Cartographic analysis of avalanche hazard maps

A comparison of relevant cartographic factors for the visualization of the avalanche bulletin

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Alpine touring received a real boost in the last few years

- A growing number of avalanche victims [cf. Würtl, 2005]:
  - Over 500 ski mountaineers on sunny days in some well-known areas
  - Winter season 2006/07: 22 people died, 52 people got injured
  - Winter season 2005/06: 48 people died, 72 people got injured
  - a total of 95 % of all victims trigger the avalanche themselves

Avalanche basics

- the dry slab avalanche is the „killer“

- a slab is a cohesive plate of snow that slides as a unit on the weak layer

- typically about 150 m long, about 50 cm deep, accelerates to around 130 km/h.

- the rapid addition of the weight of a person can easily initiate the fracture of the slope.

- meteorological and topographical factors are responsible for such terrible threats:

    - meteor. factors: wind, temperature, solar radiation

    - topogr. factors: morphology, aspect, height, slope

    [Tremper, 2001]

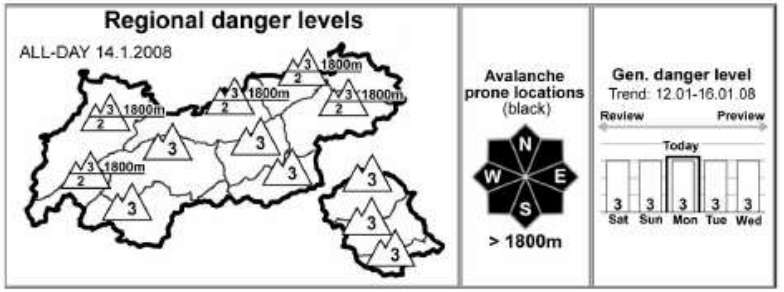
Avalanche bulletin

- Headline
- Avalanche hazard map
- The Avalanche hazard level according to the European avalanche hazard scale
- The avalanche danger and avalanche prone locations
- The composition / condition of the snow blanket (setting, layering, wetting)
- The past and present weather situation and the snow blanket resulting from it
- The assumed further development of the situation (prognosis)

[cf. Land Tirol, 1988]

Lawine **Avalanche Bulletin**
Monday, 14.01.2008, at 07:30 Uhr for Tyrol

Considerable avalanche danger widespread



Avalanche Danger:
In the backcountry skiing regions of Tyrol, generally unfavourable conditions prevail, with considerable avalanche danger.
Avalanche prone locations are found on steep slopes, areas adjacent to ridge lines and snowdrift-filled gullies and bowls in all aspects above approximately 1800 m. The snowpack is highly trigger-sensitive, a slab can be unleashed even by minimal additional loading, including the weight of one single backcountry skier or freerider.
The hazards of natural avalanches have diminished somewhat. Nonetheless, caution must be exercised, in particular on extremely sunny slopes.

Snow Layering:
In the past 24 hours a few centimeters of snow fell in East Tyrol only. All measurement stations show significant consolidation of the new snow. In areas adjacent to ridge lines and in those areas subject to foehn winds in particular, new snowdrift accumulations have formed.
The new snow and the snowdrift cover an old snowpack extremely prone to triggering, particularly in inneralpine regions: the base consists predominantly of a floating snow layer; yet also further up in the snowpack, loosely packed intermediate layers and surface crust are deposited which could form avalanche glide surfaces. The high trigger-sensitivity of the snowpack was corroborated yesterday by numerous natural avalanches as well as by avalanches triggered by backcountry skiers and freeriders. The snow layering along the northern flank of the Alps is somewhat more favourable.

Alpine Weather Forecast (ZAMG Weather Service Innsbruck):
A complex low front over Iceland and England will supply Tyrol with very cloudy, relatively mild Atlantic air. Intermittently foehn weather patterns are expected repeatedly in the course of the week. From the southwest, cloudbanks of a disturbance not affecting North Tyrol will move across the land today, although on the southern flank of the Alps light showers cannot be ruled out.
Tyrol's mountain summits are generally clearly visible, only the peaks from the Ötztal to the Ortler group are in clouds. The cirrostratus clouds moving in will dim views of the distance and make contours in the snow difficult to recognize. The freezing level is at 1800 m, the foehn winds will be evident primarily on the Main Alpine Ridge. Temperatures at 2000 m will be minus 2 degrees, at 3000 minus 7 degrees. High altitude winds will be moderate, on the Main Alpine Ridge strong southwesterly winds of 40 km/h will prevail.

Short-term development:
The avalanche danger is not expected to diminish soon.

Rudi Mair

Avalanche Warning Service Tyrol

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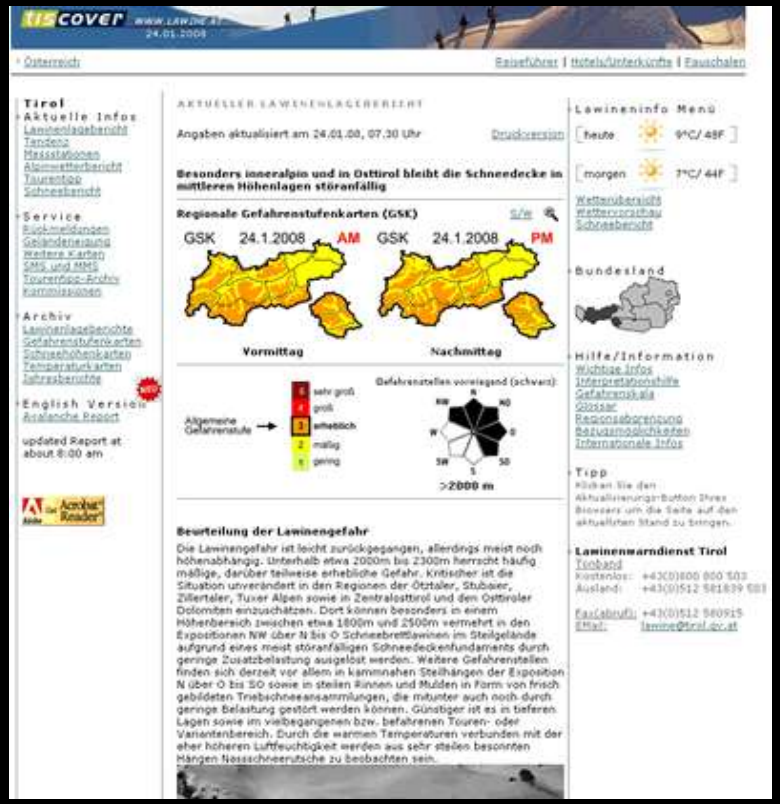
Relative frequency of the avalanche bulletin-check	
Avalanche bulletin-Check	**Percentage**
Several times a week	43 %
Only while planning a tour	32 %
Every day in winter	22 %
Rare	2 %
Never	1 %



