Response to the interactive comment on the manuscript:

*"**Hillslope subsurface flow is driven by vegetation more than soil properties in colonized valley moraines along a humid mountain elevation**"*

by Fei Wang, Genxu Wang, Junfang Cui, Xiangyu Tang, Ruxin Yang, Kewei Huang, Jianqing Du, Li Guo

We thank the referee for the thorough and constructive comments on the manuscript. In the following document, we reproduce the referee's comments related to the research content, group comments addressing common issues in red, and provide our point-by-point replies in black. The revised contents are shown in italic.

Anonymous referee #2:

[Comment 1]: This work is interesting and could bring a valuable contribution to the scientific discussion about hillslope hydrology. In my opinion it could be published after some adjustments. I suggest you double check the writing of the entire manuscript one more time, as some sentences make little sense and I am not sure some words are used properly.

Reply: We thank the referee for the positive comments and thoughtful language suggestions. Accordingly, we will take specific actions in response to the comments. (1) For specific modification suggestions, we will implement the changes directly as suggested; (2) For unclear statements, we will either adopt the referee's suggested phrasing when provided or rephrase the text to improve clarity and precision; (3) For the statements that are inappropriate or doubtful, we will rephase them based on relevant literature and expert advice; (4) Finally, we will engage a professional English editing service to ensure the overall language quality, including grammar, style, punctuation, and syntax, as well as content clarity, such as reconstruction of sentences for better interpretation of the intended meaning.

[Comment 2 (grouped)]: Provide the coordinate range of the study area along with a picture of the real experimental apparatus for additional information. Some figures and tables require improvement due to insufficient information, inaccurate citations, and inadequate explanations.

Reply: Thanks for the suggestions. We will take following principles to address the referee's comments: (1) Specific suggestions on figures and tables provided by the referee will be implemented directly (e.g., adding R^2 value to graphs and including dates in Fig. 5 to clearly indicate the growing season referenced in this study). (2) The coordinate of the study area (Hailuo Valley) and a picture of the experimental apparatus will be presented and included in the "Supplementary" materials (see Fig. 1 below). (3)

We will carefully check all figures and tables to assert that the information they present is adequately and correctly explained in the text, thereby reducing potential uncertainties in interpretation.

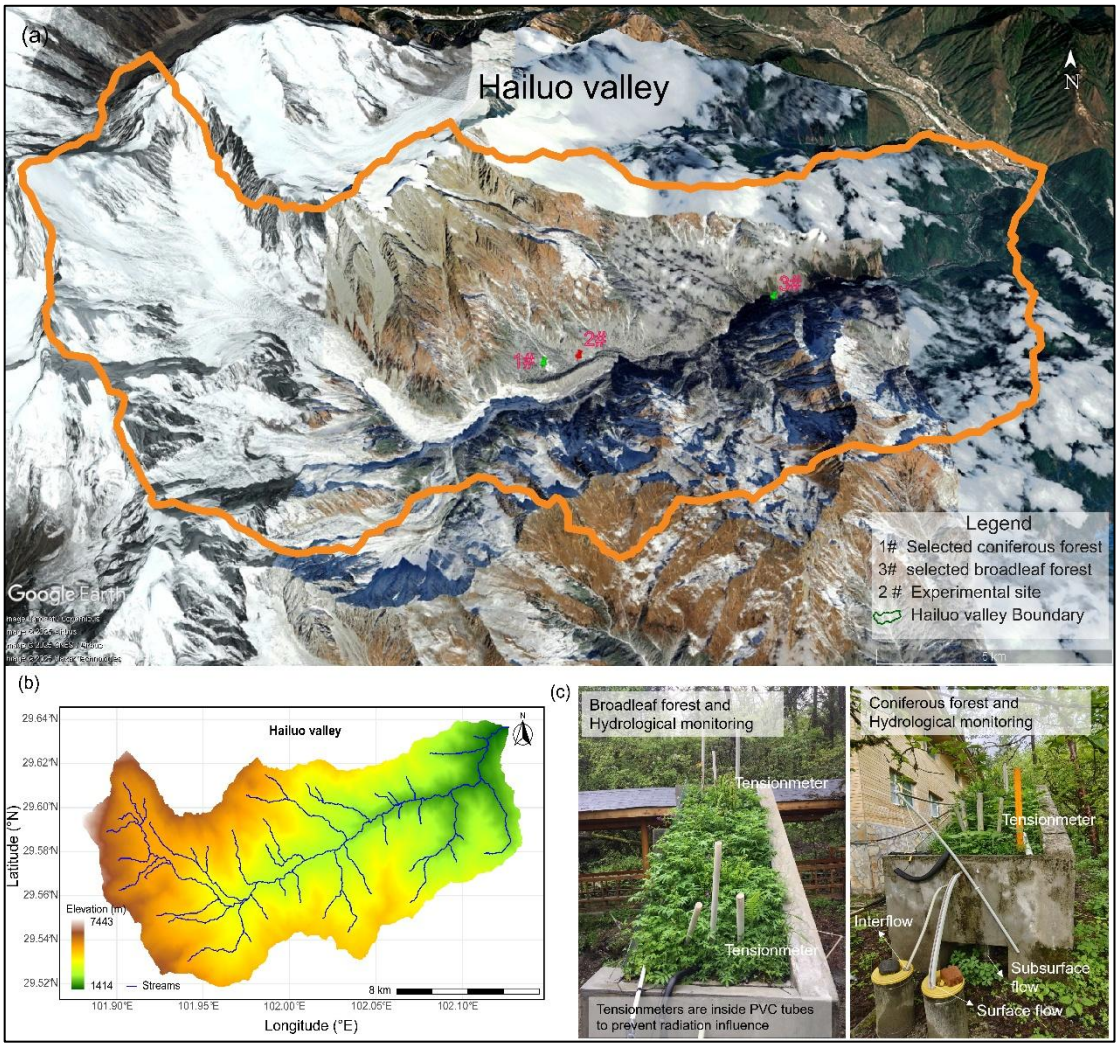

Figure 1: Overview of (a) the selected forests (1# and 3#) and the experiment site (2#) at Hailuo valley (image retrieved from Google Earth; note that the blue areas represent shadows in the satellite view), (b) digital elevation model of Hailuo valley, and (c) a photograph of the experimental apparatus at 2#.

