Geophysical Research Abstracts
Vol. 20, EGU2018-6567, 2018
EGU General Assembly 2018

Rainfall simulation as an aid for assessing and determining the importance of subsurface storm flow

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In the field of hydrology rain simulation has become a common tool for observing surface runoff (i.a. Newessely et al. 2015). In such experiments subsurface water flow usually remains unobserved or only monitored indirectly. Indirect methods for measuring subsurface flow processes often rely on soil moisture measurements in different soil depth (e.g. with TDR, or FDR), on indirect measurements with geoelectrics, georadar or on isotopic or tracer analysis. Measuring subsurface storm flow directly requires significant efforts and costs, and in some cases even is impossible, e.g. when it is unfeasible to excavate a drainage ditch.
At the BFW - Department of Natural Hazards in the last 25 years about 150 representative plots in the Eastern Alps have been irrigated by means of transportable spray irrigation installations for large plots (50 up to 400 m^2). In total more than 350 rain simulation experiments were carried out. This BFW rain simulation database contains in particular data from 11 plots and 21 experiments where subsurface storm flow has been quantified directly. This does not necessarily mean that there was no preferential flow at the other sites: it simply means that subsurface storm flow at these plots has not been quantified due to different reasons (i.e. investigation focus on surface runoff solely, too high effort for quantification of subsurface flow necessary, no permission of the land owner for the comprehensive excavation work, etc.)
The results derived from these 11 test-plots are confirming the statement by Weiler et al. (2005): Different types of heterogeneities in soil result in different preferential flow paths.
Four specific categories may be distinguished: phytogenic macropores (e.g. cavities left by decomposing roots); zoogenic macropores e.g. mole burrows, mouse holes); geogenic heterogeneities (e.g. periglacial cover beds, bedrock fissures and cracks) and anthropogenic heterogeneities (e.g. drainage systems, tillage pans).
Each of these four categories is covered by at least one experiment in the BFW data record. The observed subsurface hydrographs enable an insight into the process dependent differences in rainfall-subsurface runoff response, such as threshold relationship between precipitation and subsurface flow depending on the antecedent moisture conditions, an estimate of subsurface flow velocity and percentage proportion of subsurface storm flow in relation to the total runoff volume.