Geophysical Research Abstracts
Vol. 13, EGU2011-10722, 2011
EGU General Assembly 2011

Regional analysis of peak-volume relationships of floods in Austria – time scales and correlations

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Hydro-climatological extremes (floods, low flows, precipitation etc.) are usually analyzed in a univariate way, e.g., a univariate distribution function is fitted to the observed data in order to estimate the return period of an observed extraordinary event. Univariate models, however, have a limited scope; for instance, they only are able to model the flood peak values while the flood volume may also be the matter of the interest (e.g., in designing dams). In such cases, dependence models such as copulas should be used, which represent the joint probabilities of flood characteristics. The presented work is meant as a first step in examining the dependence structure of flood peaks and flood volumes in a relatively dense network of stream gauges in Austria.

Based on runoff observations with 15 min time resolution at 435 Austrian catchments from the period 1971-2007, rainfall-runoff events were identified using a numerical filtering methodology of Merz and Blöschl (2009). The total number of flood events (characterized by pairs of flood peaks and flood volumes) exceeded 60 thousands. This database was further narrowed down to events that corresponded to annual maxima of flood peaks at each catchment (altogether 12.448 events).

We analyzed pairs of flood peaks and flood volumes in terms of (i) time scale, which is the ratio of the event volume to the peak discharge, and (ii) Pearson's correlation coefficient. In general, the time scale is a measure of the shape of a particular flood event on the hydrograph. For instance, flash floods can be characterized by low time scales, while floods of frontal or snowmelt origin are associated with larger time scales. The correlation coefficient is a measure of consistency of the flood regime. Large correlation means that peak flow is always associated with the same volume, which is usually due to same hydrological process. Conversely, low correlation indicates that the same magnitude of flood peaks may be associated with different flood volumes, which is usually caused by a mixture of different hydrological processes.

The presented study focuses on spatial and temporal patterns of time scales and correlations as well as their relationship to static and dynamic catchment attributes. As expected, we found considerable regional differences between the average time scales (correlations), which can be explained by the dominating hydrological processes. An analysis of the temporal trends suggests that in Styria (SE Austria), the time scale decreased in the past, while there are no significant trends in the rest of Austria. It is finally shown that the consistency between flood peaks and volumes increases (i) with the catchment size as catchments act like a filter (i.e. larger catchments filter out flash floods), and (ii) with the flood magnitude because of the effect of the infiltration (i.e. higher portion of rainfall is transformed to runoff).

References:

Merz, R., Blöschl, G., 2009. A regional analysis of event runoff coefficients with respect to climate and catchment characteristics in Austria. Water Resources Research, 45, W01405, doi:10.1029/2008WR007163.