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

Anonymous Referee #2

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General comments:

The authors present a rainfall experiment on the Landscape Evolution Observatory, LEO's artificial hillslope in Biosphere 2. It is interesting and unique to set up so large physical model for exploring the rainfall-runoff process under controlled conditions. Nevertheless, though set up with high density sensors, many state values, e.g., the soil structure during the wetting and drying processes, remain unknown. These uncontrollable or possibly undiscernible conditions may lead to a contradict conclusion towards to the anticipated results. In this study, as reported by the authors, the saturated hydraulic conductivity of the filled material is 0.67m/d, while the effective value for the whole hillslope is as large as about 12.10m/d, and the observed soil volumetric water content in Phase 3 significantly exceeded the laboratory determined maximum

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porosity. It is a big difference. After being filled for several years ever since 2009, whether the internal structure can keep homogeneously as initial state?

The authors have observed the whole process of two-step soil saturation under intense rainfall event, however, the two-step saturation may be not a novel concept in the traditional conceptual models. Many traditional models like the Sacramento model (Bumash et al. 1973) and the Xinanjiang model (Zhao et al. 1980) have two soil water storage reservoirs, i.e., the tension water reservoir and the free water reservoir which can represent the saturation processes of natural soils on a hillslope. When rainfall infiltrate into the dry soil, it becomes wet, and if soil water content is larger than field content, the tension water reservoir is full-filled. Thereafter, water is free and can move to fill larger size of pores, i.e., the free water reservoirs more likely from bottom to up by gravity drive. This process can be seen as a conceptualization of two-step saturation. Note that although the generalized hydrologic models are simplified approximations to natural processes, the total effect of soil saturation is consistent with observations of the soil moisture profile made by earlier experimental studies (e.g., Green et al. (1970) and Hanks et al. (1969) and recent field studies like Tromp-van Meerveld et al. (2006).

Finally, the authors revealed a phenomenon about soil profile saturation along a hillslope, while failed to explain it with sufficient data. Therefore, I suggest that the authors provide more data about soil structures, and maybe add a dye tracer experiment to verifying their present discussions and conclusions. I also suggest that the hydraulic characteristics of the filled material, a granular basalt material should be discussed carefully through 1D soil column experiments.

Other concerns:

P means page, and L means lines

P2L11-14: In some conceptual models, similar two-step soil saturation has been considered like the Sacramento model (Bumash et al. 1973) and the Xinanjiang model (Zhao et al 1980).

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P3L12-14: The saturation excess mechanics as well as the variable source area concept are the dominant mechanisms (as mentioned also by the authors in P2L18) in humid regions where hillslopes are characterized by highly permeable, thin soil layer overlying an impermeable bedrock (Bogaart and Troch, 2006). So, if you want to reveal saturation excess runoff generation mechanism of convergence, can the filled homogeneous material represent the highly heterogeneous soils of natural hillslopes?

P4L5: Since 2009, have the overall shape and relief of the hillslope been changed under sprinkle tests? Do you re-shape the micro-terrain every time after a rainfall experiment?

P4L15: there are a very big different between the saturated hydraulic conductivity and the effective value. Is there some preferential path ways like soil cracks within the soil material along the artifical hillslope? If you could provide more soil hydraulic experiment, e.g., 1D soil column test, it will help the readers understand your observations.

P5L9: Do you only carry out one rainfall experiments?

P5L24: in figure 5a, the volumetric water contents in Phase 3 exceed the maximum porosity. Could it be the reason that there are some macropores which lead to larger hydraulic conductivity and water contents?

P6L27: in figure 7, it is better to add the rainfall line in the legend.

P8L14-21: The discussion that lateral redistribution of water was a major contributor to groundwater table and overland flow generation in this part is not sufficiently supported by present data. Because justly in L10-13, the authors admit that the volume water content will not exceed the maximum soil porosity at the bottom of the soil profile at the toe of the slope, where should mostly tend to be saturated due to the lateral subsurface flow. So the data is not enough to obtain present conclusions.

P9L5-8: could you really exclude the macropore flow? Soil macropores can be shaped through vegetation roots, worm holes as mentioned by the authors. While other factors like the soil processes from wetting to drying, freeze thawing. . .. . . also cause soil cracks. So I suggest a dye tracer experiment may help to verify it.

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