Geophysical Research Abstracts
Vol. 16, EGU2014-9718, 2014
EGU General Assembly 2014

Measurements and data analysis of suburban development impacts on runoff event characteristics and unit hydrographs

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Urbanisation strongly changes the catchment hydrological response to rainfall. Monitoring data on hydrological variables are most commonly available from rural and large areas, but less so from urban areas, and rarely from small catchments undergoing hydrological changes during the construction processes associated with urban development. Moreover, changes caused by urbanisation in the catchment hydrological response to snowmelt have not been widely studied. In this study, the changes occurring in runoff generation were monitored in a developing catchment under construction and in two urban control catchments. The developing catchment experienced extreme change from forest to a suburban residential area. The data used included rainfall and runoff observations from a five-year period (the years 2001-2006) with 2 to 10 minute temporal resolution. In total, 636 and 239 individual runoff events were investigated for summer and winter conditions, respectively. The changes occurring in runoff event characteristics such as event runoff volumes, peak flow rates, mean runoff intensities, and volumetric runoff coefficients were identified by the means of exploratory data analysis and nonparametric comparison tests (the Kruskall-Wallis and the Mann-Whitney tests). The effect of urbanization on event runoff dynamics was investigated using instantaneous unit hydrographs (IUH) based on a two-parameter gamma distribution.

The measurements and data analyses demonstrated how the impact of urbanization on runoff was best detected based on peak flow rates, volumetric runoff coefficients, and mean runoff intensities. Control catchments were essential to distinguish the hydrological impact caused by catchment characteristics from those caused by changes in the meteorological conditions or season. As the imperviousness of the developing catchment increased from 1.5% to 37%, significant increases were observed in event runoff depths and peak flows during rainfall-runoff events. At the same time, the only statistically significant changes observed for the cold period runoff events were the shorter event duration and smaller runoff depths. Negative trends were detected in the gamma parameters of IUHs, which became more consistent across events as the construction works progressed. Because urban development caused the greatest relative changes in runoff during frequently occurring minor rainfall events, the study results underlined the importance of monitoring small storms with high accuracy and temporal resolution to reveal changes in runoff regime. During infrequent major rainfall events and the cold period snowmelt events, the hydrological changes caused by suburban development were less pronounced than during the minor rainfall events.