Dear Reviewer 2

Thanks for your constructive comments.

Please find responses for your comments. All of your comments were addressed in revised paper.

Once again, Thanks for your efforts.

I found the manuscript very interesting, however, I would say the manuscript needs significant improvement to get to the publication level and some major changes or clarification should be done. My major comments:

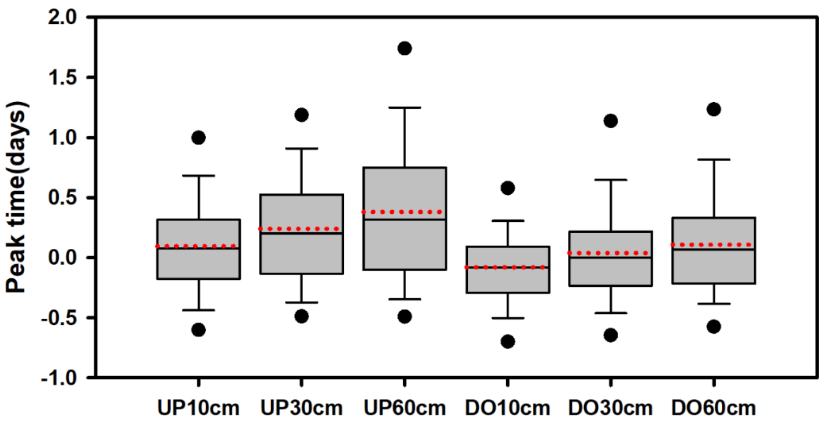
The manuscript is written with a simple language however it is still very difficult to easily follow the manuscript. I think, although, the use of the English language in formulating the sentences is sufficient however the logical flow of the text is not intuitive and hampers by evolving around the technicalities and repetition.

1. I think figures can be improved and can be better explained in the text. For example, it is very hard for me to comprehend Figure 2 (and other figures which perhaps has a lot of dense information).
    - Figure 2 and Figure 3 were revised to improve readability (simple way) and corresponding explanations were added.
    - “The statistics of soil moisture response from 30 points are summarized in terms of the P2P and maximum variation, as displayed in Fig. 2(a) and 2(b). The P2P ranged from –0.2 d to +1.8 d, indicating that the maximum soil moisture can be reached even before the rainfall peak. SDP2P tends to increase at higher depths except for locations DO2 and DO5 (Fig. 1).
    - While the mean P2P for the upslope area was 0.24 d, the downslope area was 0.02 d. The means of P2P at depths of 10, 30, and 60 cm were -0.08, 0.04, and 0.011 days for the downslope and 0.1, 0.24, and 0.38 days for upslope, respectively. The difference in P2P between other points at an identical depth for the downslope was smaller than that for the upslope. This suggests that the soil moisture response in the downslope area is faster and more uniform than that in the upslope area. The accumulated soil water flow from the upslope area to the downslope area appears responsible for quicker and less spatially variable soil moisture responses in the downslope area. The maximum variations at 10 cm and 60 cm depths were higher than those for the 30 cm depth both in the upslope and downslope directions (Fig. 2(b)), indicating primary lateral flow tends to be generated along boundaries (surface and subsurface). However, the maximum variation did not display any notable pattern for the transect to the downslope and the depth profile.
    - 3.2 Soil moisture responses feature in measuring locations and depths

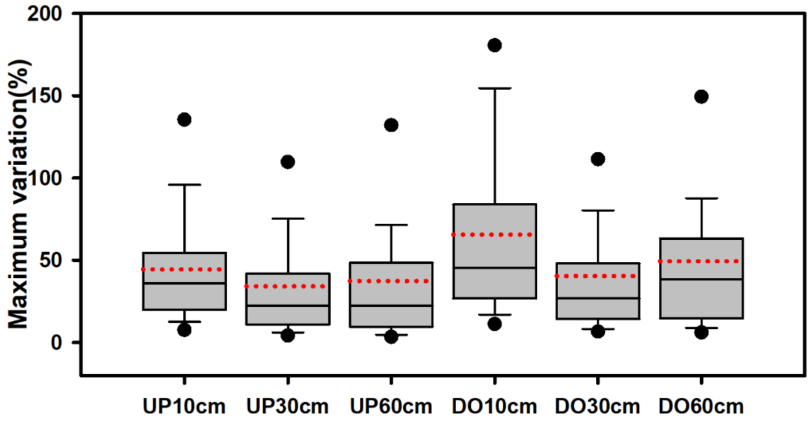
The soil moisture response features (e.g., ASM, maximum variation, and SDP2P) were expressed into different spatially averaged responses (Fig. 3) depending on the depth and location. As displayed in Fig. 3(a), the ASM in the downslope area was higher than that in the upslope area. It is apparent that the higher the depth, the higher the ASM in the downslope area, but those for the upslope area did not display any notable trend in the depth profile. This means that soil water infiltration upslope did not necessarily always occur for all depth profiles.

