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Identification of avalanche-prone areas through topographic analysis in Nunavik, Canada

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General context

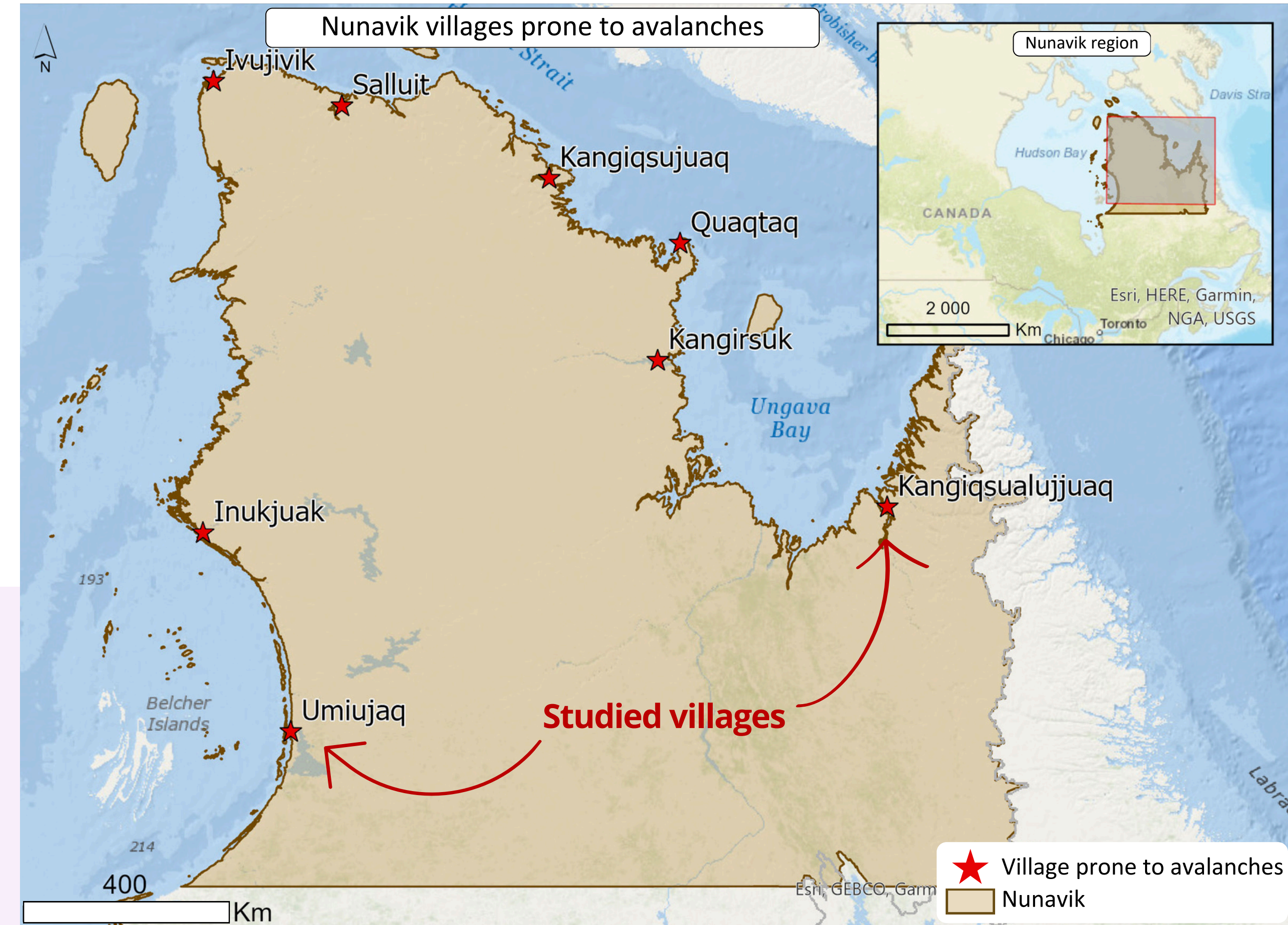
Nunavik, a northern Quebec region located beyond the 55th northern parallel and characterized by a hilly terrain, presents **topographic and meteorological conditions** that may lead to slope hazards.