Avalanche hazard map

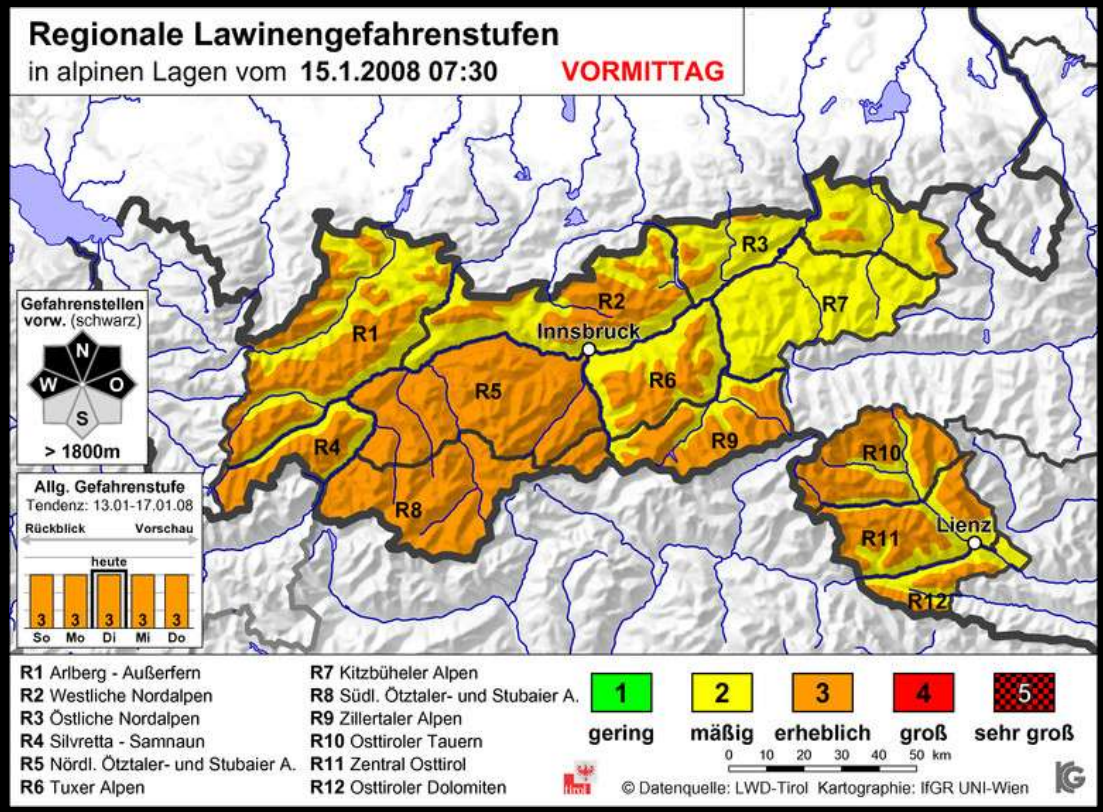
- incorporates mainly a topographic map with thematic avalanche features [Kriz, 2003].

- communicates the information quickly

- „translates“ the very difficult and specific written avalanche bulletin

- shows current avalanche risk levels

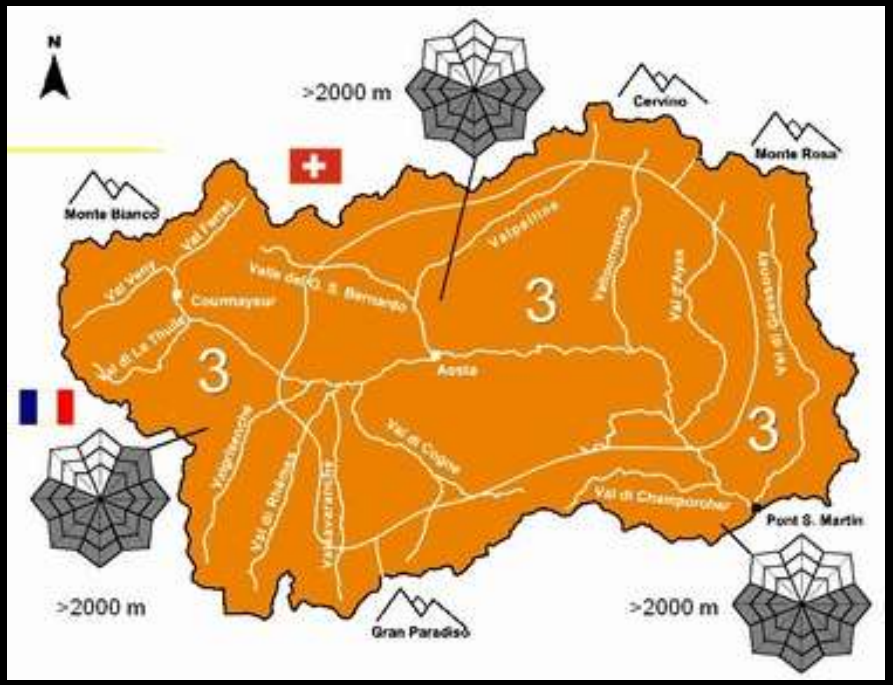
THIS IDEAL CASE IS NOT ALWAYS GIVEN!



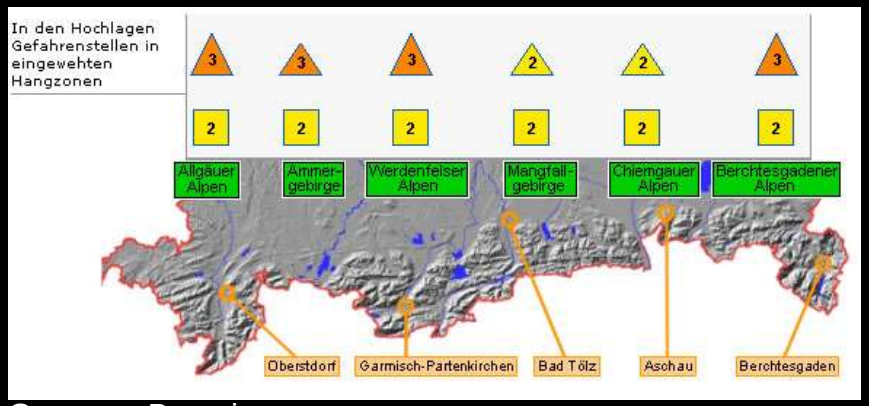
Questionnaire

- cartographic analysis of the avalanche hazard maps of 26 avalanche warning services in Europe

- range of cartographic products from high quality visualizations over simple bitmaps to hazard charts



