# Reply to RC1

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RC1 is in black font, author comment on RC1 in red font, proposed changes in the manuscript in *italic*

I would like to begin by thanking the authors for their research and for sharing their findings for discussion. Given the increasing frequency of intense rainfall events with significant damage potential, and the considerable efforts by federal states to produce high-resolution heavy rainfall hazard maps, advancing hydrological and hydraulic modeling remains crucial. In particular, there is an urgent need to better quantify and model how varying vegetation conditions affect runoff generation and overland flow dynamics. In this context, the authors' work is highly valuable, offering insights that are both scientifically relevant and practically applicable.

At the same time, I see room for minor improvement in the presentation of the results, with the aim of making the findings clearer and more accessible to the professional community. Before providing our detailed comments and questions, I would like to share some general critical-constructive observations:

The model setup appears to differ from the study sites described by Ries et al., as the discharge in the model is measured at a different location compared to Ries, where, to my understanding, discharge was recorded 10–20 m downstream of the plot via drainage tubes. This discrepancy could lead to distortions in the subsequent evaluation and should at least be acknowledged as a source of uncertainty. It may also partly explain the differences observed between the model results, the Feldmann data (which presumably have comparable uncertainties), and the experimental measurements.

We sincerely thank the reviewer for the positive and encouraging assessment of our work. In response, we will revise some parts of the manuscript to improve clarity and readability.

We acknowledge that differences between field measurements and model configurations inevitably introduce a degree of uncertainty. In the experiments by Ries et al. (2020), discharge was measured using a trench and drainage tube system, where water levels were recorded with a pressure-compensated piezometer and subsequently converted to discharge using a calibrated stage–discharge relationship. As reported by Ries et al. (2020), this relationship was adjusted using a correction factor derived from calibration experiments, which already accounts for part of the hydraulic effects associated with the measurement setup.

We agree that the simplification in the models may introduce additional uncertainty in the model–data comparison. Following the reviewer's suggestion, we will explicitly acknowledge this limitation in the revised manuscript and discusses as a potential source of uncertainty affecting the comparison between simulated and observed hydrographs.

Additionally, providing a rough overview of the ranges of discharge, flow velocities, and water depths across the plot would be highly useful for context and interpretation.

The range of rainfall intensity and discharge is provided in Table 2. Flow velocities and water depths were not directly measured in the field experiments by Ries et al. (2020).

The study emphasizes the influence of vegetation cover, suggesting effects not only on the roughness coefficient but also on key infiltration parameters. However, this impact may be partly inherent to the modeling approach: because the model is calibrated using the original data, where these patterns are already present, the results could reflect a degree of circular reasoning, effectively producing a self-fulfilling confirmation of the initial observations. Also, some of the figures are partly difficult to read and could be improved.

We should note that the calibration was performed just for Run2 and the validation was performed using independent rainfall events (Runs 1, 3, 4, 5, and 6) and across multiple sites. The consistent model performance across these independent conditions indicates that the representation of vegetation effects is not solely an artifact of the calibration process, but is required to reproduce the observed runoff dynamics.

We would like to clarify that our intention is not to provide independent proof that vegetation affects both surface roughness and infiltration processes, as this has already been demonstrated in previous studies. Instead, our objective is to highlight that, for accurate runoff simulation, it is essential to account for vegetation effects not only through roughness coefficients but also through infiltration-related parameters such as saturated hydraulic conductivity (Ksat).

L10 introduce also ksat and psi to complete the picture

The revised sentence now reads:
*"This study evaluates multiple methods for estimating Manning's roughness coefficient and explores the influence of vegetation on infiltration parameters, namely saturated hydraulic conductivity (Ksat) and wetting front suction (Psi), using the OpenLISEM model."*

L98 Original data resolution of 1min. Does this have a impact on the results? What are the uncertainties?

Temporal resolution effects in representing rapid changes in runoff dynamics and peak discharge. However, given the overall duration of the rainfall events and the relatively uniform rainfall intensity applied during the experiments, the 1-minute temporal resolution is considered sufficient to capture the dominant hydrological processes.

L105 To explore the impact of roughness on overland flow -> To explore the impact of different roughness functions on overland flow... would be more appropriate?

