

Interactive comment on “Soil temperature response to 21st century global warming: the role of and some implications for peat carbon in thawing permafrost soils in North America” by D. Wisser et al.

Anonymous Referee #1

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General comments

A huge amount of soil organic carbon (SOC) is currently stored in permafrost in northern high latitudes. It has been a great concern that climate warming induced permafrost thaw could release some of this carbon pool to the atmosphere, further enhancing climate warming. In this study, Wisser et al. modeled changes in soil temperature and permafrost conditions in northern North America (NA) with a special attention to their implications for the SOC, especially in peatlands. They used the long-established permafrost model (GIPL) with considerations of snow dynamics and soil

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moisture conditions. A drier and wetter peatlands, corresponding to bogs and fens, were considered in a general way. The climate for the 21st century was generated by ECHAM 5 (emission scenario A1B). This is not a bad choice since ECHAM5 generated historical climate data matched observations in the northern NA better than most of the other climate models (Walsh et al., 2008) although the projection is relatively warmer comparing to most of the other modeled scenarios. The modeled distributions and changes with time of permafrost and active-layer thickness are comparable with other studies, and clearly show the differences under different soil conditions. The most important conclusion of this study is that an additional 670 km³ of peat soil in northern NA, containing about 33 Pg C, would be seasonally thawed from permafrost by the end of the 21st century. That could have significant impacts on ecosystems and the climate system. The paper was well written and the issue is within the scope of the journal. I recommend the paper to be published with some minor revisions.

Specific comments/suggestions

1. It would be clearer if the sub-sections in section 2 (data and methods) can be grouped into two sub-sections (2.1. model and 2.2 data). The model sub-section can include the GIPL model, snow dynamics, and soil thermal parameters, and the data sub-section can include descriptions of model domain and resolution, mineral soil conditions, peat soil conditions, climate data, and model setup, water treatment, etc.
2. The climate scenario generated by ECHAM 5 (A1B) is not a bad choice for this study but it would be convincing to provide some explanations. The assessment paper by Walsh et al. (2008) may provide a good support. The grids of ECHAM5 are coarser than half degree latitude/longitude, please explain why and how you down-scale the daily scenario data.

1. I understand and experienced the difficulties to compare modeled grid results with site observations, but Fig. 3 is still not very informative. You can revise it or even delete it since a detailed description has been provided in the text.
2. A table for the permafrost extent was presented (Table 4). I would like to see a similar table for active-layer thickness, which is more directly related to the major conclusion of the paper.
3. Page 182, Lines 14-17: Your model estimated permafrost extents for peatland varies from 34-43% to 72% of the total area of peatland depending on the depth of the ground temperature used for defining permafrost (Table 4). The former is similar to the results from map-overlaying and Tarnocai (2006), but the latter is larger. It would be clearer to indicate this difference since the depths used to define permafrost have significant impacts as you show in Table 4 and the discussions in the following paragraph (the last paragraph in Page 182).
4. For the discussion of the modeled snow conditions and impacts on permafrost (section 4.1.1), a spatial modeling work for Canada by Zhang et al. (2008) seems relevant. You may check to see the differences and similarities.

Zhang, Y., W. Chen, and D.W. Riseborough (2008). Modeling long-term dynamics of snow and their Impacts on permafrost in Canada. Proceedings of the Ninth International Conference on Permafrost. p2055-2060.

Some minor comments/suggestions

1. Page 162, Line 20: "of the atmosphere" seems should be "below the land surface".

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2. Page 163, Line 23: add "from Russian permafrost region" at the end of the sentence.
3. Page 166, Line 7: "1159 million km²" this number did not equal the number given in Table 4 (1.41+11 = 12.41 million km²). In Table 4, [km³] should be [km²].
4. Page 168, Line 6: Change "[Wm⁻² K⁻¹] (set to 20.14)" to "(set to 20.14 Wm⁻² K⁻¹)", and add the unit m² K W⁻¹ at the end of "snow thermal resistivity". Add the units for D_s and ρ_s.
5. Page 176, Line 5: "in the next century" should be "by the end of the century".
6. Page 177, Line 19: Add "consecutive" between before 24 and months.
7. Page 178, Line 18: "almost complete decline" should be "almost completely disappeared".
8. Page 178, Lines 23-26: Add "from 43%" between "decline" and "to". Deleting "next". The sentence "By the end of the century, the peatland area underlain by permafrost at 2m depth will have decreased by one third and only ~200 000 km² of the total peatland area of 1.4 million km² will have permafrost at a depth of 2 meters": The numbers "~200000km², and one third" are based on the 0.5 m (not 2m) depth ground temperature under dry conditions (bogs) according to the Table 4; You may just use relative change since you do not know the actual area of the dry peatlands (bogs).
9. Page 179, Line 20: "important" means "significant"?
10. Page 179, Line 24: "661 km³" seems did not match the number in Table 5 (600 km³).
11. From line 23 in Page 183 to line 15 in Page 184. This part seems fit better in the next section (section 4.2).

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12. Page 185, line 5. You may check/cite a study by Hossain et al. (2007) for SOC content in mineral soils in northern Canada. The content seems similar or slightly higher than that from Finland.

Hossain, M.F., Y. Zhang, W. Chen, J. Wang, and G. Pavlic (2007). Soil organic carbon content in northern Canada: A database of field measurements and its analysis, *Canadian Journal of Soil Science*, 87, 259-268.

13. Table 5. Since peatlands and uplands are separated land units, I feel Table 5 would be more intuitive by arranging the soil horizons based on uplands and peatlands. The term "mineral soil" some times means upland, and some time means mineral soil horizons. It would be clearer using different terms.

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