The maximum variation in the downslope area was higher than that of the upslope area, as displayed in Fig. 3(b). The mean maximum variation in the downslope area (50.67%) was higher than that of the upslope area (38.73%), and the mean maximum variations at depths of 10, 30, and 60 cm for the upslope area were 44.51%, 34.27%, and 37.39%, while those for the downslope area were 64.49%, 40.83%, and 46.69%, respectively. This indicates higher wetness along both surface and subsurface boundaries, and this trend is pronounced in the downslope direction.

- The SDP2Ps for the soil moisture datasets represent the degree of spatial heterogeneity in the temporal soil moisture response. The statistics of the SDP2P (Fig. 3(c)) revealed that the downslope response varied less than the upslope response. While the SDP2P of downslope displayed an apparent increasing trend at deeper depths, those for the upslope showed a similar in-depth profile. The difference in the SDP2P profile between the upslope and downslope indicates that the impact of rainfall on soil moisture response timing can be completely different between the upslope and downslope directions."

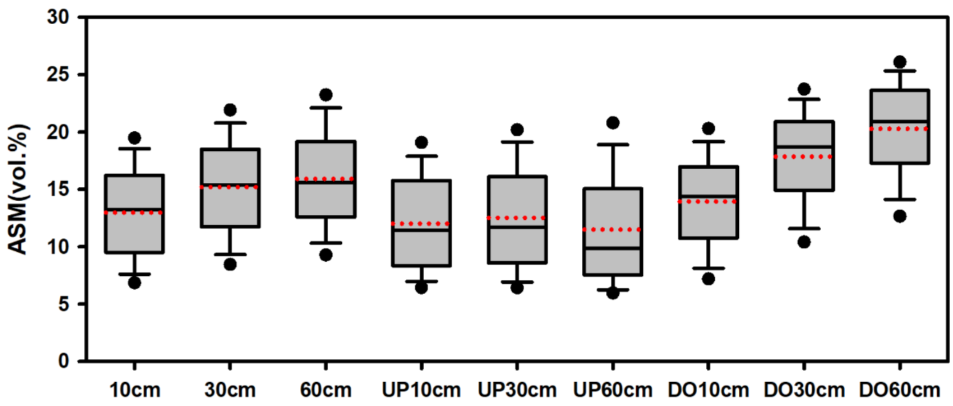


(a)

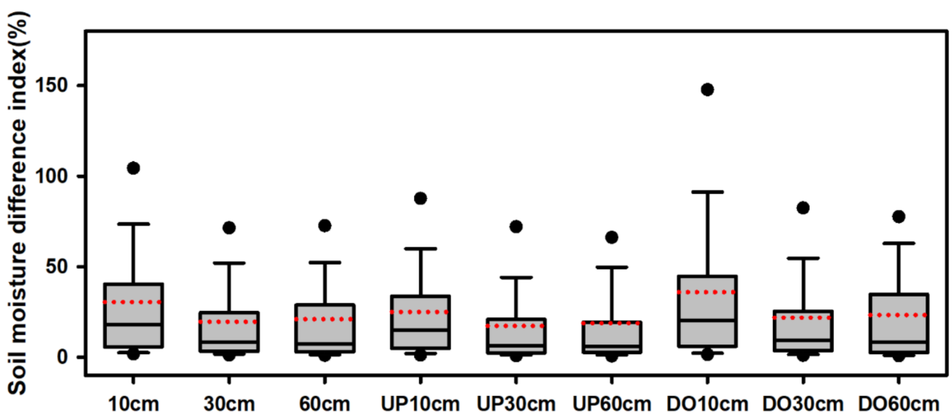


(b)

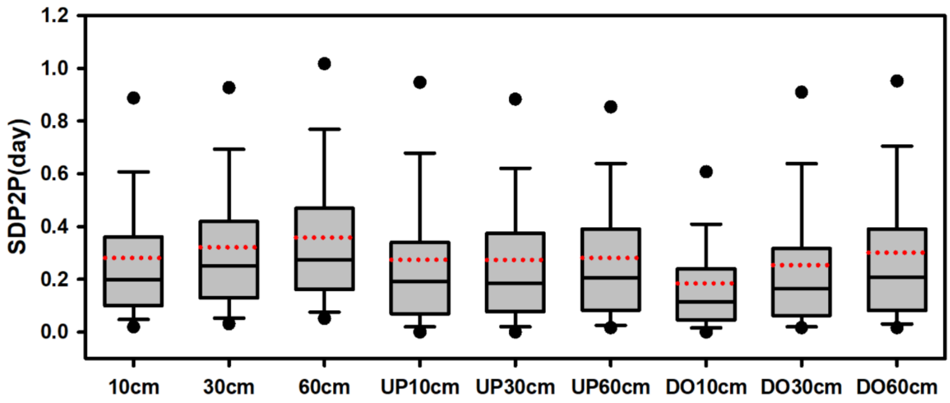
Figure 1 Boxplots of soil moisture responses of P2P (a) and maximum variation (b) for 30 points.