Italy



Germany Bavaria

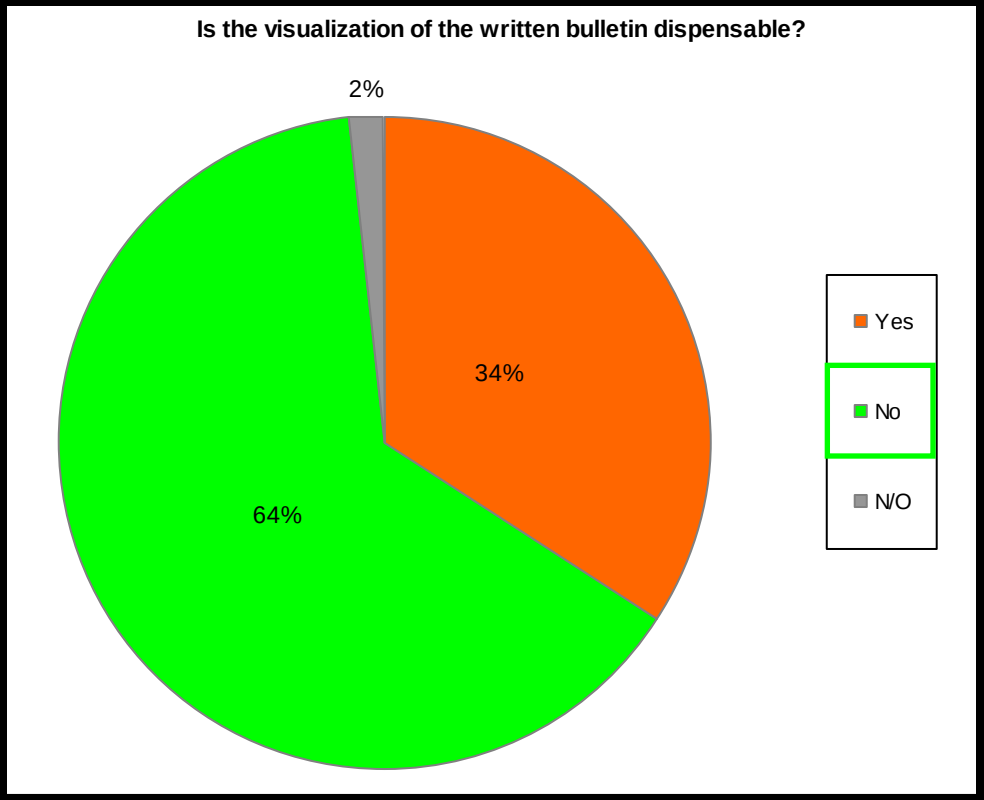
Lavínová situácia na horách dňa 24.01.2008 o 9.oo hod.

Poveternostné podmienky v odtrhových zónach lavín

Pohorie:	Vysoké Tatry	Západné Tatry	Nízke Tatry	Veľká Fatra	Malá Fatra
Stupeň lavínového nebezpečenstva:	3 - zvýšené	3 - zvýšené	2 - mierne	1 - malé	2 - mierne
Tendencia lavínového nebezpečenstva:	→ zotrvalá	→ zotrvalá	→ zotrvalá	→ zotrvalá	→ zotrvalá

Slovakia

- a survey carried out on 167 protagonists was made:
  - maps with detailed hazard levels for small, well-defined areas are indispensable
  - maps with the hazard level dissolved over a large area is dispensable



Is the Avalanche hazard map dispensible?

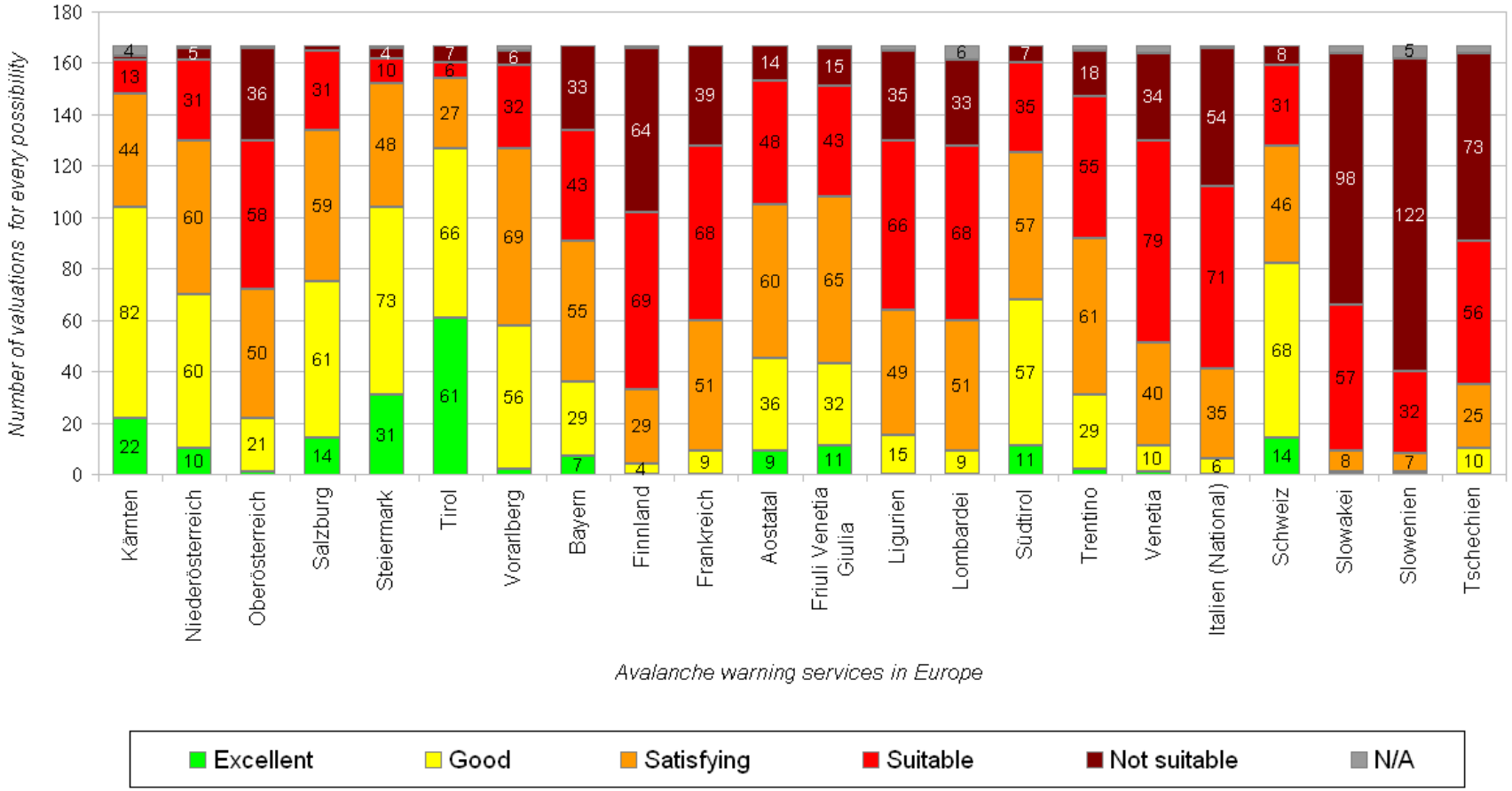
= 64 % say NO

- a consistent high-quality standard for avalanche hazard maps, following common cartographic rules should be achieved

