## Review #2

Major comments

1. Figures 7-10 show the significant differences among models in simulated ground temperature dynamics. It would be very useful if the authors can provide a similar time- depth panel for the observed ground temperature dynamics for each site.

We agree with the reviewer, that including such a comparison with the observational dataset would be great. Unfortunately there was not enough multi-layered observational data available from each site to provide such a plot. Please see Appendix A for the temperature observation depths from each site. Only Schilthorn has data available to provide such a plot (Fig 1). We have chosen to be consistent with all the sites, so didn't include this one. If the reviewer thinks it would improve the paper, we can certainly do it.

2. Although Figures 1 and 2 are interesting, it would be more direct to show time series of observed and modeled topsoil temperatures, especially multi-layer soil temperature observations are not available to provide time-depth dynamics as I suggested above.

We fully agree with the reviewer. Time series plots are the first tools for understanding how the models work, for example to see the zero-curtain. We decided to use boxplots instead due to the difficulty of distinguishing each model from timeseries. Please see attached plots for example (Figs. 2-5). If the reviewer wishes, we can also include these plots as supplementary material.

3. Figure 5 shows the modeled difference of ground temperature in snow cover period and snow-free period. With this and other figures (1, 2, 4), Figure 6 seems not necessary and it is not so clear.

We agree with the comment here and we have removed this figure from the manuscript.

4. Figure 11. The temperature range of the x- axis is so wide (80 $^{o}$C) that it is hard to see the differences between the model results and the observed. It may be more meaningful to plot the profile of annual mean temperature for comparison purposes.

We thank the reviewer for this suggestion, so we have updated the figure by changing the axis ranges of each site separately. Additionally we now include the annual mean profiles (Fig. 6) to the manuscript.

5. Figure 12, panel d. This panel is not very clear and probably not very meaningful. Anyway, there is no close relationship between active-layer thickness and annual mean air temperature.

We agree with the comment here and we updated this figure removing the comparison to mean annual temperatures.

6. All the five models under-estimate snow depth for the Samoylov site. Are there any common mechanisms that all these models missed for such a high arctic area, or some other reasons, such as input or observations (snow drifting)?

This is indeed discussed in the manuscript under Samoylov site description as well as references to Boike et al., (2008, 2013).
p:4970.l:19-20: *"Site conditions include strong snow-micro-topography, snow-vegetation interactions due to wind drift (Boike et al. 2013)."*
p:4976.l:1-4: *"While the soil temperature comparisons were performed for the polygon rim, snow depth observations were taken from polygon center. Due to strong wind drift almost all snow is removed from the rim and also limited to ca. 50 cm (average polygon height) at the center (Boike et al., 2008)."*

7. The result analysis is well structure, but some messages and sentences are not very clear or not focused. Some improvement is needed (see some examples in the following minor points).

Minor points

1. P. 4961, Line 8: "to quantify" or "to identify"?

Corrected.

2. P. 4961, Line 12 "Snow insulation is of major importance for estimating topsoil conditions and must be combined with accurate subsoil temperature dynamics to correctly estimate active layer thicknesses". You demonstrated that snow is important for topsoil temperature, especially winter soil temperature. However, the effects of snow on subsoil temperature and active-layer thickness is about how to simulate soil temperature process (heat conduction) rather than "combining snow". Some rewording may be needed.

Sentence revised as: "*Snow insulation is of major importance for estimating topsoil conditions, however soil physics is essential for the subsoil temperature dynamics and thus the active layer thicknesses.*"

3. P. 4962, Lines 23-24, "we assume that lateral processes do not influence the observations". Probably revised as "the observation sites are generally large and uniform, therefore we assume that lateral processes can be ignored and the ground thermal dynamics are mainly controlled by vertical processes".

Sentence revised as: "*In such "site-level runs", we assume that lateral processes can be ignored and the ground thermal dynamics are mainly controlled by vertical processes.*"

4. P. 4972, Lines 18-21. These sentences seem not necessary. You may say something about the importance of topsoil temperature for model validation/comparison.

