

An App for Visualisation of Avalanche Hazard

BEng Project Presentation - Chongyang Shi

Image Credit: The SAIS, Lochaber, Feb 8, 2017.

Outline

- Motivation and background of the project
- Literature review
- Design and implementation of the application
- Evaluation of the application and risk model
- Application demos

Motivation

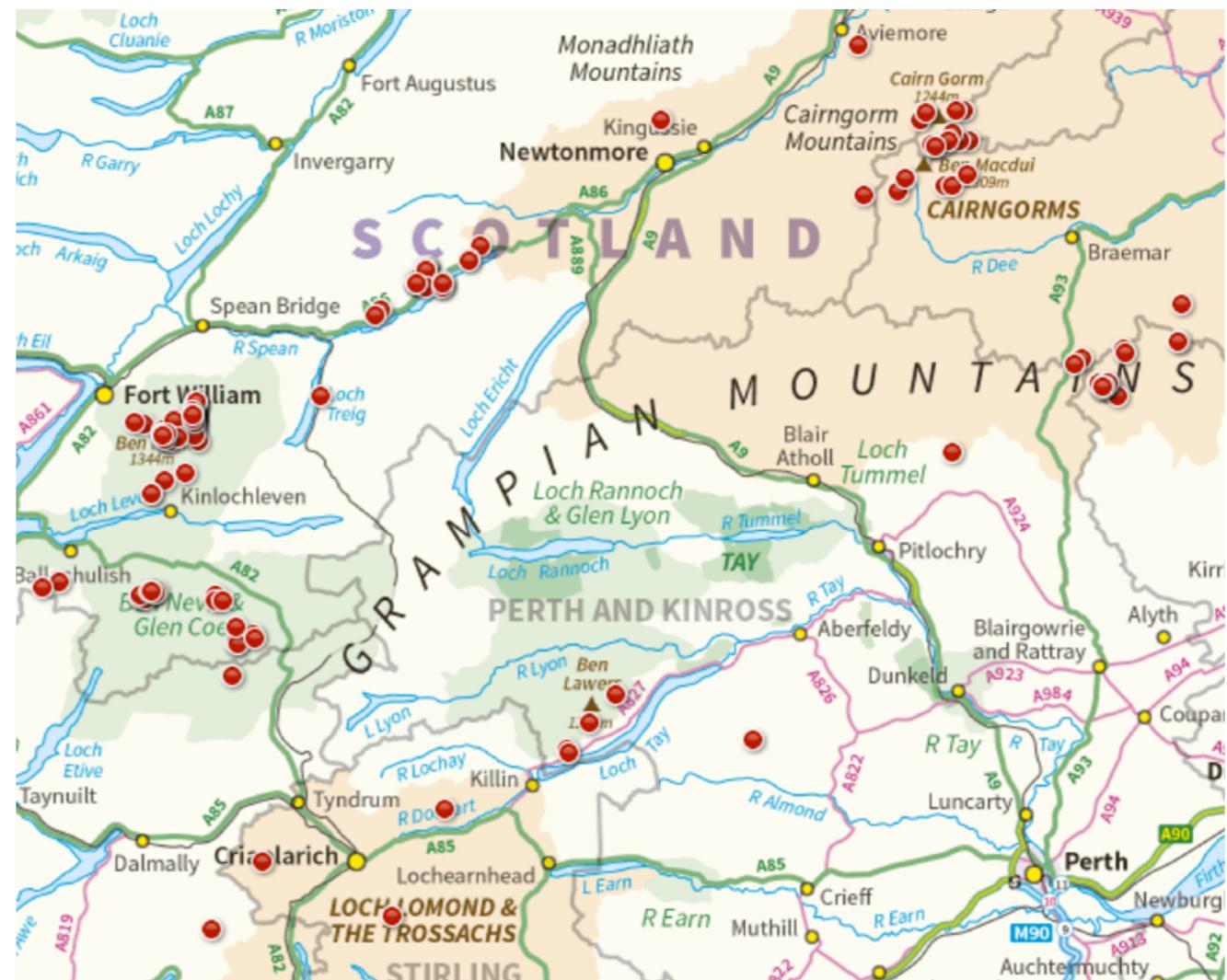


Video Credit: Kristoffer Carlsson / Youtube

Motivation

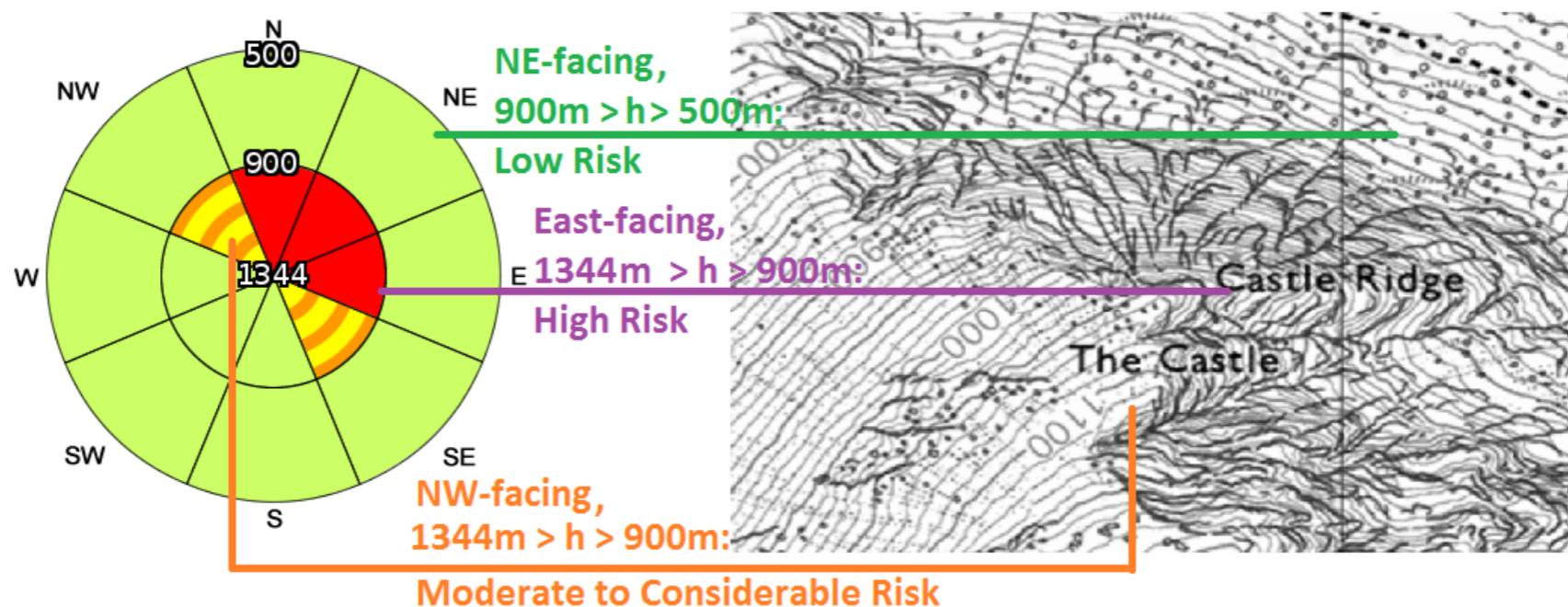
- Snow avalanches are frequent and often deadly.
- Second half of the 20th century: at least 73 fatalities in Scottish Mountains (Barton & Wright, 2000).