Glacial valley + Snowfall + Winter thawing episodes = Avalanche-prone conditions

The rapid **population growth** in the Inuit communities in **permafrost thawing context** results in **village expansion** towards potential avalanche-prone areas, thus **further exposure of inhabitants**.

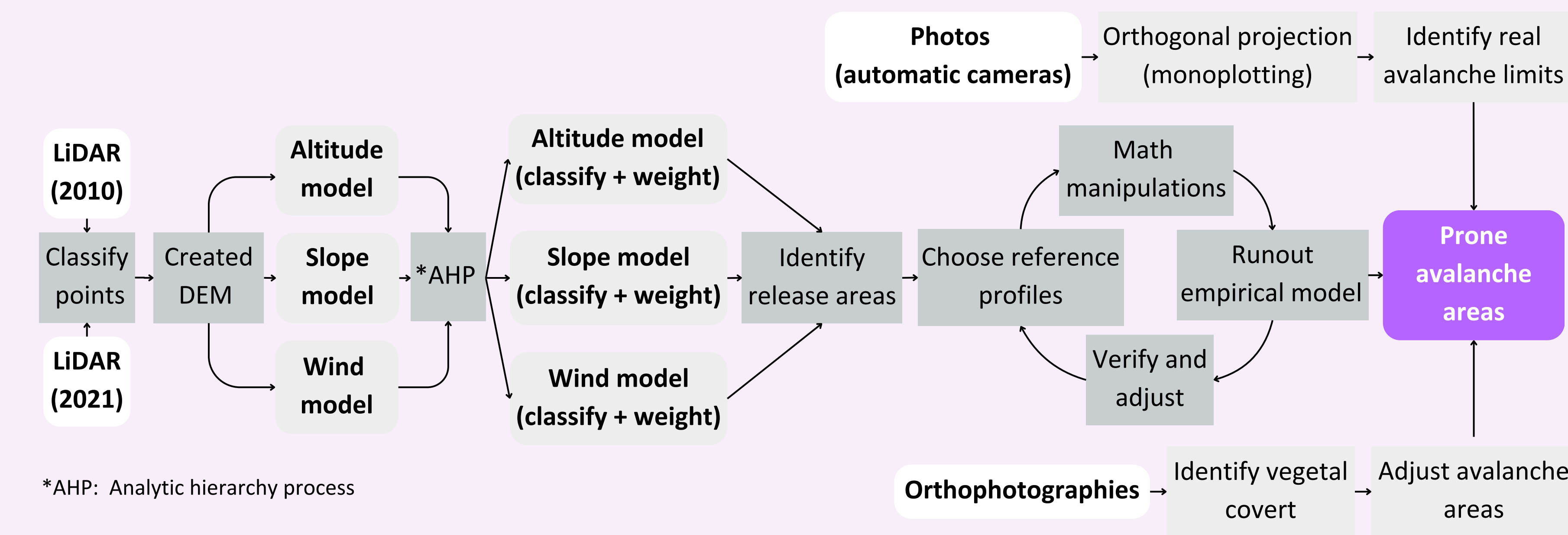
Seven Inuit villages were identified in 2000 as **prone to avalanches**: Inukjuak, Ivujivik, Salluit, Kangiqsujaq, Quaqtaq, Kangirsuk, and Kangiqsualujuaq; we also identified Umiujaq in 2016.

Historical data on slope events are **very limited or nonexistent**, thus there is a need to update and enhance knowledge related to avalanche conditions in Nunavik.