Revised as: "*Validation of topsoil temperature from observations and models gives an important estimate of the accuracy of several model processes such as atmosphere-soil coupling, surface insulation, subsoil thermal dynamics etc.*"

5. An important message of the paper is about the effects of snow. You may focus on this at the first several paragraphs in the section 3.1. Delete some distractive sentences such as "However, summer comparison also shows considerable deviations from the observations as well as among models" (P. 4973, Line 2-3). "However, the combined effects of snow cover and vegetation insulation together with soil organic content is needed to accurately estimate soil temperatures (Schaefer et al., 2009)" (P. 4973, Line 25-27).

Removed those sentences and the section 3.1 is reduced by removing some general statements and repeating information.

6. P.4977, Line 17-18, "the snow free season shows large among-model discrepancies in topsoil temperature (Fig. 6b)". Not clear what do you mean. It is not larger than snow cover periods.

Removed those parts.

7. P.4978, Line 4-12. Such a general comment seems not necessary. It is better to be more specific based on the results.

Removed the first paragraph of section 3.2 except the first sentence.

8. P.4981, Line 14-15, Line 21-22. The effect of snow on active-layer thickness is usually not significant, especially when permafrost is cold and stable, such as at Samoylov. The over estimation of ALT at this site is most probably due to underestimate the effects of moss and peat rather than over-estimation of snow.

Removed that sentence.

9. P.4982, Line 9-10, "By doing so, they attributed most of the ALT biases to insulation effects, which is mostly from snow processes in these regions". Probably not correct. Most simple or analytical relations between topsoil temperature and ALT do not consider snow effects. They usually based on thawing-period air or topsoil temperature.

Sentence revised as: "By doing so, they missed the effects of soil internal factors on ALT"

10. P. 4983, Line 1-2. The sentence, especially the word "amplified", is not very clear.

Sentence rephrased as: "*The sensitivity of soil temperature to snow insulation depends on site snow conditions (sub-/supra-critical)".*

11. P.4983, Line 7-8, "but models need more detailed representation of vegetation cover thickness", it is better to say "therefore models need more detailed representation of moss and top organic layers".

Revised as suggested.

12. P.4968, Line18. Delete "it".

Corrected.

13. P.4969, Line 13, "for degradation of this warm permafrost site". Revised to "for degradation of the warm permafrost at this site" ?

Rephrased as: *"…reflecting the potential for degradation of permafrost at this site*".

14. P.4969, Lines18-21. The sentence is too long and not clear.

Sentence revised as: "*One dimensional soil model sensitivity studies showed that impacts of long-term atmospheric changes would be strongest in summer and autumn, due to this*

*late snowmelt and the long decoupling of the atmosphere from the surface. So, increasing air temperatures could lead to a severe increase in active-layer thickness*".

15. P.4970, Line 23. Move the bracket before the author Maturilli.

Corrected.

16. P.4985, Line 6. "depts" should be "depths".

Corrected.

**Figures**

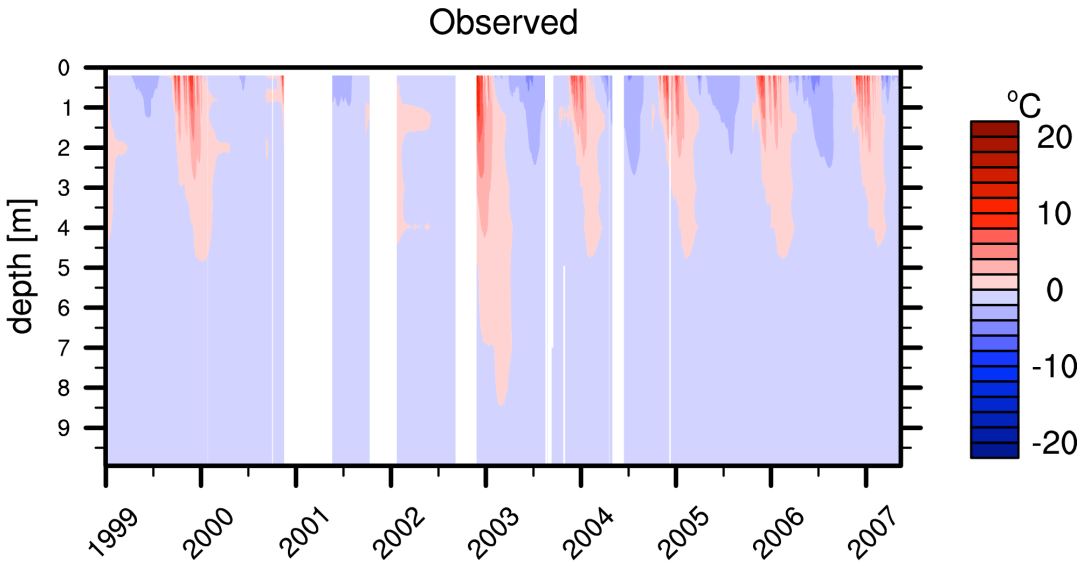


Figure 1: Time-depth plot of soil temperature evolution from Schilthorn site observations.

