Journal of Hydrology (NZ) 36(1): 101-103, 1997

Reply to 'Comment on "The changing spatial variability of subsurface flow across a hillside" by Ross Woods and Lindsay Rowe', by Jeffrey J. McDonnell

Ross Woods[1] and Lindsay Rowe[2]

[1]*National Institute of Water and Atmospheric Research Ltd, P O Box 8602, Christchurch, New Zealand*

[2]*Manaaki Whenua - Landcare Research, P O Box 69, Lincoln 8152, New Zealand*

McDonnell (this issue) has made several interesting and helpful points related to our analysis of the data collected at the Maimai hillslope. The main point he makes is that bedrock topography may explain spatial variability in trough flows at individual troughs which was unexplained in our paper. We certainly accept that for regions such as the Maimai hillslope, where subsurface runoff is dominant, bedrock topography is more suitable than surface topography for delimiting the area draining to each trough. The detailed bedrock topography data recently collected by McDonnell and colleagues provides valuable additional information for understanding patterns of flow across the hillslope.

The comparison of bedrock- and surface-accumulated areas in Figure 1 (McDonnell, this issue) is a key point of the comment. There are substantial differences between the areas contributing to individual troughs calculated by the two methods. It is interesting to note that if the troughs are taken in groups of four or five (as in Woods and Rowe (1996)), then surface and bedrock topography appear to provide similar estimates of areas. As a result, the estimates of areas for groups of troughs made by Woods and Rowe (1996) are not substantially affected. Thus the major additional information provided by the bedrock data seems to be at the scale of one or two troughs.

The main point we wish to make in reply is that lack of precision in topographic data (whether surface or bedrock) may ultimately limit the extent to which areas contributing to single troughs can be reliably estimated. The areas upslope of each trough have been derived by analysing a rectangular grid of elevation data points over the hillside. This grid is obtained by interpolating from a mathematical surface fitted to a large number of irregularly-spaced survey data points. These data points are subject to measurement error, and in addition the surface fitting procedure is subject to 'model error', i.e., the surface cannot exactly reflect the shape of the hillside between the survey data points.

Before fitting the surface, we analyzed sensitivity to small changes in individual surface elevations. Some very significant changes can occur in areas calculated for individual troughs (factor-of-five changes in area), and this uncertainty was noted briefly on p.67 of Woods and Rowe (1996). Since the *cross-slope* gradients of surface elevation are low near the base of the slope, a small change in elevation there can reallocate a significant amount of area among troughs 11, 12 and 13. We suspect that similar problems could potentially arise with the bedrock accumulated areas. Some sensitivity analysis of the kind mentioned above may be needed for the bedrock topography data, before conclusions can be drawn about how well bedrock topography correlates with patterns of flow at individual troughs. A small change in one or two of the observed bedrock elevations could reallocate large proportions of area among troughs 11, 12, and 13, possibly resulting in a pattern of accumulated area which does not explain the flows from the corresponding troughs.

McDonnell (this issue) also suggests that there may be a switch between bedrock-controlled saturated flows during rainfall and topographically-controlled unsaturated flows during dry periods. This is a reasonable alternative to the suggestion of Woods and Rowe (1996, page 77) that at high flows there may be a 'hydraulic gradient to drive flow laterally', i.e., a cross-slope component of subsurface saturated flow causing more flow than might otherwise be expected in troughs 13 and 14. In effect Woods and Rowe (1996) were suggesting that the fine details of bedrock contributing area may be *less* useful in explaining spatial patterns at the very highest flows, because the flow need not be perpendicular to topographic contours. Both these points of view are speculative; they might be resolved by more detailed tensiometric data over two or more parallel 4-5 m wide transects at the base of the Maimai hillside (cross-slope spacing of the order 0.5 m). Alternatively some form of distributed, transient flow modelling of the hillside might be useful, if the flow processes taking place between computational nodes can be adequately defined.

Finally, McDonnell (this issue) comments that the spatial averaging recommended by Woods and Rowe (1996) (i.e., using troughs which are long enough to smooth out variations at the scale of 2-3 metres) may lead to a loss of 'signal'. In our view, one hydrologist's signal can easily be another's noise. This comment highlights the essential and valuable tension between what might be called 'point' and 'catchment' views of hydrology; this tension is at the heart of the problem of spatial scale in hydrology (Klemes, 1983). Often, hydrologists can more easily understand what happens at a point because it is easy to observe, but the variability between points can be so great that point measurements cannot be considered representative of their surroundings. Woods and Rowe (1996) used within-hillslope measurements in an effort to scale upwards towards an understanding of variability in catchment hydrology, on the assumption that although fine-scale variability did exist, it did not need to be understood in detail to understand flow at a catchment scale. We infer from McDonnell's comment that an understanding at the scale of a metre or two is of value in itself, and may be valuable in understanding catchment response. We value this difference in approach, and can only suggest that both should be pursued, with the maximum practical interaction between the two.

References

Klemes, V. 1983: Conceptualization and scale in hydrology. *Journal of Hydrology 65*: 1-23.

Woods, R. A.; Rowe, L. K. 1996: The changing spatial variability of subsurface flow across a hillside. *Journal of Hydrology (NZ) 35(1)*: 51-86.

Acknowledgements

This work has been funded by the Foundation for Research, Science and Technology under contracts CO1635 and CO9406.