Methods

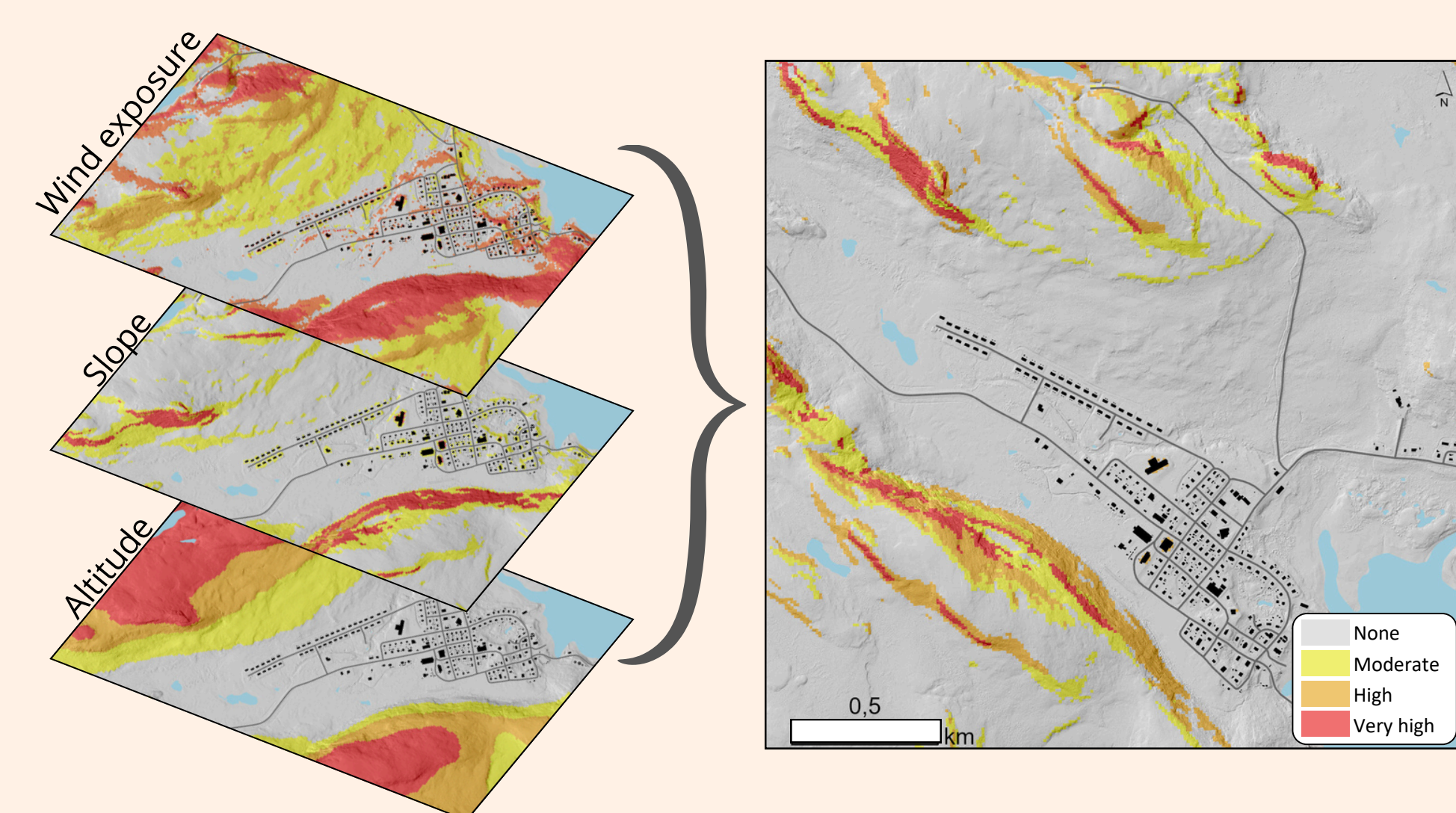
- 1) Producing a digital elevation model (DEM) with classified LiDAR data
- 2) Using DEM to **calculate and classify the variables** needed in the analysis (altitude, slope, wind exposure)
- 3) **Weighting** the variables considering their contribution in avalanche release (multicriteria analysis)
- 4) Identifying the **avalanche-prone release areas**
- 5) Estimating the **runout distance** with an **empirical topographic model**
- 6) Using the **images** taken by automatic trigger cameras and **monoplotting** for validation purpose