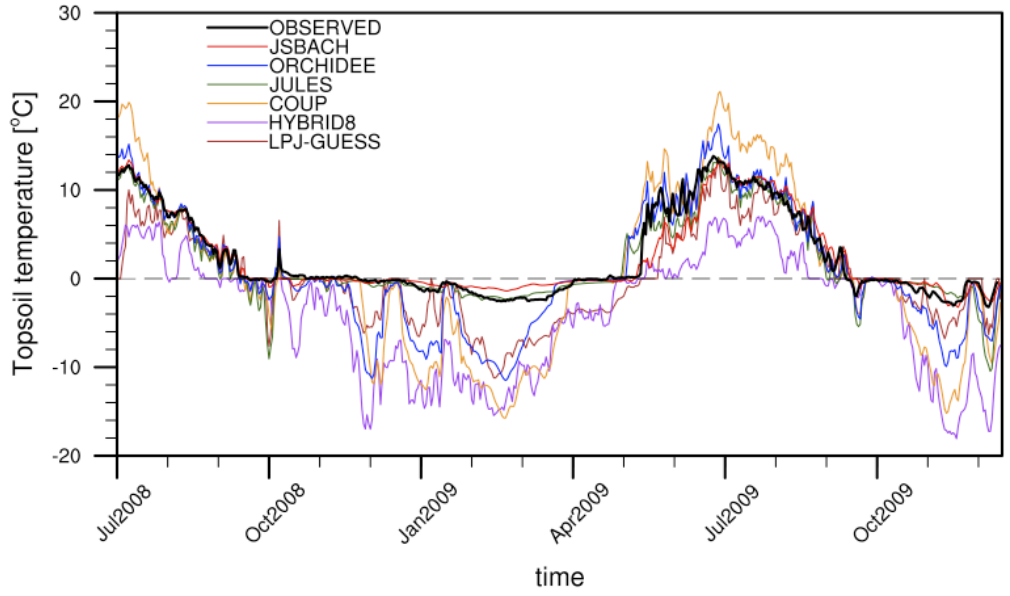


Figure 2: Timeseries of daily topsoil temperature from observations and models at the Nuuk site.

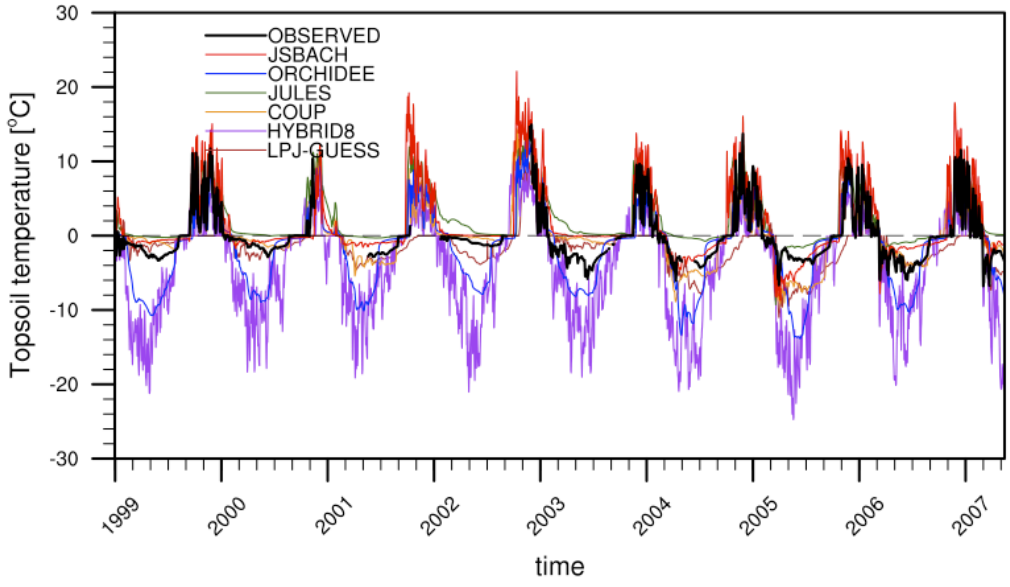


Figure 3: Timeseries of daily topsoil temperature from observations and models at the Schilthorn site.

