Reply to

Interactive comment on "Effects of Stratified Active Layers on the High-Altitude Permafrost Warming: A Case Study on the Qinghai-Tibet Plateau" by X. Pan et al.
Referee #3

We thank Dr. Endrizzi for his insight comments of the modelling issue. Regard to the suggestions about model sensitivity analysis, although we could not take all the suggestions in this paper, they will motivate us to do a thorough investigation in future.

With regards to the major comments:

1. "*The model settings are extremely important since they strongly affect the results. However, the paper does not fully describe them. For example, the paper should list the van Genuchten parameters, since the behaviour during freezing/thawing is based on them. It is not enough to refer to neural network routines.*"

The van Genuchten parameters are listed in revised Table 1.

2. "*The characteristics of the 3 soil architectures A1, A2, A3 are not completely clear to me. You should put a table or drawing that clarifies the soil layers with correspondent properties and parameters*"

Soil properties of the three architectures were detailed in Line 12 - 27 in page 5 as well as shown in the revised Table 1 (attached at the end).

3. "*In the papers the parameters are assigned in a deterministic way. Apart considering 3 soil architectures, no or little sensitivity to parameters is performed. This is extremely important, since many parameters are actually idealised or strongly simplified. The van Genuchten parameters result from a strongly simplified model of soil retention, and, since the results are dependent on them, a sensitivity analysis is essential. Pedotransfer functions and, probably, neural network routines have limitations and cannot be fully trusted. The sensitivity to other parameters should also be considered, for example, when no data are available, for bottom soil, snow precipitation, lateral flow, albedo, etc. In addition, you set the vegetation coverage to 0.3, referring to Gubler at al. (2013), but in this paper we did not consider vegetation.*"

We agree with the reviewer concerning the nature of the model parameters and the validity of methods to estimate them independently. The approach in this paper is to use best available independent information for the simulation. Besides corroborating the general understanding of the observed processes, this also demonstrates the challenges for quantifying situations where data are not available, which is the vast majority, unfortunately.

The next step will encompass a site-specific sensitivity analysis of the simulation followed by a proper inversion for the parameters. This will then also provide the statistical basis for better assessing the true uncertainties. That next step is beyond the scope of the current paper, however.

4. "*The simulation settings also assume simplified conditions that are described only at the end of paragraph 3.5, namely to justify disagreements between observations and model results. The simplifications should be listed at the beginning, and their plausibility discussed in advance.*"

Agree. It is revised in the new manuscript.

5. "*In par. 3.6 you write that the effect of stratified active layer is validated with modelling. Validate is a strong word. You are not validating, but you are using the model to understand physical processes.*"

Agree. See more explanation in the reply for referee #1.

6. "*The formula of Cosenza et al. (2003) is just one parameterisation of bulk thermal conductivity. GEOtop gives also the possibility to use other formulae (De Vries for example). Maybe it would be worth checking if there are significant differences in the results if other formulae are used."*

First of all, we do believe that there might be significant differences in the results if we use improper formulae for the bulk thermal conductivity. Here we choose the formula of Cosenza et al. (2003), because it has been verified with some published data in satisfactory agreement both for saturated rocks and for unsaturated soils.

7. "*In Fig. 6a you consider only unfrozen water content. However, bulk thermal conductivity also depends on ice content. You should discuss this point.*"

We did consider the ice content for calculating the bulk thermal conductivity. The total water content in the caption means the sum of unfrozen water content and ice content. To avoid misunderstanding, the total liquid water content has been replaced with "total water content" in the text.

8. "*I do not understand why in Fig. 5b the 0 °C isotherm is not close to the curve of the unfrozen water content decrease.*"

This is quite common in field observations. First of all, the freezing point of soil water will be reduced below 0°C due to soil salinity. Secondly, the soil temperature gradient is so small within the zero-curtain that the 0°C isotherm is not close to the curve of the unfrozen water content decrease.

9. "*In the paper you often use temperature/time as a proxy of permafrost warming. However, temperature only describes the effect of sensible heat, but not the latent heat. If permafrost has a temperature close to 0°C, more heat is needed to increase soil temperature, because some energy is needed for thawing. Therefore, I do not think that a temperature difference of 0.01°C to end spinup is good. Performing a good spinup is also essential to have good model results. This should be more completely described. For how many years the spinup simulation was run? You should also check that water and ice content differences are small to end spinup.*"

We agree that checking temperature difference in conjunction with water and ice content differences would be more reliable. In this study, to reach a temperature difference of 0.01, the spinup simulation runs for 150 years, and the total mean annual water content difference is less than 0.01. This should be fine.

10. "*In 2014 I wrote a paper describing the model, in particular the version 2.00. Although you used a previous version, you should have a look and cite the paper. This is the link to the paper: http://www.geosci-model-dev.net/7/2831/2014/gmd-7-2831-2014.html*"

Done.

11. "*I saw some errors in the English language. Please correct them.*"

Done.

Table 1. Soil properties of shallow soils (A: 0-3.0 m) and underlying soils (B: 3.0-30 m) for three soil profiles (A1/B, A2/B and A3/B). K_s: saturated hydraulic conductivity; α and n: van Genuchten parameters; θ_r and θ_s: residual and saturated soil water content, respectively; λ_{sp}: thermal conductivity of soil particles; C: thermal capacity.

Soil architecture		A1	A2	A3		B
		0-3.0 m	0-3.0 m	0-0.3 m	0.3-3.0 m	3.0-30 m
Soil texture %	sand	66.3	92.2	66.3	92.2	-
	silt	12.0	3.8	12.0	3.8	-
	clay	21.7	4.0	21.7	4.0	-
Hydraulic properties	K_s / m d^{-1}	0.19	4.68	0.19	4.68	2.2×10^{-3}
	α / cm^{-1}	0.03	0.03	0.03	0.03	0.01
	n / -	1.33	2.85	1.33	2.85	1.5
	θ_r / m^3 m^{-3}	0.06	0.05	0.06	0.05	0.10
	θ_s / m^3 m^{-3}	0.38	0.38	0.38	0.38	0.2
Thermal properties	λ_{sp} / W m^{-1} K^{-1}	5.0				2.0
	C / J m^{-3} K^{-1}	2×10^6				