Analyses and results for Kangiqsualujuaq

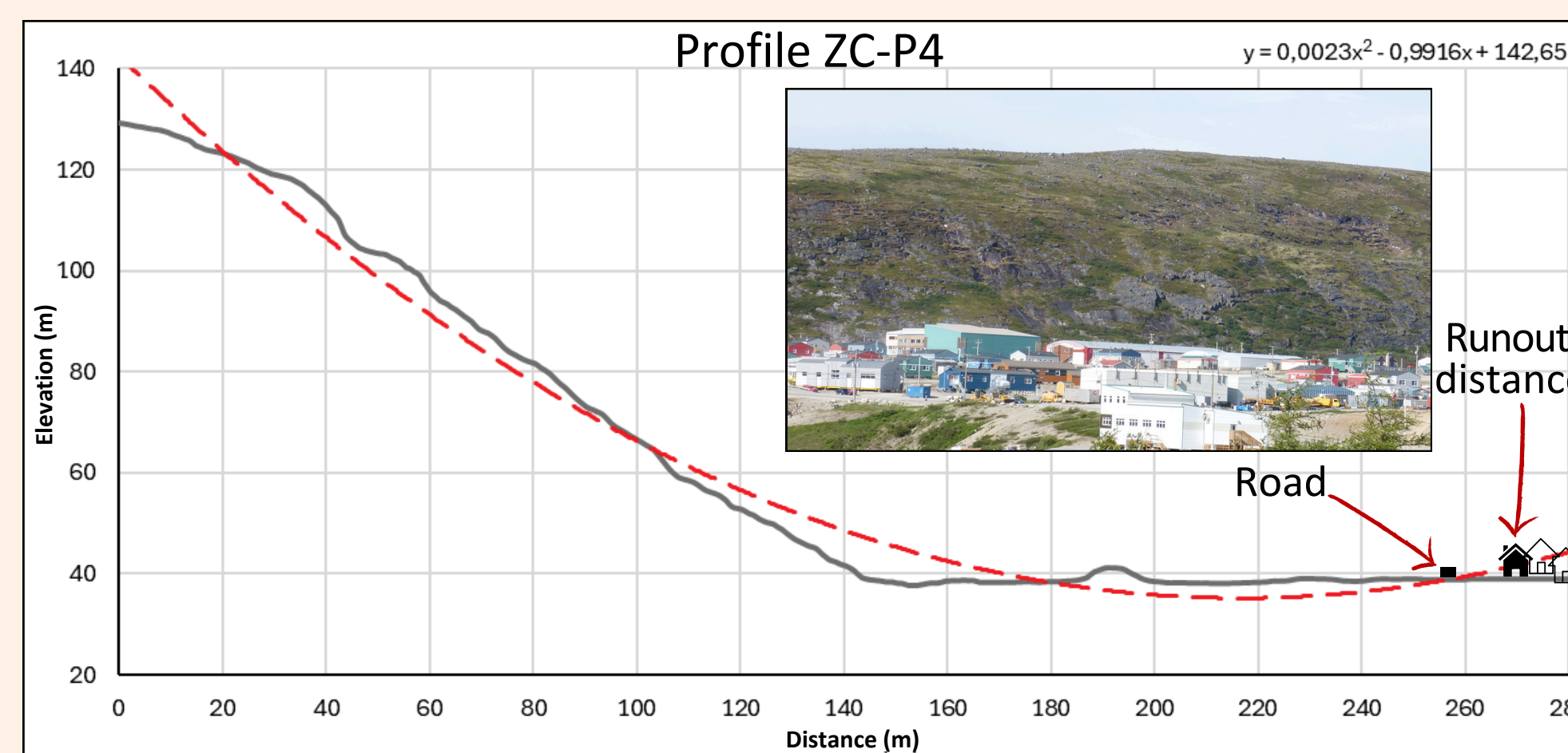
January 1999, a **deadly avalanche** occurred in the village of Kangiqsualujuaq (northeastern Nunavik): 9 people killed (including 5 children), 25 injured.

