



Effects of topography and infiltration heterogeneity on surface runoff and connectivity in the Hühnerwasser catchment

Shahin Khosh Bin Ghomash, Daniel Caviedes-Voullième, and Christoph Hinz

Brandenburg University of Technology, Hydrology, Cottbus, Germany (caviedes@b-tu.de)

The Hühnerwasser catchment is a monitored, early-development constructed catchment within the Lower Lausatia post-mining landscape in Germany. From the initial bare catchment state, a sequence of landscape-forming processes occurred, including erosion-based topographic change and vegetation establishment, which are at the centre of this study. Erosion-based topographic change is strongly driven by surface runoff, while in turn itself also modifying runoff in the catchment. These topographic changes can have a significant impact on the hydrological response of a catchment, as they can affect flow paths, flow speeds and rainfall-runoff-infiltration partitioning, all of which manifest in different ways in runoff hydrographs in response to rainfall events. Vegetation establishment enhances local infiltration capacity, introducing infiltration heterogeneity, thus affecting the topography-controlled flowpaths as water infiltrates at vegetation patches.

Critical-zone observatories and monitored early-development systems allow to document signatures of the evolution of catchments and to correlate certain behaviours to processes. However, readily and easily achievable runoff signatures often cannot provide a clear nor full description of process interactions, as the individual roles of processes are stacked together, and strongly shaped by the temporal distribution of rainfall, making it very difficult to disentangle the effects of each process, and making modelling a necessary approach to understand these interactions and their manifestations. All such processes occur at small spatial scales, and are difficult to observe or assess when experimentally studying catchment hydrology. Moreover, given that the complexity of processes contributing to morphological changes and the corresponding alteration of runoff signatures, single catchment experiments and even comprehensive monitoring programmes of whole catchments will neither allow to decipher all processes interactions nor will it allow to apply a statistically derived experimental.

In this work, we study the effects that spatial distributions of surface topography and infiltration properties have on surface runoff and surface connectivity in response to single rainfall events, in the context of the Hühnerwasser catchment. We simulate rainfall/runoff processes by means of a physically-based, spatially explicit surface flow model, and assess the results in terms of hydrological signatures (hydrograph, hydrological balance), spatial distribution of the hydrodynamics of runoff, and surface flow connectivity. To do this, we use several DEMs of the Hühnerwasser catchment recorded during the erosion-based development of the surface (2006-2010), different hypothetical infiltration properties distributions, and a set of different singular rainfall events. The study allows to observe the individual effects that topographic properties and infiltration distributions have on the hydrograph signatures and connect cause-and-effect through an intermediate, conceptual property of the system: surface runoff connectivity, arguably an indicator of hydrological organisation of the runoff response. Moreover, by systematic analysis, the interactions between topography and infiltration can also be assessed in the hydrograph and explained through connectivity. The results show a range of possible magnitudes of influence of topography and infiltration on the runoff response, while highlighting that the onset of runoff and the rising limb of the hydrograph are mostly affected by these features and their interactions, and strongly related to surface runoff connectivity.