RESPONSE TO REVIEW COMMENTS

We thank the reviewer for the valuable input, which has helped improve the quality of our manuscript. Our responses are provided below. **Please note that the original comments are in black letters and our responses are in blue letters**. In addition to these responses, we will provide a revised manuscript that reflect the proposed changes, as well as a copy with the tracked changes where revisions were implemented.

General Comments:

In this manuscript, the authors address the effect of rainfall velocity on soil-air roughness quantified via the random roughness (RR) parameter. They showed that as rainfall velocity increased from 30 to 75 mm/hr the random roughness index increased as well, which is in contrast to those reported in the literature. Although more experimental data on support are required to have a more conclusive conclusion, the manuscript is well written and well organized and suitable for publication in the journal. However, some moderate revisions are required before publication.

Response:

We thank the reviewer for the insightful comments and suggestions. We believe that the revisions we made in response to the comments have significantly improved the quality of the manuscript.

Minor Comments:

Comment 1: P3L23: Could the authors address/discuss on how changes in median diameter would affect air-soil roughness?

Response:

To respond to this great question, we have utilized the median drop diameter estimated for each intensity test to calculate the terminal velocity of the rain drop (see Eq. (1d)). Several studies have shown that soil surface redistribution under the action of rainfall is dependent on the median raindrop diameter (e.g., Warrington et al., 2009; Fu et al., 2016). The kinetic energy (KE) corresponding to the median raindrop diameter is estimated using a collection of equations presented in Atlas et al. (1973), Begueria (2015), and Kathiravelu (2016):

$$\mathrm{KE_i} = \frac{1}{2}\mathrm{m_i v_{t\,i}^2} \tag{1a}$$

$$\mathrm{m_i} = \mathrm{\rho_i V_i} \tag{1b}$$

$$\mathrm{V_i} = \frac{4}{3}\pi\left(\frac{\mathrm{D_i}}{2}\right)^3 \tag{1c}$$

$$\mathrm{v_{ti}} = 9.65 - 10.3\exp(-0.6\mathrm{D_i}) \tag{1d}$$

where m_i is the mass of raindrop i (kg), v_{ti} (m/s) is the raindrop terminal velocity, ρ_i is the density of raindrop i (kg/m^3), and V_i is the volume of the raindrop i (m^3) which assumes a spherical shape.

In our study, the calibration of the rainfall simulators with the disdrometer allowed us to match the median raindrop sizes that are predominantly found at the study site for all 3 intensities (see Table 1.1 below).

Table 1.1 Median drop diameters corresponding to the rainfall intensities of the experimental runs.

Rainfall Intensity (mm/h)	Median Drop Diameter (mm)
30	2.25
60	2.60
75	2.75

The rate of change in relative roughness (RR_{post}/RR_{pre}) and the other indices against intensity (summarized in Tables 1-3 of the manuscript) essentially reflects the effects of the median drop diameter on roughness.

Eqs. (1a-d) imply that for different intensity and median drop size diameter, both the terminal velocity and mass play an important role to the RR change due to different raindrop kinetic energy. The roughness index increases with intensity; however, the relative change in roughness reduces with increasing intensity, as shown in Fig. 1.1 and summarized in Table 1.2 below (these have not been included in the paper due to space requirements). A change in rainfall intensity from 30 mm/hr to 60 mm/hr results in a 16% increase in the median drop diameter which leads to a 165% increase in the RR ratio. However, a change in intensity from 60 mm/hr to 75 mm/hr results in a 6 % increase in median drop diameter which leads to only a 29% increase in the RR ratio.