1. To identify avalanche release area

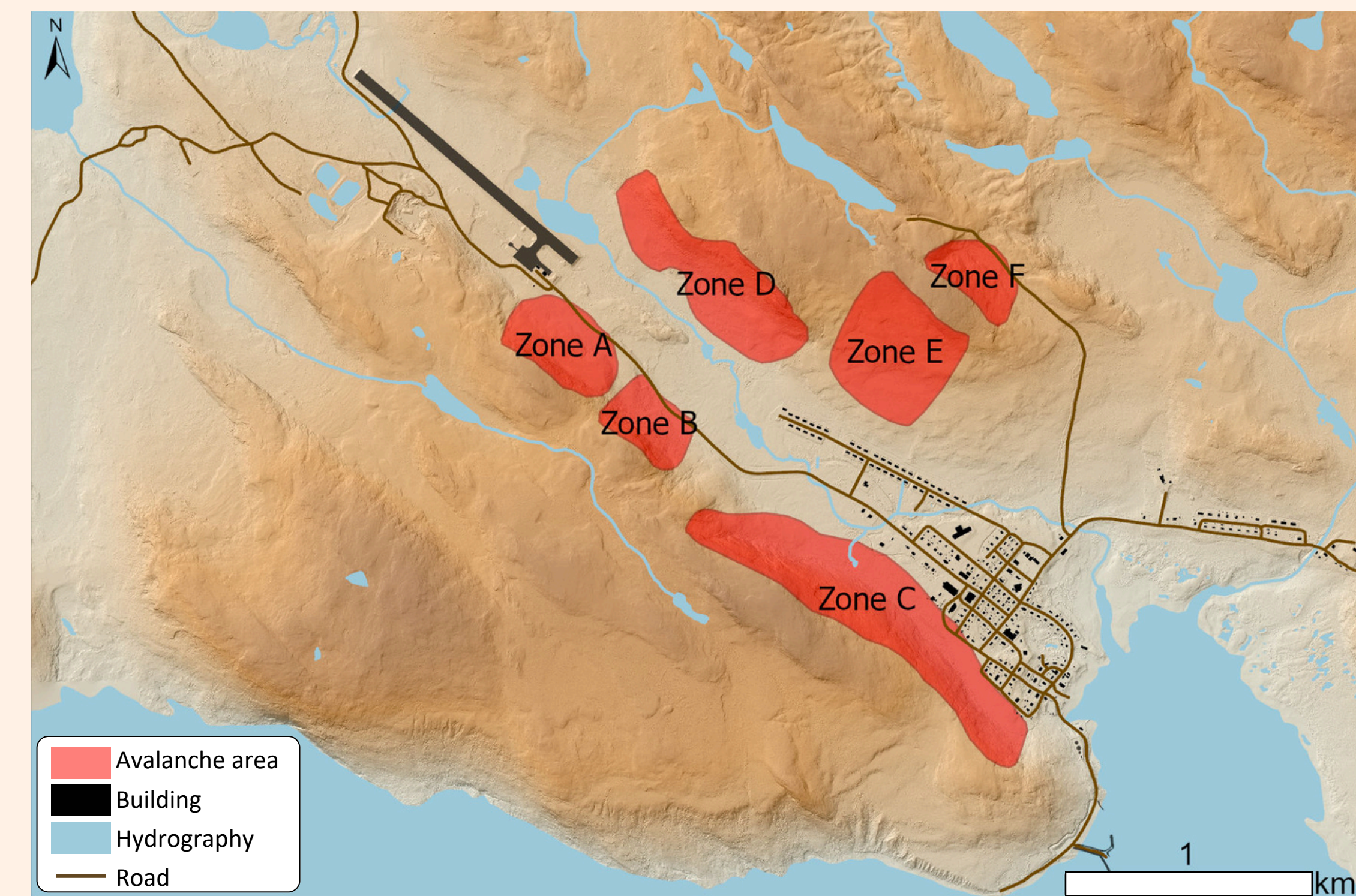


3. Empirical model to estimate runout distances

