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An integrated multi-scale risk analysis procedure for pluvial flooding

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Mitigation of or adaptation to the negative impacts of natural processes on society requires a better understanding of the spatio-temporal distribution not only of the processes themselves, but also of the elements at risk. Information on their values, exposures and vulnerabilities towards the expected impact magnitudes/intensities of the relevant processes is needed. GIS-supported methods are particularly useful for integrated spatio-temporal analyses of natural processes and their potential consequences. Hereby, pluvial floods are of particular concern for many parts of Austria. The overall aim of the present study is to calculate the hazards emanating from pluvial floods, to determine the exposure of given elements at risk, to determine their vulnerabilities towards given pluvial flood hazards and to analyze potential consequences in terms of monetary losses. The whole approach builds on data available on a national scale.

We introduce an integrated, multi-scale risk analysis procedure with regard to pluvial flooding. Focusing on the risk to buildings, we firstly exemplify this procedure with a well-documented event in the city of Graz (Austria), in order to highlight the associated potentials and limitations. Secondly, we attempt to predict the possible consequences of pluvial flooding triggered by rainfall events with recurrence intervals of 30, 100 and 300 years.

(i) We compute spatially distributed inundation depths using the software FloodArea. Infiltration capacity and surface roughness are estimated from the land cover units given by the official cadastre. Various assumptions are tested with regard to the inflow to the urban sewer system. (ii) Based on the inundation depths and the official building register, we employ a set of rules and functions to deduce the exposure, vulnerability and risk for each building. A risk indicator for each building, expressed as the expected damage associated to a given event, is derived by combining the building value and its vulnerability. (iii) The object-based hazards, exposures, vulnerabilities and risks can be scaled to any spatial unit desired. For this purpose we have developed an automated work flow building on the Python programming language in combination with ArcGIS and the R statistical software. This enables us to easily adapt the resulting risk indication maps to different zooming levels; to build statistics for various types of units; to flexibly react to the needs of the end users; and to account for the availability of reference data for validation. In the present study, we scale the results to the level of postal code zones.

The evaluation of the results is based on loss reports of an insurance company and on photographs and videos obtained from various sources. We show a potential of the suggested work flow to reproduce the documented damages at the level of postal code zones. However, the results are very sensitive to the input parameters and model assumptions, and a robust back-calculation even of well-documented events remains a major challenge.

Ultimately, we aim at integrating the procedure presented in a work flow for generating risk indication maps for pluvial flooding throughout the entire territory of Austria.