 # Reviewer :

This study aims to derive a robust, yet computationally efficient initialization parameterization approach that can be applied to regions where data are scarce and simulations typically require large computational resources. An upscaling approach to inform large-scale ESM simulations based on the insights gained by modelling at small scales was performed. The results show that the model has good performance in reproducing present-climate permafrost properties at the three sites at the Mackenzie River Valley. The results also demonstrate that the simulations are sensitive to the soil layering scheme, the depth to bedrock, and the organic soil properties.

It is really important to investigate the performances of hydrological and land surface models in permafrost regions under climate change. However, there are some shortcomings that might affect the contribution of this study. My main concern and comments are listed as follow.

General comments

1. Lin 34:...however, are not so clear…You should give citations.
2. Line 39: What do you mean “uncertainty”?
3. Line 46-50: You give importance of permafrost here, which may be not suite for this paragraph. I suggest that you provide separate paragraph to show the importance of permafrost and the progress in interaction between permafrost and hydrological at the beginning of the introduction.
4. Line 51 and 91: Here the authors give the modeling work in hydrological processes in permafrost regions, I noticed that the models were all land surface models. As I know, there were many modeling work that has been done by hydrological models in cold regions, such as VIC, GBHM. I would suggest that the authors to provide the different with hydrological models and land surface models on the previous modeling work in hydrological processes in cold regions, then clearly state why you choose the land surface model for this study.
5. Section 3.2 Study Sites and Data: This section is too long. Please make it concise using figures and tables. In addition, you may combine Section 3.5 (Climate Forcing) with this Section. They are all data introduction.
6. Line 170-171, Permafrost, which is defined as ground in which temperatures have remained at or below 0℃ for at least two consecutive years. There is variation in temperature between different years, the bottom of the active layer is not necessarily connected to permafrost table, and a melting sandwich may occur. The author judges the active layer thickness by the change of soil temperature one year. This should be distinguished from the permafrost table.
7. Line 190-193: As I know, there are two alternative schemes for soil organic layer in land surface models, one is assuming one or more organic matter layers cover the mineral layer at a vertical depth, the other is the weighted combination approach, such as in CLM. I suggest that you should compare the two schemes and give their different.
8. Line 343-344, 557-560: I am confused by the description of the lower boundary conditions of the model. The author should clearly state which boundary conditions are used in the model, the Dirichlet condition (fixed temperature in boundary), Neumann conditions (fixed geothermal flow in boundary) or Robin conditions (fixed temperature and geothermal flow in boundary). In addation, the upper boundary conditions should also be properly explained.
9. Line 436-438，455 :You also should give the soil moisture figure using different number of

cycles, and when it stabilizes. Your title is "…a Large Scale Hydrological…", and your results were only soil temperature, how about the soil moisture?

10. Line 466-467: Please check this sentence, the temperature difference reached 1.0 k between 100 times and 2000 times cycles. It revealed that 100 times cycle was not stable, but you said that "there is no significant change after 100 cycles and sometimes less."(In Line 453-454), Why?
11. Line 481-482: The simulations have very longer time period (1979-2016), and the deep soil temperature change was evaluated. As you know, the geothermal flow will have a great influence on the deep ground temperature at a long-time scale, which may be more than the impact of climate change. Strongly recommend that you should use the geothermal flow for the lower boundary by observed data from drilling or the relevant data from references.
12. Line 492-494: It is very confusing here. Active layer thickness is only 3m at JMR. The soil temperature and moisture should be stable values, which are the initial conditions for the next step simulation after 100 cycles (100 years) in theory. However, there were larger differences from simulation results given by Figure 9 because of the initial values of different cycles (50-2000 times). This is very abnormal. You should check the simulation results again, whether the cycle is not enough, or other reasons that make the initial value do not converge. Please give a detailed explanation.
13. Line 527-528: Simulation results of temperature envelopes were lower than observed values, which may be caused by neglecting geothermal flow.
14. Line 554-555: The explanation for the cooling effect of the model increased the depth of SDEP is unreasonable. From Figure 14, it can be seen that the location of SDEP after increasing is located in permafrost, and soil water content in this layer should be frozen throughout the year. I am not sure that the model could take into account the difference in thermal properties between permafrost including ice and ice-free bedrock, and the thermal convection generated by little unfrozen water in the frozen soil. These could explain the cooling effect. If so, further explanations should be provided.
15. Line 575: I suggest that you should check variation in the upper boundary drive (climate) during the simulation time. This may be the reason why the temperature envelope tends to be at a given temperature at lower boundary.
16. The discussion needs be strengthened. You should compare your results with others, then conclude what your new fingdings and contribution.

Specific comments

1. Line 101: What is ALD? When you give an abbreviation for the first time, you should give the explain. I found the explain in Line 158, but this is the first time here. In addition, active layer thickness is more commonly used, I suggest use ALT instead of ALD.
2. Line 166: The no (or zero) oscillation depth (ZOD) should be instead of depth of zero annual amplitude (DZAA). DZAA is a professional vocabulary in the field of permafrost research.