



AVALANCHES

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INTRODUCTION



Traditionally the isolation of the mountain regions has limited the danger of avalanches for the people living there. However, population pressure and the increase in alpine based, recreational activities has widened exposure to the hazard.

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INTRODUCTION

PRESENTATION TOPICS:

- Theory; types and modes of initiation
- Avalanche frequency and fatalities
- Mitigation techniques
- Case studies
- Disaster pressure model
- Future climate change

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THEORY: AVALANCHE TYPES



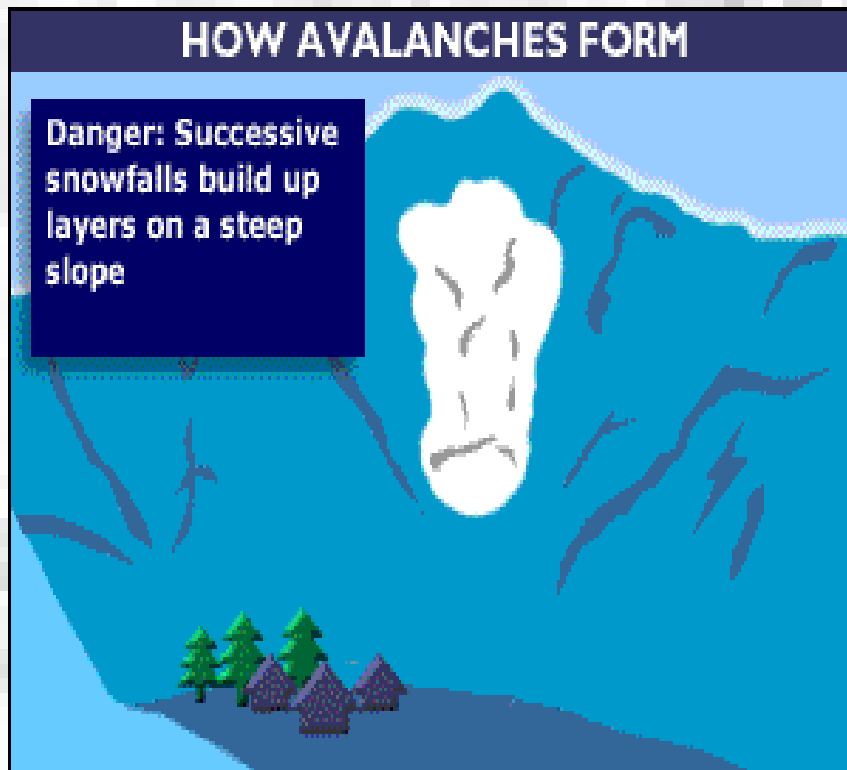
- **Loose snow avalanches**
 - **Surface snow**
 - **Wet and dry**
- **Slab avalanches**
 - **Traditional type**
 - **Rectangular block**
 - **Wet and dry**
- **Ice avalanches**
- **Slush avalanches**
- **Roof avalanches**

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THEORY: AVALANCHE TRIGGERING



- **LOSS OF COHESION**
 - Solar melt
 - Precipitation
 - Complex failure at depth
- **ANTHROPOGENIC**
 - Recreation
 - Deliberate snow release
- **TECTONIC ACTIVITY**
- **VOLCANIC ACTIVITY**

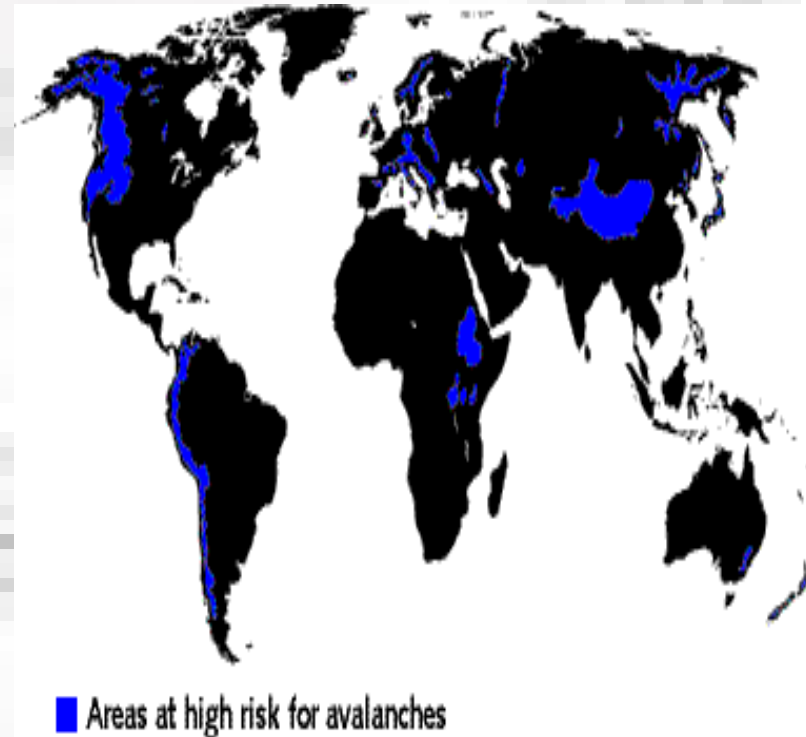
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AVALANCHE FREQUENCY