Avalanches in Scottish Highlands recorded by the SAIS in the 2015 - 2016 winter season.



Difficulties in Using Current Services

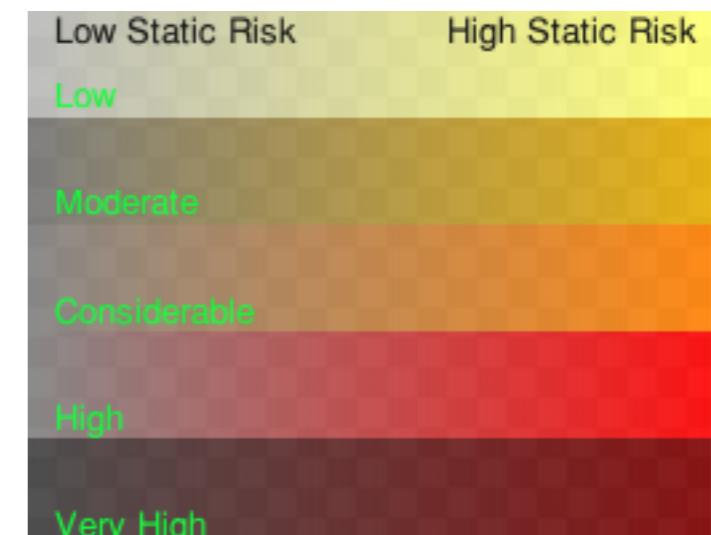
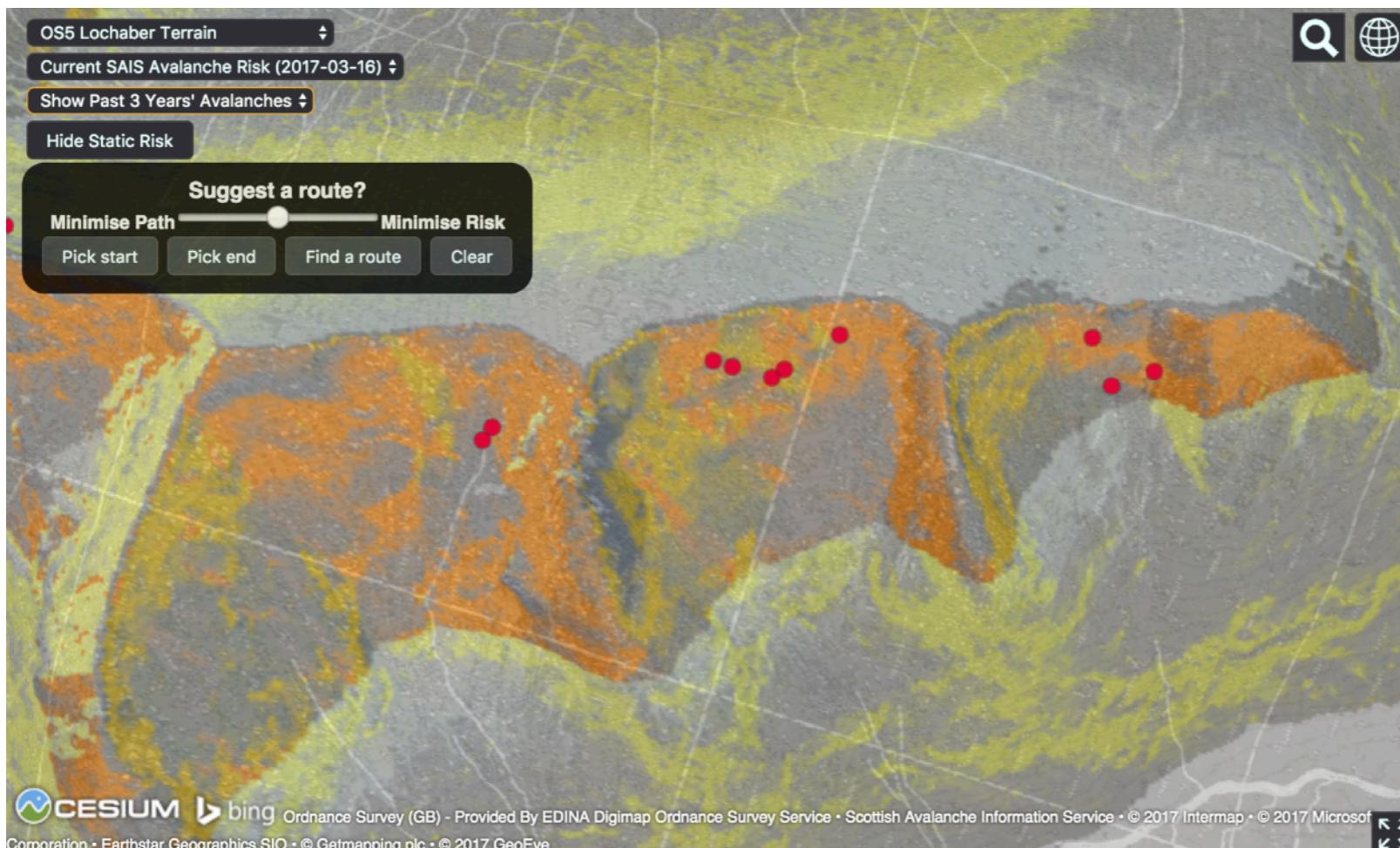
- The Scottish Avalanche Information Service (SAIS).
- Statistical forecasts.
- Mountaineers must manually match aspects and altitude to the terrain contour map.
- This process is tedious.
- Extensive application of own judgements required.