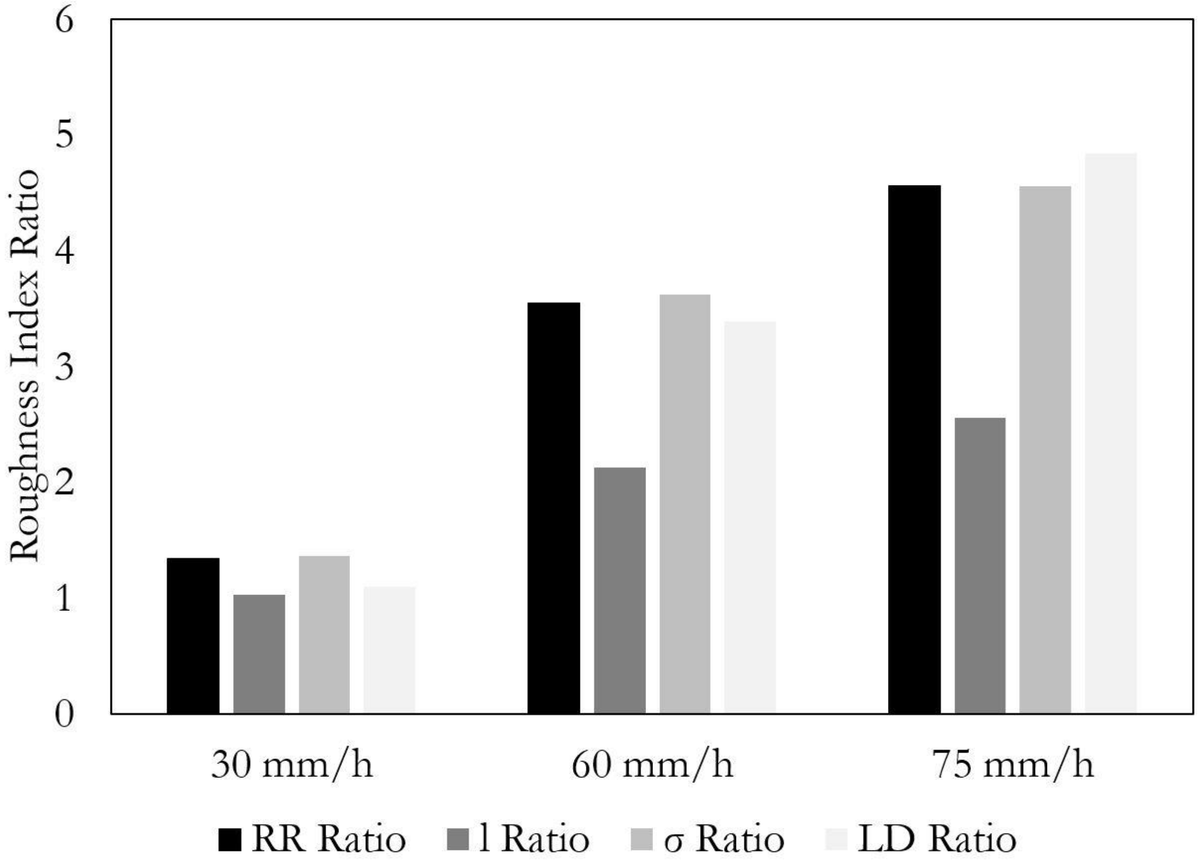


Figure 1.1 Relative ratios of the roughness indices as a function of rainfall intensity.

Table 1.2 Increase in median drop diameter

Change in Rainfall Rate	Increase in Median Drop Diameter	Increase in RR Ratio	Increase in l	Increase in σ	Increase in LD
30mm/h - 60 mm/h	16%	165%	107%	165%	207%
60 mm/h - 75 mm/h	6%	29%	20%	26%	43%

References

Atlas, D., Srivastava, R. C., and Sekhon, R. S.: Doppler radar characteristics of precipitation at vertical incidence, Reviews of Geophysics, 11, 1, doi:10.1029/RG011i001p00001, 1973.

Beguería, S., Angulo-Martínez, M., Gaspar, L., and Navas, A.: Detachment of soil organic carbon by rainfall splash: Experimental assessment on three agricultural soils of Spain, Geoderma 245–246, 21–30, doi:10.1016/j.geoderma.2015.01.010, 2015.

Kathiravelu, G., Lucke, T., and Nichols, P.: Rain Drop Measurement Techniques: A Review. Water 8, 29. doi:10.3390/w8010029, 2016.

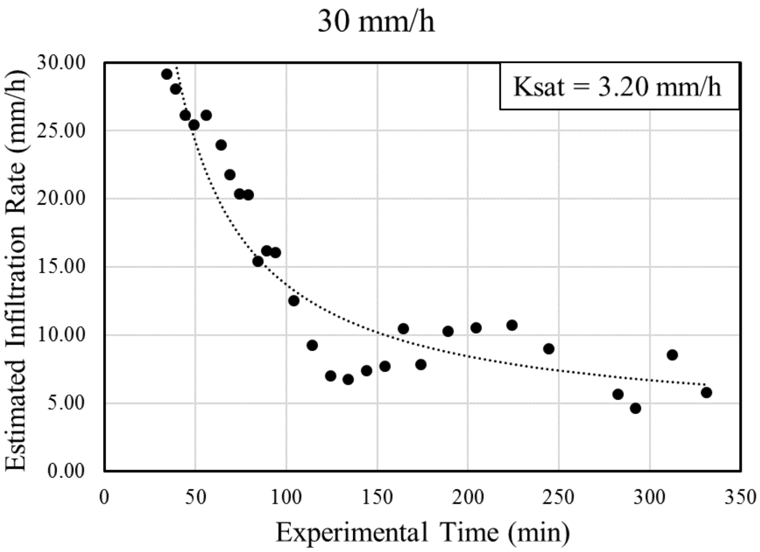
Comment 2: P4L2: The authors should clearly state that with such a low resolution some rough features with scale less than 0.5 mm have not been captured via their laser scanner. As the title indicates the authors address soil surface microroughness, while the resolution of the laser scanner is 0.5 mm. How is it possible to capture microroughness with a scanner of resolution of millimeters?

