The Cryosphere Discussions

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Comment on tc-2021-191

Anonymous Referee #1

Referee comment on "Convective heat transfer of spring meltwater accelerates active layer phase change in Tibet permafrost areas" by Yi Zhao et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-191-RC1, 2021

Convective Heat Transfer of the Spring Meltwater Accelerates Active Layer Phase Change in Tibetan Permafrost Areas

By Zhao et al.,

In this study, the authors applied the SHAW model to investigate temperature dynamics at the Tanggula site at the Eastern Qinghai-Tibetan Plateau. The modeling experiment includes the cases: 1. control (fully coupled diffusion convection), 2. NoSurf (no convective heat flux between surface and subsurface, but preserves the convective flux in the subsurface as a results of water movement in soil pores), 3. NoConv (no convective heat flux from surface to subsurface as well as no flux due to water movement in the subsurface). If I understand correctly, in case 2, the second left term in eqn. 2 remains for the subsurface formulation and is completely removed from the eqn. 2 for case 3.

Overall, the study is interesting and well presented. I suggest including a discussion on a similar mathematical formulation described by Painter et al., (2016). How is the current mathematical formulation different from Painter et al. What are pros and cons of each formulation? Is q_l a Darcy flow or water head potential in the current formulation? My understanding was that the current model considers both saturated and unsaturated soil conditions. It would be nice to include the discussion on the compute time difference between saturated and unsaturated cases.

What is the equation for the vertical water flux? It is not clear how one would define subsurface water transport without addressing the soil permeability? I suggest including the permeability paragraph in the Discussion section. During snowmelt, the surface is typically frozen. That said, most if not all of the snowmelt water should runoff the surface. Not clear why it would percolate into the subsurface? Westermann et al., has a publication on the effect of water percolation in the snow layer and its impact on surface

temperatures, worse to mention as well.

I found Figure 3 not necessarily helpful for understanding the effect of convective heat flow. Does it mean that convective flux adds to the 5C difference in soil temperatures over a short period of time?

Can the changes that are shown in Figs 3 and 4 be verified against observations or in lab measurements? L353 concludes that convective flux could contribute to up to 10C temperature change during snowmelt. This is massive warming or cooling, which I am having a hard to believe. Short-term 10C warming/cooling should lead to substantial changes in subsurface thermal state over time. Are there any pieces of evidence of the accelerated ground warming in the region? I suggest quantitively estimate the impact of these short-term warming/cooling pulses on mean annual ground temperatures. Are these pulses significant, and on what temporal scale? For example, on the yearly scale, those pulses could be less important than on a monthly scale and so on....

Taking into consideration the above comments and questions, the paper needs more clarification on the mathematical formulation, application, and discussion with similar studies.

Minor

L45-48 …influenced. Influenced by what? Not clear. I suggest to re-write.

L121-124 need a reference.

In Table 1. Are any of the parameters been tuned during this study?

On Figure 2. It is hard to tell the time of snowmelt.

Additional language improvements are needed as well.