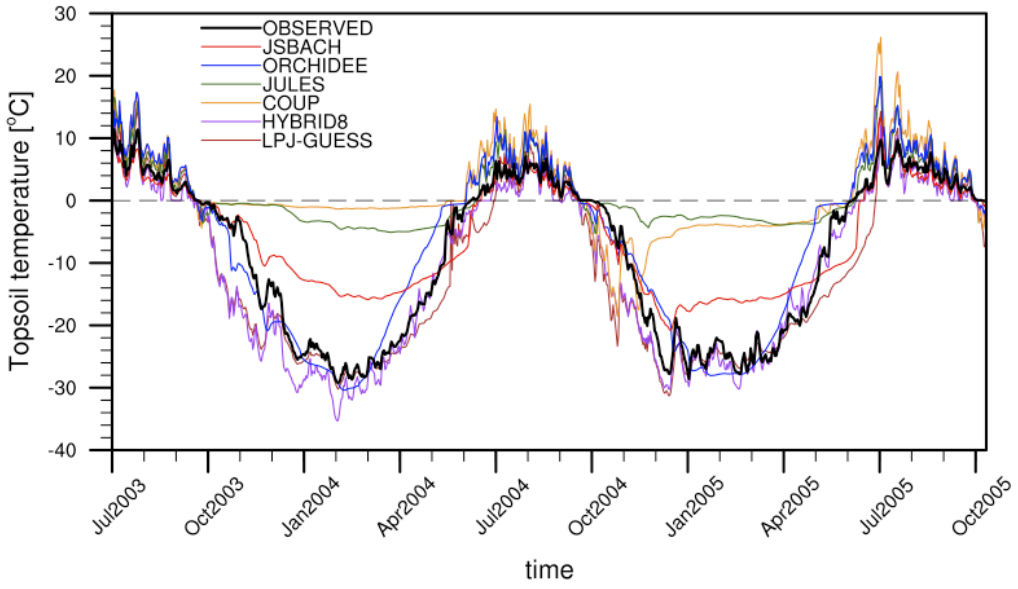


Figure 4: Timeseries of daily topsoil temperature from observations and models at the Samoylov site.

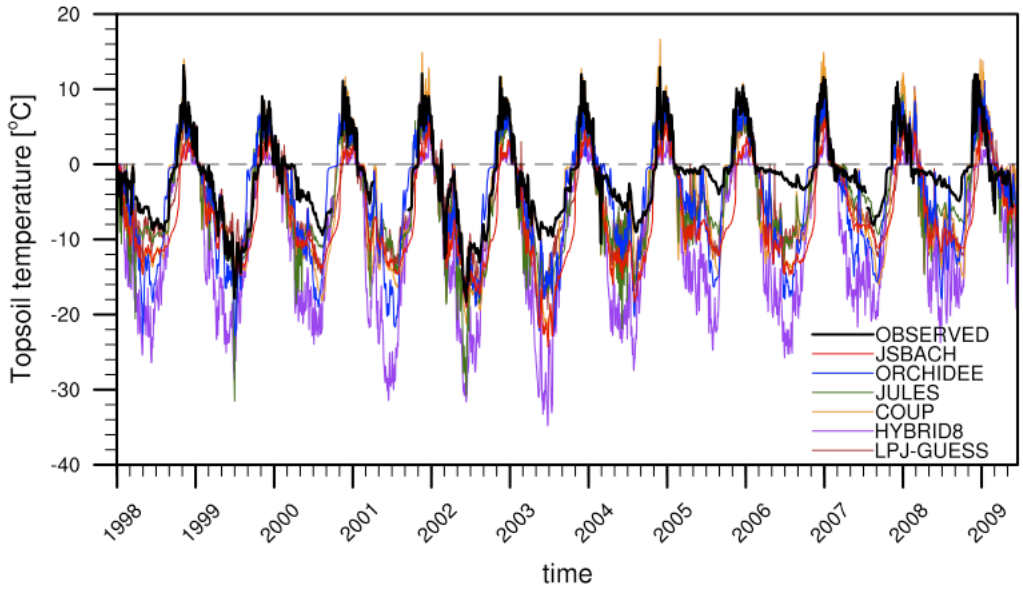


Figure 5: Timeseries of daily topsoil temperature from observations and models at the Bayelva site.

