Improving avalanche forecasting: requirements and challenges

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TEAMx Meeting, 6 May 2020
... in complex terrain ...
Avalanche forecasting

- Alpine countries + …
- Many different approaches
- Met offices, civil protection…

www.avalanches.org
Avalanche forecasting

- Alpine countries + …
- Many different approaches
- Met offices, civil protection…
- Some coordination:
  - 5-degree danger scale
  - Daily bulletins
  - Regional “probabilistic” forecasts

![Danger Scale](image-url)
Avalanche forecasting

• Alpine countries + …
• Many different approaches
• Met offices, civil protection…
• Some coordination:
  – 5-degree danger scale
  – Daily bulletins
  – **Regional** “probabilistic” forecasts

<table>
<thead>
<tr>
<th>Danger Level</th>
<th>Scale</th>
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<tbody>
<tr>
<td>Very high</td>
<td>5</td>
</tr>
<tr>
<td>High</td>
<td>4</td>
</tr>
<tr>
<td>Considerable</td>
<td>3</td>
</tr>
<tr>
<td>Moderate</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
</tr>
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Reuter et al. (2016)
Moderate danger of dry and wet avalanches will prevail

Avalanche danger
updated on 4.5.2020, 17:00

Wind slabs
Avalanche prone locations

- Mostly small wind slabs will form. These are in some cases prone to triggering. The number and size of avalanche prone locations will increase with altitude. The new snow of the last few days can be released in isolated cases, but mostly only by large additional loads.

- The Avalanche Warning Service currently has only a small amount of information that has been collected in the field.

Wet avalanches
Wet and gliding avalanches are possible.
Avalanche forecasting

- Alpine countries + …
- Many different approaches
- Met offices, civil protection…
- Some coordination:
  - 5-degree danger scale
  - Daily bulletins
  - Regional “probabilistic” forecasts
- Limited use of models

<table>
<thead>
<tr>
<th>Danger Level</th>
<th>Description</th>
</tr>
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<tr>
<td>5</td>
<td>Very high</td>
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<tr>
<td>4</td>
<td>High</td>
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Reuter et al. (2016)
Avalanche forecasting

- Weather forecasts, numerical model output
- Measurements:
  - automatic weather stations
  - manual observations
- Snow cover data: snow profiles
- (Avalanche) observations, estimates

Observers

Data-driven, experience-based «manual» decision-making process

→ Patterns + Experience → Forecast: danger

Uncertainty! → Verification?
Avalanche forecasting

- Primary target variable: avalanche danger cannot easily be verified.
- Avalanche danger:
  - Snowpack stability
  - (Spatial) distribution of snowpack stability
  - Avalanche size

Techel and Schweizer (2017)
Avalanche forecasting

- Primary target variable: avalanche danger cannot easily be verified.
- Avalanche danger:
  - Snowpack stability
  - (Spatial) **distribution of snowpack stability**
  - Avalanche size

<table>
<thead>
<tr>
<th>Danger level</th>
<th>Snowpack stability class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>very good, good, fair</td>
</tr>
<tr>
<td>Moderate</td>
<td>good, fair, poor</td>
</tr>
<tr>
<td>Considerable</td>
<td>poor, very poor</td>
</tr>
</tbody>
</table>

Proportion per stability class (%)

Techel and Schweizer (2017)
Schweizer et al. (2003)
Distribution of snowpack stability
Improving avalanche forecasting

- Forecast of **snowpack stability** (+ spatial distribution) with at least 100 m resolution in complex terrain.

**Meteo-logical input from NWP**

(complete energy balance at snow surface)

**Snow cover model**

(«Snow» in NWP is not enough)

[Diagram showing stability prediction and related data]
Snowpack models

• Physically-based snowpack models operate at the point scale: Crocus, SNOWPACK

• Currently implemented meteorological forcing configurations and associated geometry:
  – Station-based
  – Topographic class-based
  – Grid-based

Bellaire et al. (2018)
Morin et al. (2020)
Schweizer et al. (2016)
Improving avalanche forecasting

Requirements and Challenges

Yes, of course, numerical forecasting is the future.

- Sound prediction of instability (and avalanches)
- NWP output downscaling and data assimilation
- Realistic snow distribution: snow transport by wind
- Operationalizing model chains
- Information post-processing and visualization
- Lack of validation possibilities

How to improve?

- Better forecasts or better communication?
References


