CASE STUDY 5

Snow

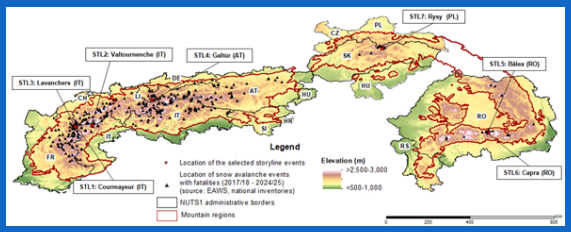
CrossEU

European Alps
Carpathians Mountains

Context

Snow avalanches represent a major mountain hazard with increasing complexity due to climate change. This case study investigates how evolving snow conditions, interact with socio-economic dynamics across the European Alps and Carpathian Mountains. Using a composite climate hazard index (CHI), terrain susceptibility estimations, climate projections with the perspective of 2030, 2050 and 2100 (scenarios RCP4.5/SSP2 and RCP8.5/SSP5), and regional socio-economic indicators, the study evaluates the socioeconomic vulnerability and potential risks to communities, tourism, transport, and forests in the NUTS3 regions having at least 30% share of mountain areas on their administrative territory.

The study selected **seven major avalanche storyline events** based on their significant impacts - fatalities and damages to tourism infrastructure, road networks, and forests - as reference points for hazard and risk assessment in regions with a history of intense avalanche activity.



Spatial distribution of the selected snow avalanche storylines in the European Alps and Carpathian Mountains

Climate Change Hotspots (CCH)

European Alps

- **CCH1 (southeastern France and northwestern Italy)**, including parts of the Haute-Alpes, Savoie, Haute-Savoie, Drôme, Alpes-de-Haute-Provence and Valle d'Aosta NUTS3 regions, showing moderate to very high hazard levels across all timeframes.
- **CCH2 (south-central Switzerland and northern Italy)**, particularly around the Valais, Graubünden, Uri, Ticino, Oswalden and Sondrio NUTS3 regions, known for historic avalanche activity and complex terrains.
- **CCH3 (western Austria and northern Italy)**, including Tiroler Oberland, Osttirol, Pinzgau-Pongau and Bolzano NUTS3 regions, where dense tourism infrastructure overlaps with high hazard levels.

Carpathians Mountains

- **CCH4 (northern Slovakia and southern Poland)**, notably in the High Tatra region, especially in Nowotarski and Zilinsky kraj NUTS3 regions, where high hazard levels persist from the baseline through end-century scenarios.
- **CCH5 (central-southwestern Romania)**, covering the mountain areas of Brașov, Sibiu, Hunedoara, Gorj, Caraș Severin, Argeș, Prahova and Vâlcea NUTS3 regions, where hazard level is shifting from moderate to high levels.
- **CCH6 (northeastern Romania)**, particularly Maramureș and Bistrița-Năsăud MUTS3 regions, where localized hazard intensification is expected.

Objectives

The research objectives of the case study are:

1. **Storyline development:** Identification and documentation of significant avalanche events using various sources (i.e., avalanche inventories, press releases, rescue reports);
2. **Climate hazard analysis:** Evaluation of snow avalanche hazard conditions, considering weather triggers, terrain-prone susceptibility and defining specific snow-hazard indicators.
3. **Hotspot identification:** Detection of climate change hotspots based on seasonal trends snow-hazard indicators (e.g., fresh snow accumulations, rain-on-snow events).
4. **Socio-economic vulnerability assessment:** Analysis of socio-economic vulnerability at the NUTS3 level using sector-specific sensitivity and adaptive capacity indicators;
5. **Potential risk estimation:** Estimation of the current and future snow avalanche potential risk for coomunities and sensitive sectors (tourism, transport, forestry) under different RCP/SSP scenarios with the perspective of 2030, 2050 and 2100 future time-horizons.

Methods

CSA5 applies a **multi-step framework** to assess the socio-economic vulnerability and potential risk of snow avalanche in mountain communities and sensitive sectors (tourism, transport, and forestry) at NUTS3 level across the Alps and Carpathians.

Step 1: Analysis of climate and socio-economic scenarios. Analysis of changes in climate hazard conditions, based on CERRA and EURO-CORDEX datasets (RCP4.5/SSP2 and RCP8.5/SSP5 scenarios) and demographic trends (2030, 2050, 2100).

Step 2: Spatial aggregation. Climate hazard and socio-economic data (sectoral exposure, sensitivity and adaptive capacity) are combined and aggregated at the NUTS3 level.

Step 3: Assessment of impacts. Impacts are expressed as number of fatalities at NUTS1 level.

Step 4: Estimation of the potential risk. Risk is estimated following IPCC/ESPON-Climate 2022 risk evaluation framework (Risk = Hazard x Exposure x Socio-Economic Vulnerability).

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