Author's response to the reviewers' comments:

We would like to thank Referee #1 for the very constructive comments and suggestions that helped improving our manuscript.
We will address the comments point-by-point where **referee comments are in bold**, our answers are without formatting, and *changes to the initial manuscript are in Italics*.

Pg 6662, line 24 – what means in this paper: ground temperatures (MAGT) -> in which depth please define! MAGT is here defined as the depth at top of the permafrost or at the bottom of the seasonal freezing layer. However, at page 6662 and line 24 we refer to the temperatures at the ground surface. Since this was not clear, the following revision is made for clarification:

Page 6662, line 24: This small-scale pattern of varying snow depths results in highly variable ground *surface* temperatures on the meter scale.

Page 6667, line 17: MAGT (Mean Annual Ground Temperature *at the top of the permafrost or at the bottom of the seasonal freezing layer*)

Page 6662, line 25: Citations: please add 'eg' because there are hundreds of such studies showing this effect.

The reviewer is correct, and we have included *e.g.* before "Gisnås et al., 2014; Gubler et al., 2011", as suggested.

Page 6663, Line 12: The effect of sub-grid variation is not only important in high latitudes but also in high altitudes. Please add.

The sentence is revised as suggested: At high latitudes *and altitudes*,…

Page 6663, Line 17: I would suggest to write this sentence in a more general sense, because accumulation season can be very different in different latitudes and under different climate conditions (eg tropics).

Following the suggested revision from the reviewer, we have deleted "*during accumulation season*". The sentence is now as follows:

The spatial variation of snow is a result of several mechanisms operating on different scales in different environments.

Page 6666, Line 9: …seven search vectors. Do the authors not mean eight search vectors?

Seven is here the correct number. The upward slope is calculated along search vectors with 5° increments within a 30° window, giving seven search vectors that are averaged to estimate the exposure for this particular wind direction. Thereafter, this is done for eight wind directions, and then weighted. This was maybe not entirely clear in the manuscript, and to clarify we have added one sentence after the sentence on page 6666, line 7 – 8:

This gives in total seven search vectors for each of the eight 30° wide sectors.

Page 6666, Line 21: accumulation season January to March. Is this justified for whole Norway?

On average more than 60% of the solid precipitation in Norway falls in the months January, February and March, with some variations between the regions. The calculations in this paper, however, aim to estimate the general distribution pattern at snow maximum, under the

assumption that the snow distribution at this point is mainly controlled by the topography and general exposure to main wind directions over the winter season. We realize that the sentence "The accumulation season is here chosen as January to March" is imprecise, and should be reformulated. We have now changed the sentence into: *"The period of wind directions influencing the redistribution of snow is here chosen as January to March."*

Page 6666, Line 22: What is about wet snow? Insert please a short reasoning why you do not discuss wet snow deposition. Humidity, temperature and radiation conditions can influence the deposition of snow and the possibility of snow transport considerably (eg wet or dry snow deposition or formation of 'firnspiegel' in spring preventing further redistribution of snow).

This is absolutely true. Minor transport will of course occur when the snow is wet, compared to when the snow is dry. However, we do not model the snow transport, but estimate how a given terrain would be filled up by snow during the winter season. Field observations show that in mountainous areas the snow cover reaches an "equilibrium level" over the terrain where irregularities are smoothed out. The snow distribution does therefore highly depend on the topography and main wind the directions while snow was available for transport. In this modelling exercise we assume that the snow distribution at the time of maximum snow depth is still mainly controlled by the terrain and the main wind directions over the winter season.

For clarification we include the following sentence on page 6666, line 22:

We assume that the snow distribution at snow maximum is highly controlled by the terrain and the general wind exposure over the winter season, and we do not account for the variation in snow properties over the season that controls how much snow is available for transport at a given time.

Page 6667, Line 6-13: This approach is not really physically-based and therefore in strong contrast to the other used approaches, where the authors try to be as physically based as possible?