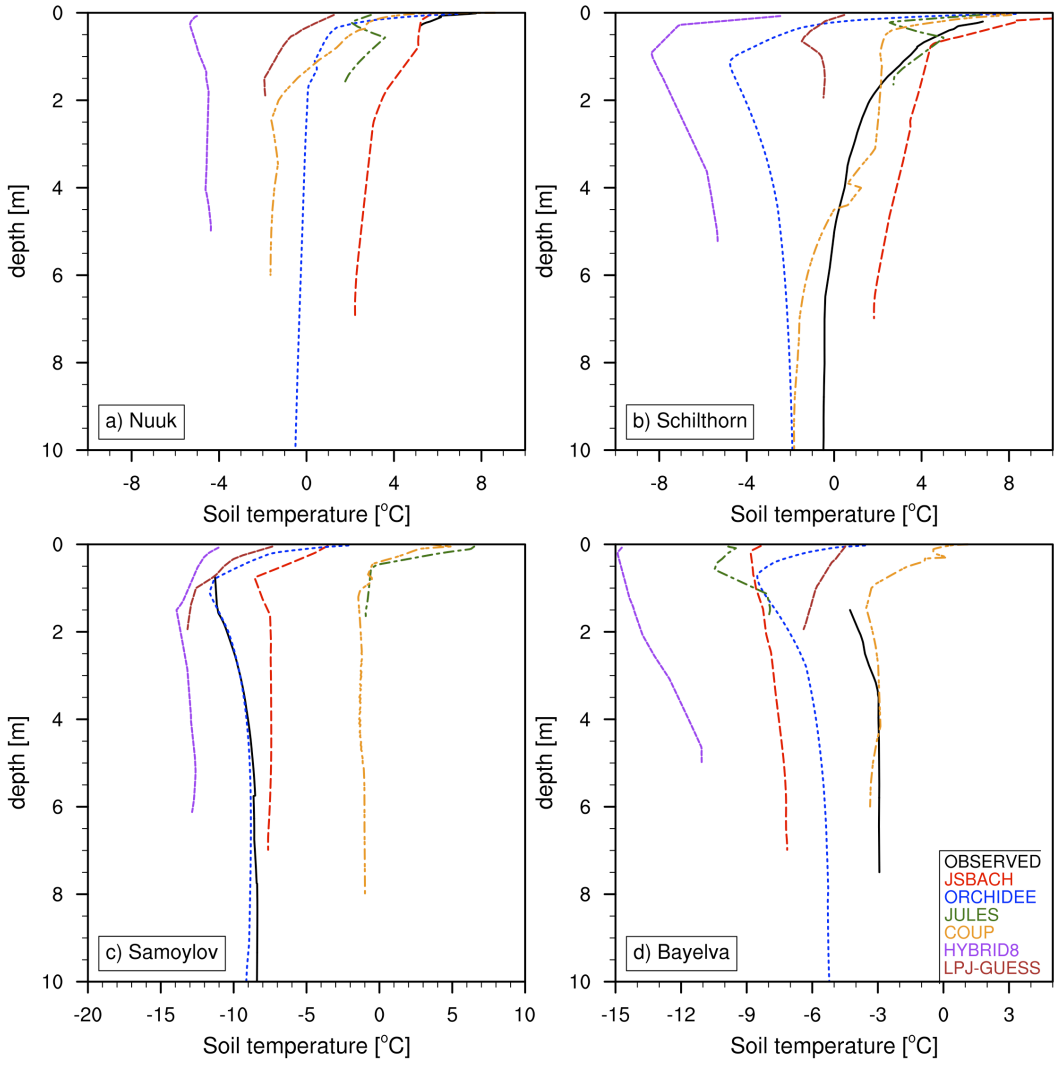


Figure 6: Vertical profile annual soil temperature means of observed and modeled values at each site (Samoylov and Bayelva observations are from borehole data).