SAIS Forecast, January 6, 2016, for Lochaber.
Ordnance Survey Map - Castle Ridge near Ben Nevis

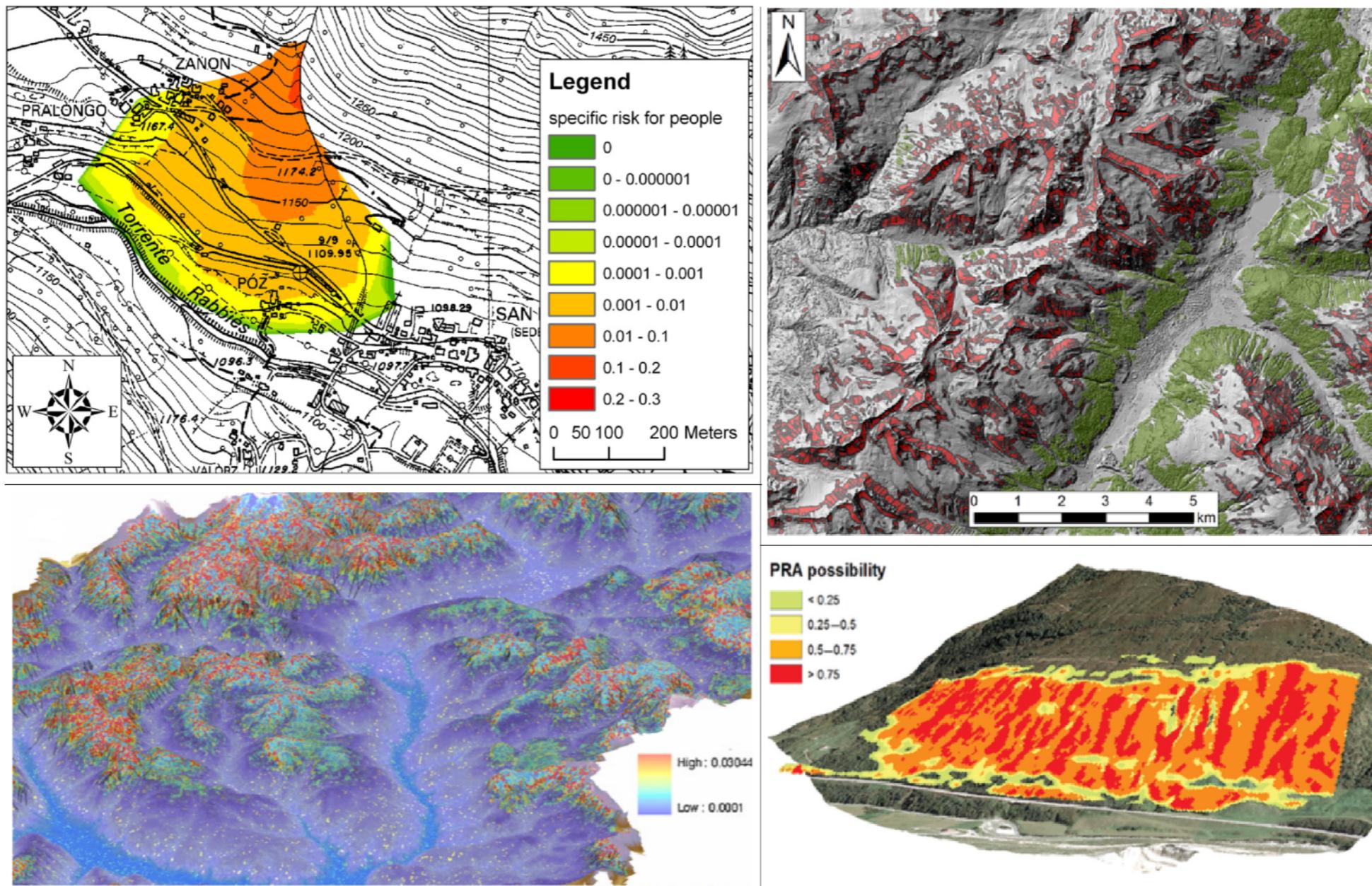
What this project seeks to provide

- 3D terrain and avalanche hazard visualiser
- Combined dynamic (SAIS) and static (topographical analysis) risk model.
- Mountaineering utilities: pathfinder and historical avalanche locator.



