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GIS-based modeling of debris flow processes in an Alpine catchment, Antholz valley, Italy

Christine Sandmeier (1), Bodo Damm (2), and Birgit Terhorst (1)

(1) University of Würzburg, Germany, Institute of Geography (christine.sandmeier@gmail.com, birgit.terhorst@uni-wuerzburg.de), (2) University of Regensburg, Germany, Institute of Geography (bodo.damm@ku-eichstaett.de)

Debris flows are frequent natural hazards in mountain regions, which seriously can threat human lives and economic values. In the European Alps the occurrence of debris flows might even increase with respect to climate change, including permafrost degradation, glacier retreat and variable precipitation patterns. Thus, detailed understanding of process parameters and spatial distribution of debris flows is necessary to take appropriate protection measures for risk assessment. In this context, numerical models have been developed and applied successfully for simulation and prediction of debris-flow hazards and related process areas. In our study a GIS-based model is applied in an alpine catchment to address the following questions: Where are potential initiating areas of debris flows? How much material can be mobilized? What is the influence of topography and precipitation?
The study area is located in the Antholz valley in the eastern Alps of Northern Italy. The investigated catchment of the Klammbach creek comprises 6.5 km^2 and is divided into two sub-catchments. Geologically it is dominated by metamorphic rock and altitudes range between 1310 and 3270 m. In summer 2005 a debris flow of more than 100000 m^3 took place, originating from a steep, sparsely vegetated debris cone in the western part of the catchment. According to a regional study, the lower permafrost boundary in this area has risen by 250 m.
In a first step, during a field survey, geomorphological mapping was performed, several channel cross-sections were measured and sediment samples were taken. Using mapping results and aerial images, a geomorphological map was created. In further steps, results from the field work, the geomorphological map and existing digital data sets, including a digital elevation model with 2.5 m resolution, are used to derive input data for the modeling of debris flow processes. The model framework 'r.debrisflow' based on GRASS GIS is applied (Mergili, 2008*), as it is capable of simulating the potential spatial patterns of debris flow deposition, as well as their initiation and movement. Furthermore it is a freely available and opensource software and can thus be improved and extended. 'r.debrisflow' couples a hydraulic, a slope stability, a sediment transport and a debris flow runout model, which are combined differently in 6 simulation modes. In a first step, model parameters are calibrated using the runout only mode with known parameters of the 2005 debris flow. Finally, the full mode will be used to evaluate the debris-flow potential of the whole catchment.
First results from the geomorphological mapping reveal numerous surface forms, like levees, debris flow lobes or scars that indicate past and recent debris flow activity in the area. In both sub-catchments, there are large areas of unconsolidated, sparsely or unvegetated sediments, surrounded by high rock walls, which conduct precipitation rapidly into the debris. The two sub-catchments, however, have different topographic characteristics, which can be analyzed with the model in more detail. In a next step, the potential starting areas of future debris flows shall be identified and the potential amount of mobilized material shall be estimated by the model.
*Mergili, M. (2008): Integrated modelling of debris flows with Open Source GIS. Ph.D. thesis. University of Innsbruck. http://www.uibk.ac.at/geographie/personal/mergili/dissertation.pdf