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The role of initial moisture on the runoff characteristics in the low and high mountains of Germany and Austria

P. Chifflard (1), B. Zillgens (2), R. Kirnbauer (1), H. Zepp (3), and N. Tilch (4)

(1) Institute for Hydraulic and Water Resources Engineering, Vienna University of Technology, A-1040 Vienna, Austria, chifflard@hydro.tuwien.ac.at, (2) DuPont Deutschland, Bad Homburg, Germany , (3) Ruhr-University of Bochum, Institute for Applied Physical Geography, D-44780 Bochum, Germany, (4) Geological Survey of Austria, Depart. of Engineering Geology, A-1030 Vienna, Austria

To analyse the influence of initial moisture conditions on the runoff characteristics in the mountains of Germany and Austria, several rainfall-runoff events were examined in low (Sauerland, Germany) and high (Kitzbüheler Alps, Austria) mountains at different scales.

In the Austrian Alps, 201 rainfall runoff events were examined in three nested catchments of the upper river Saalach. The Saalach basin is a nested catchment covering different spatial scales; a micro-scale (Limberg, 0.07 km^2), a small-catchment scale (Rammern, 15.5 km^2) and a meso-scale (Viehhofen, 150 km^2). At these three scales, two different event types could clearly be identified depending on the rainfall characteristics and initial baseflow level: (1) a unimodal event type with a quick rising and falling hydrograph, responding to short duration rainfall, and (2) a bimodal event type with a double peak hydrograph at the micro-scale and substantially increased flow values at the larger basins Rammern and Viehhofen, responding to long duration rainfall events. In all cases where a bimodal event was identified at the microscale, the hydrographs at the larger scales exhibited significantly attenuated recession behaviour, quantified by recession constants. At all scales, the bimodal events are associated with considerably higher runoff volumes than the unimodal events. From the investigations at the headwater Limberg, it can be concluded that the higher amount of runoff of bimodal events is due to the mobilization of subsurface flow processes. The analysis shows that the occurrence of the two event types is consistent over three orders of magnitude in area.

In the catchment area “Obere Brachtpe” (2.5 km^2; Sauerland, central west Germany), more than 130 rainfall-runoff-events were recorded over a period of 3 years (from 2001 to 2003) and have been distinguished and described by several variables. Additionally, for every event the antecedent soil moisture was determined by using the soil water potential in the upper soil of every measurement location. The measurement locations are arranged in a gently convergent slope ranging from the upper slope to the riparian zone. They are equipped with several tensiometers installed at different depths (20 to 200 cm). The soil water potential is registered automatically every 10 minutes and is used as an indicator for the soil moisture. To evaluate statistically the relationship between antecedent soil moisture and rainfall-runoff, the rainfall runoff events were subdivided into six clusters using cluster analysis whereas the antecedent soil moisture for each event was used as variables. The six clusters describe different soil moisture conditions of the convergent hill slope ranging from wet to dry conditions. In every cluster a multiple regression model was derived to predict the peak runoff of the different rainfall-runoff events at the catchment outlet. The independent variables of the regressions change with the soil moisture conditions. The validation of the regression model shows a good correlation between predicted and measured values of peak runoff (correlation coefficient = 0.88).

In summary, the analysis of several rainfall-runoff events at different scales in different landscapes shows that the runoff behaviour of the headwater (Austrian Alps) and the antecedent soil moisture (Germany) may be used as an indicator of the runoff behaviour of much larger areas. Moreover, based on soil moisture measurements in the point scale the peak runoff in the catchment scale (2.5 km^2) could be predicted.