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Controls on variability in surface and ground waters in a headwater catchment

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Hydrologists recognise the importance of vertical drainage and deep flow paths in runoff generation, even in headwater catchments. Therefore, characterisation of the joint surfacewater-groundwater system is needed to improve hydrological understanding and model representation. Both soil and groundwater stores are highly variable over multiple scales, and the distribution of water has a strong control on flow rates and timing. In this study, we instrumented an upland headwater catchment in New Zealand to measure the spatial variation in unsaturated and saturated-zone responses. Over a period of 16 months we measured continuous soil moisture at 32 locations and near-surface water table (< 2 m) at 14 locations, with varied aspects, hillslope position and distance from stream, as well as recording streamflow at 3 gauges. In this presentation we describe the controls, types and implications of variability.

Our results showed several distinct causes of variability in water stores. Some types of variability involve a response of only part of the catchment to a rainfall event, e.g. partial response of deep soils in the summer months. Other types of variability involve differences in dynamics, e.g. recession shapes; or differences in response rates in different parts of the catchment, e.g. timing of winter wet-up, and a distinctive split between slow and fast groundwater responses. A further type of variability occurs when some parts of the catchment respond more strongly than others, as in the partial saturation responses seen in winter.

Soil moisture and water table show different variability characteristics. Soil moisture on the North facing slope is qualitatively different to that on the South facing slope: it does not have the long winter plateau seen on the South facing slope. Groundwater variability appears to be more location specific, with both North and South facing slopes showing a combination of fast and slow water table responses to rainfall events.

The many types of variability occurring in this catchment have important implications for prediction of runoff generation. It is common for some parts of the catchment to wet-up or become saturated, and hence potentially contribute to a runoff response, while other parts remain dry. The relative wetness of different locations can also change during the year, suggesting that runoff routing and generation processes, and hence emergent behaviour, may also change.