We will modify the text accordingly to: *''To explore the impact of different roughness functions on overland flow"*

L113 Microrelief / Microtopography should better fit to roughness coefficients instead of depressions which are mainly connected to retention effects

We will change it to microtopography.

L115-120 The differences between original setup and model needs to be addressed somehow. At least that this leads to uncertainties of the results. Could be also an explanation for the differences to the results of Feldmann?

Ans: We agree that there are differences between the original experimental setup and the model representation. It is not possible to fully replicate all aspects of the experimental setup in a catchment model. For example, the model does not explicitly account for small-scale heterogeneities such as the spatial distribution of vegetation or the presence of preferential flow paths. These simplifications may introduce additional uncertainty in the simulation results. Following the reviewer's suggestion, these points will be incorporated into the methodology section as a new part, "Applying a catchment model on a plot experiment":

''*A catchment model can only applied to a small scale field experiment with some workarounds and assumptions, leading to additional source of structural uncertainty.*

*First, differences between the experimental setup and the model representation introduce structural uncertainty. In the field experiments (Ries et al., 2020), runoff was collected using a trench and drainage tube system, whereas in the model, discharge is recorded at a defined outlet cell. Although adjustments were made to approximate the experimental conditions, the simplified representation of the measurement may influence the comparison between simulated and observed results.*

*Second, the model does not explicitly represent small-scale heterogeneities such as the spatial distribution of vegetation, microtopography, or preferential flow paths. These factors can significantly affect overland flow and infiltration processes in real field conditions, but uses a simple surface retention factor as a proxy for micro-topography. Third, the temporal resolution of the experimental data (1 minute). While the relatively uniform rainfall intensity and duration of the events suggest that the available resolution is sufficient, higher resolution would give us more detailed information about the hydrological process. Forth, the infiltration modelling approach (Green–Ampt) assumes simplified soil conditions, which may not fully represent complex field situations, particularly under very dry or near-saturated initial soil moisture conditions. This limitation is reflected in the reduced model performance for extreme antecedent conditions (e.g., Runs 1 and 5). However, using any explicit infiltration model for runoff modelling is already a great improvement in comparison to the still common "effective rainfall" approach based on the curve-number approach, where the estimated infiltration is simply subtracted from the rainfall, as it allows infiltration of water that has already travelled at the surface.*

*Differences between modelling approaches can further contribute to variations in results. For example, the model setup used in this study and the framework proposed by Feldmann et al. (2023) rely on different assumptions regarding roughness parameterization, calibration strategies, and representation of hydrological processes. These methodological differences, combined with the inherent uncertainties in both models and measurements, may partly explain the observed discrepancies between the results.*

L125 model data 1s. original data 1min. How does this influence the results?

The model simulations were conducted with a temporal resolution of 1s to ensure numerical stability. However, for comparison with the observed data, the simulated results were aggregated to a 1min temporal resolution, consistent with the original measurement interval.

L126 … kinematic wave is used together …

we will modify it.

L128 Porosity and initial soil moisture was estimated or measurement data? Same for all model runs?

Both porosity and initial soil moisture were derived from field measurements. The initial soil moisture was measured prior to each rainfall experiment and therefore varies between model runs, reflecting the actual antecedent conditions for each run.

In contrast, porosity was measured once for each site and assumed to remain constant across all model runs at that location. This approach is based on the assumption that soil porosity does not change significantly over the short duration of the experimental campaign.

L131 What are the reasonable ranges?

The parameter ranges used in this study are Ksat = 5–100 mm $h^{-1}$ and Psi = 0–50 cm. These ranges have been included in the manuscript in Line 215.

L142 Surface roughness functions -> maybe “Flow resistance parameterisation” is better

we will modify it.

L146 complicated sentence, maybe: In this study, two depth-independent and five depth-dependent roughness functions were implemented in OpenLISEM to assess the impact of the investigated approaches on vegetation modelling.

We will modify this to:

OpenLISEM uses the Manning’s equation to calculate flow resistance with a constant Manning’s n, to be provided by the user. We have extended the code of OpenLISEM (see https://github.com/philippkraft/openlisem/tree/modified_manning_console) with five depth-dependent roughness functions (Sections 2.2.3-2.2.7) and compare the results with two depth-independent Manning’s n estimations (Section 2.2.1 and 2.2.2).

