Geophysical Research Abstracts,
Vol. 11, EGU2009-708-1, 2009
EGU General Assembly 2009

Effects of riparian water table depth and microtopography on stream discharge generation

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The interaction between streams and their surrounding near stream zone (riparian zone) during rainstorms of variable intensity is still poorly understood. Field observations suggest that distinct exchange flow paths develop, which are difficult to characterize and a challenge for simulation. Recent studies based on hydro chemical and hydrometric data analysis showed that runoff generation and water quality during storm flow events is dominated by surface-subsurface flow processes occurring in the channel near riparian zone. The chemical composition of stream flow during high intensity rainfall events often shows typical signatures of solute concentrations of the surrounding riparian zone. Hydrometric data indicates that discharge generated in these zones reacts very quickly, almost instantaneously to rainstorms and snowmelt events. Although the significance of the riparian zone for runoff generation has been acknowledged for some time, there still exists no conceptual framework that could coherently explain the often complex, nonlinear relationships between hydrologic conditions in the riparian zone, stream discharge generation and the chemical signature of the stream water. It is hypothesized that the interplay between water table depth and surface microtopography in the riparian zone results in distinct shifts between surface and subsurface flow dominance that can explain observed discharge behavior.

A finite element, coupled surface-subsurface flow model is used to simulate the interactions between rainfall, the riparian zone and a near stream channel. By discretizing a 10m x 20m x 2m synthetic system on a sub-meter scale a geostatistically generated microtopography of the riparian zone land surface can be included in the model. Effects of topography at that scale are usually neglected in models of runoff generation. Simulations focus on shallow subsurface and surface flow processes, transitions between them and their relative contributions to stream flow generation. In addition transport simulations and water age estimates are used to obtain insights into residence times and slow and fast flow components.

First results show distinct non-linear relationships between water table depth and stream discharge that reproduce relationships observed in the field. Rainfall of variable intensity results in complex, dynamic patterns of surface and subsurface flow paths, which seem to be characterized by a wide range of residence times.