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Impacts of climate change on floods in alpine catchments

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Recently, unusual natural disasters have occurred in parts of western Austria. The storms “Kyrill” (January, 2007), “Paula” (January, 2008) and “Emma” (February/March, 2008), but especially the disastrous avalanches (February 1999) and the catastrophic floods (during Pentecost in 1999, in the summer of 2002 and in August, 2005) impressively demonstrate how sensitive mountain areas respond to extreme weather conditions.

According to the new scenarios of the Intergovernmental Panel of Climate Change (IPCC), heavy precipitation events are projected to become more frequent over most regions. Various studies indicate a shift in the frequency-magnitude relationship of floods, but have not been conducted for the Alps so far, because the currently available climate models have reached their limits in areas of complex topography.

The aim of this study is to examine, if an increasing danger potential can be expected in alpine catchments. Such questions are socially extremely relevant and essentially contribute to the attempt to protect the Alps as living environment in times of global change. The focus of the study lies in a model-based analysis of the impacts of climate change on floods in a valley in Tyrol.

The research is based on three methodical steps. The first is to create local temperature and precipitation scenarios for the baseline and the future climate. Second, this meteorological data are used to simulate daily river flows and third, the simulated future river flows are compared with those simulated for the baseline. In the following, especially the first step is described more detailed, as there are considerable differences to existing studies.

The currently available global climate models with low spatial resolution plausibly reflect the climate on a global to a continental scale. Besides, there are many regional climate models that use the results of the global climate model as initial and marginal conditions. But even such climate models of significantly higher resolution are currently not able to realistically illustrate the meteorological conditions of a topographic complex terrain like the Alps. Especially precipitation is not well represented. Hence, the climate data of these models cannot directly be used as input data for hydrologic modeling.

In order to be able to make predictions on future flood behavior, in this study weather generators are applied to overcome the limitations of the regional climate models. Weather generators are stochastic models that calculate a large number of statistical core sizes of the given times series. Conversely, these models are also able to use these parameters to generate time series for temperature, rainfall, and global radiation that correspond to the statistical characteristics of the analysed time series. In order to create climate scenarios, the weather generators are supplied with average monthly climate changing signals of the regional climate models. These numbers can be used to create synthetic time series of any length on a daily basis that reflect the changes of mean values and the future climate variability.

Despite the mentioned advantage, the currently available stochastic weather generators have one essential limit: So far, they can only create weather data at a single point or independently at several points. For many climate change impact studies meteorological data must be known at several locations, for example to evaluate regional hydrological behaviour. But it seems that also this deficiency will be solved soon, as first models that are also able to generate spatially correlating weather data will shortly be operationalized. Within the scope of this

research project such new weather generators will be used for the first time in a complex topography like the Alps.

The hydrologic simulations were carried out using the rainfall-runoff model HQsim, which is based on the water balance model BROOK. It was originally developed for the simulation of runoff in small torrent catchments, but it also showed a good performance in newer applications on a regional scale.