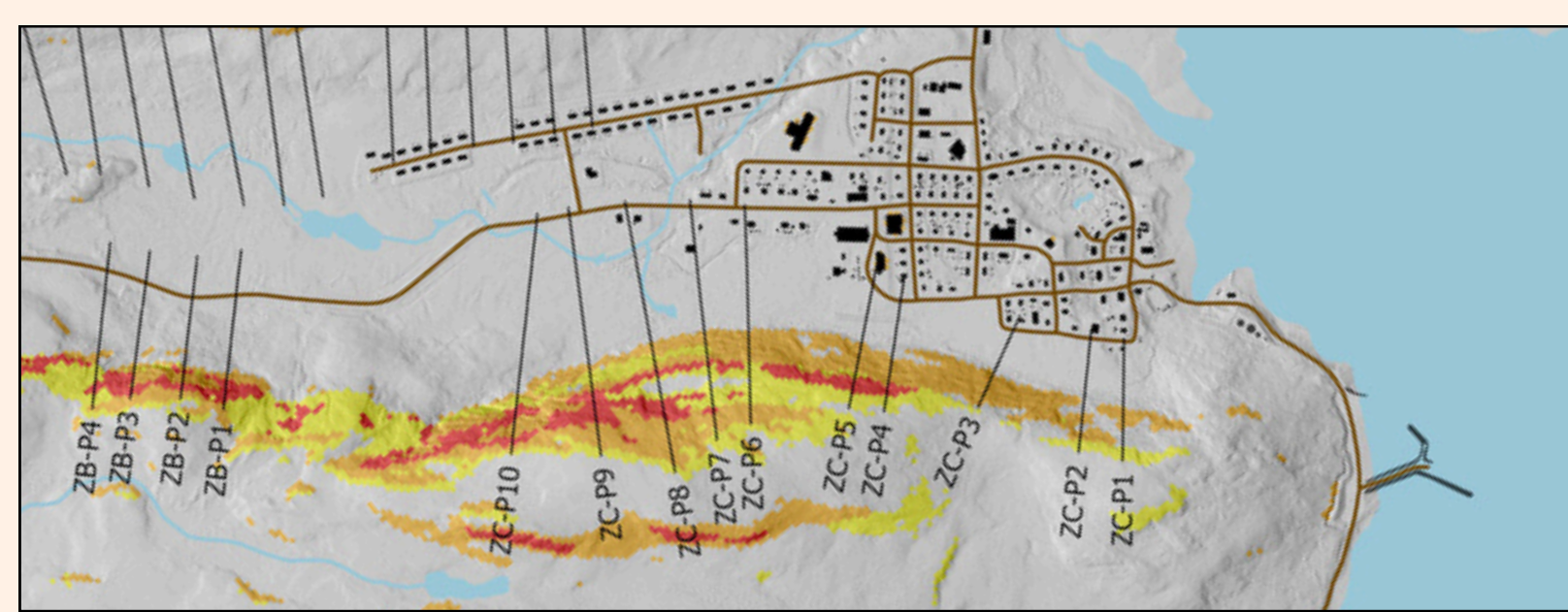
$$\alpha_P = 21.11 + 22.41H_0y'' - 3.02TP + 0.01H_0 - C_PSE$$