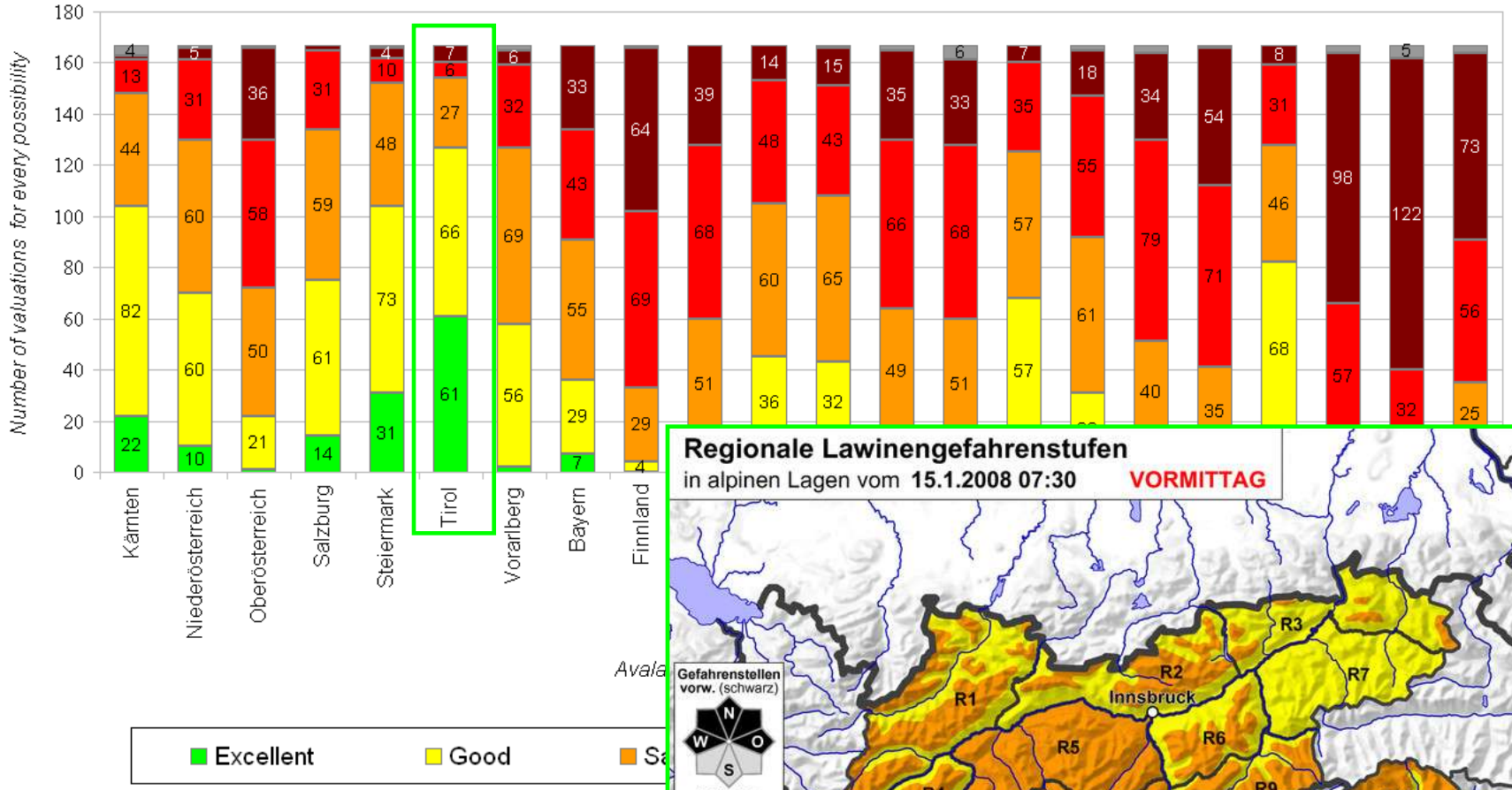
- the avalanche hazard map should fulfill its role as a carrier of communication and information in the sense of the cartographic communication process.

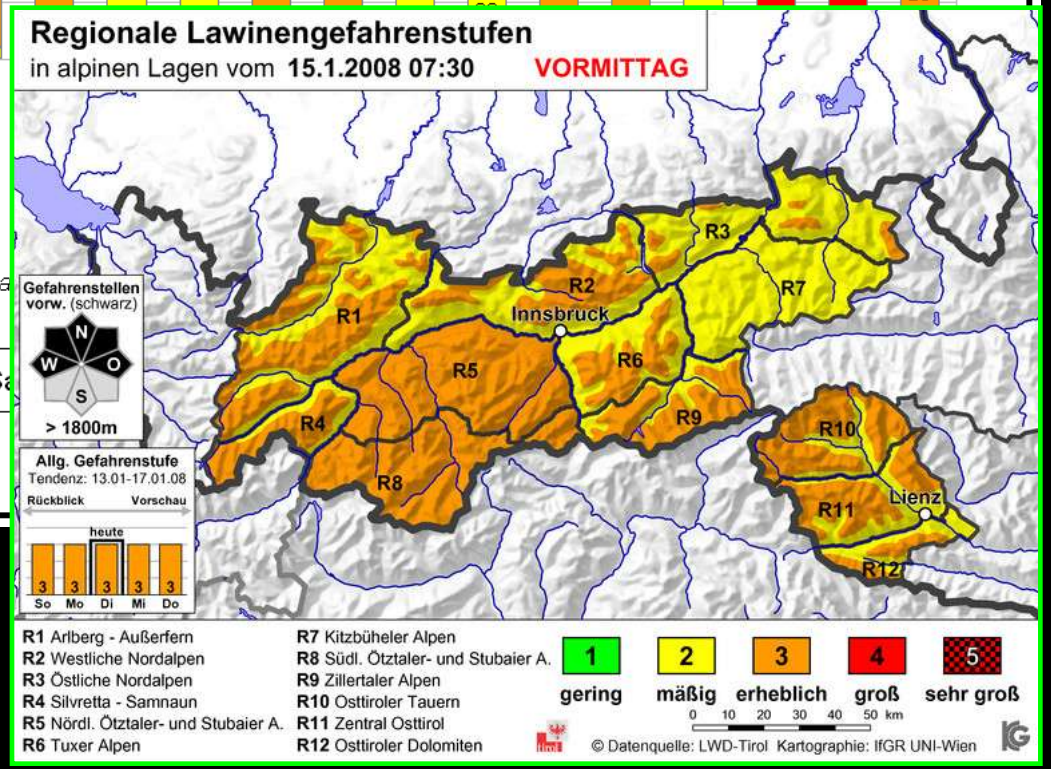
- the avalanche hazard map offers a direct connection between the cartographic product and the user, as well as the possibility to respond.