Risk Colour Coding

Literature: Previous Attempts at Avalanche Hazard Visualisation



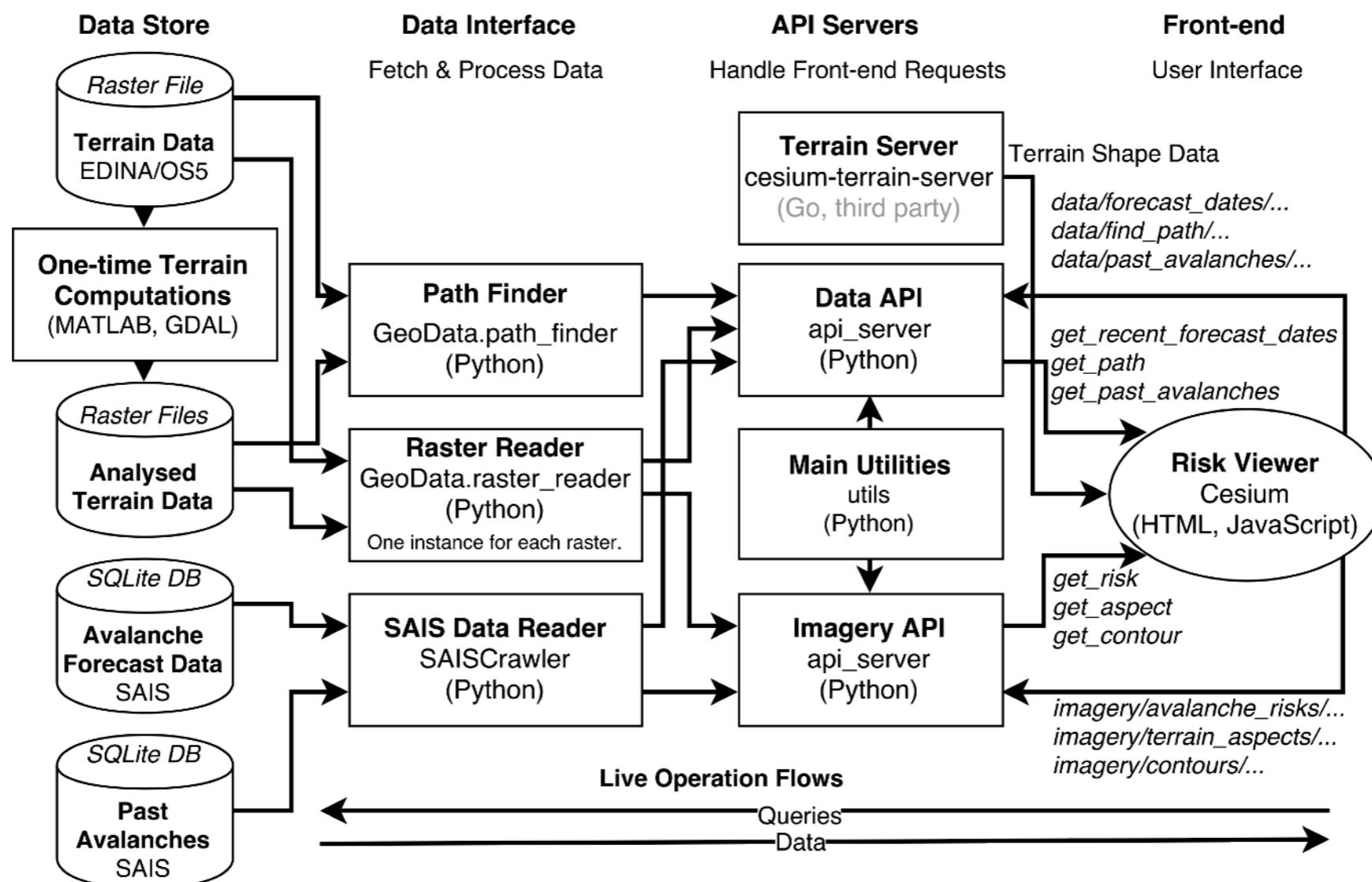
(Clockwise: Cappabianca *et al.*, 2008; Pistocchi and Notarnicola, 2013; Bühler *et al.*, 2013; Veitinger *et al.*, 2016)

Other Literatures Reviewed

- Statistical avalanche forecast methods
(SNOWPACK, Nearest Neighbour, etc.)
- Effectiveness of risk colour coding.
- Human-computer Interaction aspects
(touchscreen, field use, etc.)

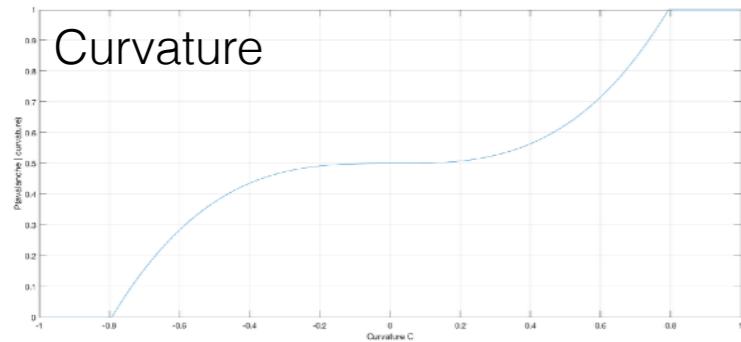
Design: Avalanche Visualiser Application

- Front-end: HTML5 and JavaScript on Cesium WebGL.
- Back-end: Almost entirely implemented from scratch.
- Requirement engineering, version controlled.

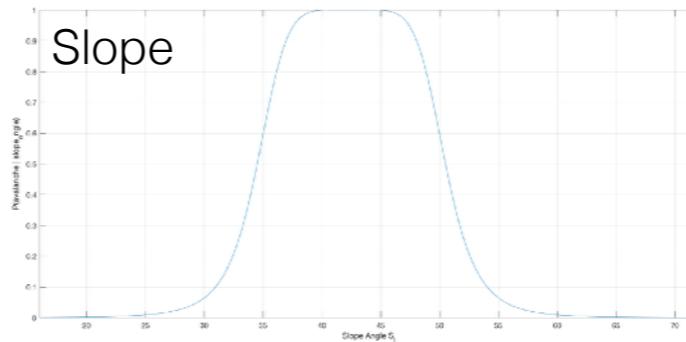


Design: Advanced Static Risk Model

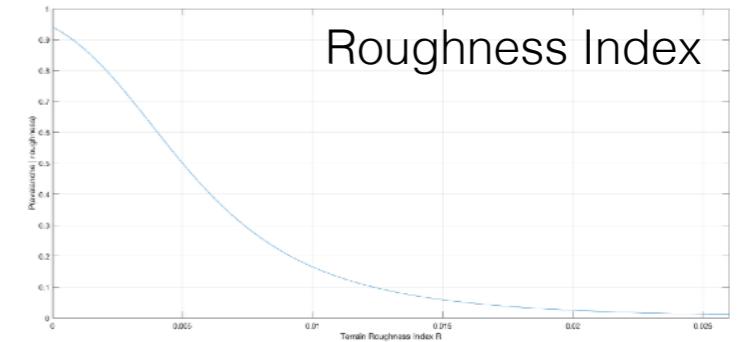
- Localising avalanche hazard by computing per-point risk.
- Topographical analysis based on curvature, slope angle and roughness index.



