Rockfall Modelling in High Alpine Terrain

Validation and Limitations, Kitzsteinhorn, Hohe Tauern, Austria

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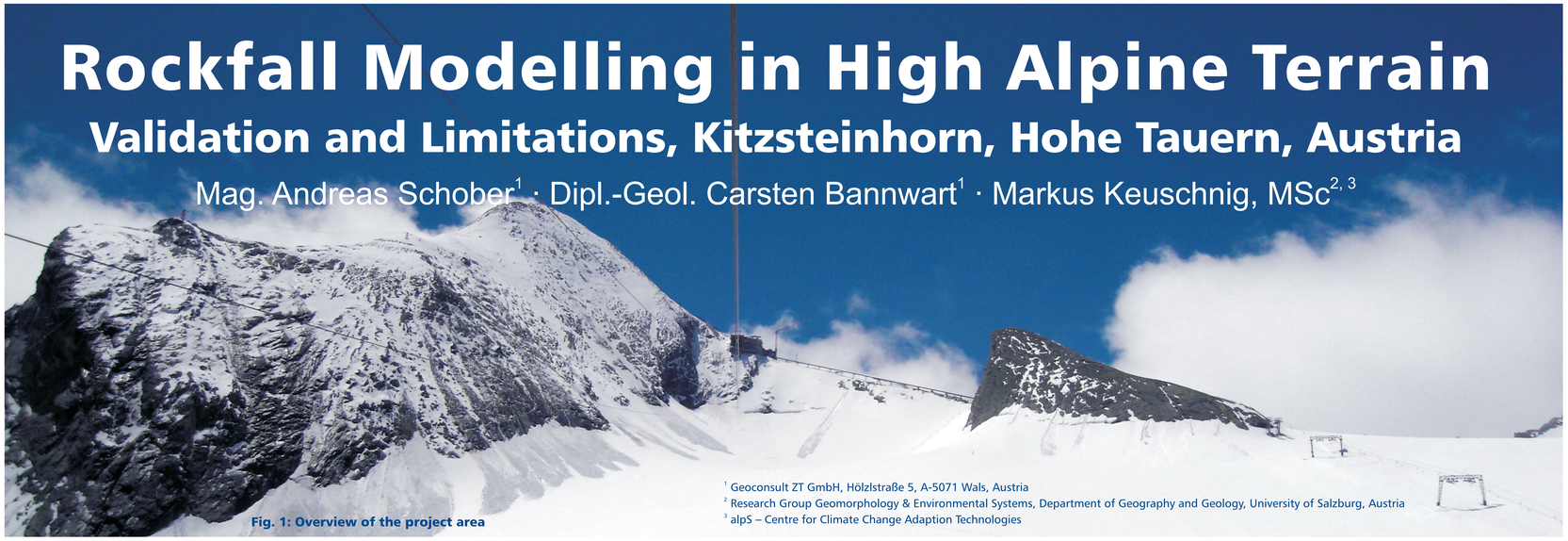