Valuation of the visualized avalanche hazard maps in Europe



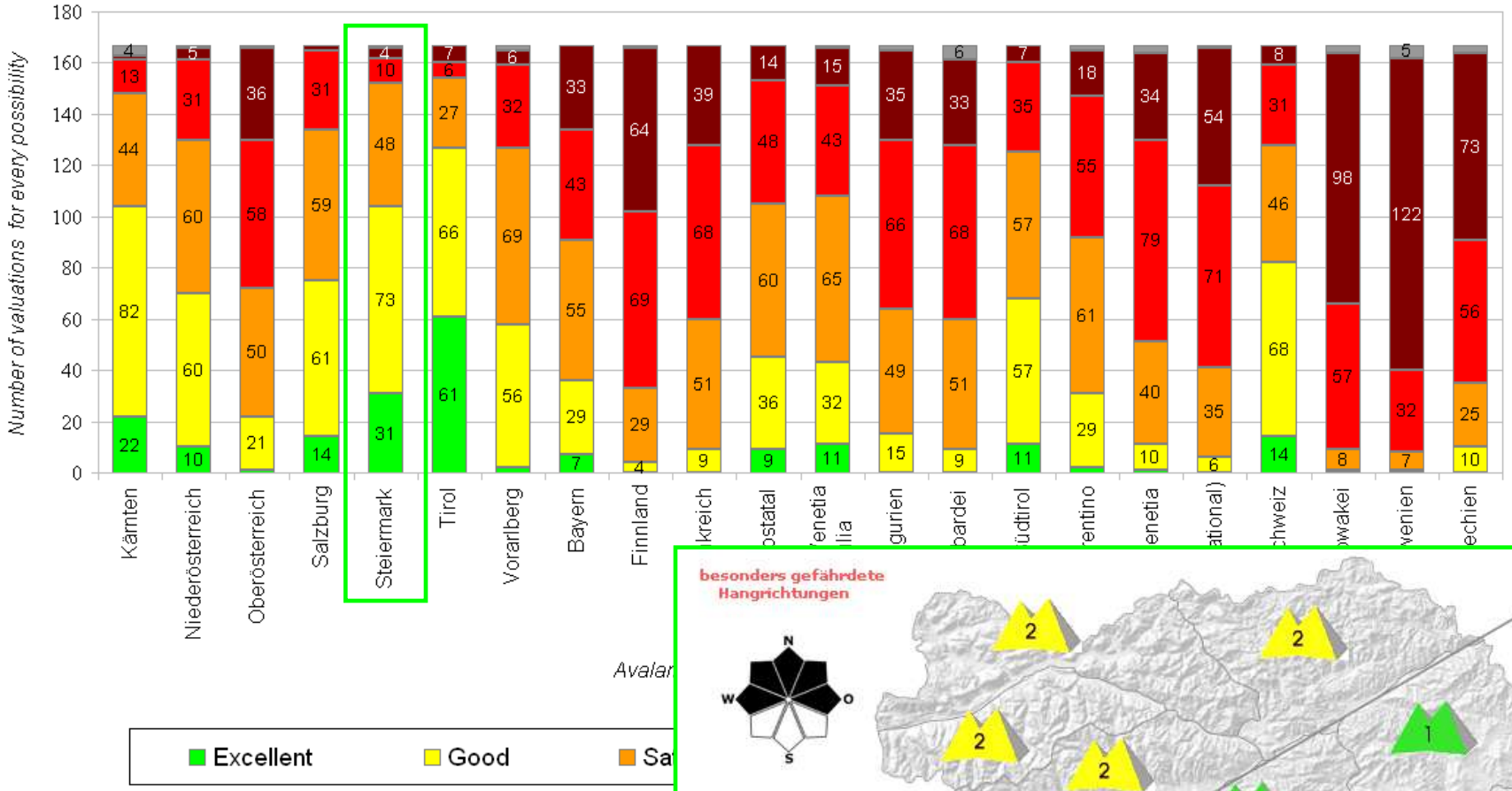
Valuation of the visualized avalanche hazard maps in Europe

