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Hydrology and Earth System Sciences Discussions

Interactive comment on "Rainfall threshold for hillslope outflow: an emergent property of flow pathway connectivity" *by* P. Lehmann et al.

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The main concerns of the reviewer were that (i) our model approach is limited to systems dominated by macropore flow and (ii) that our model is in contradiction to observations at Panola that showed free water storage and flow in bedrock depressions. This is explained in the specific comments on page S1445 and S1446.

These two arguments are related and indicate that the model description has led to the misunderstanding that our approach is valid only for macropore flow whereas the model was designed to capture different processes (such as groundwater flow along bedrock and macorpore flow) that relate to spatial connectivity.

A) Observations/measurements at Panola: At Panola, it was shown that water was

collected in the bedrock depression until it could be spilled in downslope direction. This means that free water was found in the depression before the threshold was reached while in the modeled behavior the depressions (high soil depth) have free water for high rainstorm amounts only. Similarly, subsurface flow was observed in the valleys of the bedrock along the gradient of the bedrock. Free water flow was measured in the local minima of the bedrock level (corresponding to high soil depths) while free water is modeled preferentially for the sites with small soil depth.

B) Representation in the model: The first effect - free water can exist but is not flowing downwards as long as a certain threshold is not exceeded - is modeled by the reduced connectivity of the system. Water flow in the model is not dominated by the soil depth alone but by the connectivity as well. The connectivity does not only represent the effect of macropores but the heterogeneity of the bedrock as well. The other phenomenon - water flowing in the valleys of the bedrock - is sort of a dynamic effect. Free water generated at shallow soil sites flows along the gradient of the bedrock profile. With the model, we do not intend to reproduce the redistribution of free water and the exact geometry of the flow paths but the amount of free water connected to the trench.

We explained these model assumptions and interpretations in more detail in the modified sections 2.1, 4.1 and 5.1. The corresponding modifications are given below:

Section 2.1 Connectivity and occupation probability: The bond may be interpreted as a fast flow pathway such as a macropore, a soil volume with a high hydraulic conductivity or as a configuration of the bedrock topography that allows water to flow in down slope direction along the bedrock valleys.

Section 4.1 Measured parameters: The bedrock topography affects the flow paths because it is possible that water flow is restricted if the bedrock elevation increases in down slope direction. Such a configuration exists in a bedrock depression that was in fact a dominant factor at Panola (Tromp van Meerveld, 2006b). These local bedrock highs are modelled as decreased connectivity. A site without connection to a down

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slope site can be interpreted as such a configuration. For this reason, the connectivity expressed as coordination number was not set to 8.0 as for the standard orthogonal lattice but was determined by fitting and relates therefore to bedrock topography (section 4.2).

Section 5.1 Assumptions in the percolation theory approach: (iii) In the model, water flow occurs if two open sites are connected. These connections can be interpreted in two different manners. Firstly, the connections may be macropores that enhance lateral flow when the connectedness of subsurface saturation is achieved. Secondly, water flow along the bedrock in down slope direction is only possible if the bedrock elevation decreases in down slope direction (e.g. connected bedrock hollows). Therefore, a connection corresponds to a configuration fulfilling this condition.

The minor comments 1) and 3) were taken into account. But we do not skip the subsection 5.1 as suggested by the reviewer because it summarizes the observations that are the basics for the percolation model discussed in section 5.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 2923, 2006.