

Interactive comment on “Modeling the spatio-temporal variability in subsurface thermal regimes across a low-relief polygonal tundra landscape” by J. Kumar et al.

Anonymous Referee #3

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J. Kumar et al. presented a pilot study using PFLOTRAN model to investigate the role of micro-topography in soil thermal dynamics of different types of ice-wedged tundra, which is important for further studying the responses of large-amount of frozen soil carbon to warming. Field measurements were provided for parameterization and validation. Therefore, I think the topic is important and the method is appropriate. The 3-D modeling is computing-intensive, it is hard, if not impossible, to be coupled in large-scale climate or terrestrial ecosystem models to investigate the effects of fine scale heterogeneity. Meanwhile, it is well-known that micro-topography of ice-wedged tundra ecosystem plays an important role in redistribution of surface water and vegetation growth. Therefore, the manuscript should focus on quantitatively assessing the

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role of micro-topography in soil thermal dynamics by comparing sensitivity tests with and without 3-D heat transfer. Unfortunately, the manuscript reached two main conclusions: 1) the 3-D modeling can properly simulate the soil thermal dynamics under the complex micro-topography, which is good; and 2) microtopography is important, which is already known without the 3-D modeling. I believe the authors can do better work with this 3-D model and provide readers more informative results than the current one. I do not recommend publication of the manuscript in the current form.

I would suggest the authors to split the manuscript into two since there were already too much content in the current manuscript. The first deals with model description, model validation and detailed sensitivity tests on only one of the four sites. The second manuscript then deals with differences among different types of ice-wedged tundra ecosystems and upscaling to larger regions.

More specifically, I would suggest to do the following model runs on one site in the first manuscript: 1) shut down the lateral heat flow in the 3-D model and compare the results with those using fully 3-D heat transfer. This work is to demonstrate the importance of lateral heat exchange; 2) in one simulation, use the same soil texture for all micro-topography positions, e.g. rim and center. Compare results with different soil textures; 3) prepare future climate data using GCM outputs under different scenarios. You might also need to convert atmospheric driving to near surface soil temperatures for different micro-topographic components. The long-term simulating might reveal some modeling issues, e.g. lateral boundary conditions; 4) implement different amount of excess ice in soil column to test whether excess ice causes disagreement between simulated or measured soil temperatures.

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