This is true. The authors acknowledge this fact and have tested more physically-based approaches over smaller areas. However, such models have shown not to be applicable over regional scales, both due to the need for calibration and the requirement for fine resolved input data. The aim of this study is to improve the previous implementations of very coarsely resolved distributions of CV used in some hydrological studies (see p. 6663 l. 17 – 30), and assess the effect of implementing this method in permafrost models. To clarify: we include the following sentence at page 6663, line 20:

Physically-based snow distribution models are useful over smaller areas, but are not applicable on a regional scale.

Page 6668, Line 1: What means thermal conductivities if you have also convective transport of water and air? Please specify or better use another expression like 'apparent thermal conductivities', which you have to define beforehand!

For this study looking only at annual averages and equilibrium situations over several years we assume that the energy transfer within the ground is purely controlled by thermal conduction.

We clarify this in the paper with the following revision on page 6668, Line 1:

"…, rk is the ratio of thermal conductivities of the ground in thawed and frozen states *(assuming that heat transfer in the ground is entirely governed by heat conduction)*, while *nT*

and *nF* are semiempirical transfer-functions including a variety of processes in one single variable (see Gisnås et al., 2013, Westermann et al., 2015 for details)."

Page 6669, Line 12: MAGT means always the temperature at the top of permafrost?

Yes. The following sentence is corrected for clarification:

Page 6667, line 17: MAGT (Mean Annual Ground Temperature *at the top of the permafrost or at the bottom of the seasonal freezing layer*)

Page 6669, Line 21: à instead of á

Corrected as suggested.

Page 6670, line 11: you mean that the logger measures really the surface temperatures? Please be more precise and define depth of temperature sensors.

The following revision is made for clarification:

…data loggers have measured the distribution of ground surface temperatures *at 2 cm depth*...

Page 6676, line 5-8: A table would be more clear.

The text is now partly revised, and the following table is included:

"The observed and modelled range in MAGST was [-1.8 °C, 1.0 °C] and [-2.6 °C, 0.8 °C] at Juvvasshøe, and at Finse [-1.9 °C, 2.7 °C] and [-1.6 °C, 1.0 °C]. The average MAGSTs are -0.5/-0.5/0.8 °C (Juvvasshøe) and 0.8/0.2/1.3 °C (Finse) for observations, the sub-grid model and the model without sub-grid temperatures, respectively" is changed into:

"*The measured ranges of MAGST within the 1 x 1 km areas were relatively well reproduced by the model (Table 3). The average MAGST within each field area was also improved compared to a model without a sub-grid representation of snow (Table 3, in parenthesis).*"

Table 3: Observed and modelled values for the coefficient of variation for maximum snow depth (CV_{sd}) and spatial distributions of Mean Annual Ground Surface Temperatures (MAGST) at the field sites at Finse and Juvvasshøe. The MAGST modelled without a sub-grid distribution of snow is given in parenthesis.

	Juvvasshøe		**Finse**	
	Observed	Modelled	Observed	Modelled
CV_{sd}	0.85	0.80	0.71	0.77
MAGST < 0 °C	77 %	64 %	30 %	32 %
$MAGST_{min}$	-1.8 °C	-2.6 °C	-1.9 °C	-1.6 °C
$MAGST_{max}$	1.0 °C	0.8 °C	2.7 °C	1.0 °C
$MAGST_{avg}$	-0.5 °C	-0.5 °C (0.8 °C)	0.8 °C	0.2 °C (1.3 °C)

Page 6678, line 4: This depends strongly from the snow and the surface processes if snow can blown away easily or not (see already comment above)! This approach should then be probably more process-based.

The authors agree with this comment, and we are aware that this snow distribution scheme is a simplification in order to be able to implement sub-grid distribution on a regional scale. However, as we have shown, the snow distribution in wind exposed mountain areas are highly dependent on the topography, and even with differences in the snow pack and weather systems between the winter seasons, the snow distribution at snow maximum is fairly similar.

We therefore believe it is valid to assume that wind exposed areas with rough topography also will have bare blown areas with a changing climate.

Page 6679, line 15: …and of course the roughness of the surface eg coarse material.

This is true. The meaning was a 0.5 – 1 m thick snow cover over the entire ground surface (also including blocks). However, we see that this was not clear, and included the following clarification (in italics):

"depending on the physical properties of the snow pack *and the surface roughness* (e.g. Haeberli)."