[Comment 3]: What possible hypothesis may account for the mismatch between simulated and observed outflow under heavy rainfall conditions?

Reply: We did discuss this phenomenon in Section 4.3 (Uncertainties and future outlooks) of the manuscript, specifically at lines 390-393 and 400-405. We will reorganize and expand the discussion to better address the discrepancy between simulated and observed outflow, thereby benefiting future improvements in model conceptualization and predictive accuracy. The revised content is as follows:

"Specifically, there are noticeable deviations between simulated and observed subsurface flow under heavy rainfall conditions (Fig. 5). Although, these deviations may appear rather small given the complexity and heterogeneity of natural hillslopes, we nevertheless delve into them in light of the aforementioned uncertainties, aiming to provide insights for improving model conceptualization and predictive accuracy. First, we defined macropores as pores with diameter or aperture over 30 μm; however, it is evident that fracture apertures ≤ 30 μm can still transmit preferential flow in the form of film or rivulet flow (Tokunaga and Wan, 2001; Lange et al., 2009); Secondly, although the model reproduced acceptable results using a fixed and below-average number of PFPs, increased soil wetness during continuous rainfall promotes the self-organization of PFPs into larger flow networks, thereby engaging more PFPs in subsurface flow (Sidle et al., 2001; Nieber and Sidle, 2010; Zehe et al., 2013). Finally, the potential initiation of other preferential flow types–such as finger flow and funnel flow, which are induced by heterogeneity in soil moisture, soil hydraulic conductivity, or water flux–was not considered (Hartmann et al., 2020; Nimmo, 2021). In summary, the simplified conceptualization of PFPs, the assumption of their static nature during rainfall, and the omission of other preferential flow regimes collectively contribute to the underestimation of subsurface flow under heavy rainfall conditions. Addressing these limitations in numerical models would help improve simulation accuracy, particularly for flood prediction under extreme rainfall events."

Specific revisions:

Replace Line19"contrasting ultimate forests" with "*contrasting forests*";

Remove Line20 "the";

Replace Line25 "were" with "*covered*";

Change sentences at Line43-44 to "*Preferential flow is the rapid movement of water through dominant pathways at velocities and fluxes orders of magnitude higher than those through the soil matrix, effectively bypassing much of the porous medium*" for clarity;

Replace Line49 "explained" with "*explains*";

Change sentences at L61-62 to "*Deciduous or evergreen forests typically establish as the final and stable vegetation succession*" for clarity;

Replace Line67 "determined" with "*determines*";

Replace Line82 "to applied" with "*to be applied*";

Replace Line98 "hypothesis" with "*hypothesize*";

Replace Line99 "than" with "*from*";

Change Line135 figure citation from "(Fig. 1b) to "(Fig. 1a and b)" to ensure that both relevant subfigures are properly referenced;

Replace inconsistent abbreviation "Kms" at L147 and 151 with "K_{ms}";

Replace Line164 "The HYDRUS 2D" with "*The HYDRUS 2D software*";

Change figure caption at Line185 to "*Figure 2: A set-up of hillslope form with explicit structures (a), and discretization of the flow domain (b, c) in the numerical model.*" to include all subfigures;

Change sentences at Line194-196 to "*The ground layer was treated as an equivalent soil layer, with the residual soil water content set to a high value and the saturated soil water content defined as the sum of residual water content and the equivalent interception capacity*" for clarity;

Move Line244-248 the table note originally placed below the table into the table caption;

Change sentences at Line282-283 to "*Due to the high flow velocity in the ground layer, water is rapidly transported downslope where it infiltrates into the soil, leading to increased soil moisture and thereby enhancing soil hydraulic conductivity.*" for clarity;

Change sentences at Line303-304 to "*Previous studies have shown that over long periods of soil development spanning thousands of years, moraines commonly exhibit decreases in bulk density, increases in clay-sized particles, and accumulation of organic matter.*" for clarity;

Replace Line336 "related soil" with "*related to soil*";

Replace Line375 "and connectivity" with "*and that connectivity*";

Replace Line379 "account for" with "*accounts for*";

Replace Line386 "isotopic" with "*isotropic*";

Replace Line398 "through" with "*though*";

Replace Line410 "floods" with "*flood*";

References

Hartmann, A., Semenova, E., Weiler, M., and Blume, T.: Field observations of soil hydrological flow path evolution over 10 millennia, Hydrol. Earth Syst. Sci., 24, 3271-3288, doi:10.5194/hess-24-3271-2020, 2020.

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Nieber, J. L. and Sidle, R. C.: How do disconnected macropores in sloping soils facilitate preferential flow?, Hydrol. Processes, 24, 1582-1594, doi:10.1002/hyp.7633, 2010.

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Sidle, R. C., Noguchi, S., Tsuboyama, Y., and Laursen, K.: A conceptual model of preferential flow

systems in forested hillslopes: evidence of self-organization, Hydrol. Processes, 15, 1675-1692, doi:10.1002/hyp.233, 2001.

Tokunaga, T. K. and Wan, J.: Approximate boundaries between different flow regimes in fractured rocks, Water Resour. Res., 37, 2103-2111, doi:10.1029/2001WR000245, 2001.

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