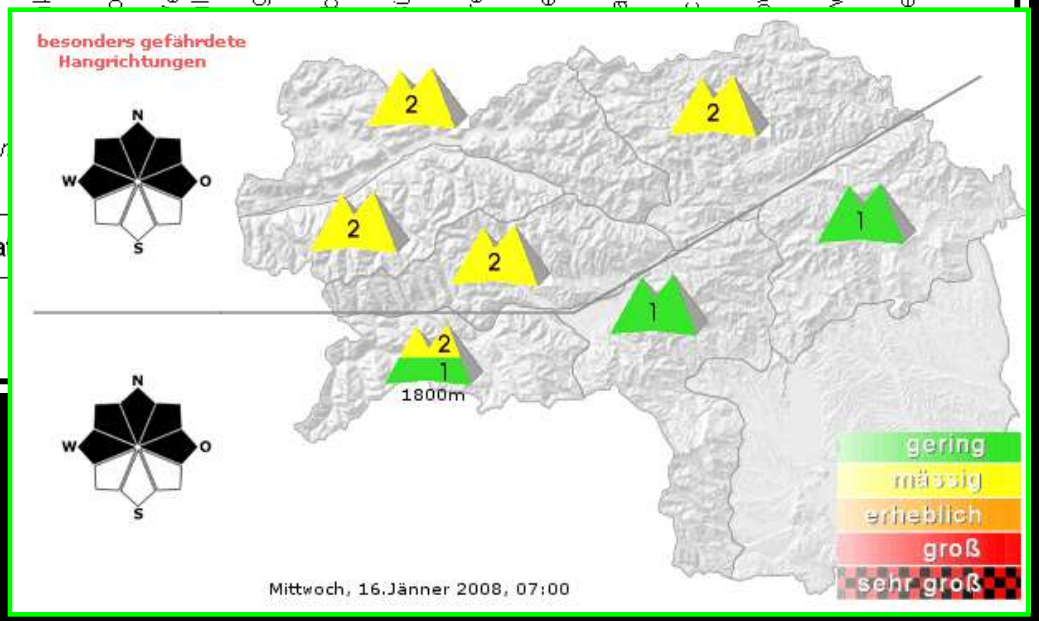




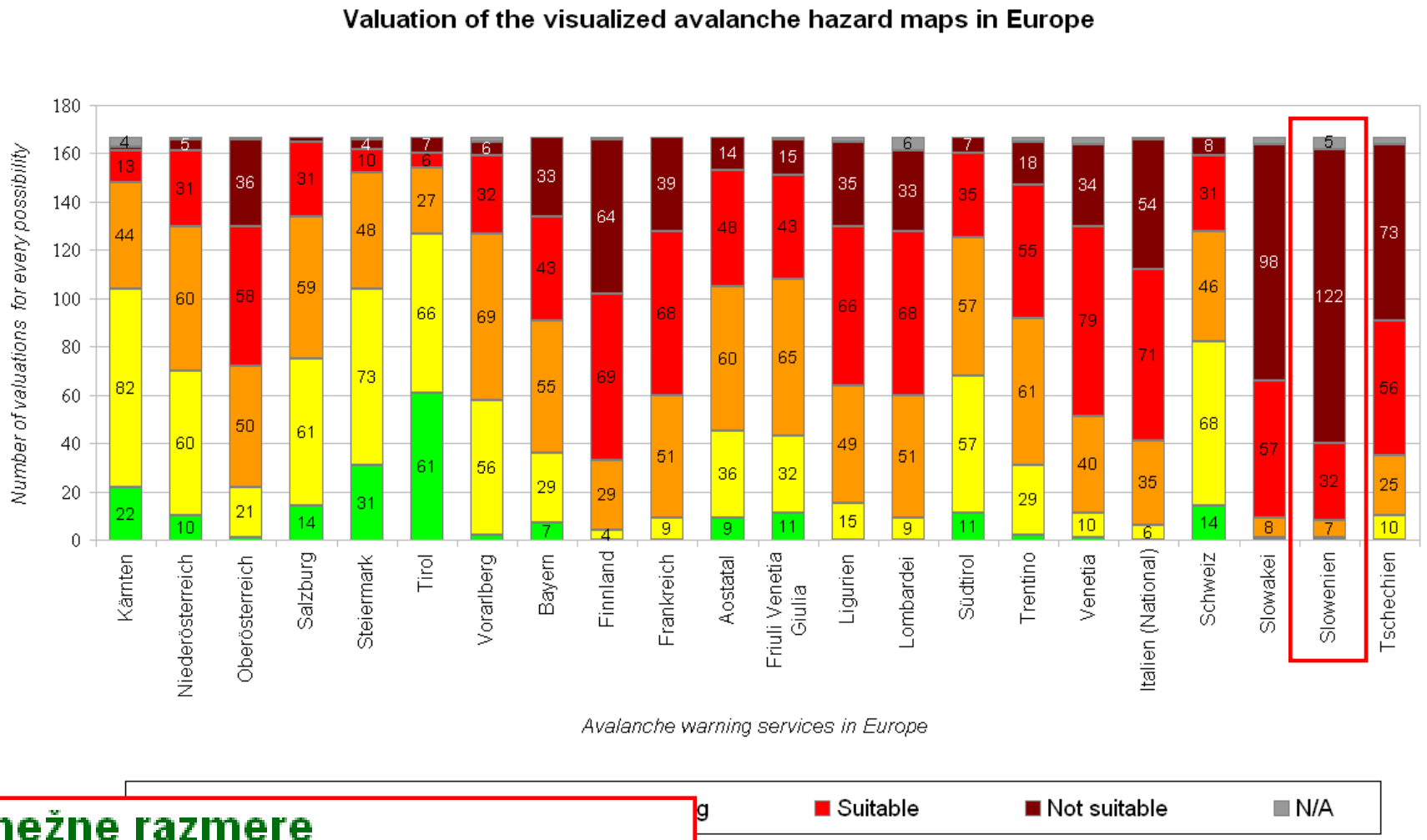
Tyrol = 61 from 167 rated „Excellent“

Valuation of the visualized avalanche hazard maps in Europe





Styria = 31 from 167 rated „Excellent“

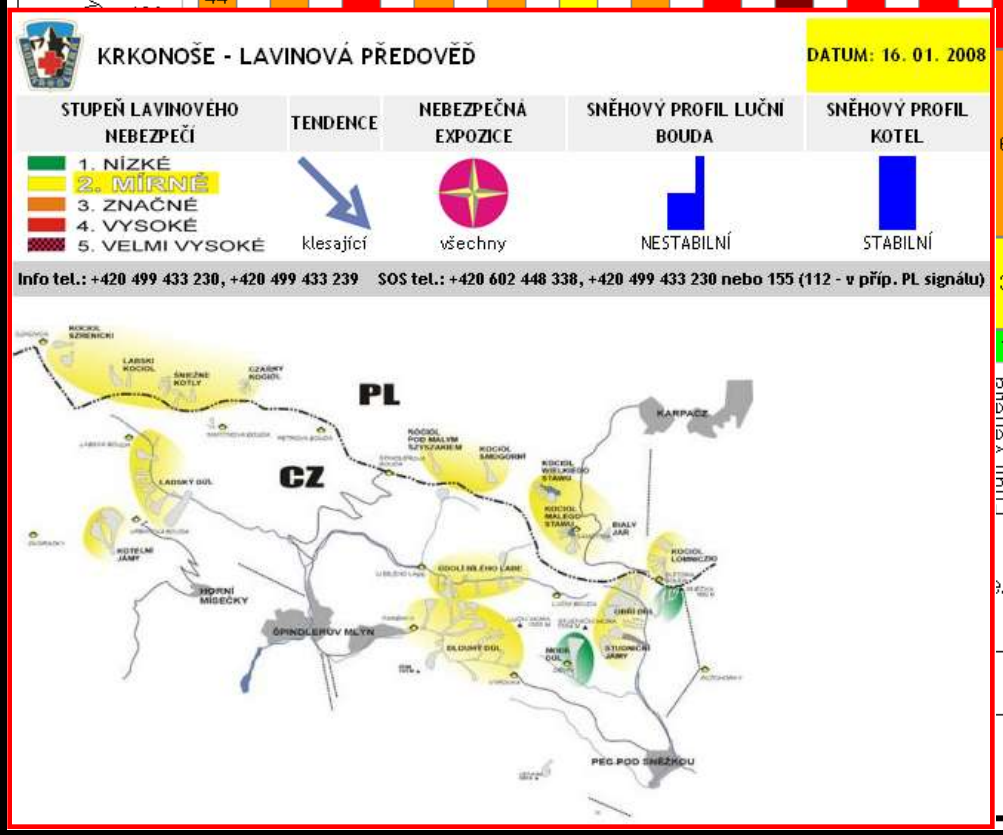


Snežne razmere

Sreda, 16. januarja 2008

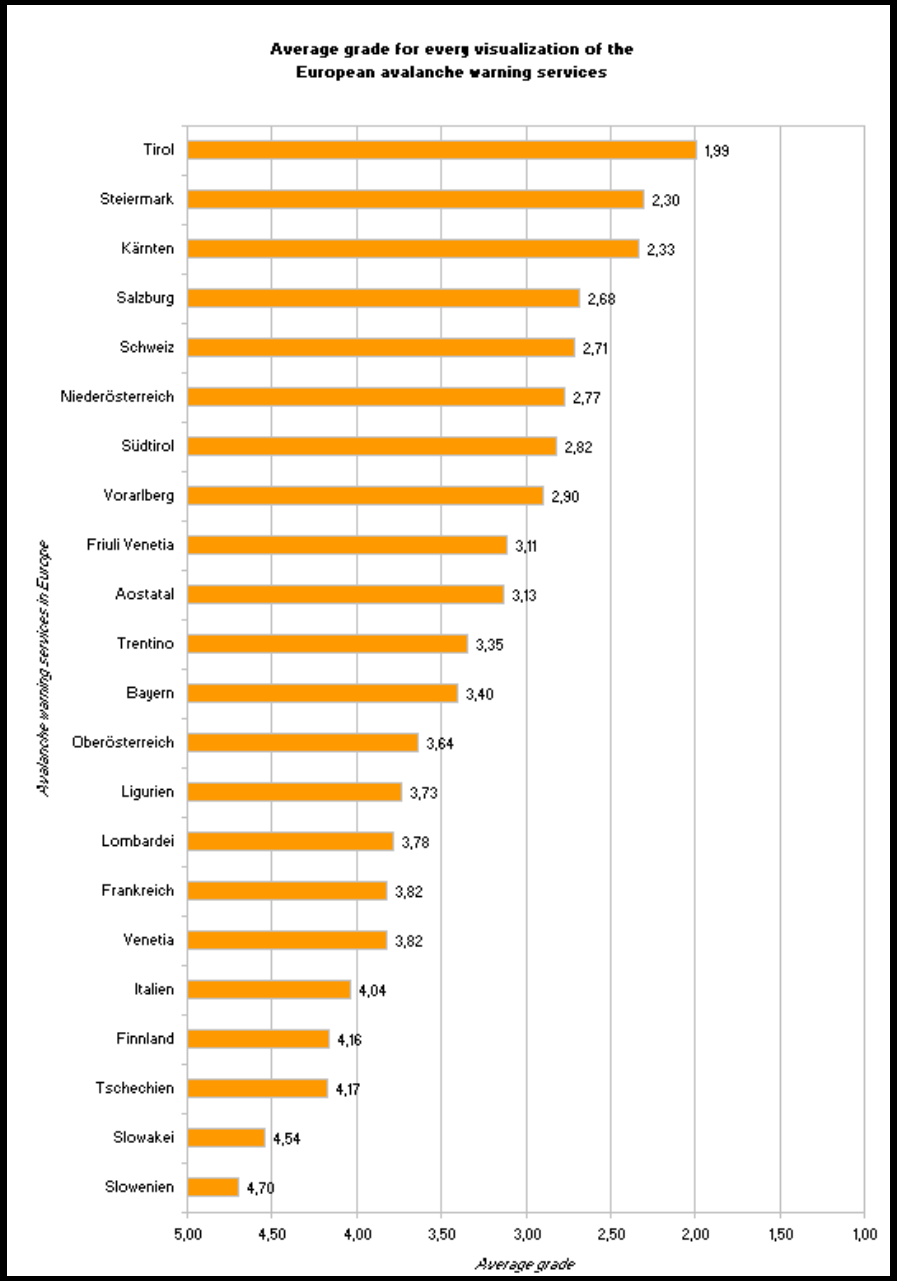
Slovenia = 122 from 167 rated „Not Suitable“