Fig. 1: Overview of the project area

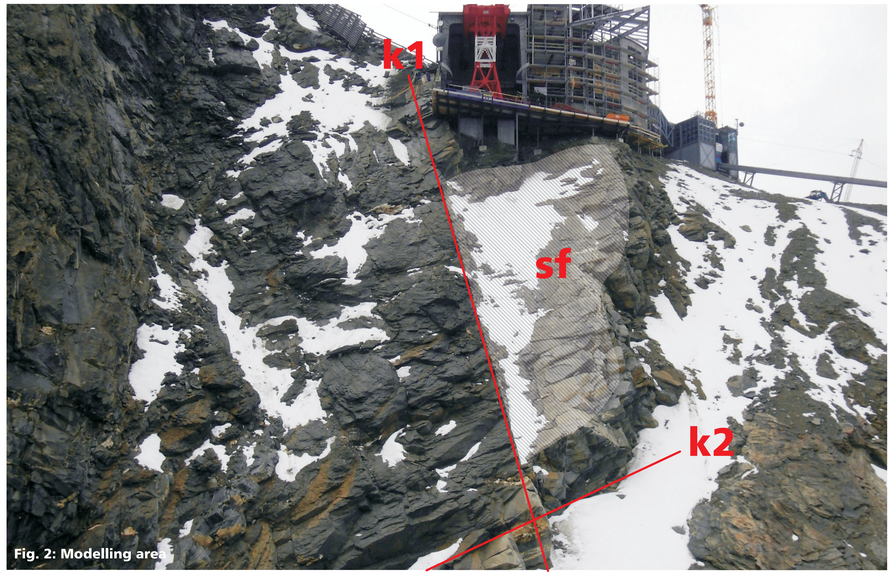


Fig. 2: Modelling area

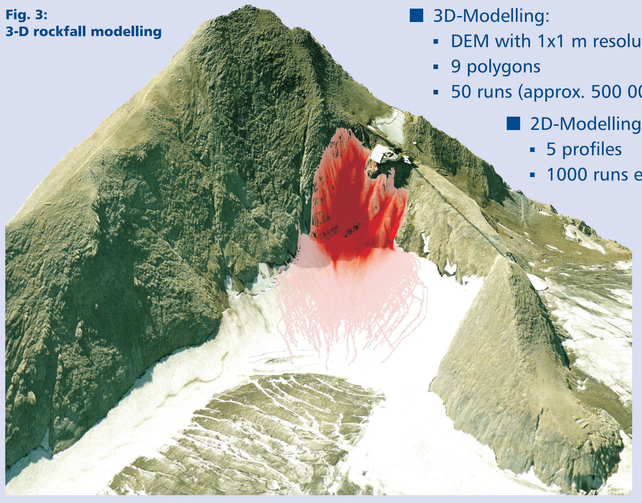
Motivation

The study area is situated at the Kitzsteinhorn (Fig. 1 & 2), located in the Hohe Tauern mountain range. It is made up of rocks of the Glocknerdecke, primarily consisting of limestone-micaschists and greenstones (Cornelius & Clar). In context to climate change, the distribution of glaciers and permafrost is declining and the occurrence of mass movements, such as rock fall events and rock slides is increasing in affected areas (Gruber & Haeberli 2007). As a result the existing infrastructure within the study area (ski-slopes, ski-lifts etc.) is directly affected by alterations of the rock mass. To get a better overview of the possible hazards, 2D (Rockfall 7.1) und 3D (Rockyfor3D 4.1) rockfall modelling was applied as a part of the research project MOREXPERT ('Monitoring Expert System for Hazardous Rock Walls'). The presence of permafrost and the steep and rough alpine terrain are immense challenges for a rock fall modelling and its validation. Existing models have to be calibrated and adapted and modelled results validated respectively for a better understanding and prediction of these gravitational induced processes. Additionally the handling of these modelling programs is a critical factor.

Modelling and Validation

First step of the modelling approach is to get an overview of the potential rock fall hazard of the whole project area. Geological mapping in combination with 3D rockfall modelling (Fig. 3) shows excellent results. Using these results hot spots can be identified for further analysis. As a second step 2D modelling (Fig. 6) provides a more detailed understanding of rockfall processes in specific areas of the rock wall. The results can be used, for instance, for the design of rockfall protection measures.

Fig. 3:
3-D rockfall modelling



- 3D-Modelling:
  - DEM with 1x1 m resolution
  - 9 polygons
  - 50 runs (approx. 500 000 blocks)
- 2D-Modelling:
  - 5 profiles
  - 1000 runs each

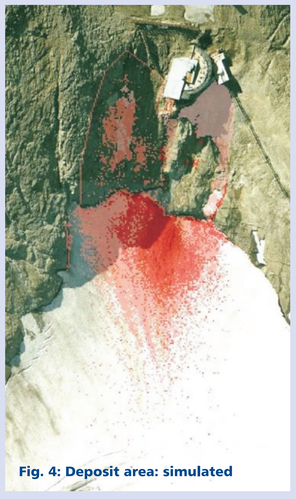


Fig. 4: Deposit area: simulated

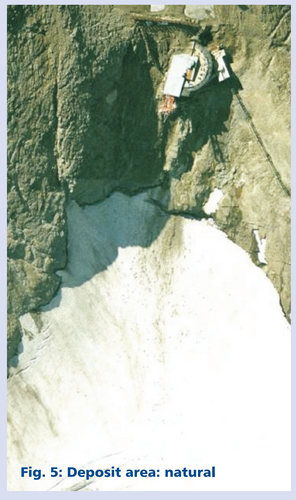


Fig. 5: Deposit area: natural

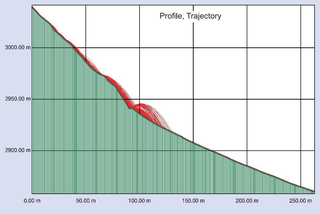


Fig. 6: 2-D rockfall modelling

The results of the 3D modelling were validated using orthophotos of 2003 and 2009 on which recent rock fall deposits can be identified very well on the glacier surface. The results of the modelling coincide with the deposits below the project area on the surface of the glacier, as well as with the blocky deposits along couloirs and flattenings in the rock wall (Fig. 4 & 5).

Limitations

The main element of uncertainty concerning both models is the ground surface cover with snow and ice, respectively the surface of the glacier, highly depending on the weather conditions and the season (Fig. 7 & 8). The boundary conditions change within different time scales (hours to years). For this reason every modelling is temporally limited. Furthermore the sensitivity of the models especially the 3D model is an exceedingly important factor.

- Input parameters for snow and ice
- Models are just snap-shots (high dynamics)
- Sensitivity of the models (resolution of DEM, accuracy of Polygons)

Fig. 7: Project area 24.06.2010

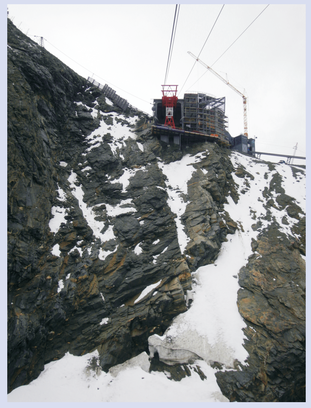


Fig. 8: Project area 10.08.2010

Outlook

For further investigations and a better handling of the programs it would be necessary to implement surface parameters for snow and ice. Additionally the accumulation of block material within the simulation area should be taken into account in the 3D model in respect to the gradually landscape evolution. Another important factor is the sensitivity of the 3 D model. Especially the resolution of the DEM and the accuracy of the homogeneity areas are critical elements of the modelling.