GIS-AIDED DETERMINATION OF SLUFF/SNOW GLIDE PROCESS AREAS FOR PRACTICAL APPLICATION IN HAZARD ZONING

Manfred Egger[1,*], Christian Tollinger[1], Felix Oesterle[1], Helmut Hochreiter[1]

[1] *Austrian Service for Torrent and Avalanche Control, Innsbruck*

ABSTRACT: The delimitation of sluff/snow glide process areas is an increasingly important question in the current practice of hazard zone mapping in Austria. Margreth (2016) specifies relevant basic indications, like slope inclination, exposition, snow height and surface roughness. Up to now a rough empiric approximation to the runout length was used to create hazard maps. As this is a manual (point by point) process, it is not easily applicable to complex terrain. The article presents a new objective, automated GIS-approach to indicate areas prone to sluff/snow gliding, allowing for a replicable detection of relevant areas for hazard zone mapping.

Keywords: sluff/snow glide areas, hazard zone mapping, GIS-approach

1. INTRODUCTION

An avalanche hazard map shows extent and intensity of avalanches (of all sizes) as well as sluff and gliding snow. When hazard zone mapping was still in its infancy (started with the Forestry Act, first introducted in 1975) large avalanches in "planning relevant areas" (current and potential settlements) were most important. New requirements due to increased population density and traffic volumes, as well as new technological possibilities, lead to a recent focus on investigation of gliding sluff and gliding snow for Austria (Figure 1 and 2). The aim of the Austrian Torrent and Avalanche control (WLV) is to find a simple and objective method to determine relevant areas.

Figure 1: Sluff/snow glide process area

2. STATE OF THE ART

2.1. Process Description

While established methods are available for assessing avalanches, there is no commonly established method to differentiate sluff/snow glide zones. Objective criteria and methods for differentiation are unavailable, except for some WLV-internally developed approximations. A definition for hazard sluff/snow glide process is currently developed in the Austrian Standards (ÖNORM B 4801 (exp. 2019)) (targeted release in 2019). The following general definitions describe a potential sluff/snow glide area:

- ”surface phenomenon”, no turbulent flow
- no aggregation or channeling
- release slope inclination ≥ 28° to 55°
- maximum difference in altitude 60 m / 80 m
- sea level ≥ 500 m to < 1500 m
- three day new snow sum
- snow density 300 kg/m^3
- runout length (hazard zones) by expertise

2.2. Current method in Austria

Up to now, a slope map and an inclinometer was used during field work to determine sluff/snow glide

*Corresponding author address:
Manfred Egger
Austrian Service for Torrent and Avalanche Control
Wilhelm-Greil-Straße 9, 6020 Innsbruck, Austria
email: manfred.egger@die-wildbach.at

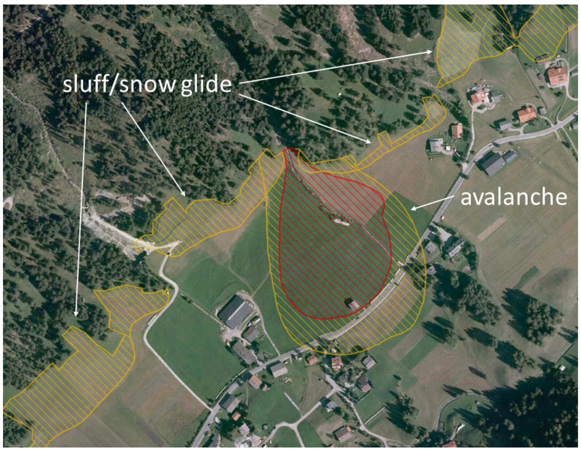

Figure 2: Hazard map with sluff/snow glide areas and avalanche

hazard maps. Using the geometric angle method (Figure 3) with empirical slope angle values between upper glide crack and runout, each slope was painstakingly mapped point by point. The height difference limit of 60 m / 80 m is an empirical value based on experiences and observations within the WLV. Above 60 m / 80 m turbulent dynamic avalanche processes and higher impact forces start to arise.

3. TECHNICAL IMPLEMENTATION

The possibilities of geographic information systems (GIS) are used to create a common method for application at the WLV, allowing for an automated zoning analysis. Zones with high probability for sluff/snow glides are reliably classified. Using the resulting classification maps potential hazard areas are easier to find and field trips can be accomplished much more targeted.

3.1. Input data

The following data is required for "planning relevant" areas: A digital terrain model (DTM) with (min.) 5 m resolution, and a geospatial layer for areas where sluff/snow glide processes cannot occur (mainly forested areas). To take potential snow glides reaching the "planning relevant areas" into account, a generous buffer is applied.

3.2. Parameter

- Difference in altitude

The difference in altitude (max/min [m]) from the upper glide crack to the maximum runout is limited to a maximum of 80 m if there is no aggregation channelization and no turbulent flow. For channeled slopes, the height difference is limited to 60 m. A minimum of, e.g., 5 m (altitude and extent) allows to exclude tiny areas from being mapped (so-called artefacts) where the difference in altitude is too small for sluff/snow glide processes.

- Slope angle

The slope angle (max/min [°]) for release zones of sluff/gliding snow corresponds to the criteria for avalanche fracture zones (Rudolf-Miklau et al. (2014)).

- Geometric angle method

Different to the empirical "geometric angle method" [°] height difference is measured according to the slope angle (not maximum runout). Measurements start at the upper glide crack (see Figure 3). Close to the upper limit of height difference (80 m) results have to be interpreted with caution, as the maximum runout can have significantly more height difference.