- 1 million per year.
- Mostly during spring melt season
- Occur in mountainous regions of the developed and developing world.
- Press coverage ensures European and North American events receive more attention.



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AVALANCHE FATALITIES



- **1765 deaths in North America and Europe since 1985.**
- **332 deaths globally since 1996, but probably more.**
- **Fatality records in developing nations are unreliable.**
- **Highest fatalities during spring melt.**

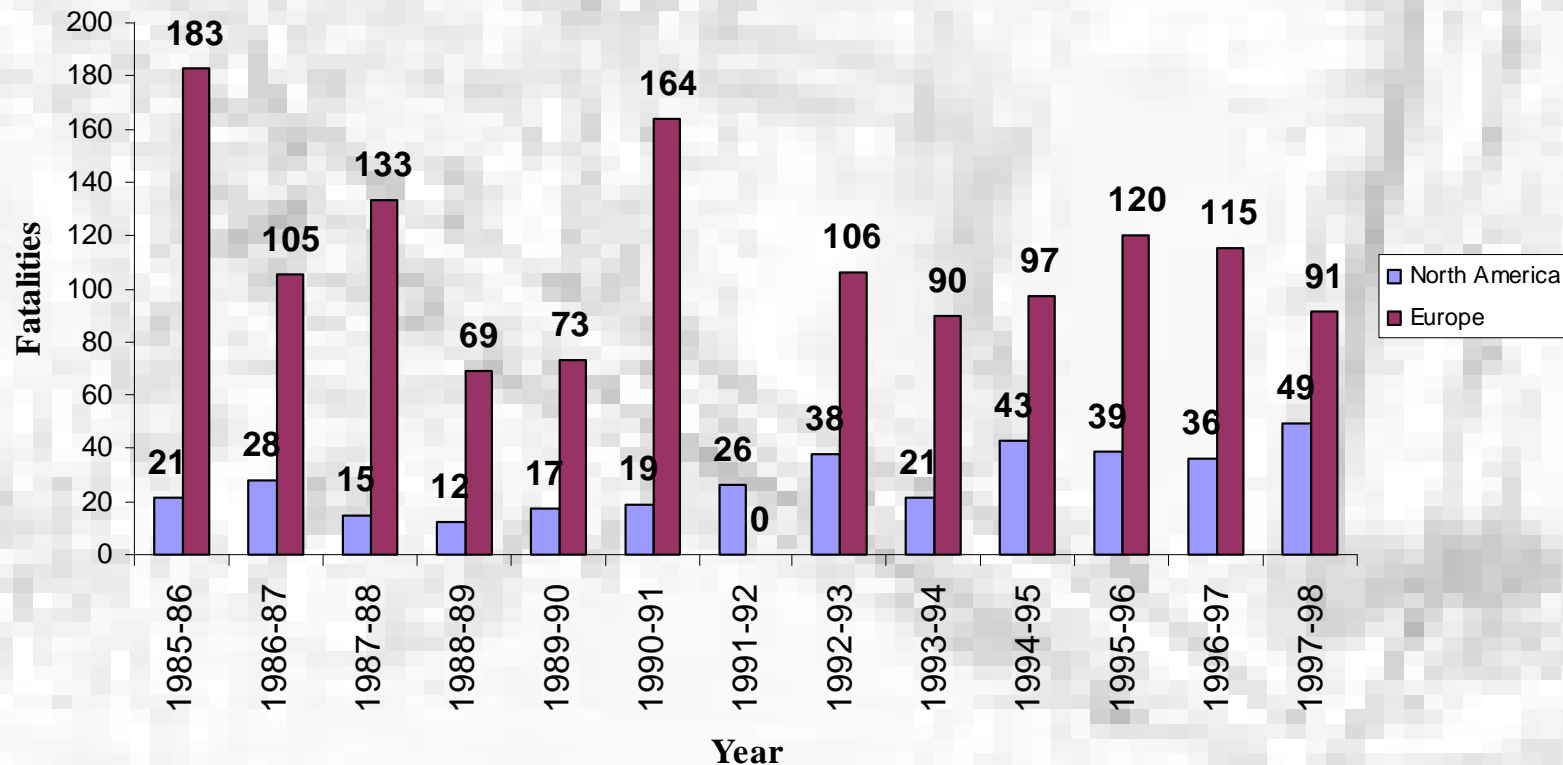
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FATALITIES IN EUROPE AND NORTH AMERICA

