Rockfall susceptibility assessment in the “Upper Moelltal” Carinthia, Austria

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Introduction

Many regions in Austria and Italy are recurrently affected by rockfall processes which pose a significant hazard to settlements and infrastructure. Decision makers in the Federal State Governments/Local authorities are strongly dependent on methods/techniques and adequate data in order to delineate potentially endangered areas to plan more detailed investigations.

As part of the INTERREG IVA Project MASSMOVE (Project Code 1381-08-1) an area of approximately 120 km² in the Upper Moelltal (Carinthia, Austria) was investigated concerning potential rockfall susceptibility. Spatially continuous field mapping for such a large study area (regional study) is expensive and time-consuming. Hence the project applied and evaluated various methods at regional scale to identify potential conflict areas within the study region (Dorren et al. 2011B, Melzner et al. 2011A). For the selected regions a comprehensive, detailed assessment at local extent was carried out subsequently (Melzner et al. 2011A, Melzner et al. 2011C).

Study area

Size: ca. 120 km²

Location: Upper Carinthia, “Sonnblickgruppe”

Dimension:

- orogr. left slopes of the Upper Moellvalley
- tributaries Zirknitz, Asten und Kolmitzen

Communities:

- Großkirchheim
- Moertschach
- Winklern

Challenges of assessment

Large size: impassible terrain conditions and remote areas

Tectonic and lithologic complexity: large variety of areas with different lithological and structural anisotropies

Large variety of potential source areas: cliffs, deep seated mass movements, scree and glacial deposits

Available data: high quality data (e.g. Laserscan) versus low quality data in terms of scale (e.g. Geological map 1:50.000) and erroneous content (e.g. landuse map)


(Quelle: S. Melzner, GBA)


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Methods

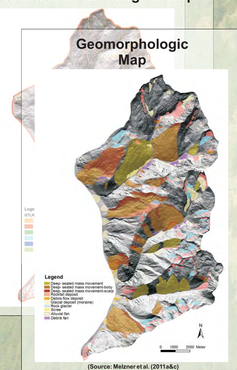
A spatially continuous map of potential rockfall release areas was achieved by overlaying various parameter maps (e.g. Geomorphologic map, Map of geotechnical-lithologic units) and expert knowledge of specific terrain properties such as slope threshold values by which potential scarp areas become apparent. After delineating the potential rockfall source areas potential runout distances and trajectories of rockfalls were determined by applying an empirical model and by performing a 3D simulation with Rockyfor3D. The results of these modelling approaches were overlayed with information on infrastructure and inhabited areas in order to delineate potential conflict areas as targets for detailed mapping. The hereby identified possible conflict areas have been studied in detail with respect to the actual existing rockfall susceptibility, i.e. whether, where and to what extent a conflict may exist due to fall processes (see Melzner et al. 2011A, Melzner et al. 2011C).

Results

Area knowledge due to preliminary field survey and GIS analysis

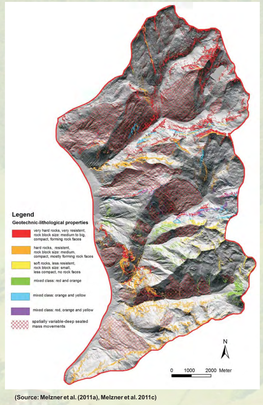
Geotechnic-Lithological Map

Geomorphologic Map

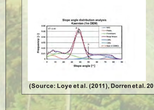

(Source: Melzner et al. (2011a&c)

GTL 2000: 50°
GTL 3000: 50°
GTL 4000: 48°
GTL 23000: 48°
GTL 24000: 48°
GTL 34000: 48°

Potential rockfall release areas


(Source: Melzner et al. (2011a), Melzner et al. 2011c)

“Slope angle distribution” (SAD)


(Source: Loye et al. (2011), Dorren et al. 2011)

Slope family		Morphological unit
range	mean	
0-4°	4°	Plateau
4-30°	17°	Foot slopes
30-35°	32°	Talus slopes
35-45 / 51°	45°	Rock faces
51-87°	75°	Steep rock faces

