Observation and modelling of snow at a polygonal tundra permafrost site: spatial variability and thermal implications

The study explores the spatial variability of snow properties at the polygonal tundra site at Samoylov site, Russia. Researchers use 1D snow and heat flow models to study spatial impact of snow on polygonal tundra, which somewhat limits the full understanding of the corresponding changes. The manuscript includes solid description of the current methods used to measure snow thermo-physical properties. The overall results states that adding the effect of wind, vegetation, and anisotropy improves the modeling of the ground temperatures at the Samoylov site. The current version of the paper lacks of discussion of the previous work that includes the effect of wind and vegetation (see SnowModel by Liston and Elder [2006]). It is important to include the description on how the SnowModel is different/similar from the current model development.

I was not sure what is the purpose of doing WIND, WIND+VEG, WIND+VEG+ANISO, since all three looks similar to me (Figure 3). Wind is the dominant factor in tundra, why should we care about other cases? For example, if you calculate the total difference between calculated and observed ground temperatures, I bet you would not see much improvement between those three cases. The changes in the snow over first part of the winter (dark winter) can be done by increasing snow density (i.e. chose the right empirical formula and adjust snow densities). To me the most interesting part would be matching temperatures toward the end of snow season (snowmelt). How should it be done, what kind of parametrization can improve the Figure 10, May jump in the temperatures.

Overall, there is a lack of the discussion on what scientific knowledge does it add to the current state of knowledge on snow. The flow in the manuscript require further improvement. Snow modeling literature review has to be complemented with the work by Liston and Elder (2006). How these results can be extrapolated locally/globally? What improvements the CLM modeling community have to do in order to improve snow representation in the current CLM type models? Please check and add that to the literature review. Current version of manuscript requires flow improvement and more clarity.

Abstract

P1. L20. Introduce the definition of the snow anisotropy.

P1. L23. Similarly, ‘depth hoar’ has to be defined.

P1. L24-25. “The potential of an …”, this sentence is not clear to me.

P1. L25. “Dark part of winter” has to be defined.

P1. L25-26. Is that local to the Samoylov only?

P1. L27. It is common to reference Brown et al., (1997) about 24% of the land in Northern Hemisphere occupied by permafrost. Instead I suggest to say significant portion of land in Northern Hemisphere since permafrost is dynamic and shrinking spatially.

P2. L7. I would say, that soil temperatures beneath the thick snowpack would usually be warmer …. What is the difference between snowpack and seasonal snow?

P2.L9. Why to study snow in tundra is important? To me, in tundra vegetation should not play much role, I would say that the wind will play the most dominant effect on snow. Why would even consider the effect of vegetation?

-. L17. 'HS' change to h_s, otherwise it is associated with word abbreviation.

This paragraph has a lot of abbreviations (CT, HFP and so on). I suggest to make a table that reader can quickly refers to when forgets the abbreviation. The table can include short description of the method and a reference.

P3. Model literature review paragraph does not include work by Liston and Elder (2006), which includes wind and vegetation. What lessons can be learned from that model?

P3.L27. 1m high rims. Is that true?

P5.L26 Add the equation used for the heat conductivity.

P5.L29. Changes "figures" to "values". Does that mean that for other temperatures (not -10 ^oC) the values will change? Do you know what is the possible range?

Figure 3A. Differentiating snow layers by colors are confusing, since several colors looks the same to me. Consider no colors, just boundaries to separate layers and add notations inside each layer (RG, FC and so on), can also increase the resolution to fit the notation.

Figure 3B. Bulk density and K_{eff} are they step functions or piece-wise linear functions?

P9.L8. define the R_{th}

Figure 6. How anisotropy (Q) was calculated? Provide an equation.

Section 3.3. List equations for C2011, R2013, L2013. Why only these three formulas? How do they compare with Sturm et al., (1997) or Goodrich (1982) or others equations for conductivities? It is not clear how those empirical relationships account for Q?

P12. L12-15. How K_{eff} is calculated for each 4 cases (DEFAULT, WIND, …)?

Figure 7. I assume these profiles are simulated by model. Are the grain type inputs or calculated by model? How these grain types evolve in the model?

Figure8. Make c and d plots. Separate rim from grass. Is that possible to plot snow observed texture next to the profiles?

P13. L23-26. Phases1-4 show them on the Figure 9.

Section 6. Think about how you can revise that section. There is too much information in it, which is hard to follow.

Figure 11. The colors on the plot is hard to see (especially magenta).

P18. L30. P19.L24. It will be interesting to discuss how new version CROCUS might change the result of current modeling. It looks to me that the conductive heat transport within the snowpack during snowmelt is complemented by an adjective heat transport that the melted snow water carries with it in the snowpack. Typically, the temperature gradient changes in sign or fluctuates near 0 C (making thermal conductivity useless during snowmelt). It will be nice to discuss what could be an easy (straight forward) way to parametrize the adjective heat transfer introduced by flowing water in the snowpack.

References

1. Liston, G.E., Elder, K., 2006. A distributed snow-evolution modeling system (SnowModel). J. Hydrometeorol. 7, 1259–1276. http://dx.doi.org/10.1175/ JHM548.1.

2. Sturm, M., Holmgren, J., Konig, M., Morris, K., 1997. The thermal conductivity of seasonal snow. J. Glaciol. 43 (143).
3. Goodrich, L.E., 1982. The influence of snow cover on the ground thermal regime. Can. Geotech. J. 19, 421–432.