

Line numbers refer to the version with tracked changes.

1) Lines 81 & 82. Sentence should be rephrased: “it potentially affects” is not clearly related to the preceding part of the sentence (where the subject is plural, namely “LTNE effects”).

The sentence has been rephrased to: “This work investigates under which meteorological and hydraulic/thermal snow conditions **LTNE can sustain and how **LTNE** potentially affects the thermo-hydraulic response of the snow pack to the rain.”**

2) Lines 88 & 89. Sentence “Following studies varying meteorological and thermo-hydraulic parameters further reveal conditions promoting LTNE effects and address the uncertainty in model parameterization” should be rephrased.

The sentence has been rephrased to: “Subsequent simulations varying meteorological and thermo-hydraulic parameters investigate which conditions promote LTNE and address the effect of uncertainty in model parameterization.**”**

3) Line 95. I prefer “matric potential” to “pressure head”.

Changed

4) Line 98. It would be useful to recall the measurement units for α , i.e., [m⁻¹].

Done. Also for n (-)

5) Equation (3). I am afraid that this equation is incorrect. If I am not missing something, it does not correspond to equation (23) of van Genuchten (1980). Basically, $(\epsilon_{l,sat} - \epsilon_{l,ref})^{1-m}$ should be substituted with $(\epsilon_{l,sat} - \epsilon_{l,ref}) \times (1 - m)^{-1}$. Am I wrong?

You are right! Thank you very much for catching this error. As you can see in the Matlab function calcMoistCapac provided in the GitLab repository for the reviewers, this function was implemented correctly, so this is only a mistake in the manuscript.

6) Lines 103, 104, 107, 108, 259. A space is missing in “van Genuchten”.

Spelling was corrected throughout the manuscript.

7) Line 108. A space should be added after “season”.

Added.

8) Line 111. Word “been” is missing in “have also successfully used”.

Added.

9) Equation (4). It is necessary to recall the measurement units for α . In particular the equation could be rewritten as $\alpha = 7.3 \text{ m}^{-1} \times \text{mm}^{-1} \times d + 1.9 \text{ m}^{-1}$.

The formula has been adjusted accordingly.

10) Equation (5). Analogously to (4), a preferred format for this equation is $n = -3.3 \text{ mm} \times d + 14.4$.

The formula has been adjusted accordingly. Please note it is $n = -3.3 \text{ mm}^{-1} \times d + 14.4$

11) Line 127. I think that “From rocks” should be substituted, possibly with “For saturated porous media”.

Rephrased as suggested.

12) Equation (7). The definition of phi and phi0 is missing.

Added.

13) Line 142. Sentence “Throughout... respectively” should appear much early, when the indices for the three phases are used for the first time.

The sentence has been moved following equation 2, when the subscript l is introduced for the first time.

14) Lines 149, 169. “K” (kelvin) should be preferred to “°C”.

Done.

15) Line 156. “Dispersivity” could be substituted with “Dispersion coefficient”, as the term dispersivity is often used for the “dispersive length”. The same term appears elsewhere, so if it is changed, it is necessary to check it throughout the whole manuscript. Notice that alpha appears earlier as one of the van Genuchten parameters: different symbols should be selected for these two quantities.

The term Dispersivity was replaced by Dispersion coefficient throughout the manuscript (2 occurrences). The alpha was modified using a subscript T to distinguish it from the van Genuchten parameter.

16) Line 170. I prefer the use of braces “{ }” to denote a set of variables, instead of square brackets.

Square brackets changed to { } as suggested.

17) Line 171. May be an adjective different from “complex” could be better, because, at a first reading I interpreted this as a complex number.

The adjective has been removed completely as the meaning is explained in the following half-sentence anyway.

18) Line 175. Expression “besides better knowledge but due to the lack of any robust data” should be rephrased.

The sentence has been split into three sentences for a better reasoning.

19) Line 185. Erase “,” after “shown”.

Done

20) Line 194. I would use a n adjective different from “classical”, may be “standard” or “common”.

The adjective has been shared to common.

21) Line 217. “Per unit time” should be added after “melted”, shouldn’t it?

