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# Controls on water table response and hillslope-stream connectivity during wet and dry periods in an Alpine headwater catchment

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Variations in transient groundwater levels affect catchment runoff and hillslope stability. However, due to practical limitations in field monitoring, the dominant factors that control the spatial and temporal variability in transient groundwater levels in mountain headwater catchments are still poorly understood. This study takes advantage of a network of spatially-distributed groundwater wells in the 0.14 $km^2$ Bridge Creek Catchment in the Italian Dolomites to identify the main controls on: i) the variability in peak water table levels and the magnitude of the water table response; ii) the variability in the hysteretic relation between streamflow and water table level; and iii) subsurface hillslope-stream connectivity. Water levels were measured in 17 piezometers equipped in three transects across the hillslopes and riparian zone of Bridge Creek Catchment. Volumetric soil moisture content was measured by 15 probes installed at three depths at six locations along a riparian zone-hillslope transect. Water level and soil moisture were measured during the snow-free months (roughly from May to October) of 2011, 2012 and 2013. This period included 86 selected rainfall-runoff events that were analysed in detail.

The piezometric response to rainfall depended on the wetness status of the catchment. The area with piezometers that responded to rainfall tended to expand upwards from the riparian zone and the lower part of the catchment with increasing wetness and rainfall depth. Groundwater levels in the riparian zone were always higher than on the hillslopes and were more variable, especially during wet periods. Peak water table levels in the riparian zone and the hillslopes were positively correlated with antecedent soil moisture and rainfall depth, but only during dry periods. The magnitude of water table response was negatively correlated with antecedent soil moisture during wet periods, when groundwater levels were generally high.

The relation between streamflow and water table levels was remarkably non-linear and hysteretic, particularly during dry periods. The correlation between groundwater levels and streamflow increased during wet periods. This was likely due to the activation of preferential flow pathways and the establishment of hillslope-stream connectivity that resulted in high runoff coefficients for these events. Accordingly, the normalized size of the hysteretic loops decreased with increasing antecedent soil moisture conditions, indicating a rapid hydrological response and high connectivity when the catchment was wet. These results underline the importance of transient groundwater levels and subsurface hillslope-stream connectivity for the overall hydrological response of the catchment and contribute to a better understanding of water table dynamics in mountain terrains.

Keywords: headwater catchment; water table; hysteresis; connectivity.