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Interactive Comment

Interactive comment on "Hillslope experiment demonstrates role of convergence during two-step saturation" *by* A. I. Gevaert et al.

Anonymous Referee #3

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Gevaert et al (2014) presents a study on the hillslope runoff generation mechanism based on a unique dataset obtained from a large scale rainfall simulation experiment with a large number of continuous soil moisture sensors, which provide 4D soil moisture information during a rainfall event. This is a valuable contribution to the hillslope hydrology and I believe it will help us understand in more depth of the rainfall-runoff process. The authors found from their study that the hillslope experienced a two-step saturation process indicating a saturation excess runoff mechanism. Also, the convergent topography is important for the local saturation and a groundwater ridge, which is a critical reason for the saturated runoff. Here I have some comments/questions regarding their analysis to the dataset and conclusions.

1. The two-step saturation process is not a surprise from the standpoint of soil hy-

draulics. It is easy to speculate that, with rainfall intensity much less than the saturated soil hydraulic conductivity, soil cannot be fully saturated from the top. Also, Jackson (1992) shows that, on a homogeneous and isotropic slope, downslope soil water movement will NOT occur during rainfall before the wetting front hits the bottom boundary. Thus, during the experiment described in this study, soil water was not likely to converge under the trough before the saturation occurred at the bottom of soil layer. A shallow soil depth provides the opportunity for soil to saturate during rainfall from the bottom and saturation to extend upward. Once the bottom soil is saturated, groundwater can move downslope and result in a smaller gradient in the groundwater table than in the topography. Water will thus exfiltrate to the surface at downslope locations when saturation reaches the ground surface, which can more easily occur at local depressions. Therefore, a two-step saturation process is anticipated from a conceptual analysis based on soil hydraulic theories. This study provides some direct evidence to support the theoretical framework, rather than challenge it.

2. The groundwater 'ridge' mentioned in this paper should be defined more clearly. I think the authors meant that the groundwater table in the lateral cross section shows a 'ridge' shape, not in the longitudinal direction. Fig.6a seems imply that the groundwater table has a peak in the middle of the slope in the longitudinal direction, but I don't think this is real. It is worth more clarification in this point. On the other hand, the lateral ridge may be explained by the topographic effect since the bottom topography (note that the bottom of the experimental slope is not a planar surface) can result in the downslope convergence of saturated water. As long as the downslope flux is larger than the lateral flux, such a ridge can maintain. However, this means that the groundwater in the trough was divergent laterally rather than convergent (directly implied from Fig.6b), contradictory to the authors analysis that side slopes contribute to the ridge (P.2220 L.28). Regarding the role of topography, it should the bottom (the impervious layer) topography, rather than the soil surface topography, that caused the convergence and resulted in the groundwater ridge. This should be made clear in the paper.

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3. Fig. 5a shows that the sensors measured volumetric water content higher than the maximum possible water content, which I feel that is related to pressure head and measured water content (after saturation) should be proportional to the depth. This speculation is true except the sensor at 85 cm depth, which measured a lower water content than others. I don't know if this is due to disfunction of the sensors, but suggest the authors check the sensor functionality in controlled cases, including over saturated conditions.

4. The rainfall depth applied in the study is large compared to most natural events. It would be helpful that the authors discuss the relevance of the experimental rainfall to natural conditions.

References

Jackson, C. R. (1992). Hillslope infiltration and lateral downslope unsaturated flow. Water Resources Research, 28(9), 2533–2539. doi:10.1029/92WR00664

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