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Assessment of climate change impacts on flood hazard potential in an Alpine watershed

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The complex process of runoff genesis in mountain watersheds results from a combination of higher precipitation induced by orographic effects, reduced evapotranspiration rates caused by relatively low mean temperatures, and temporary storage in form of snow and ice. Global climate change may lead to a modification of these factors and thus may have considerable impacts on the hydrological behaviour of mountain watersheds. The aim of this investigation is to assess the impacts of climate change on frequency and magnitude relationship of floods thus quantifying the hazard potential for the 21st century. The catchment of the river Lech ($\sim$1,000 km^2) in the northern limestone Alps was selected as study area.

The impacts of climate change were assessed by following a classical 'one-way' approach from global to local climate information, and eventually to the hydrological model. In this investigation the coupled Atmosphere-Ocean General Circulation Models (AOGCMs) ECHAM5 and HadGEM2 were used to simulate current and future climate. In order to bridge the gap between the coarse AOGCMs output and the needs for local climate information, downscaling methods are usually applied. However, most methods are able to reproduce the mean behaviour of the variables and fewer methods allow to reasonable downscaling of extreme events. In this study the Expanded Downscaling (EDS) technique introduced by Bürger (1996) was applied. EDS is a further development of multiple linear regression concept and is particularly suited to the simulation of extreme events like floods. Initially, EDS was calibrated (1979-2000) by establishing a statistical relationship between observed atmospheric fields, taken from the ECMWF (European Centre for Medium Range Weather Forecast) reanalysed dataset and local climate data. The validation period (2001-2005) that was determined in this way shows the quality of the process by comparing observed and simulated local climate and hydrological data. Finally, EDS was derived from the large-scale AOGCMs output.

The climate simulation data was used to drive the semi-distributed hydrological model HQsim to examine possible changes in flood hazards. When forcing the hydrological model with downscaled climate data from the ECMWF dataset, a good agreement between observed and simulated average and extreme runoff was detected. Changes in flood hazard potential were assessed by comparing simulated runoff series for future times with the control period. Projected shifts in the occurrence of peak flows during winter and summer will be presented and the resulting changes in the frequency-magnitude relationship of floods will be discussed. An analysis of the uncertainties in the projections will show the reliability of the obtained results.