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Interactive comment on "Projecting Circum-Arctic Excess Ground Ice Melt with a sub-grid representation in the Community Land Model" *by* Lei Cai et al.

Anonymous Referee #1

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The manuscript presents an incremental change to the Community Land Model (CLM) v.5 to include sub-grid representation of excess ice. The aim is to examine whether sub-grid representation of excess ice shows more promise for modelling permafrost degradation than simulations that include homogenously distributed excess ice within each CLM grid cell (as in Lee et al. 2014).

The authors present single-grid simulations for two locations – Yakutsk and the North Slope of Alaska. Three excess ice cases with similar grid-scale excess ice contents, but differing sub-grid distributions, are presented.

Simulations over the entire circum-Arctic are also presented. These include 5 cases:

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1-homogenous ice distribution in each cell; 2- sub-grid area weighted ice distribution based on ice content data from the Circum-Arctic map of permafrost and ground-ice conditions (Brown et al. 2002); 3 – sub-grid tiling scheme meant to represent 3 different types of excess ice [low – segregated; medium – relict; high – wedge], with ice prescribed between 1 to 4 m depth; 4 – same as case 3, but with excess ice beginning at a predefined depth below the permafrost table.

The paper describes implementation of these sub-grid excess ice configurations in the CLM. A climate-change scenario is applied and excess-ice melt is projected into the future. After reading this paper several times, I believe the novel contribution of this paper is the description and implementation of the sub-grid excess ice routine. However, the results of the modelling highlight similar outcomes as in Lee et al. (2014). There is no clear evidence to suggest improved model performance, partly because the model results are not validated in any meaningful way. The paper focuses on simulations of specific geographic locations rather than providing a rigorous assessment of the sub-grid routines and their benefits.

The empirical basis for the parameterization of excess ice is lacking. For the single grid simulations, the grid-scale excess ice content is about 5% for Yakutsk and North Slope of Alaska, which the authors rightfully indicate is "not even close to reality". It is curious then to associate this test with specific locations, where empirical data (e.g., Kanevskiy et al. 2013) and the CAPS indicate much higher ice content.

The conclusions indicate that simulations are based on 'state-of-the-art knowledge on excess ice conditions". However, the text does not suggest a clear comprehension of empirical ground ice studies and knowledge of ground ice conditions. For example, the authors indicate that the active layer thickness is about 0.5m at the end of the spinup (∼line 240), and that excess ice is then incorporated at 1 m depth. Therefore, there is an ice-poor layer 0.5 metre thick at the top of permafrost in the simulations. This is contrary to many empirical studies of ground ice in the continuous permafrost zone that have highlighted the ice-rich nature of upper permafrost. This

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excess-ice placement explains why you have little melt early in the simulation. The conceptualization of low/medium/high ice content landunits as being representative of segregated/relict/wedge ice is also not consistent with empirical observations, and the model does not consider ice morphology in this fashion anyways. Reference to studies to support key parameterization decisions are limited, sometimes selective, and in some cases missing from the reference list (e.g., both references to papers by Fritz et al.). The model results are idiosyncratic because they depend on, as the authors state in the discussion "the initial condition of excess ice" (line 334).

In summary, I cannot recommend this paper for publication in its current form. Though the implementation of the sub-grid excess ice routine is novel, the presented model results are a product of parameterizations that are neither well justified nor adequately representative of current understanding of ground ice conditions. The simulation results and discussion presented do not convince the reader of the benefits of the sub-grid routines.

Lee, H., Swenson, S.C., Slater, A.G. and Lawrence, D.M., 2014. Effects of excess ground ice on projections of permafrost in a warming climate. Environmental Research Letters, 9(12), p.124006

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