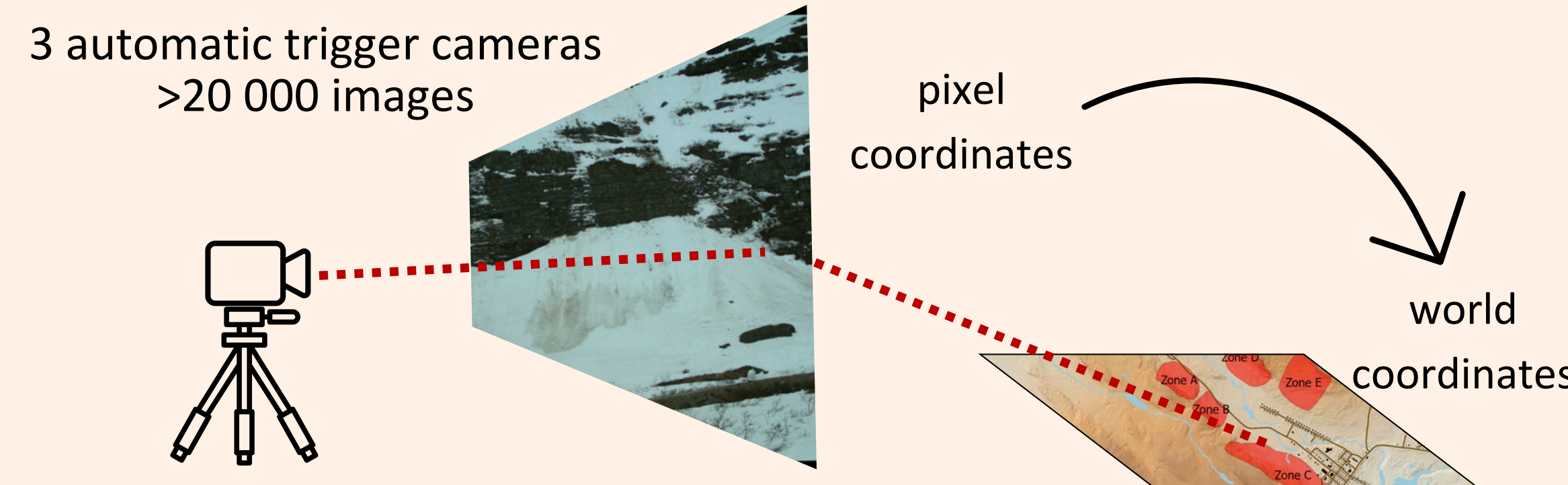
5. Map of avalanche-prone areas



2. To choose reference profiles



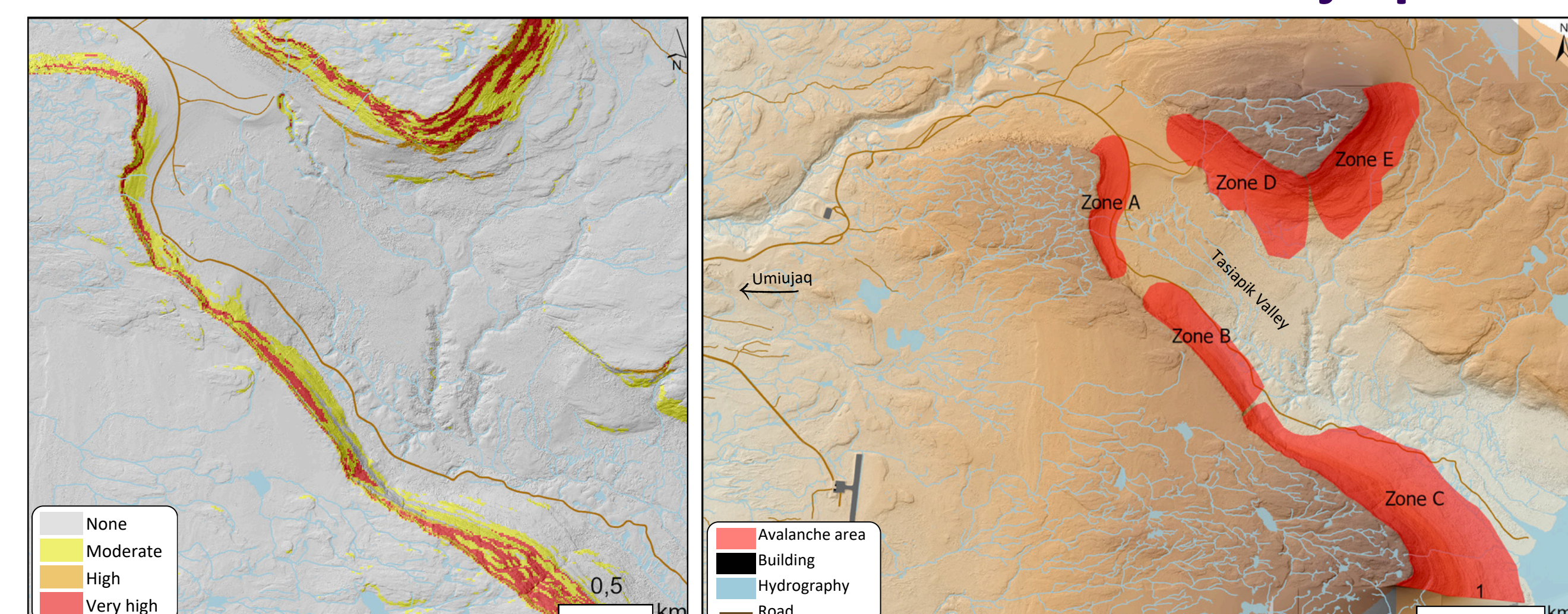
4. Validation through monoplotting



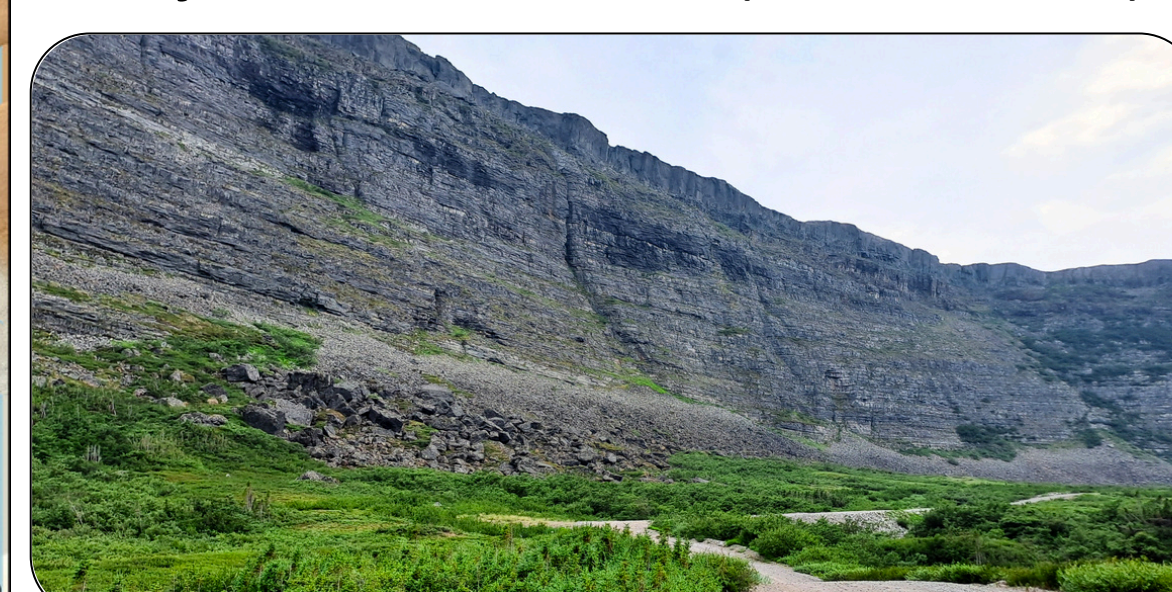
6. Results

- Prone-avalanche areas > 1.5 km²
- Potential issues for the population or the infrastructures:
 - Zones A-B: Access road to the airport
 - Zone C: Streets and some buildings
 - Zone F: Access road to the water reservoir
- Zone E: Prone to slush avalanche which can reach further downslope.

Results for Umiujaq



- Prone-avalanche areas > 3 km²
- Zones A-B-C: Cross the access road to the Tursujuq National park.
- Zones D-E: Traditional activities off-trails
- Major role of the wind (snow cornice)



Conclusion

This study enables the validation and mapping of avalanche potential near the villages of Kangiqsualujuaq and Umiujaq despite the absence of historical data. It shows that some slopes present potential issues that need to be addressed and considered in the planning of village expansion.

Avalanche-prone conditions in Nunavik: absence of tall vegetation, significant slope, sufficient relief, winter thawing episodes, wind exposure, increase in snowfall, etc.

Further work is ongoing for the villages of Inukjuak, Ivujivik, Salluit, Kangiqsujaq, Quaqtaq and Kangirsuk.