Geophysical Research Abstracts, Vol. 9, 08661, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08661

Comparison of several conceptually different approaches to subsurface runoff modeling at the hillslope scale

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In order to understand hydrological response of small headwater catchments, several models have been applied to simulate subsurface flow at the hillslope scale. The mechanism of the subsurface runoff generation at the experimental site Uhlirska in Jizera Mountains, Czech Republic, is studied in detail and compared with the model simulations. The following models were included in the analysis: (1) One-dimensional variably saturated flow model, based on the dual-continuum formulation of the Richards equation, coupled with one-dimensional saturated stormflow model, employing a Boussinesq type equation. (2) Zero-dimensional nonlinear morphological element model coupled with a zero-dimensional soil water storage component. (3) Model based on the storage discharge relationship established from a simplified steady state theory for the saturated subsurface downslope flow. All three models are applied to the data measured at the experimental site in a summer period in which extreme hydrological conditions were observed. Soil water contents and hillslope runoff hydrographs, predicted by the models, are compared with the measured data. The results of the analysis suggest that the simplified models, with reduced amount of parameters, are satisfactory to predict general trends of the watershed response. However, for more detailed runoff predictions, a more complex model, incorporating both the soil matrix flow and the preferential flow components, is needed.