Yes, the clarification has been added.

22) Line 223. “Note, that” can be erased.

Done.

23) Line 238. “Per unit time” should be added after “freeze”, shouldn’t it?

Yes, the clarification has been added.

24) Line 253. Expression “of 13 - 90%” should be substituted with “between 13 % and 90 %”.

Done.

25) Line 254. Expression “within the affects” should be corrected.

The sentence has been corrected to: Melting of snow and freezing of liquid water affect porosity, permeability, and heat transfer area of the snow.

26) Line 268. IS “donating” the right word? May be, “denoting”?

Yes, the spelling has been corrected to denoting.

27) Line 289. “A porous media” should be corrected: either singular (a porous medium) or plural (porous media).

The sentence has been corrected to “a porous medium”.

28) Table 1, last line. It is not clear that “e” is used to denote scientific notation: 1.7×10^{-3} and 1.7×10^{-5} should be preferred. The same applies to lines from 480 to 482, 494 & 495, 497, 530 to 532, and to the K values in Table 2.

The notation has been modified throughout the manuscript accordingly.

29) Line 314. “10 hours” could be substituted with “10-hour-long”.

Done.

30) Lines 319 & 320. Expression “of 0.1–0.5mm” should be substituted with “between 0.1 mm and 0.5 mm”.

Done.

31) Line 324. Word “observations” should be corrected.

Done.

32) Lines 325 & 327. The same format should be used for “first” and “second”. May be “shallowest” and “deeper” or similar could be used.

2nd has been corrected to second. Shallowest and deeper were added for clarification.

33) Line 344. “Quantitative” or “qualitative”?

“quantitative” but the sentences have been slightly rephrased for clarification.

34) Line 381 & 382. Sentence “the effect... meteorological quantities” should be corrected.

The sentence has been corrected.

35) Line 400. Expression “coincides similar” should be corrected.

The sentence has been corrected.

36) Figure 4. “(c)” is missing in the figure caption. Expression “describe to the scenario” should be corrected.

The (c) was added and the sentence was corrected.

37) Line 420. “between 20 to 70%” should be rephrased either as “between 20 % and 70 %” or “from 20 % to “70 %”. Analogous corrections should be introduced in the following lines.

Done throughout the manuscript.

38) Table 2. The measurement units of h should be written more precisely as “W/(m² K)”.

**Done as the unit notation has been fixed according to requirements throughout the manuscript
W m⁻² K⁻¹**

39) Line 580. I would use “down to a depth of 30 cm” instead of “up to 30cm”.

Done

40) Throughout the whole paper, the space between values and measurement units is often missing.

The units have been corrected according to the Copernicus format.

41) The vertical axis of all the figures should be changed. At line 95, it is stated that the z-axis is assumed positive downwards. Therefore, it would be better to use positive numbers increasing downwards for the vertical axes of the figures. Moreover, the axis title is “depth of the snow column” and this is 0 at the top of the glacier or snowfield and increases downwards, so that it should be positive.

The figures have been revised accordingly.

Moreover, I did not find a stability analysis of the numerical model, so that I wonder if the oscillations found in some cases (Figures 1 and 11) can be indeed explained as physical processes or if they are related to numerical instabilities.

As stated in lines 282 – 284 (previous round of revisions, version with marked changes), the LTNE model requires an explicit time stepping, which is subjected to a stability criteria derived in Heinze & Hamidi (2017). This is the upper bound for the computational time step due to the comparably high difference in phase temperatures at the initial conditions and the time step is

set constant throughout the simulation. Consistency of the numerical implementation was secured through variation of spatial and temporal resolution (lines 307-308). In addition, multiple parts of the code have been successfully validated with analytical solutions and compared to experimental data in past publications (such as Heinze & Hamidi, 2017; Heinze & Blöcher, 2019; Heinze, 2021).

Also, please note an important difference: The fluctuations shown in Fig. 1b (note the scale of the x-axis!) are numerically induced due to the corrector-predictor scheme applied to simulate the freezing/melting processes – but are no indications of instability. The variations seen in Fig. 11 are indeed interpreted as physical processes