$$S_c = \begin{cases} Cur^3 + 0.5 & -0.7937 \leq Cur \leq 0.7937 \\ 1 & Cur > 0.7937 \\ 0 & \text{otherwise} \end{cases}$$

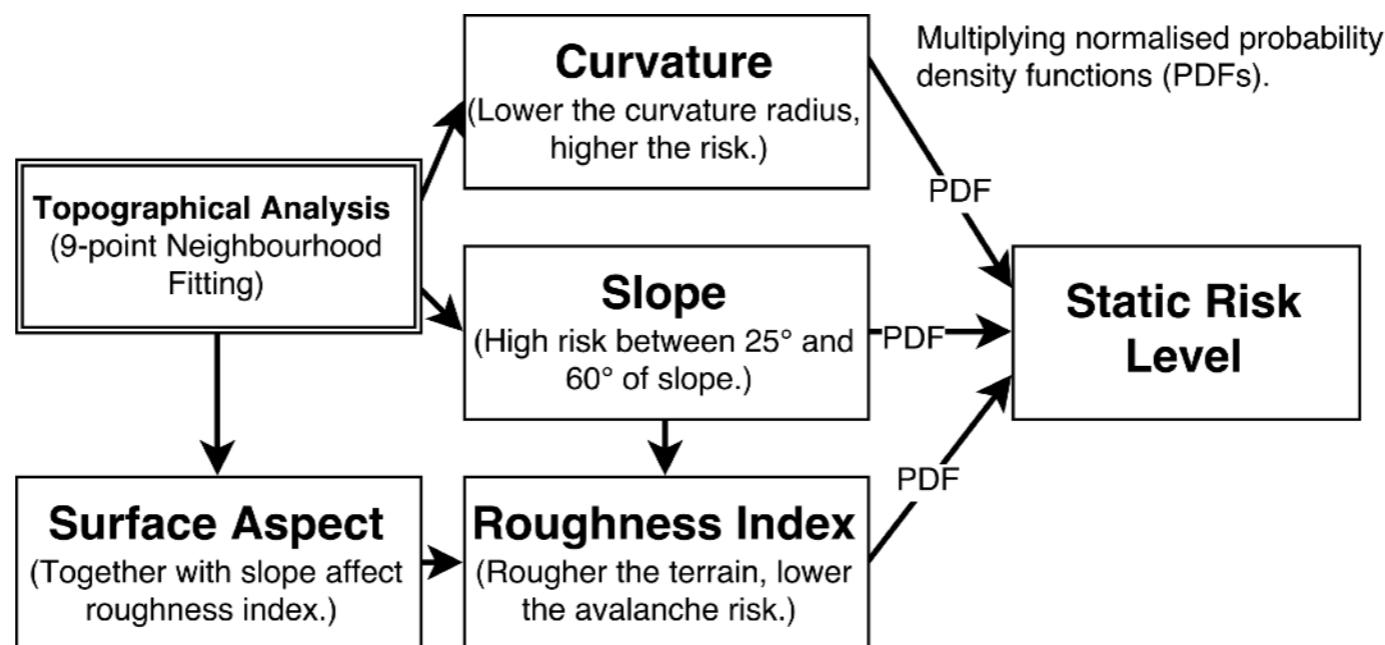


$$P(\text{avalanche}|S_s) = \frac{1}{(1 + (\frac{S_t - 42.5}{8})^6)} \cdot \frac{1}{C_s}$$



$$P(\text{avalanche}|S_r) = \frac{1}{(1 + (\frac{R + 0.005}{0.01})^4)} \cdot \frac{1}{C_r}$$

$$P(\text{avalanche}|S_s, S_c, S_r) = P(\text{avalanche}|S_s) \cdot P(\text{avalanche}|S_c) \cdot P(\text{avalanche}|S_r)$$



