Comparing empirical models, 2D- and 3D process-based models for delineating maximum rockfall runout distances

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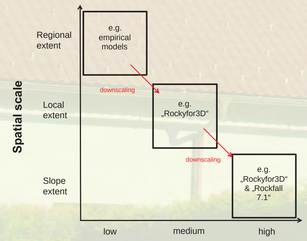
Introduction

An important step in rockfall hazard analysis is the delineation of potential maximum runout distances. Different approaches exist to determine the runout zones of rock falls varying from emperical models to 2D and 3D process- based models. Depending on the research goal, spatial scale, and quality of available input data, the appropriate model approach has to be applied according to the requested data validity domain of the output data.

The present work compares the capacity of empirical models and a 2D resp. 3D process-based model (”Rockfall 7.1” resp. “Rockyfor3D”) to predict rockfall runouts at different spatial scales. Special focus is on the analysis of the effects of the quality of the model input data on the modelling results. This is conducted by a step-wise downscaling from the region scale to the slope scale, which brings about an increasing quality of the accompanying model input maps.

A highly rock fall prone area in Carinthia (Austria) was chosen for a model comparison, also because of the fact that a large amount of field data about past rockfall events and rock fall determining factors was already available (see Mölk 2008, Melzner et al. 2009a&b). This allows an evaluation of the different model types and a more accurate validation of the different modeling results in respect to the real conditions of the study area.



Models/ Input parameters

Input parameter	„Fahrböschung“ & „Geometrisches Gefälle“	„Rockfall 7.1“ (see Dr. Spang GmbH 2008)	„Rockyfor3D“ (see Dorren 2009)
Source areas	v	v	v
DEM	v	--	v
Topography	--	v	--
Rock density	--	v	v
Shape & size of the falling block	--	v	v
Surface roughness	--	v	v
Surface elasticity	--	v	v
Dynamic friction coefficient for rolling	--	v	--
Vegetation	--	(v)	v
Starting velocity	--	v	v
Initial falling heights	--	--	v

References

Dorren (2009): Rockyfor3D revealed. Description of the complete 3D rockfall model, ecorisQ-publication.

Guzzetti et al. (2002): STONE: a computer programm for the three- dimensional simulation of rock falls, Com.& Geosc. 28: 1079-1093.

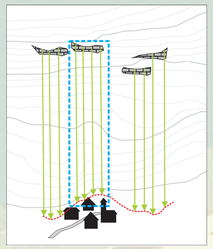
Mölk (2008):Steinschlagschutz Bad Bleiberg. Steinschlagsimulation als Basis für die Dimensionierung von Schutzmaßnahmen. Unveröffl. WLV Bericht, Innsbruck, Österreich

Melzner et al. (2009a):Erstellung einer detaillierten Gefahrenhinweiskarte und ingenieurgeologische Ausarbeitung relativer Gefahrenklassen für ausgewählte Gebiete Kärntens im Maßstab 1:10.000. Testgebiet Bad Bleiberg-Prozessgruppe Fallen/Stürzen. Unveröffl. GBA Endbericht, Wien, Österreich.

Melzner et al. (2009b): Entwurf zur Entwicklung einer Bearbeitungsstrategie für die Einschätzung des Gefahrenpotentials durch Sturzprozesse im Rahmen von Regionalstudien.Unveröffl. GBA Bericht, Wien, Österreich.

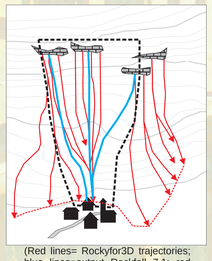
Methods

Regional Extent



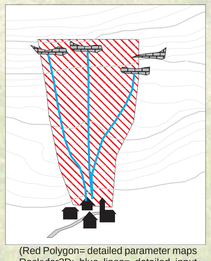
(Green line= energy angle lines: red dots= maximum runout distance; blue polygone= possible conflict)

Local Extent



(Red lines= Rockyfor3D trajectories; blue lines=output Rockfall 7.1; red dots= maximum runout distance; black dots= possible endangered area)

