Snow-avalanche hazard forecasting in the Krkonoše Mountains, Czechia

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Aims of the project

• Creation of Snow avalanche hazard forecasting system
• Project of the Ministry of Interior (2013-2015)

• Main tasks:
  – Revision of traditional avalanche paths using RAMMS code and new LiDAR data;
  – Renewal of the snow avalanche database;
  – Historical analysis of snow avalanche hazard degrees and corresponding meteo and snow situation;
  – Creation of modular prediction system for the assessment of avalanche hazard
  – Creation of DSS for Mountain Rescue Service and National Park Administration
  – Creation of WebGIS for general public
  – Expanding from Krkonoše Mts. to other mountain areas in Czechia
Krkonoše Mountains

• relatively small mid-mountain range (454 km²)
• Maximum altitude 1602 m a.s.l. (Sněžka)
• Climatic conditions like Greenland coast (mean t~0°C, 130-180 days with snow pack)
Krkonoše Avalanches I

- more than 1100 avalanches in period 1961/62 – 2012/13 on 55 permanent avalanche paths
- every avalanche is classified according to International Avalanche Classification, including dimensions
- climatic and snow properties information for more than 50 years
- more than 150 people killed in last 100 years
Krkonoše Avalanches II

- 55 traditional avalanche paths
- Mountain Rescue Service responsible for hazard level prediction
- Krkonoše National Park Administration is responsible for land management and is collecting avalanche data
- Czech Hydro-meteorological Institute is collecting meteo data
Project workflow

Calibration Data
- Validation Data
  - LiDAR

Historical Database Data 1961 - 2013
- Avalanche Records
- Meteo Data
- Snow Pit Records

Avalanche Runout Model - RAMMS
- Avalanche susceptibility model
- Snow Development Model
  - Fitting of validated model

Avalanche Hazard Model (Ensemble)

Refresh every 12/24h

Avalanche Hazard Forecast

Feedback

Public Platform Apps

Distribution

Mountain Rescue Service Decision Making

5 Extreme
4 High
3 Considerable
2 Moderate
1 Low
Modrý důl Valley

- Traditionally high snow accumulation (up to 14 m) on leeward slope
- In the period 1961/62 - 2012/13 16 registered and documented avalanches
- 8 deaths up to present (1918, 1931, 1935, 1942, 1952)
- Highest triggering height 3 m
- Most frequent triggering height 1 m
- Longest avalanche from 3rd February 1985 ($l=600$ m, $w=150$ m)
- triggering height 1 m
- results l=680 m, w=260 m
Modrý důl Valley - largest recorded avalanche

- triggering height 3 m
- results l=1200 m, w=400 m
Revision of traditional avalanche paths
Snow avalanche susceptibility analysis

• Decision Tree method using C4.5 algorithm (Quinlan 1993)
• 5 m DEM (and derived data: slope, aspect, curvature, roughness, etc.)
• Forest coverage data
Snow avalanche susceptibility analysis – results I

• 95% of avalanches in less than 10% of the area
• Area under SRC – 96.96 %
• Area under PRC – 95.72 %
• Classification threshold probability of 0.99
Snow avalanche susceptibility analysis – results II
Runout modelling - approach

- Flow-R regional model (Horton et al. 2013)
- Avalanche runout based on modified modified Holmgren algorithm (Holmgren 1994) for spreading assessment and Perla et al. (1980) friction model
- Sources from susceptibility modelling
- $M/D = 2500; \mu = 0.27; \text{max velocity } 35 \text{ m/s}$
Runout modelling - results
Snow distribution modelling

- HBV-ETH model using Degree-day or Energy balance approach
- Degree-day is much simpler and less data demanding
- Energy balance shows near-real results but the model is highly data demanding (Walter et al. 2005)

1st February 2012

1st May 2012
Snow stability modelling

- SNOWPACK (Lehning et al. 2002) is being used for reconstruction of the snowpack evolution including grain type, temperature, size, density and viscosity of the snow layers
- Model is currently being calibrated with historical data from available snowpits
Through a WebGIS!
Conclusions

- Permanent avalanche paths area have been re-assessed (and are usually larger than mapped)
- Snow avalanche susceptibility model showing potential release zones has been calculated
- Snow avalanche runout potential has been calculated (showing avalanche potential even in currently forested areas)
- Snow distribution model using Energy balance algorithm is under testing using historical data
- Snowpack evolution model is under calibration using historical data
- We have started the process of putting all the puzzle pieces together using a WebGIS platform (www.laviny.info)
Thank you for your attention!

Bialy Jar avalanche 20th March 1968 - 16 victims