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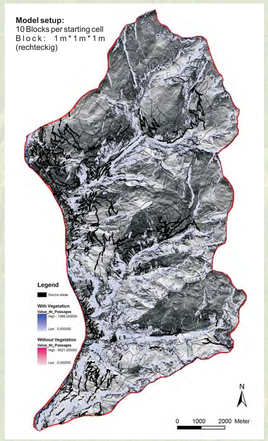
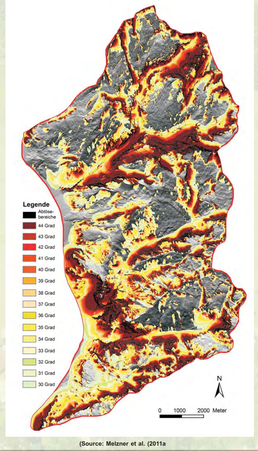
Input data Rockyfor3D:
1x Raster: DTM
1x Raster: starting cells with rock densities
3x Raster: block axes
1x Raster: block shape
3x Raster: surface roughness
1x Raster: soil type
Forest information

Potential runout zones -Rockyfor3D-


(Source: Dorren et al. (2011a&b))

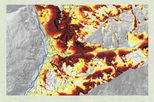
Input data “Energy line principle (Geometrisches Gefälle)”:
1x Raster: DTM

Potential runout zones -energy line principle-

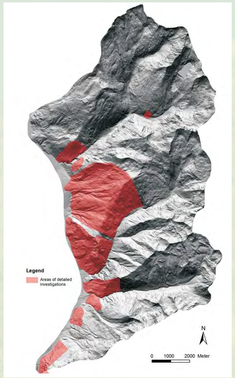

(Source: Melzner et al. (2011a

Overlay with element at risk


Rockyfor3D

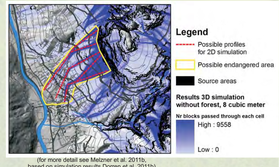

Energy line principle

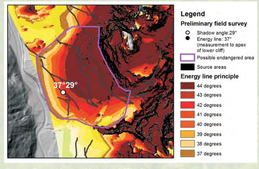
Delineation of possibly endangered settlements for detailed assessment


(Source: Melzner et al. (2010a&c))

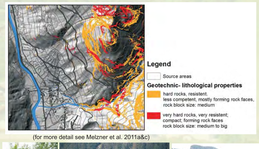
Planning of detailed investigations

Runout susceptibility


(for more detail see Melzner et al. 2011b, based on simulation results Dorren et al. 2011b)


(for more detail see Melzner et al. 2011a&b)

Onset susceptibility


(for more detail see Melzner et al. 2011a&c)


(Source: S. Melzner, GBA) (Source: S. Melzner, GBA) (Source: S. Melzner, GBA)

Quality of results

Data validity domain of results strongly depends on quality of input data, e.g.:

- Rockfall release area map of high quality-> high resolution 1m Laserscan
- Geotechnical-lithological properties of rockfall release areas low quality-> geologic basic data 1:50.000

Results at regional area extent are indication maps:

- first indication where detailed investigations at local or slope area extent are necessary
- “zooming in“ at results from regional studies (e.g. results of runout) for detailed assessments not appropriate

Process data/ Basic data	Scope A (Regional Assessment)	Scope B (Local Assessment)	Scope C (Slope Assessment)
	-/-	-/-	-/-
	-/+ +/-	-/+ +/-	-/+ +/-
	+/+	+/+	+/+

\- Low quality data
\+ High quality data

Multi-scale assessment strategy to reduce costs/time

Conclusions

- A combination of the applied methods at regional area extent enables the delineation of potentially endangered areas and results in a considerable reduction of time and cost concerning the assessment at local extent.
- Reliable delimitation of potentially conflict areas is only possible if all potential source areas and damage potentials (elements at risk) are considered.
- Depending on the project goal, e.g. hazard zoning as basis for preventive landuse planning or dimensioning of protective measures, a catalogue of “elements potentially at risk” must be established before the assessment begins.
- An increase in the number of “protection categories” also increases the complexity of detailed assessment.
- The data validity domain of the resulting output maps can be evaluated as medium-quality, which at maximum will allow semi-quantitative, more spatially differentiated indications of the rockfall susceptibility.
- These maps are particularly important to define priorities for large scale investigations at slope scale, e.g. hazard assessment and the proposal of protective measures.

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Rockfall, landslide, avalanche and protection forest experts

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