Slope Extent

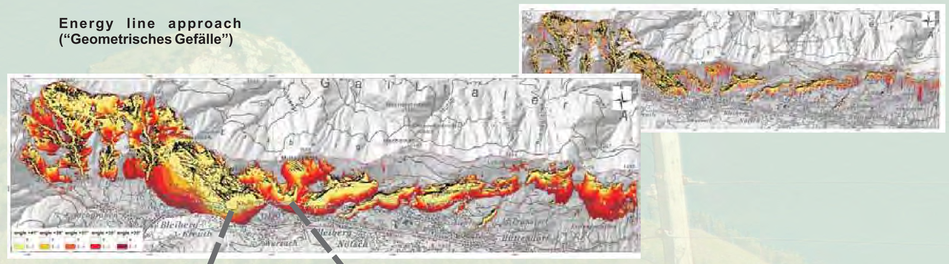


(Red Polygon= detailed parameter maps Rockyfor3D; blue lines= detailed input parameters Rockfall 7.1)

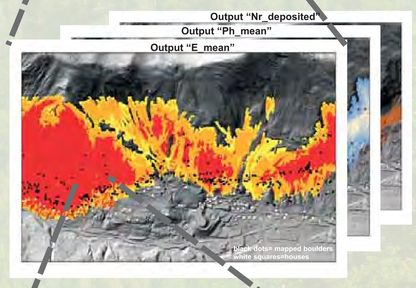
First results

Energy line approach (“Geometrisches Gefälle”)

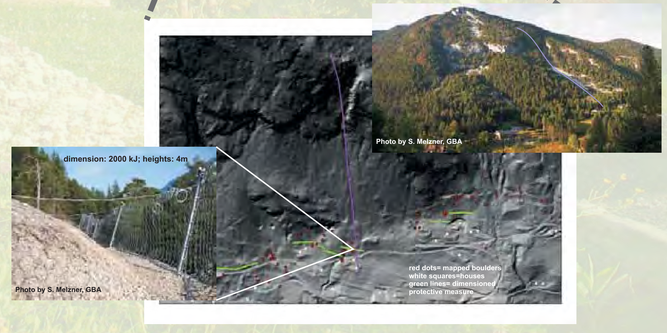
“Fahrböschung”



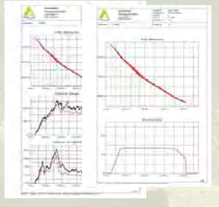
OUTPUT “Rockyfor3D”



File name (raster)	Describtion
E_mean.asc	Mean kinetic energy (translational & rotational; inkJ) percell
E_95.asc	The 95% confidence level of all kinetic energy values (in kJ) in each cell
Ph_mean.asc	Mean passage height (in m; measured in normal direction to the slope surface) percell
Ph_95.asc	The 95% confidence level of all passage height values in each cell
Nr_passage.asc	The number of blocks passed through each cell
Nr_deposited.asc	The number of blocks passed through each cell
Rvol_deposit.asc	The maximum block volume (in m³) stopped in each cell
EL_angles.asc	Mean energy line angles per cell (in-)



OUTPUT “Rockfall 7.1”



Strategy

Step 1: Identification of potential conflicts within large regions (regional extent)

To define maximum rockfall runout distances at regional scale, usually simple methods are used (e.g. energy line principle, shadow angle or “Fahrböschung”), due to the lack of high resolution and accurate slope cover and type information for larger areas. A regional simulation with Rockyfor3D was tested, using greatly generalised parameter maps, which were prepared by calculating mean values from samples of a representative number of punctual information of mapped parameters in predefined homogeneous classes. Overlaying these results with areas of habitations and infrastructure could identify potential conflict areas.

Goal: Comparing different regionally applied methods for delineating potentially endangered areas on local scale.

Step 2: Specification of a potential conflict in some parts of the region (local extent)

These potentially endangered areas are then investigated in more detail to pin down the potential conflict (if, where and to what extent a conflict exists).

For the 2D simulation the necessary input parameters were acquired on representative (adverse) profiles in previously determined homogeneous areas. The input parameters for Rockyfor were acquired by spatially continuous field mapping.

Goal: Comparing different locally applied methods for delineating potentially endangered areas on slope extent.

Step 3: Proposal of protective measures for a possible conflict for some slopes (slope extent)

In case these results reveal an imminent danger for certain areas, more detailed investigations should follow up. Only on basis of such detailed studies at slope scale a realistic quantitative hazard assessment can be performed. This is important when it comes to planning protective measures (e.g. what type and dimension are required) or adaption/designation of hazard zones.

Goal: Comparing different models regarding their capacity for planning purposes and dimensioning of preventive measures.

Future activities

* analysing model sensitivity to the accuracy of input data
* comparing model results at regional, local and slope scale
* comparing Rockyfor3D with the 3D model STONE (Guzzetti et al. 2002)

Acknowledgments

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