Meteorological and hydrological triggers of torrential disasters in Austria in times of climate change

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INTRODUCTION

In alpine regions torrential processes like floods, intensive bedload transport, debris floods and debris flows often lead to severe damage to settlements and infrastructure and even can cause the loss of human lifes. Different factors influence the occurrence of such disasters, like the basic disposition of the watershed (e.g. topography, geology) or the variable disposition (e.g. seasonal sediment availability or hydrologic pre-conditions). In the Alps the trigger for torrential activity is mostly either short, intensive rainfall event or long-lasting frontal precipitation. Though significant effort has been made to forecast torrential disasters, these trigger conditions as well as the hydrologic disposition of a watershed at the time when a (flash) flood or a debris flow events occurs are not well understood. A better understanding of the connection between meteorology, hydrology and geomorphology at different temporal and spatial scales would lead to improved possibilities for forecasting and warning. Another important aspect is that changes of the climatic system will lead to changes of rainfall pattern which in turn are expected to affect the hydrologic system and geomorphic dynamics of catchments. In this contribtution we present results of a long term, ongoing research effort to assess the impact of climate change on debris flow hazards and risks in the Austrian Alps (projects „Deucalion 1&2“ within the framework of the „Austrian Climate Research Program“).

METHODS AND RESULTS

In the first phase meteorological trigger conditions for debris flows on a daily basis for a limited number of representative study areas in Austria were derived by using past event information, derived with dendrogeomorphic methods and archival data, and daily rainfall information. To assess possible changes of trigger conditions, 24 regional climate simulations (based on a A1B emission scenario) were bias corrected using an empirical-statistical quantile mapping (QM) approach. was developed, implemented and compared with the original non-parametric QM method. We found that 60-90 % of the debris flow events occurred on the month June, July and August. We identified minimum, medium and maximum threshold relations (reflecting the 15th, 50th and the 90th percentile of the data) between rainfall intensity and duration (I = a.D^b). For our three study regions, the minimum threshold of daily precipitation varies between 19 and 35 mm, the medium between 32 and 59 mm and the maximum between 70 and 100 mm. There was evidence that thresholds are highest in the south-west region. For climate change modeling an improved bias correction method for extreme precipitation was developed, implemented, and evaluated, in addition to the standard QM method. The new method combines the nonparametric QM method for precipitation with an parametric extension for new extremes. According to the cross validation frame work, it was found that the new method is capable to improve the representation of new extreme precipitation events in several cases. Connecting climate change modeling with the earlier identified thresholds we found that for the „best“ climate change scenario there is almost no change of debris flow probability in all study regions from May to June, and a decrease in July and August. For the „worst“ climate change scenario we found an increased probability for several seasons in all regions, especially in summer and in the north-east (see Figure 1).

OUTLOOK

In the next phase we aim to go a step further and investigate trigger conditions of torrential disasters at different temporal (daily, sub-daily and sub-hourly) and spatial scales (nation-wide, regional and local). For this purpose, we will make use of

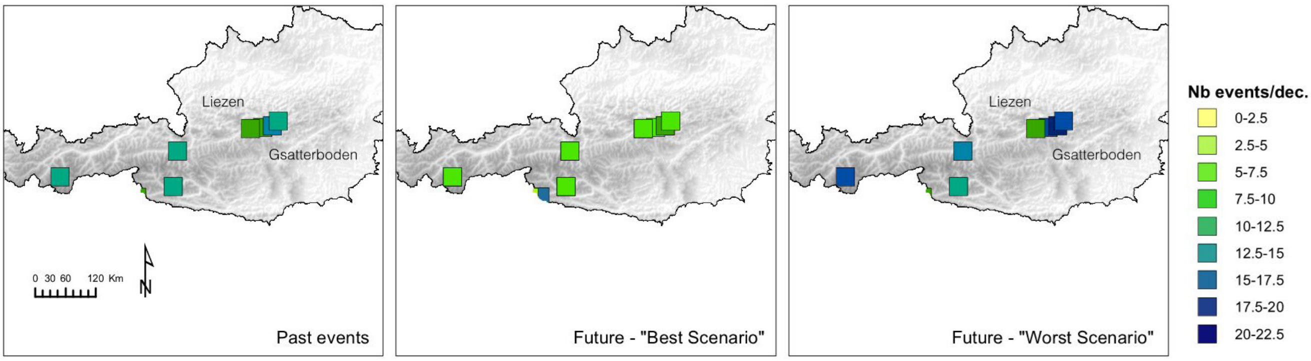

Figure 1. Evolution of number of events per decade triggered by 1 day rainfall in July-August

a database of torrential disasters (Austrian Event Database) which includes more than 32,000 torrential events back to AD 1200. Relevant for the proposed project will be more 4300 dated torrential events of (flash) floods, intensive bedload transport, debris floods and debris flows over the last 200 years, which is the period where systematic rainfall data is available. This very rich database will be connected with the dense network of meteorological stations available in Austria. Further focus will be given to the investigation of the regional hydrologic disposition of two contrasting watersheds (lower Alpine region and high Alpine region) in which torrential events regularly occurr in the headwaters. Additionally we will develop daily climate scenarios based on bias corrected regional climate models from the new EURO-CORDEX data pool. This new set of regional climate simulations for Europe are downscaling the new CMIP5 global climate projections and the new representative concentration pathways and provide much more spatial detail than available before. In particular in the orographically complex Alpine region and with regard to extreme precipitation events and short time-scales, the high resolution of the EURO-CORDEX simulations can be expected to lead to significantly higher quality than the previous generation of regional climate simulations. Based on these climate scenarios and trigger conditions derived for past events, a projection of future torrential disaster potential will be provided and linked to triggering conditions derived for past events. This interdisciplinary approach will improve our understanding of the dynamic system of torrential watersheds and aims to make quantitative projections of expected changes due to climate change. The results of the project are expected to be a valuable tool for engineers and a basis for decision-makers working for prevention of future disasters, their mitigation as well as for adaptation purposes.

KEYWORDS

debris flow; trigger conditions; climate change

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