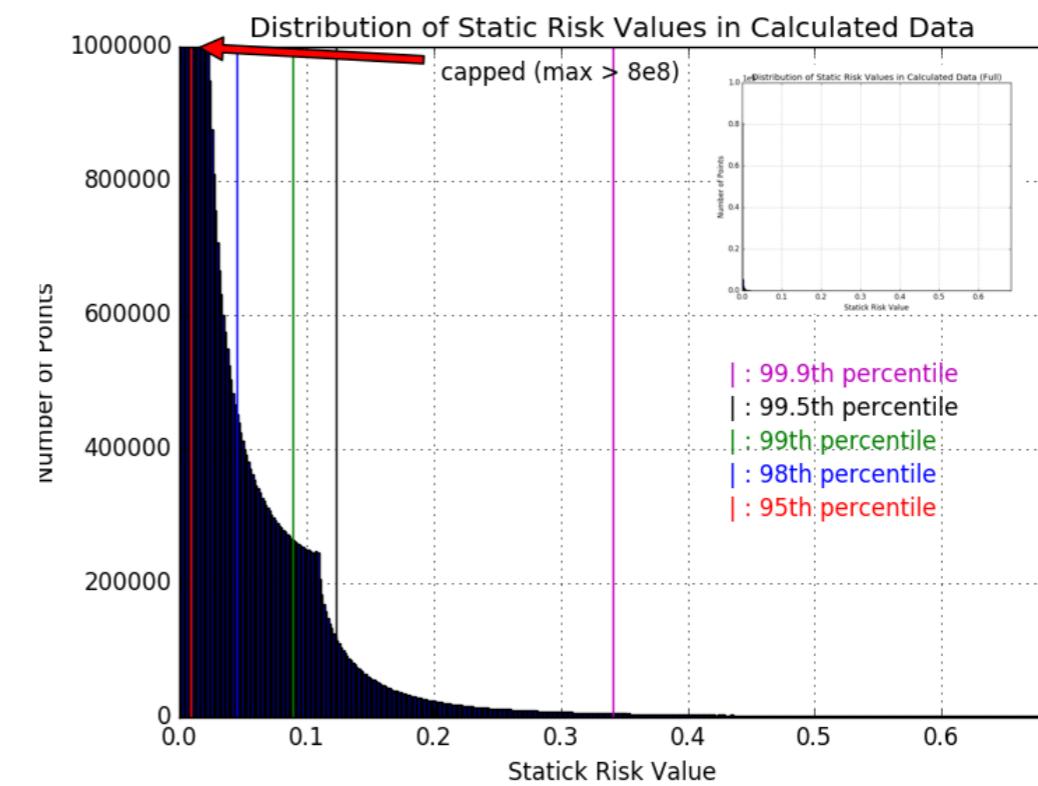
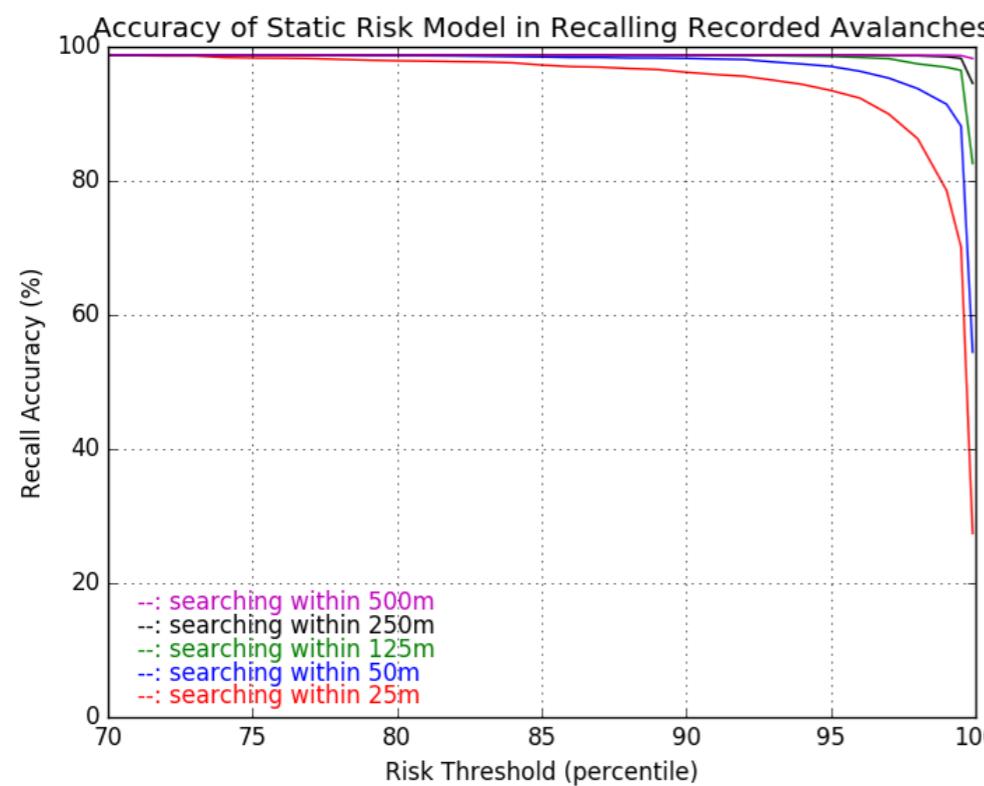
Evaluation: Accuracy of the Static Risk Model

Classifying positive identification requires a threshold on test area.

Our representative accuracy: **70.12% - 98.69%** correct identification of past avalanches, covering 0.5 - 30% of test area.

