

Thank you for your comments and suggestions. We made detailed point-by-point response to these comments and suggestions. The modified version of manuscript was uploaded as a separate file.

Anonymous Referee #1

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High gravel content is a well-known phenomenon in the Tibetan Plateau, but it is hard to quantify its impacts on land surface processes, particularly to soil freezing/thawing, because of high cost in time and labor of conducting laboratory experiment in frozen condition. This study first conducted time-consuming laboratory experiments in both unfrozen and frozen conditions, and then tested the importance of the measured parameters through sensitivity modeling analysis. I also read an early version of this study published in TCD three year ago that did not present experimental results. I believe the current study is a great contribution to deepening our understanding to the land processes in the Tibetan Plateau. As far as I know, this is the first study that quantifies the impact of typical gravelly soils on land permafrost processes. I would like to congratulate the authors for their success and contribution. I only have two minor comments:

- (1) I notice that the authors did not take into account soil organic matters (SOC) in the simulation. SOC is another important factor to affect land surface processes, including soil freezing/thawing processes. It will be beneficial to readers if you can discuss the overall effects of gravels and SOC on the PBL, ADL, and soil moisture. Are their effects additive or do their effects cancel out each other? By the way, I did not find information of SOC content for this site.

Reply: Thank you for your comments.

As shown in Figure 1 and 2, the site in this study has sparse vegetation and large amount of gravel content on surface, which is not beneficial for soil carbon accumulation (Qin et al., 2015). Therefore, we did not consider the effects of soil carbon on soil thermal and hydrological properties. However, we do agree with the reviewer that it is important to consider the effects of soil carbon, especially for regional application. We modified the 2nd paragraph in Section 4.3.3.

“Coarse fragment content affects soil physical properties. For example, soil porosity and saturated hydraulic conductivity are determined by the fraction of gravel, diameter and degree of mixture (Zhang et al., 2011). Organic soil carbon content in mineral soil on the QTP affects soil porosity and thermal conductivity (Chen et al., 2012). Alpine swamp meadow, alpine meadow, alpine steppe and alpine desert are the major vegetation types on the QTP (Wang et al., 2016; see also Figure 1b). Alpine swamp meadow and alpine meadow usually contain fine soil particles and high organic carbon density; while the other two types usually contain coarse soil particle and low organic carbon density (Qin et al., 2015). More laboratory work is needed to develop proper schemes for representing mixed soil with fine mineral, coarse fragment (including gravel) and organic carbon in permafrost models.”

Added reference:

Wang, Z., Q. Wang, L. Zhao, X. Wu, G. Yue, D. Zou, Z. Nan, G. Liu, Q. Pang, H. Fang, T. Wu, J. Shi, K. Jiao, Y. Zhao, and L. Zhang: Mapping the vegetation distribution of the permafrost zone on

the Qinghai-Tibet Plateau, *Journal of Mountain Sciences*, 13, 1035-1046, 2016.

- (2) The authors should pay attention to the readability of the tables and figures, For example; I cannot understand the numbers in Table 5. Also, it is hard to understand the slope0, slope 5, slope10 in Figure 7, if not referring to the text. The tables and figures should be self-contained.

Reply: Thank you for your comments. We now improved the readability of tables and figures. Please see the revised manuscript.