Valuation of the visualized avalanche hazard maps in Europe



Czech Republic = 73 from 167 rated „Not Suitable“

Conclusion



Top score Tyrol with average grade of 1,99

followed by Styria (2,30), Carinthia (2,33) and Switzerland (2,71)

+ clear topographic representation
+ classification of various mountain regions
+ good and fast overview and orientation
+ Differentiation of the hazard level by region, height and daily temperature curve and aspect.

last place for Slovenia with average grade of 4,70

- insufficient information of the stacked bar graph without key

followed by Slovakia (4,54), Czech Republic (4,17)

- unclear, mistakable visualization (Czech R.)

Catalog of requirements

Because of extensive measuring data, geodata, cartographic knowledge and the inclusion of other sciences (web design, psychology of perception, ...) a clear cartographic visualization should be aspired:

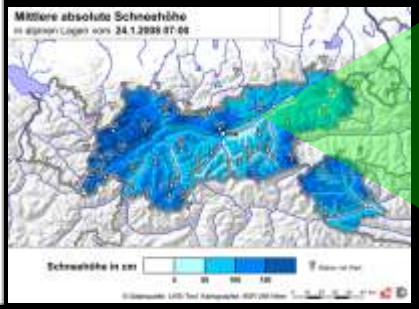
- Differentiation and cartographic visualization of the avalanche hazard level

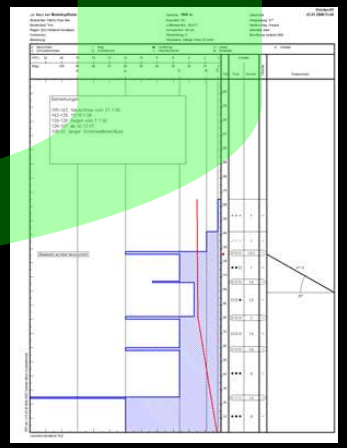
- Topography

- Map elements and cartographic visualization

- Technical implementation and web design

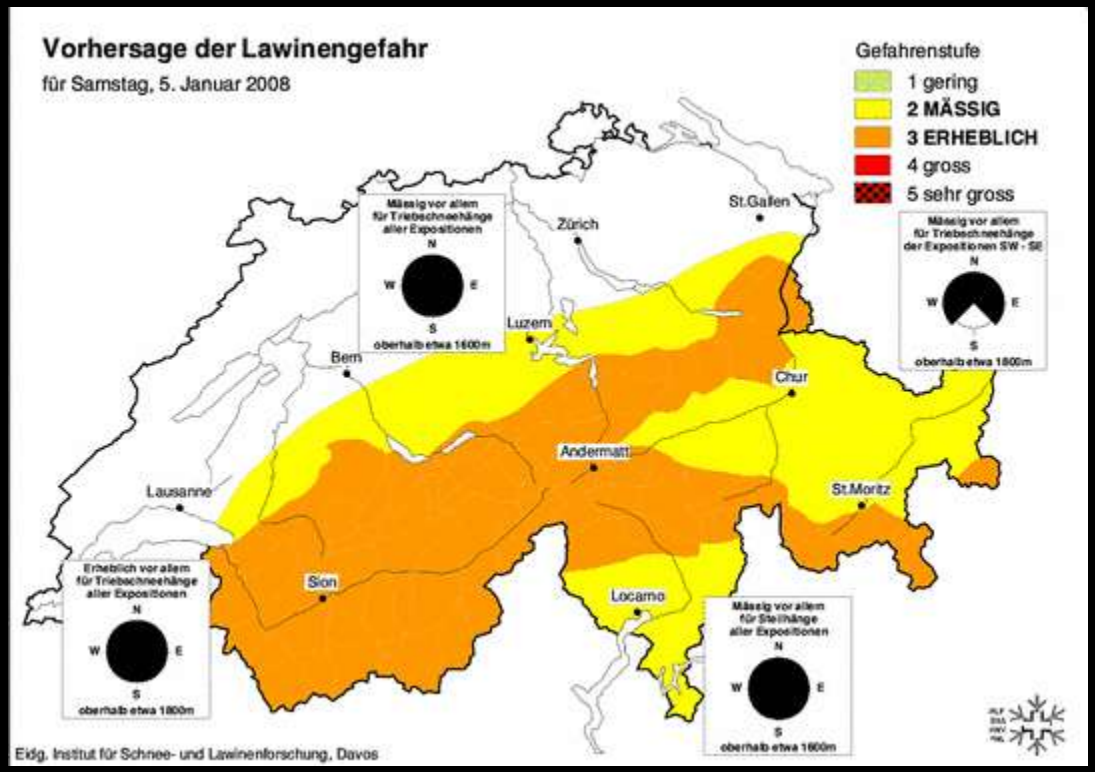
- Color and cartography / psychology of perception