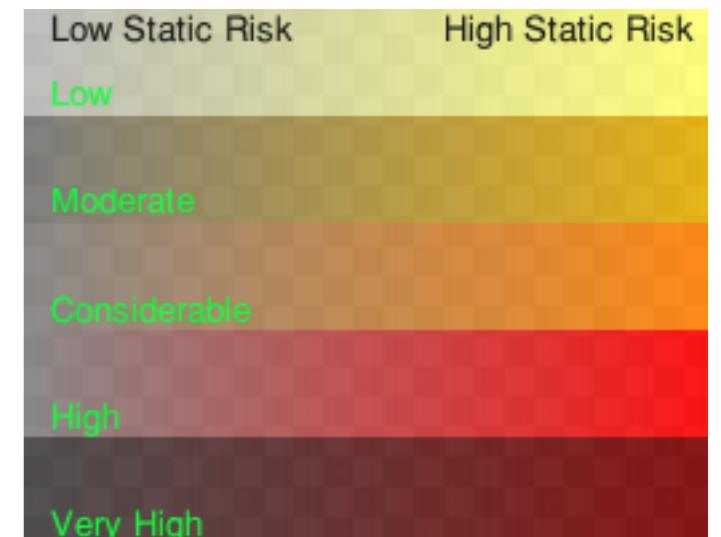
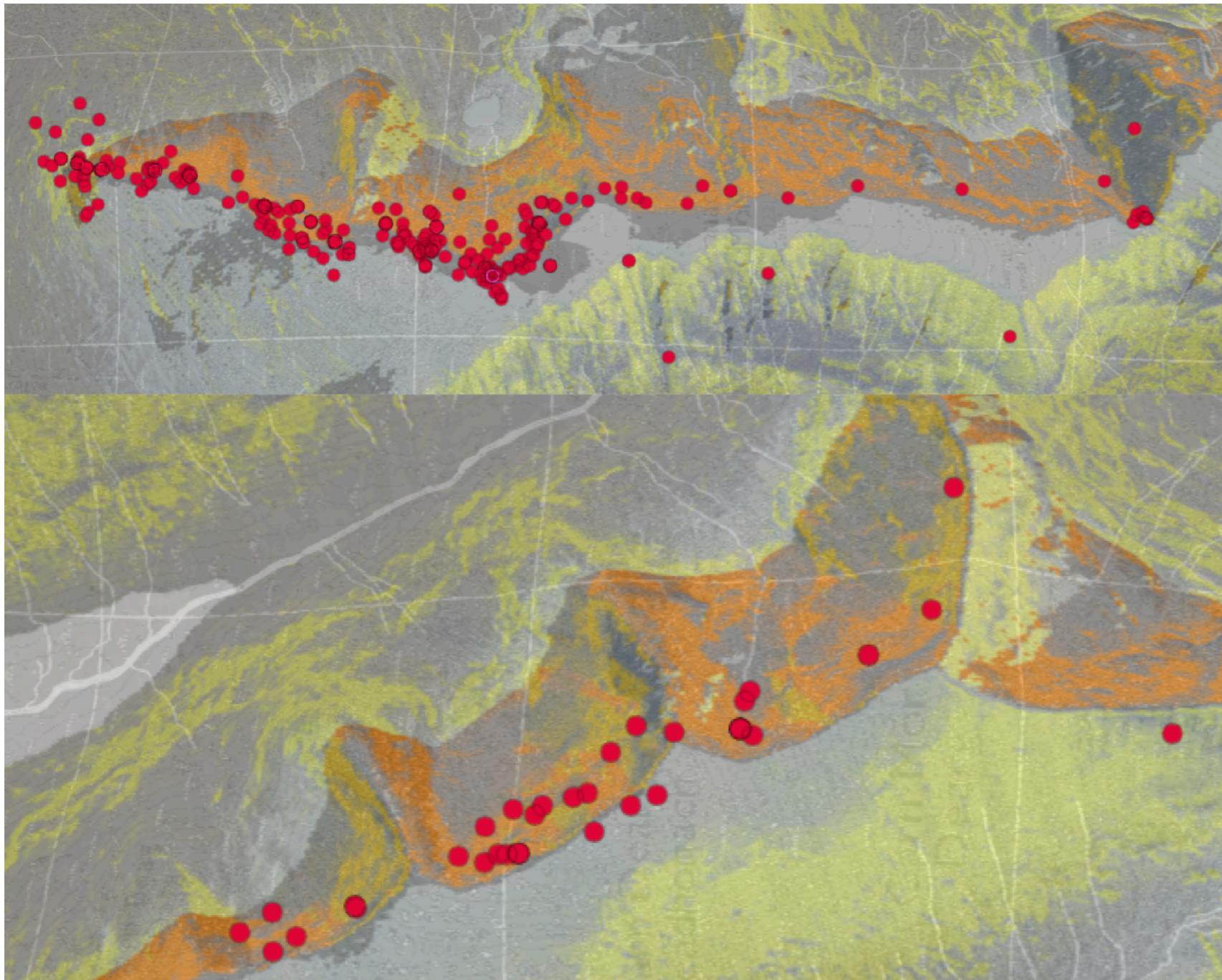
Best previous effort: 67-82% covering minimum 7% test area.

(Ghinoi and Chung, 2005)



Past avalanches data: SAIS avalanche records, 1991-2017

Past avalanches since 1991, in comparison with our risk model



Location: two different areas of Ben Nevis, Lochaber

Evaluation: User Testing

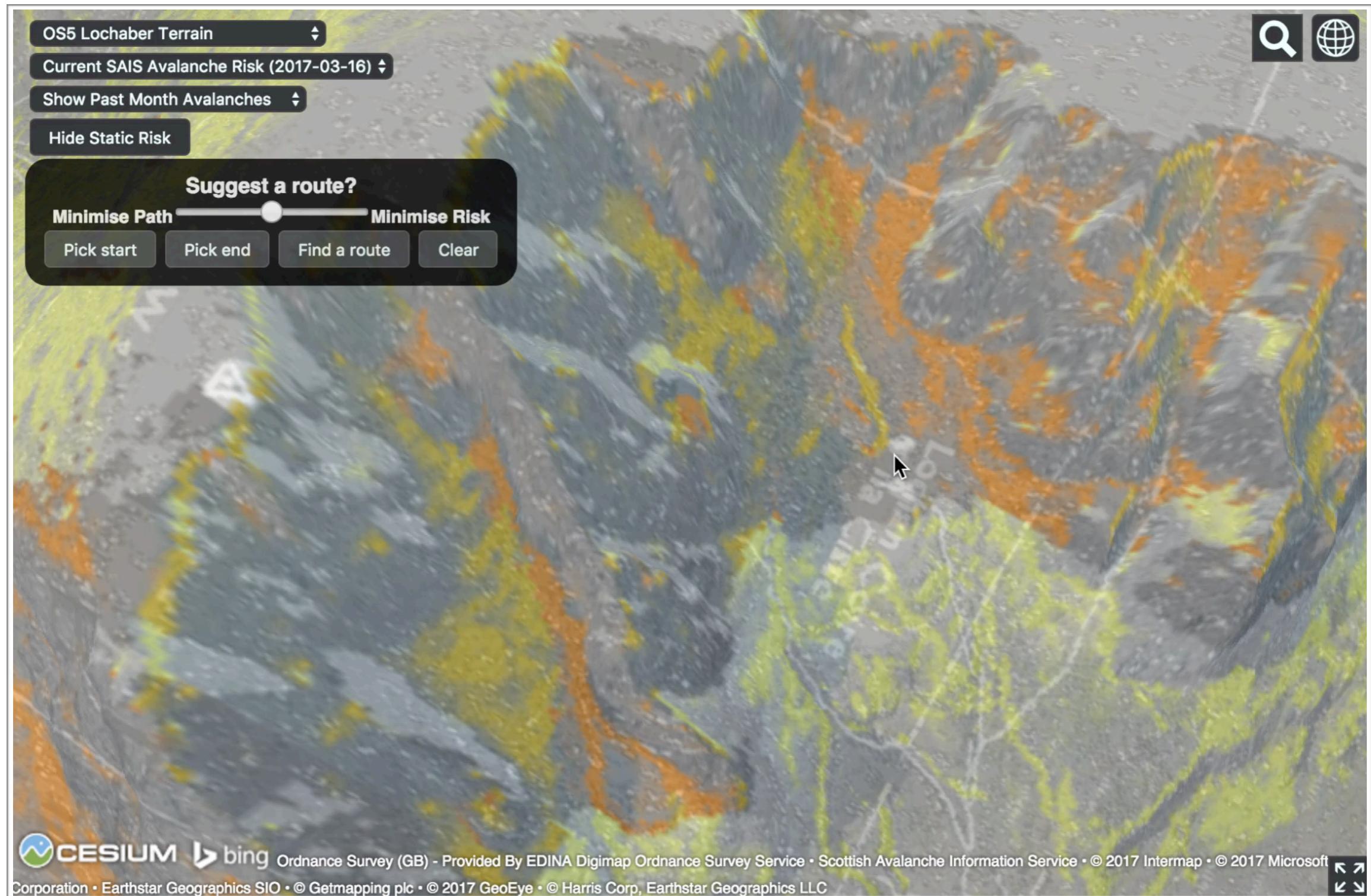
- Invited an experienced mountaineer to test use the application and compare with the traditional map-and-forecast method.



