

# ***Interactive comment on “Improving permafrost physics in the coupled Canadian Land Surface Scheme (v. 3.6.2) and Canadian Terrestrial Ecosystem Model (v. 2.1) (CLASS-CTEM)” by Joe R. Melton et al.***

## **Anonymous Referee #1**

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Comments:

General

This paper describes improvements and tests of the CLASS-CTEM model under 18 different model configurations and input data sources. The results are compared with site observations of active-layer thickness (ALT) and ground temperatures, and estimates of permafrost extent and snow water equivalent (SWE). Such systematic tests demonstrate the effects of different configurations and data sources on the model behaviour,

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therefore, it provides basis for its improvements. Such information is also useful for the improvement of other land surface models in simulating permafrost regions. The topic of this paper is a good fit of the scope of the journal, and it is worthy to be published. Following are some suggestions, which may be useful to the improvement of its readability.

### Major points

1. As the paper has indicated, the major issue is the sub-grid heterogeneity. The site conditions of the observations can be very different from the grid average used in the model. The input climate data for the model are also different from the climate at the observation sites. Thus, the nature of the modelled grid cells and the observation sites are quite different things. However, these multiple site observations are the data currently available, and could somewhat represent the conditions of the grid cell. Therefore, the approach used in this study is useful to check and improve the overall behavior of the model across the permafrost domain. The model is better constrained overall but not necessarily validated. Sections 3.12 and 3.13 indicated this issue. I think this is a limitation or shortcoming of the methodology rather than an excuse of the modelled bias (e.g., the authors seem to argue that the model can represent the reality better (Line 25, page 27)). Such limitation should be indicated clearly and to frame the assumptions/methods better.

2. The results show that the simulated ALT is improved but no significant improvement in ground temperatures according to Figure 5. Since ground temperature is the principal state variable of the model, it would be useful to provide more information about it. Figure 4 is a nice demonstration of the improvement of the modelled ALT. Similar figures should be provided for the ground temperatures about their bias distributions. If they take too much space, you can put some of them in the Appendix.

3. The paper is too long and some analysis is not very concise. Some parts of the analysis can be reduced, such as latent heat, sensible heat, and albedo as there are

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no observations for these variables anyway. Even the discharge shown in Figure 9 is not necessary. It is better just focusing on ALT, ground temperature and permafrost extent.

#### Minor points

1. P.1, Lines 16-18: “with seasonal . . . at the sites”. Not clear.
2. P.1 Lines 18-19: “Sub-grid heterogeneity estimates were derived from the standard deviation of ALT on the 1 km<sup>2</sup> measurement grids at the GTN-P ALT sites”. It sounds like you estimate the sub-grid heterogeneity for all the regions. That is not the case.
3. P.2. Line 12-13. “Since the carbon stored in frozen soils is only accessible to microbial respiration once soils thaw”. Soil respiration has been observed when soil is frozen although it is low. The word “only” is too restrictive.
4. P.3, Line 5: “that four be considered”, Four types parameterizations?
5. P.4, Line 33: “configuration. (e.g”, delete the ‘
6. Page 5: “The first seven experiments” in line 5 is too far away from “the second series of experiments” in line 32. It is better to put them closer.
7. Page 7, Line 33: It is only for ground temperature which is converted to monthly averages? ALT is the annual maximum thaw depth. “The closest CLASS-CTEM grid cell to the ALT site’s location” Why it is closest to a grid cell not within a grid cell?
8. Page 9, Line 24: delete the repeating “are’.
9. Page 10, Lines 11-12: “but comparing . . . Poor agreement”, not very clear.
10. Page 14, Fig. 3: The Y-axis is called ‘residual’. Is it the difference between simulated and observed ALT as indicated in the text? If so, it would be clearer to indicate that. The X-axis is ‘Ground depth (m)’. I think it is active-layer thickness although not sure it is modelled or observed. If so, it is better to say that.

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11. Page 15, Lines 6-11 (even to line 18). It is better to put this paragraph to the section 2.2 (study design).

12. Page 6, Figure 6. The top line “Depth = 0.05 – 5m |Season = JDF ...”, 5m should be 0.5m.

13. Page 21, Figure 7. The first sentence of the caption is not clear.

14. Page 27, Line 25, The word ‘best’ is no appropriate.

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