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Comment on "The changing spatial variability of subsurface flow across a hillside" by Ross Woods and Lindsay Rowe

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In a recent paper, Woods and Rowe (1996) presented an excellent study of the spatial variability of subsurface flow from a hillslope, using a trough system at the Maimai catchment. This comment introduces an alternative explanation for the flow variability observed across the trench face during rainfall events and discusses possible alternative explanations of hillslope hydrologic processes at the Maimai catchment. It is my contention that the bedrock surface at Maimai, and not the topographic surface, controls subsurface flow generation on the steep slopes. Since water perches at the soil-bedrock interface, this surface may determine the ultimate pathway of flow and the spatial pattern of seepage at an artificial trench.

I accept the main premise of the Woods and Rowe (1996) paper that a single trench does not an entire hillslope make. Previous studies at the site, including Mosley (1979) and McDonnell (1990), have been naive in their attempts to compute catchment-wide estimates of subsurface flow using single small trench sites. The paper by Woods and Rowe (1996) demonstrates clearly that flow may vary considerably across an apparently planar hillslope section. Notwithstanding, Woods and Rowe (1996, p. 68) go on to state that there is "some positive correlation between flow and area, but troughs 11, 12, 9 and 21 do not dominate total flow as might be expected". I believe that this may be due to the fact that the bedrock surface controls flow direction during rainfall events on the hillslope, as described in recent studies by McDonnell *et al.* (1996), Brammer *et al.* (1997), Freer *et al.* (1997) and McDonnell *et al.* (in prep.).

McDonnell (1990) showed that water perches at the soil bedrock interface during most rainfall events at Maimai and that this saturated flow controls the rapid hillslope runoff response. Thus the process of interest in understanding subsurface flow is saturation from below; a wetting up from the bedrock surface into the soil profile. Differences in flow paths not immediately related to surface topography or predicable by topographic surveys or topographically-based modeling may result from the discrepancy between the bedrock surface and the soil surface topography. Freer *et al.* (1997) have developed methods to compute the downslope accumulated areas of surface topography and bedrock topography draining to a trench face (Fig. 1). There is a marked difference in the surface and bedrock distribution at the trench face: there is a pronounced shift in accumulated area in the central trench portion to troughs 13 and 14. This may explain the higher-than-expected contributions from trough 13 and some of the variability across the face witnessed by Woods and Rowe (1996), given that saturated subsurface flow probably relates mostly to the bedrock accumulated area and bedrock topographic surface. The sharp contrast

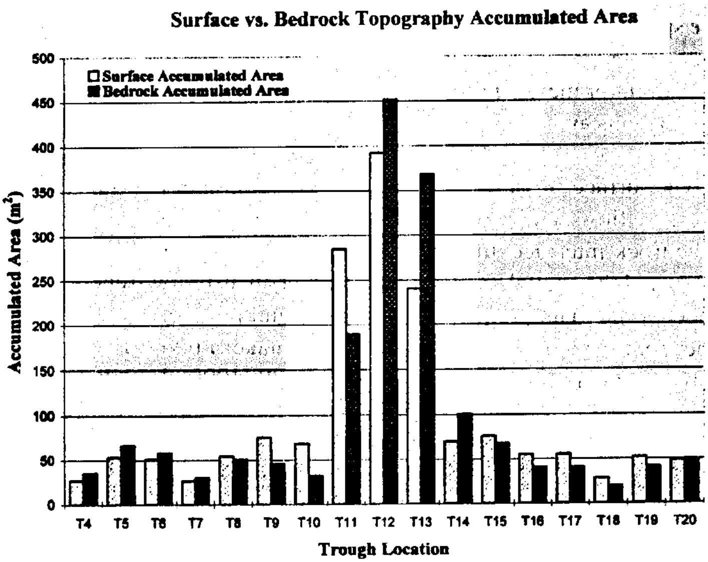

Figure 1 - Histogram plot of accumulated areas at the trough face for each section from the Woods and Rowe (1996) trench. The plot is based upon calculations developed by Freer *et al.* (1997) using surface topography and bedrock topography taken from a paper by Brammer *et al.* (1997) and data generously provided by Ross Woods. The result is a marked difference in the distribution at the trench face: there is a pronounced shift in accumulated area in the central trench portion to troughs 13 and 14 based on a bedrock surface calculation. This may explain the higher-than-expected contributions from trough 13 and some of the variability witnessed by Woods and Rowe (1996).

between trough flow from 11 and 12 that Woods and Rowe (1996) had difficulty rationalizing may be explained by the bedrock accumulated area in (Fig. 1), suggesting that some distinct difference in subsurface contributing area may exist.

McDonnell (1990) used recording tensiometers to show that water tables on the Maimai hillslope were extremely short-lived. Therefore between events, the bedrock surface may not be an important control on lateral unsaturated flow. Under these conditions, the surface topography may be the best surrogate for flow direction since gravity and matric potential together control the gradient of total potential and resulting unsaturated flow direction. The variability observed in Woods' and Rowe's (1996) sequences of snapshots in their Figure 13 (page 76), may be the result of a switch between bottom-up, bedrock-induced flow (during periods of transient water table development during events) and topographically-controlled unsaturated flow between events where top-down drainage resumes. Obviously, this explanation is speculative and identification of bedrock contributing areas are subject to survey data precision. Nevertheless, I feel that these details warrant further investigation. Woods and Rowe (1996) recommend that experimentalists and modelers should group neighboring troughs and present averaged values of flow because of the complexity of flow distributions. I fear that in doing so, much signal will be lost in the attempt to clean up the modeling noise.

The comments raised above do not detract from the original presentation by Woods and Rowe (1996). Their paper is one of the best to appear in the journal in the past decade and has spawned attempts to replicate their experimental design in the U.S. and elsewhere (McDonnell *et al.*, 1996; Brammer and McDonnell, 1996). I hope that this short comment may stimulate scientific debate as research on subsurface flow processes at the Maimai catchment continues.

References

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