(a)



(b)



(c)

Figure 2 Box plots of antecedent soil moisture (a), maximum variation (b), and standard deviation of peak time (SDP2P) (c) of 12 time series of soil moistures.

2. Can the authors perhaps provide a more physical understanding of the clusters?
    - In order to address reviewer's point, following context was added as
    - "Events from Cluster 1 were meaningless in terms of the hydrologic response, and the primary driver of Cluster 2 was rainfall that partially affected soil water storage (downslope). While the bedrock topography was important for clusters 3, 4, and 5, the surface topography played an important role for cluster 5."

3. I think the questions which the authors are asking were not directly answered. Perhaps the questions can be better elaborated in the discussions and reflect on the conclusions.
    - Following contexts were added to provide direct answers for questions
    - in discussion section

- "The machine learning algorithm (SOM) can be a useful analysis platform not only for soil moisture response patterns in conjunction with rainfall and ASM (Fig. 7), but also for effective characterization of soil water storage changes at different locations and depths (Table 2)."
- "As presented in Table 3, delineated clusters of hydrologic events distinctly explain the combinations of hydrological processes such as vertical and lateral flows (either surface and subsurface boundaries) between upslope and downslope directions. "

    - in conclusion section

"The SOM can be a useful analysis tool not only to understand the different soil moisture response patterns between the upslope and downslope but also to configure particular hydrological processes for delineated clusters."

4. The key points are very vague please make them more specific to this study and the finding of this study. Title can also be improved; title is very generic and broad.
    - Key points were revised as follows
    - "A hydrologic dataset can be classified and characterized by applying a machine learning algorithm.
    - The self-organizing map is useful to understand the soil moisture response pattern at a hillslope scale.
    - Five event clusters distinctively represent different combinations of hydrological processes."
    - Title is revised as follows
    - "Characterization of Soil Moisture Response Patterns and Hillslope Hydrological Processes Through a Self-Organizing Map"

5. Perhaps reduce the long explanation on the method and wordy results to sharpen the messages.
    - On order to address reviewer's point, many parts of text in method and results in revised paper was reduced. Thanks.

6. I would like to encourage the authors to bring their study into wider hydrological modeling efforts. What is the message of the results for the hillslope hydrology at a larger scale? The hydrological models carry memory (antecedent soil moisture) for example, so the strong correlation the author is showing here is implicitly taken care of in the models that using time-stepping of storage over time. I do not see an important message from this study which is different from the general knowledge that we already have on how hillslope might behave; the findings may not be that different from what it can be inferred from a model. as an example, how Figure 4 would look like if the authors have repeated their study on a hydrological model at hillslope scale rather than the data itself. I would say we would strongly find the same pattern, so what is new? The authors can cite modeling work at catchment scale and try to contextualize their work. The previous studies such as Fang, Clark, et al., 2019 WRR, Loritz et al., 2017 HESS, Gharari et al., 2014 HESS, Gharari et al., 2011 HESS, Gao et al., 2014 HESS among others.

- In order to address reviewer's concern following context was added as
- "Many studies have modeled the behavior of hillslope hydrology (Loritz et al., 2017; Fan et al., 2019). The SOM analysis for a large dataset showed the apparent distinct pattern in soil moisture response and flow path generation between upslope and downslope depending on antecedent soil moisture and rainfall conditions. This means that the performance of the model can be improved as the storage structure of the model (fast and slow reservoirs) (Gao et al., 2014; Gharari et al. 2015) is further classified into upslope and downslope. The appearance of cluster 4 (Table 3) demonstrates nonlinear behaviors in hydrologic response that can be explained by the apparent role of macropore flow even in low soil moisture conditions (Nimmo et al. 2012; Beven and Kirkby 2013). The implementation of bypass flow under low ASM and high rainfall conditions into the model structure can improve the modelling of soil water travel time (Kim, 2014). Further elaboration in modeling to represent dual lateral boundary flows in cluster 5 can be useful to address multiple drain flow pathways under extreme rainfall conditions."

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K. Beven, P. Germann, Macropores and water flow in soils revisited. Water Resour. Res. 49(6) 3071-3092, https://doi.org/10.1002/wrcr.20156. 2013.