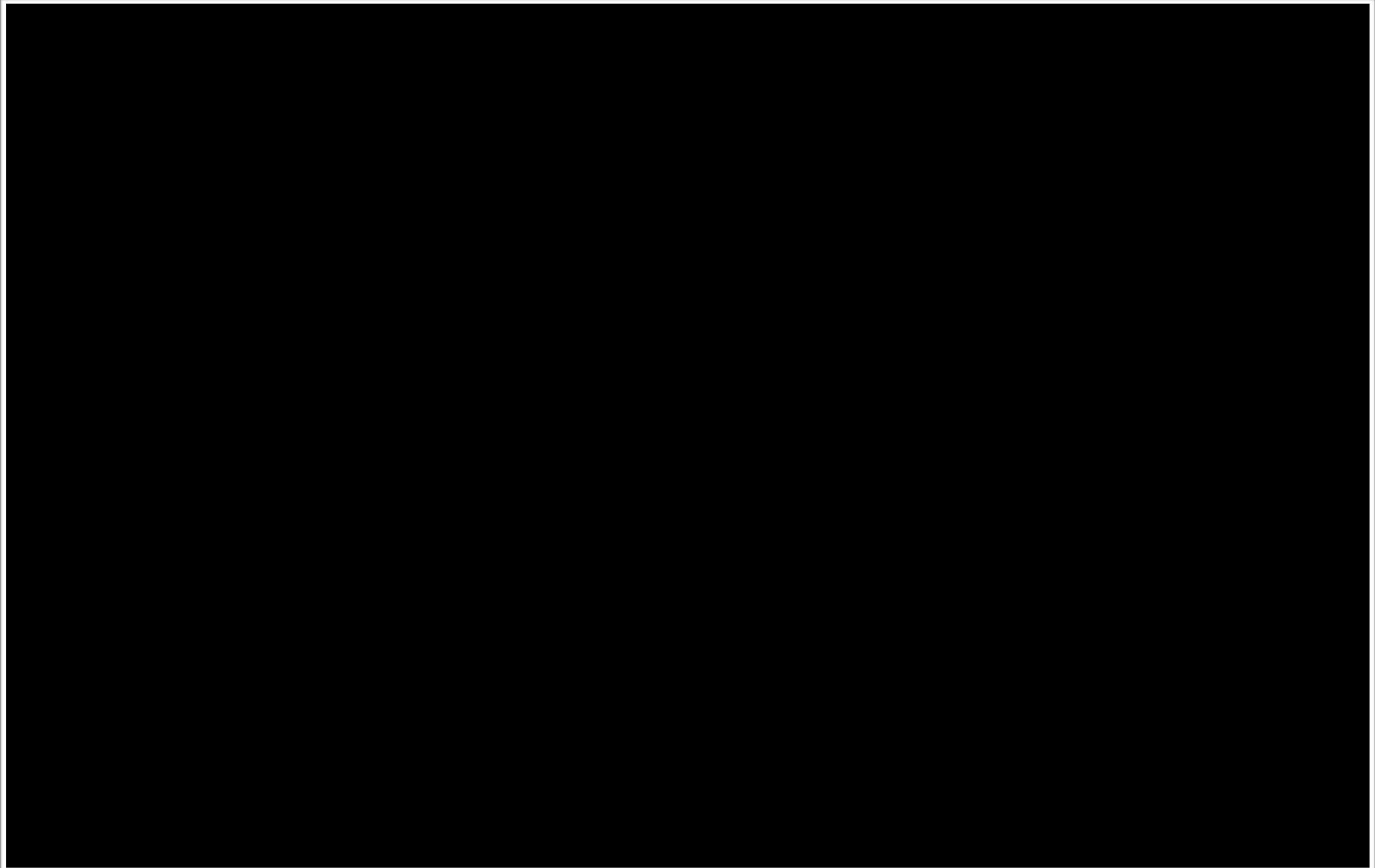
Future Work

- More dynamic information layers (snowfall, etc.)
- Advanced static risk analysis (vertical effects, cornices, etc.)
- Combined evaluation of static and dynamic risk models with more computing power.

Demo: 3D Terrain Explore



Demo: Terrain Pathfinding



Many thanks!

- **Literature:**
- B. Barton and B. Wright, *A Chance in a Million?: Scottish Avalanches*. Scottish Mountaining Trust, 2000.
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- Y. Bühler et al., “Automated identification of potential snow avalanche release areas based on digital elevation models,” *Natural Hazards and Earth System Sciences*, vol. 13, no. 5, p. 1321, 2013.
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- A. Ghinoi and C.-J. Chung, “STARTER: a statistical GIS-based model for the prediction of snow avalanche susceptibility using terrain features—application to Alta Val Badia, Italian Dolomites,” *Geomorphology*, vol. 66, no. 1–4, pp. 305 – 325, 2005.