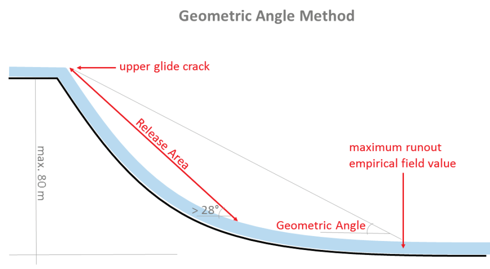

Figure 3: Geometric Angle Method

3.3. Data Processing

Figure 4 shows the implemented workflow.

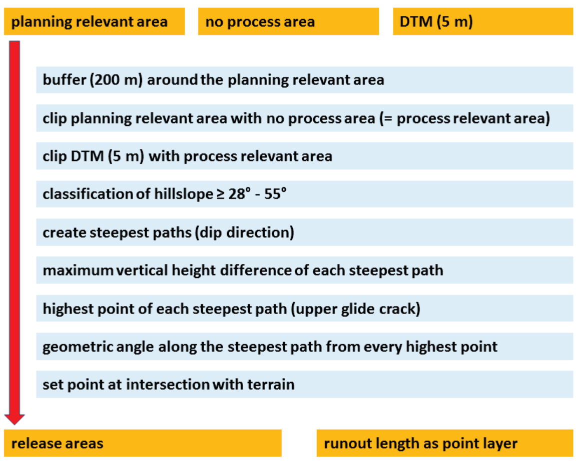

Figure 4: GIS workflow

3.4. Software Implementation

A prototype was developed in Java programming language (Version 8) using the open source Java GIS Toolkit Geotools. The graphical user interface (GUI) is basing on the platform-independent GUI framework Swing (see Figure 5).

Figure 5: GUI

4. PRACTICAL EXPERIENCE

This approach has already been tested operationally for hazard zones of different municipalities in Tirol. As an example, Figure 6 shows the planning relevant area (black line) and no process area (green), e.g. forests. The digital terrain model (DTM) is cropped to areas where the snow glide topographic criterions inclination and height differences are met. The remaining inclination map within the planning relevant area is visualized.

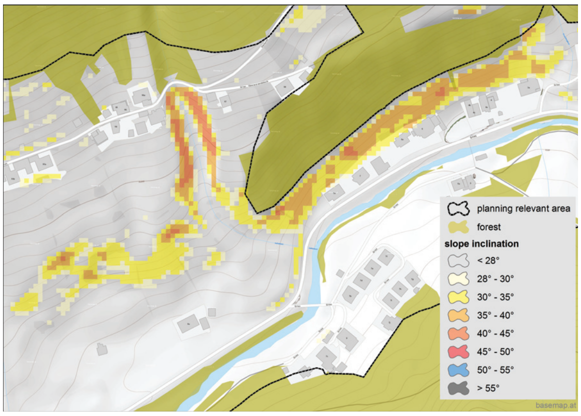

Figure 6: Snow gliding potential slopes in the planning relevant area

Starting at the upper glide crack the user defined angle is applied and the first intersection with the terrain is marked. Figure 7 shows an example with three different angles (30°, 28°, 26°). Tests show a good agreement between the old and new method, with all critical areas being detected.

To compare and verify our workflow, Figure 8 shows the hazard zones determined by the traditional, field mapped method versus the new, automatic method.

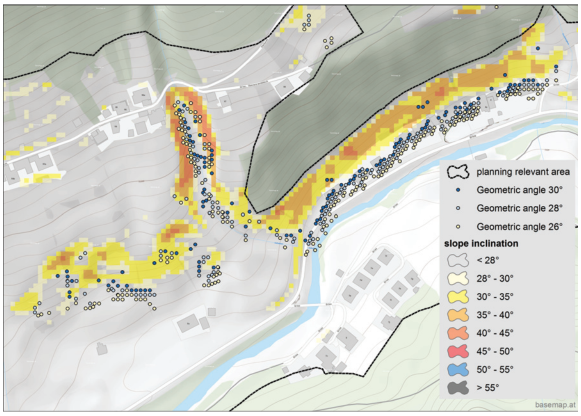

Figure 7: Automated GIS-based geometric angle method

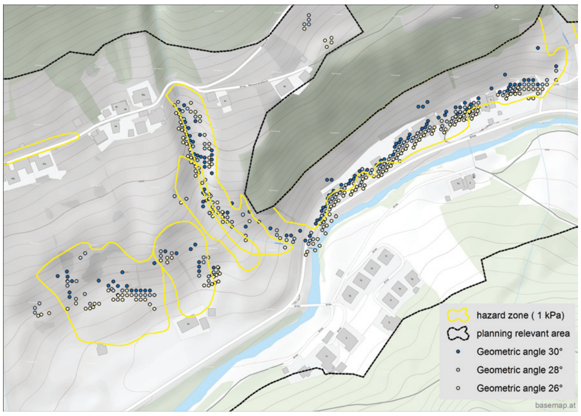

Figure 8: Automated geometric angle method in comparison with field mapped hazard zones

5. CONCLUSION

A new objective GIS based zoning analysis for sluff/snow glide was developed. This method includes slope angle and, different to the old method, the height difference of potentially affected areas. Using the "geometric angle method" with an automatically determined upper glide crack, a potential runout zone is determined. This results in a standardised and reproducible map for sluffing/snow glide prone areas. It allows end users to easily filter important areas and make field assessments more targeted/efficient.

The main problem with the new approach is the data aquisition for the "no process" areas (buildings, forested areas, etc). Determining an up to date forest layer is often a nontrivial task. Maybe new remote sensing and image classification methods could help to make this step easier.

The next step is to optimize and further test this new sluff/snowglide approach in operations for hazard zone mapping.

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