L150 Chow´s method could be changed to method with constant coefficients as it´s more like Manning´s method and chow provided reference tables / guidelines.

we will modify it.

L153 … it does not consider the effect of water depth in presence of vegetation. -> … it does not consider the dynamic effect of water depth on the roughness coefficient in presence of vegetation.

we will modify it.

L155 add that the same study site and experiments have been used by Feldmann

we will add it.

L157 They estimate surface roughness -> roughness coefficients maybe more suitable?

we will modify it.

L169 in equation (1): 5 · $h_{veg}$

we will modify it.

L185 1-2 sentences about this approach would help for understanding

we will explain it as: ''*Following Feldmann et al. (2023), Manning's roughness coefficient is parameterized as a reciprocal exponential function of water depth, enabling systematic exploration of different roughness–depth relationships. They selected a reciprocal formulation to ensure a more balanced sampling of roughness functions across the parameter space, thereby preventing the underrepresentation of low roughness values.*

L195 Only Hinsberger et al.; not in Oberle et al. 2021

We will modify it.

L208 Please insert the unknown sensitive parameters

We should change the term "unmeasured parameters" to "unknown parameters" in this context, referring specifically to saturated hydraulic conductivity (Ksat) and wetting front suction (Psi).

L211 It remains unclear on what basis the values from Chow were selected. Average? Max or Min?

The Manning's roughness coefficients based on Chow (1959) were selected according to the vegetation characteristics of each site, particularly the percentage of vegetation cover. Higher vegetation cover corresponds to higher surface resistance and therefore higher Manning's n values, while lower vegetation cover is associated with lower roughness values.

Accordingly, for sites with dense vegetation (e.g., close to 100% cover), higher values within the range reported by Chow (1959) were assigned, whereas for sites with sparse or no vegetation, lower values were used.

L222 (NSE) instead of L224

we will modify it.

L232 MSE -> NSE

we will modify it.

L248 Calibration of different roughness methods -> Wouldn´t be something like "Calibration of ksat and psi for different roughness methods" be more suitable?

we will modify it.

L265 Lag for falling hydrograph between observed data and model maybe due to differences between model and original setup?

We will explain it in ''Applying a catchment model on plot experiments (see above).

L279 add (ksat) (psi)

We will insert them.

L295 The font size appears to be inconsistent within the table.

We will modify it.

L337 line break incorrect

We will modify it.

L346 What is with loc 13, run 6. Differences look significant in contrast to statement in the text.

We will change ''For these runs" to ''For these runs except Run6 in Loc13".

L351 Isn´t this already evident from the raw data?

We agree that this trend is already visible in the raw data. However, the purpose of our modelling approach is to demonstrate that this pattern can also be consistently reproduced by a physically based hydrological model. This highlights that, for improving hydrological model performance, it is important to account for vegetation effects not only through Manning's roughness coefficient but also through infiltration-related parameters.

L357-361 From my understanding, Run 5 was carried out on the same day as Runs 2, 3, and 4. Why do the initial soil moisture conditions differ, for example, from those of Run 4?

Yes, Run 5 was conducted after Runs 2, 3, and 4, and in addition it has the most duration of rainfall, therefore the soil was already significantly wetted by the preceding rainfall events. As a result, the initial soil moisture conditions for Run 5 differ substantially from those of earlier runs, including Run 4.

The cumulative effect of prior rainfall likely led to near-saturated or even locally saturated soil conditions, which altered the dominant hydrological processes. Under these conditions, infiltration capacity is reduced and runoff generation becomes more sensitive to small changes in soil moisture and flow dynamics.

This shift in initial conditions also affects model performance. The model was calibrated under intermediate soil moisture conditions (Run 2), and therefore shows reduced accuracy when applied to more extreme conditions such as very dry (Run 1) or near-saturated (Run 5) states. We will clarify this point in the revised manuscript.

L384 emergent

we will modify it.

L384 also this leads to constant manning values for some of the eq?

Yes, under conditions where the flow depth remains below the vegetation height, the Linear method can result in effectively constant Manning's n values.

L405 Again also possible discrepancies between setup of your model, Feldmann model and original experiments could lead to differences.

we will explain it in part entitled ''Applying a catchment model on a plot experiment'.