RUNOFF AND WATER TABLE DYNAMICS: STEADY-STATE ASSUMPTION AND HYSTERESIS REVISITED IN A SMALL ALPINE CATCHMENT

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The conceptual hydrologic models typically represent the catchment by using a number of storages. One (or more) of them usually represent(s) groundwater storage. Most conceptual rainfall-runoff models are based on using a single valued, monotonic function between the groundwater storage and runoff, implying in this way a steady state assumption. A well known example of such models is TOPMODEL (Beven, Kirkby, 1979). While TOPMODEL simulates spatially distributed groundwater levels using a topographic index, these groundwater levels always go up and down in parallel. The simulated runoff from the groundwater zone follows the same dynamic. Thus, the processes involving the groundwater storage and runoff can be explained by a succession of steady state conditions.

Recently, a number of works (Seibert *et al.*, 2003; Molénat *et al.*, 2005) attempted to test the steady state assumption at the hillslope and catchment scale. The results obtained by Seibert *et al.* (2003) showed that a steady state assumption for the entire catchment is not supported by the data collected at the study site. While the steady state assumption may be appropriate for the riparian zones within the catchment, groundwater wells information showed that this is inappropriate for the upslope zone. Consequently, the physical separation between riparian and upslope zones requires a distinct approach in simulating the groundwater depth distribution within a hillslope or a whole catchment.

The runoff and water table dynamics have been recently examined by considering hysteretic behaviour. Ewen and Birkinshaw (2006) examined hysteretic loops in storage-discharge plots based on runoff data from the Slapton Wood catchment in UK. They identified a basic pattern of anticlockwise hysteretic loops: (i) wetting with increasing storage, (ii) transition to drying (change in slope), and (iii) drying with increasing discharge. Beven (2006) reported hysteretic behaviour in plots of relative storage versus relative runoff for a number of small catchments in UK. These systems demonstrated hysteresis loops associated with individual storms. Norbiato and Borga (2008) examined hysteresis in the storage-flow relationship for a simplified subsurface flow kinematic wave. They found that hillslopes exhibit generally clockwise hysteretic loop in the flux-storage plot.

This note aims at analysing the runoff and water table dynamics for the small Larch Creek experimental catchment (3.3 ha), located in the Dolomites (central-eastern Alps), ranging in altitude from 1950 to 2150 m asl. (Figure 1). The average annual precipitation is 1160 mm per year, 40% of which falls as snow; runoff is dominated by snowmelt in late spring. The groundwater height was monitored from May to September in 2006 and 2007 by a network of 12 piezometric wells; the discharge at the outlet was monitored by means of a V-notch sharp-crested weir. 0-30 cm soil moisture content was measured continuously at four sites.

The catchment exhibits hysteretic behaviour in the relationship between depth to water table and discharge at the outlet (Figure 2). The basic pattern seen in these plots is consistently of anticlockwise hysteretic loops.

The investigation analyses the controls on departure from steady state assumption and structure of hysteresis by focusing on intensity and amount of the precipitation forcing and initial soil moisture conditions.

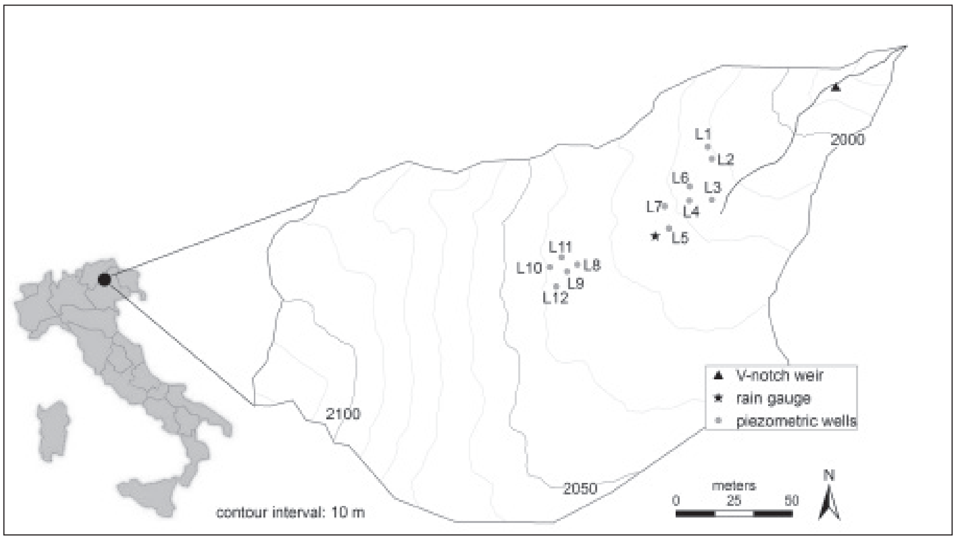

Figure 1. Larch Creek catchment

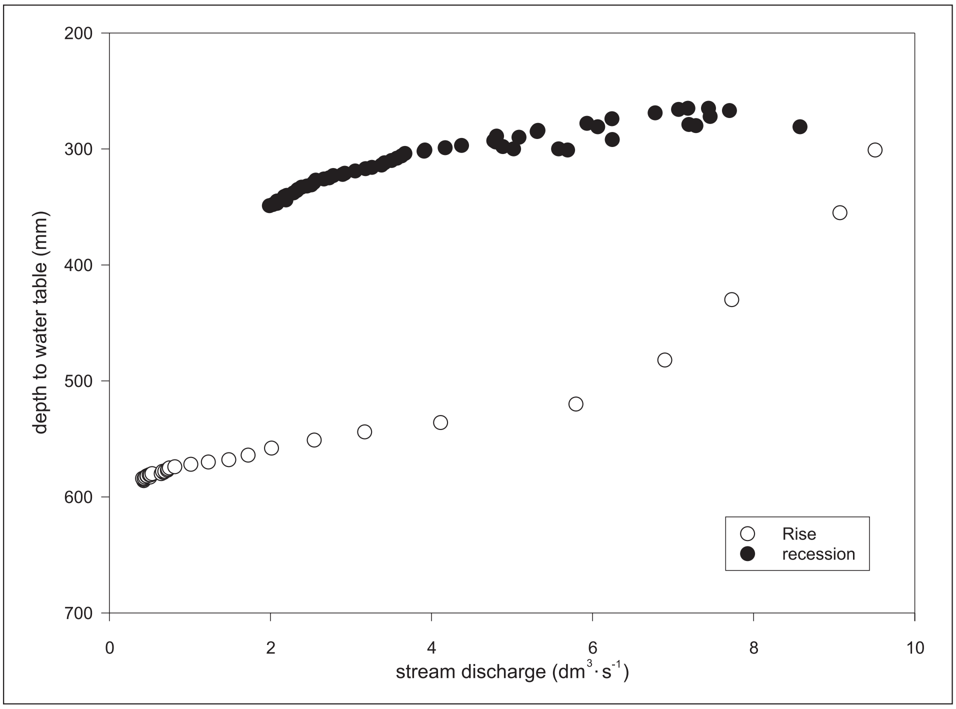

Figure 2. Examples of hysteretic behaviour of relationship between depth to water table and discharge for a flood event occurred on piezometric well L6

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