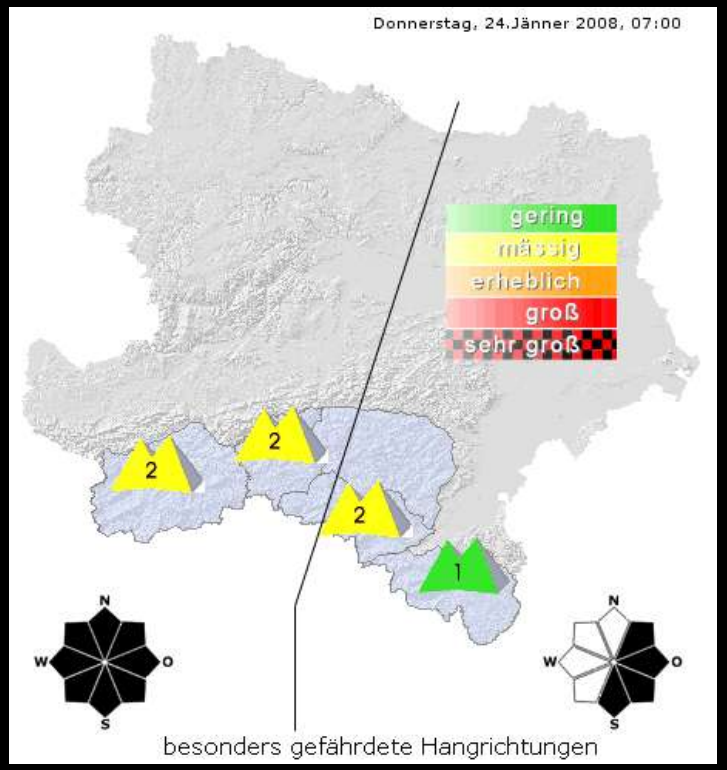


Differentiation and cartographic visualization of the avalanche hazard level

Differentiation by region



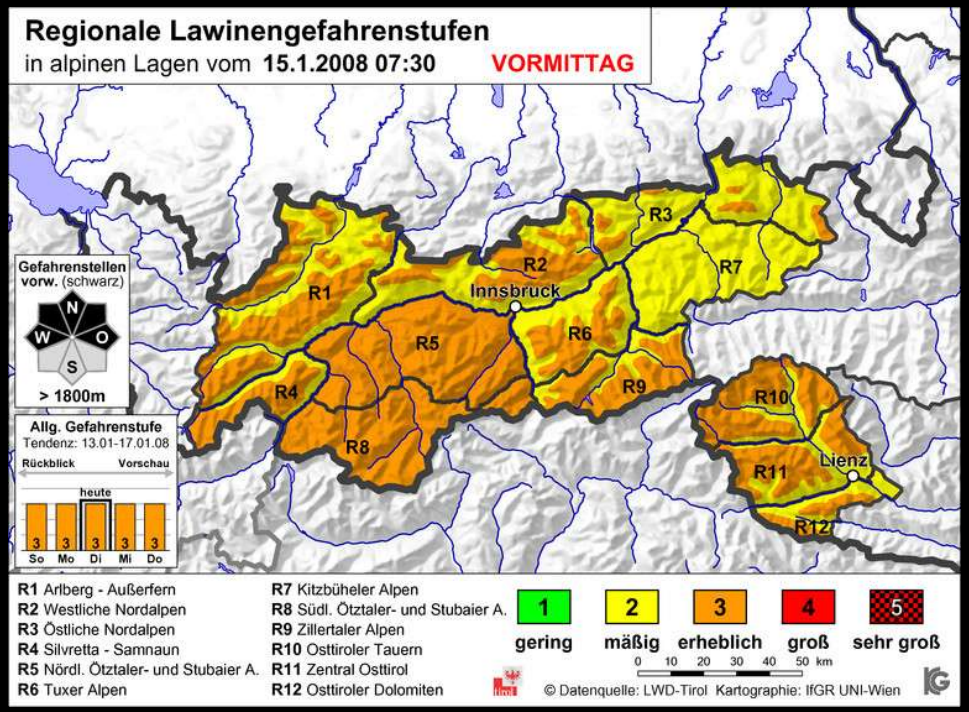
by colouring the different regions, separated by the region borders



by using a multilayer, colored signature with the hazard level as a number

Differentiation and cartographic visualization of the avalanche hazard level

Differentiation by height

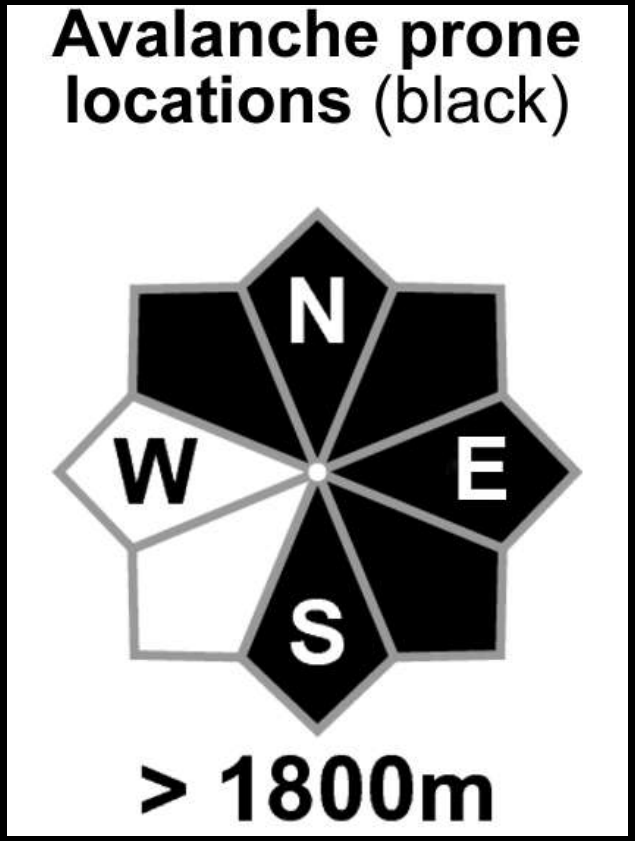


by coloring the different altitudes using a DTM

by using a multilayer, colored signature with the hazard levels as a number and the height, at which the hazard level changes

Differentiation and cartographic visualization of the avalanche hazard level

Differentiation by aspect



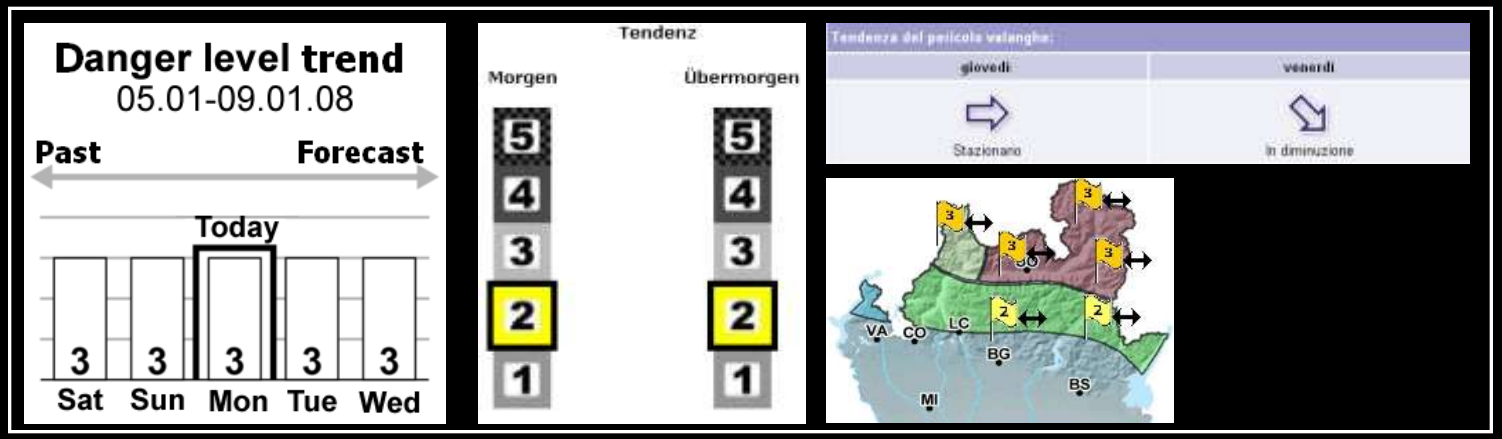
by using a wind rose displaying avalanche prone locations for the indicated altitudes

Map elements and cartographic visualization

- Cartographic design issues / visualization of the thematic elements are important to understand the topic, essential for spatial communication.

Map elements:

- Title, Frame, Key
- Highlighting important information
- Date and Time (up-to-date map)
- Hazard level trend (Arrows or a chart)



KEEP IT SMART AND SIMPLE !

Outlook

- Analyzing the gateway between hazard map and user (heterogeneous usergroup)

„What interfered with the person‘s judgment at the crucial moment“

- Try to raise the avalanche warning service‘s awareness of the importance of a high-quality avalanche hazard map

- Try to give guidelines and examples of high quality cartographic visualization

- Try to install standards for map elements and topographic representation, as well as avalanche specific features for avalanche hazard maps.

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