Response:
We thank you for the comment. We have updated the text to include a sentence that clarifies that our analysis may not have captured microroughness features less than 0.5 mm.

We have added the following sentence to clarify the length scales that we captured (Page 4, lines 20-21):
"Horizontal and vertical accuracies of the laser are 0.5 mm. Thus, microroughness features less than 0.5 mm may not have been captured in the analysis."

Comment 3: Did the authors measure infiltration rate or even saturated hydraulic conductivity of the tested soil? If so, what is the infiltration rate?

Response:
In each test we placed soil moisture probes in order to continuously record volumetric water content and determine the steady-state infiltration conditions. This was roughly 2-3 hours after start depending on the rainfall intensity. We estimated the infiltration rate during all rainfall simulation runs by subtracting the measured runoff rates from the constant rainfall rates. As mentioned in the text, runoff was collected continuously at a downstream weir and rainfall rates were set to known constant value. This approach has been commonly used in plot experiments and provides a good estimate of the spatially averaged infiltration rates (e.g., Mohamoud et al., 1990; Wainwright et al., 2000). Below we provide the graph of the estimated infiltration rate with time for the 30 mm/h case:



Averaged saturated hydraulic conductivity (K_{sat}) values ranged from 3.20 – 4.56 mm/h. In our previous study, we measured K_{sat} by means of semi-automated double ring infiltrometers at the field where this plot was located (see Papanicolaou et al., 2015). We found an average value of 4.0 mm/h, which is in agreement with our estimations.

The information outlined has been added to the text along with the cited references (Page 5, lines 7-12):

"The infiltration rate was estimated during all rainfall simulation runs by subtracting the measured runoff rates from the constant rainfall rates. This approach has been commonly used in plot experiments and provides a good estimate of the spatially averaged infiltration rates (e.g., Mohamoud et al., 1990; Wainwright et al., 2000). Averaged saturated hydraulic conductivity values ranged from 3.20 – 4.56 mm/h, which are in agreement with the averaged saturated hydraulic conductivity value of 4.3 mm/h measured by Papanicolaou et al. (2015) using semi-automated double ring infiltrometers at the field where the study was performed."

Comment 4: P8L4-8: The authors stated that, "Analysis of soil surface roughness in the region where raindrop detachment dominates and under initial smooth surface preconditions for three rainfall intensities shows a consistent increase in the RR index and crossover length, which are confirmed as reliable descriptors of microroughness. This increase contrasts the findings of most available literature…" Please provide a few references from the literature for the last statement.

Response:

Per the suggestion of the other referees, we have removed the last statement because our findings do not contradict, but rather complement the existing literature by covering a range of initial microroughness that has not been captured before. That part of Discussions and Conclusion section now reads as follows, with references added to support it (Page 10, lines 5-10):

“The results obtained are consistent with findings of other studies that have examined length scales up to 5 mm (Burwell et al., 1963; Allmaras et al., 1966; Burwell et al., 1969; Cogo, 1981; Currence and Lovely, 1970; Steichen, 1984; Unger, 1984; Zobeck and Onstad, 1987). These length scales (i.e., ~2-5 mm) have been found to be common in agricultural landscapes due to prolonged exposure to rainfall impact, runoff and freeze-thaw cycles. Within these landscapes, the reported increase is expected to occur during the early part of the storm where rainsplash action may be more important than runoff.”

Comment 5: Did the authors measure soil aggregate- or particle-size distribution? What is the range of particle sizes in mm?

Response:
Yes, the aggregate size distributions of the soil studied were measured. We found 19% of the soil size fraction less than 250 μm, 48% between 250 μm and 2 mm, and 33% greater than 2 mm.

We have added the aggregate size distribution of our soil along with other info for a clearer presentation (Pages 3-4, lines 29-1):
“The soil series at the plot where the experiments were conducted is Tama (fine-silty, mixed, superactive, mesic Cumulic Endoaquoll) (http://criticalzone.org/iml/infrastructure/field-areas-iml/). It consists of 5% sand, 26% clay, 68% silt, and an organic matter content of 4.4%. The aggregate size distribution of the soil consists of 19% of the soil size fraction less than 250 μm, 48% between 250 μm and 2 mm, and 33% greater than 2 mm. These soils contain both smectite and illite, with high cation exchange capacity between 15 and 30 Meq/100 g.”