(Source: Colorado Avalanche Centre)



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Avalanche mitigation



- **With human populations placing themselves at risk from avalanches, the need to protect populated areas and the infrastructure they contain has increased.**
- **Especially in developed nations, it is not economically viable to close down or evacuate areas of avalanche prone terrain during periods of greatest risk.**
- **National and local governments are required to adopt mitigation techniques.**

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Avalanche prevention: structural methods

- **Snow rakes, nets and fences:**

Driving purpose is to retain the snow and to stop it drifting into unstable accumulations.

- **Jet rooves:**

These prevent the build up unstable cornices by accelerating wind speeds to discourage snow settlement.

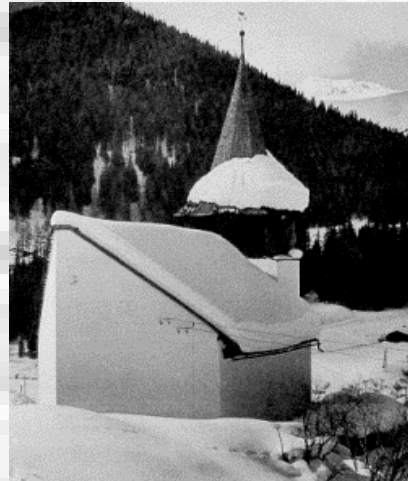


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Damage limitation: structural methods



- **Arrester dams, snow walls and earth mounds:** can all be placed in the avalanche track or run out zone. These structures vary in cost and size and are intended to reduce the power of an active avalanche.
- **Modified building design:** this may be legally enforced and involved the strengthening of vulnerable constructions.
- **Railway and road tunnels:** can be built to ensure vital communication links are not disrupted.

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Damage limitation: non-structural methods

- **Deliberate avalanche triggering:**

Releases snow in a controlled manner, 10,000 are triggered in the USA annually.

- **Land Zoning and building regulations:**

Limits and modifies construction in avalanche prone areas, reducing the presence or clustering of people in avalanche tracks or run out zones will reduce the risk to them.

- **Afforestation:** provides a natural barrier that reduces the destructive power of the



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Education and planning



- Making snow users more aware of the potential risk of accidental avalanche triggering.
- Using historical records to determine areas at greatest risk.
- Use of meteorological equipment to predict avalanche potential.

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CASE STUDY: AUSTRIA 28/3/2000

- Kitzsteinhorn Mountain, Kaprun, near Salzburg.
- 500m X 1000m snow slab.
- Triggered by off-piste snow boarders following rain and solar melt.
- 11 people in a ski class down-slope died.



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CASE STUDY: RUSSIA 2/2000



- **Mount Elbrus, Karbardino Balkaria, Russia.**
- **Triggered by icefall due to spring thaw.**
- **Killed seven mountaineers.**
- **The remote location and the size of the avalanche reduced further casualties.**
- **Rescue involved 70 rescuers but hampered by poor weather.**

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DISASTER PRESSURE MODEL:

Conceptual model for avalanches

- ROOT CAUSES
- DYNAMIC PRESSURES
- UNSAFE CONDITIONS

After: Blaikie et al. (1994)

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ROOT CAUSES

- Economic exploitation of avalanche prone regions.
- Conflict of interests: protection vs. profit.
- The often self imposed proximity of man:
 - **People living in at risk regions,**
 - **People travelling over avalanche prone terrain.**

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DYNAMIC PRESSURES

- Urbanisation of mountain regions.
- Increased populations; permanent and transient.
- Deforestation, e.g. Austrian Tyrol.
- Lack of risk awareness is a problem in both developed and undeveloped nations, especially amongst recreational snow-users.
- Ignorance of warnings.

