

Interactive comment on “Small-scale variation of snow in a regional permafrost model” by K. Gisnås et al.

Anonymous Referee #2

Received and published: 8 February 2016

SUMMARY This manuscript addresses the problem of subgrid variability of snow in large-scale (permafrost) numerical models. Snow is an effective insulator and therefore variable depths can lead to large variation in near-surface ground temperatures over short distances. It is suggested that land surface models employing aggregated values of grid-average snow depth will not provide realistic values of ground temperature at subgrid scale.

This study employs a statistically derived subgrid snow distributions within the 1km simulation grid and as a result finds an improvement in average and range of ground temperatures as compared to observations. The study interestingly finds that the modelled area of permafrost in Norway is nearly doubled by this approach.

This study is an interesting and useful contribution to an important topic - inclusion of C2963

relevant subgrid information in large area models. I recommend publication subject to the following comments.

MAIN COMMENTS

1. Section 3.1: is the subgrid distribution of snow depth conservative of the original coarse observation?
2. I think would be useful to have more information about the boreholes that were used. What depth are these boreholes? which depths are used in the analysis? Time periods? (related to point 6 below).
3. Section 3.2: Due to the great importance of nF/nT on your results, it would be nice to include a short section critical appraising the various pros/cons of such statistical approach in the context of permafrost modelling. A very first thought is how spatial and temporally consistent are these relationships likely to be? Where were they developed? Over what period of time? You of course mention the variability of snow depth as being a large driver in the variability you see in nF/nT (motivation for this paper) but what else is significant?
4. Section 3.2: Following on from the point above, you state that the relationship between n factors and snow depth is based on 13 stations in S.Norway and 80 loggers in Finse and Juvvasshoe. This seems to be quite geographically limited. Can you briefly state if/how you might expect these relationships to vary with space, i.e what might they look like in Lyngen or Finnmark?
5. P.6678, l.6-10: You mention the question of equilibrium with surface forcing on climatic scales, but how about seasonal lags ie. its quite typical to see max. temperatures at 10m or so at around beginning of winter when summer forcing has been conducted to depth. Therefore to compare model and obs (even assuming you describe conductivities perfectly) you need to drive your model with at least 6months previous atmosphere to get the warming/cooling signal of that time slice. This could

have an impact on your model performance, especially if there is an extreme season (dry, warm etc) missed in the simulation. Maybe I miss something here, but that brings me to the following point....

6. In general you use a large amount of data and have a reasonable complex model setup with multiple simulations and evaluations against various datasets. At times I felt a little lost on what was being computed, when and how. I think the paper would benefit tremendously from 3 additions: (1) a schematic of the model chain to give a very quick overview of the setup (forcing, permafrost model, wind model, subgrid distribution routine, calibrations and evaluations). (2) A table giving all data used together with details such as time period, depths of boreholes etc. (3) A table describing all your simulations with important information such as simulation period(s) - which I am really missing. To illustrate this I dont know what your MAGT and MAGST are based on? I see 2 date ranges 1961-2013 and 1981-2010 but presumably borehole data and surface loggers are a subset of this. Perhaps there is a better way to summarise but my main point is this paper really needs more synoptic figures/tables to guide the reader through the methods and evaluation.

7. P.6672, I.16. What is this 'snow algorithm' - is there a reference?

8. I think it is important to mention in the discussion that due to statistical nature inherent in core methods there maybe difficulties in inferring conclusions about future development of permafrost. That's not to say this contribution isn't valuable - just to include some discussion of possible limitations.

9. Topography isn't mentioned anywhere in the methods - can air temperature and exposure to solar radiation be important predictors for subgrid variability of permafrost within 1km grids? Particularly in the south? Both variables are reasonably easy to distribute based on terrain parameters. Is there a reason not to do this? If so can you provide some references justifying the omission. I did find this reference (also cited by you in another context) which discuss some of these points (and possibly in the end

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favours ignoring topography) - but I think this deserves a short discussion:

Isaksen, K., Hauck, C., Gudevang, E., Ødegaard, R. S. & Sollid, J. L. 2002. Mountain permafrost distribution in Dovrefjell and Jotunheimen, southern Norway, based on BTS and DC resistivity tomography data. *Norsk Geografsk Tidsskrift–Norwegian Journal of Geography* Vol. 56, 122–136. Oslo. ISSN 0029-1951.

TECHNICAL POINTS

1. P.6666, I.25: "ALS" is mentioned for the first time without explanation of acronym.
2. P.6669, I.21: accent on "a" is not needed in English.
3. P.6669, I.21: ">4000 grid cells in 70% of the areas" - I didn't understand this sentence, can you make it more clear what you mean? Why do the coarse grids of fixed area (0.5x1km) have varying numbers of 10x10m subgrids?
4. P.6670, I.21: I think "Figure 2" is the wrong reference here.
5. P.6670, I.25: Can you specify "10 m above surface" for the wind variables you use - I think that is what's meant.
6. P.6671, I.7: Now use just acronym (see point 1).
7. P.6671, I.9: ALS data instead of ALS scan? As 'S' already stands for 'scanning'.
8. P.6671, I.13: 'ASL' → 'ALS'
9. P.6671, I.16: 'when' → 'after'
10. P.6671, I.5-6: how was the wind speed scaled with elevation? Linearly?
11. P.6671, 7-10: What is the resolution of the raw ALS data?
12. P.6671, I.22: These elevations seem very similar to me, 1300/1450m - is it really significant as a difference between sites?
13. P.6672, I.15: How was this interpolation done?

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14. P.6679, l.1 'sensitivity of the model for' -> 'sensitivity of the model to'
15. P.6679, l.8 What was the conclusion of Luce and Tarboton?
16. Figure 6 caption: typo 'poability'
17. Figure 8: over what time period is the data in this correlation from?

Interactive comment on The Cryosphere Discuss., 9, 6661, 2015.

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