line 165: “Satellite Phenology (SP) mode”, I do not know what is that. Some explanation would be helpful.

Line 220: “Have the same area fraction of low ice landunit”, You may add “(20%)” to make it clearer. What is the reason behind this assumption?

You must have a percentage of land as no excess ice as the total percentage is less than 100% in Table 2 (e.g., for 5% CAPS, the no excess ice area would be 80%). If that is the case, it would be clearer to indicate the no excess ice areal percentage in Table 2, and the scheme actually uses four landunits (as shown in Figure 1) rather than three. For the grid-average ice case, you used the average of the three land units (Line 242) or the four land units?

Figure 3. The legend is in km2. You may provide the area of a grid or using % of the area of a grid.

Line 259-260: “A small amount of excess ice (24kg/m2) melts during the spinup period”, which case?

Lines 302-303: “We define the permafrost degradation in this study as when all the landunits in one grid cell has an active layer thickness greater than 6.5 meters”. That is different from the sentence in line 238. Probably the sentence in lines 302-303 is for how you treat the grid in figure 7. If so you can indicate its applications.

Line 350: “as projected until 2100”, probably revise to “as we modelled”. No observations beyond present.

Line425, 438: “modelling”, “modelled”, be consistent with “Modeling” and “Modeled”