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UNSAFE CONDITIONS

- **Physical environment:**
 - **Heavy snowfall,**
 - **Precipitation,**
 - **Melting.**
- **Influence/presence of man:**
 - **Recreation and leisure,**
 - **Accidental triggering.**
- **Vulnerable society:**
 - **Lack of protection, both structural and non-structural; risk awareness or action plans,**
 - **Poor economic status.**

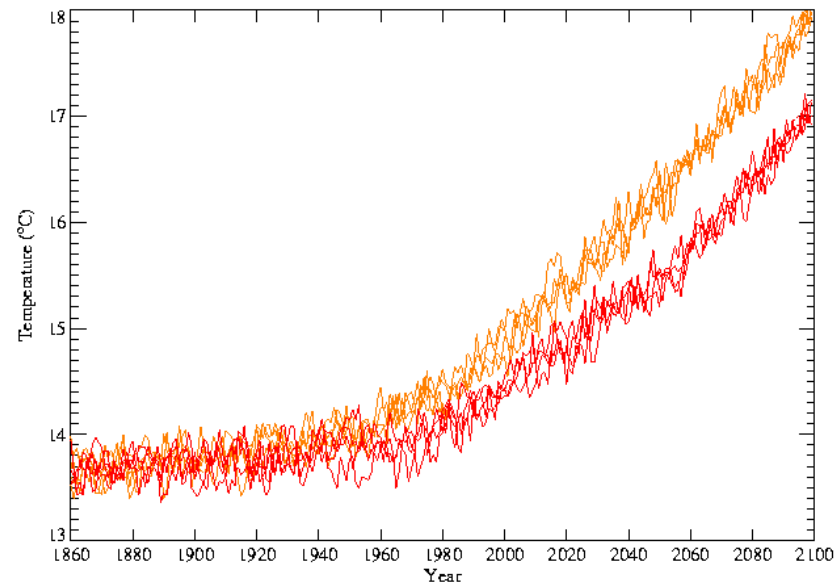
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AVALANCHES AND FUTURE CLIMATE CHANGE

- **Projected temperature rise of 1-3.5°C by year 2100.**
- **Global precipitation expected to increase by 5-80%, predicted using GCMs.**
- **Effects upon avalanche formation and frequency?**



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PREDICTED AVALANCHE CHANGES IN UNITED KINGDOM

- **Scottish Highlands.**
- **2-3°C warmer by 2100 with increase in precipitation.**
- **Avalanche frequency is likely to reduce if temperature rise outweighs precipitation increase.**
- **Temperature increase will raise the snowline by approximately 300-500 metres.**
- **Summit slope accumulation only, may reduce avalanche occurrence.**
- **Scottish avalanches, a thing of the past?**

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PREDICTED AVALANCHE CHANGES IN EUROPEAN ALPINE REGIONS

- **2-3°C temperature increase by 2100.**
- **Reduction in avalanche frequency at low altitude due to rise in snow-line.**
- **At higher altitudes increased precipitation will counteract rises in temperature to give larger snow deposits and a potentially greater avalanche frequency.**
- **Increases in freak snow storms are expected to promote unstable cornice formation.**

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PREDICTED AVALANCHE CHANGES IN NORTH AMERICA

CASCADE RANGE

- Maritime climate.
- Higher snowfall especially at high altitudes will increase snow-pack.
- However, higher temperatures (+2°C) may reduce snow cover at low altitudes.
- Low altitudes expected to see a reduction in avalanches.
- High altitudes predicted to experience a slight increase.

ROCKIES

- Continental climate.
- Similar temperature increase may reduce snow accumulation at low altitudes. Higher altitudes may be less affected.
- The drier continental climate is expected to show decrease in snowfall.
- This may reduce snow cover and avalanche occurrence.
- Low altitudes affected more than high altitude regions.
- Increased temperatures may alter the mechanism of snow-pack failure

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CONCLUSIONS.

- Natural hazard enhanced by anthropogenic activity.
- Temporal and spatial global variation in occurrence and impacts.
- Varying mitigation techniques reduce risk to vulnerable populations.
- Future climate change may increase or decrease risk, dependant upon global location

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