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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Relevance and controls of preferential flow at the landscape scale" *by* Dominic Demand et al.

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The authors present an interesting study in which soil moisture sensor response times after rainfall events are used characterize water preferential flow at various locations in a catchment in Luxembourg. The method relies on the sequence of soil sensor responses to rainfall events and on the water transport velocity as a means to separate infiltration events where a sequential arrival with reasonable transport speed occurs (i.e. consistent with a piston flow model) from sites with non-sequential arrival times or with unrealistically high transport speed (i.e. an indicator of preferential flow). The authors then explore different control factors which may explain the spatial and temporal occurrence of preferential flow at the catchment scale.

A better understanding of how preferential flow is generated at the catchment scale is of great interest. The methods used in this study are relatively novel (although mostly existing methods were used) and promising because they enable to investigate preferential flow events in a non-destructive manner and without the use of a non-reactive water tracer. The novelty of this study is the application of the method to different landscape units. Therefore, I think that the readers of HESS still would greatly benefit from the publication of this manuscript.

Despite the novelty and interesting approach to studying preferential flow, I think this manuscript is not yet ready for publication and would benefit from a more clear description of methods (e.g. using flow charts) and from focusing its content to the most interesting parts. The number of statistical analyses is rather excessive without providing much additional insights. For instance, the generalized linear regression model analysis is difficult to comprehend (especially for readers who are not familiar with this method) and does not provide clear results. Also the discussion section is too excessive should be focused on the most important results found in this study.

A new aspect of this study is usage of calculated of water flow velocities on basis of 1D steady state flow assumptions to identify preferential flow events. However, although the velocity-based preferential flow assessment of events with a sequential order of sensor response times is appropriate, the derived matrix flow velocities may be prone to large errors. First, the steady state assumption is violated during infiltration events and second, the hydraulic parameters derived from field data which are influenced by preferential flow. These circumstances may also explain why the measured NSR is lower for Marl grassland sites than predicted by the 1D steady state flow model. Previous sensor based preferential studies (e.g. Wiekenkamp et al., 2016) used infiltrometer measurements to assign a meaningful threshold for the matrix flow velocity. Given that fact that hood infiltrometer measurements are available for the study area I suggest to use this data to define maximum matrix flow velocities for the different landscape units.

Specific comments:

P3L5: Change to "…PF was more frequent during higher rainfall intensities."

P4L7: Change to "…and that therefore infiltration…"

P4L16: Add number of sites.

P5L5: Change to "…mostly exhibit loamy texture."

P5L5-6: Sentence reads awkward. Please reformulate and add landuse percentages.

P5L6: How was the macroporosity defined/determined?

P5L15: Change to "METER Group Inc., USA"

P6L8-9: You are actually calculating a "difference" and not a "macropore portion" of saturated hydraulic conductivity.

P7L6: Why 6.7 mm?

P7L10-11: This should be reformulated in a less unconditional way, e.g. "The manufacturer gives an accuracy of…"

P7L20: You should change "diel" into "diurnal" as this term is more common.

P7L24-25: But later you decide to use 12 hour rainfall breaks, which is somewhat confusing. In order to make this more comprehensive I suggest to present the rainfall event delineation methodology completely in the method section (thus moving P11L5-15 to the method chapter).

P8L6-8: This is not clear to me (e.g. what is the meaning of "0.4 %"?). Please be more specific.

P9L08-15: There exists a vast literature on showing that preferential flow cannot be described with classical capillary theory. Why do you still pursue this analysis although this approach is obviously prone to fail?

P9L11: The term "pore water pressure" only applies to subsurface water. Ponded water

on the soil surface shows even positive pressures.

P9L13: better: "during a rainfall event infiltration capacity decreases as the soil approaches saturation"

P9L27: Why should the aspect has an effect on the frequency of NSR occurrence?

P10L4-5: better: …as the velocity determined from the first responses of two sensors"

P10L9-11: During infiltration events soil water flow should be governed by non-stationary conditions. Why do you believe that your stationarity assumption can be applied?

P10L19-20: What does "in combination with parameter sets of Sprenger et al. (2016)" exactly means?

P10L23-26: Nevertheless, as the inversely derived Ks-parameter of Sprenger et al. (2016) are derived from field data, they will still be affected by preferential flow and thus will be higher compared to a Ks derived from pure matrix flow.

P11L22: Either use proportion or percentage

P12L13: Add explanations of the abbreviations

P13L18-26: This section comes somewhat out of the blue as it is not well related to the previous analysis. I suggest separating both sections and adding a short introduction to new one concerning soil water content changes.

P13L20-21: This is difficult to understand. Please try to rephrase in a more comprehensive way.

P15L2-3: This is an interesting finding. Does this correspond with seasonally varying precipitation properties?

P15L5-6: What are the possible reasons?

P16L6: The formulation "of up to ∼25 % of events" can be misinterpreted.

P16L10-11: Does this finding indicate that the inversely derived Ks-parameter of Sprenger et al. (2016) overestimate pure matrix flow?

P17L1-17: I find this section not very meaningful as it cannot be well reproduced and the results are not very much enlightening. Therefore, for the sake of comprehensibility I suggest removing it.

P18L11: It should "increasing" instead of "decreasing"

P18L15: I guess it should be again "increasing" instead of "decreasing"

P19L10: It would be interesting to see how choosing other rain gaps would influence the results (e.g. the proportion of NSR to SR events).

P21L26: Did you compare pre-response analysis with entire event analysis? This would be interesting with respect to the comparison with the other studies.

P21L28-29: I cannot follow this argument. Please explain in more detail.

P23L7-11: In my view, the results of this study rather suggest that the occurrence of preferential flow is governed by unresolved small-scale structures and processes. The study of Wiekenkamp et al. (2016) used an even denser soil moisture sensor network and still could not find landscape properties to explain their results.

P23L17-18: Why should the lower k_mat values of the Marl site lead to more NSR events and how do you know that the matrix infiltration capacity was underestimated?

P23L18-19: Why should the overestimation of NSR by capillary theory in the Marl grassland be an indication of more vertical macropore flow?

P24L23-28: These arguments are rather dubious.

P24L23-P25L11: This section is a rather excessive discussion that does not provide much additional insights.

P24L29: I guess it should be "increase" instead of "decrease".

P25L2-4: Remove repetition.

P25L16: "…showed…"

P25L17: "…in deeper…"

P25L20: "showed" instead of "had"

P25L21: You did not prove the occurrence of "non-homogeneous wetter fronts". There are other mechanisms that can lead to preferential flow (e.g. by-pass flow).

P25L23-P26L7: Please focus on presenting the main results in the conclusion section and avoid vague speculations.

Figures

Figure 9: Dots are difficult to discern.

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