GEO-COMMUNICATION AND DAILY AVALANCHE AWARENESS

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Abstract: *Thematic maps depicting avalanche relevant information can be useful for planning winter outdoor activities as well as for preventing avalanche accidents. Together with the Avalanche Warning Centre Tyrol, the University of Vienna, Department of Geography and Regional Research has been developing a cartographic application for the visualization of the daily avalanche report in the region of Tyrol. The cartographic results are regularly updated thematic maps representing topics such as the predicted regional avalanche danger level as well as maps of snow accumulation within the last 24, 48 and 72 hours. After solving the technical challenges of map updating, the next step was to improve the already existing cartographic representation. The following paper discusses topics on how avalanche relevant information can be communicated and visualized in a perceptive way.*

BACKGROUND

Together with the Avalanche Warning Centre Tyrol, the University of Vienna, Department of Geography and Regional Research have been working on the visualization of the daily avalanche report for nearly five years. The daily avalanche report is a summary of information necessary to describe the current avalanche situation, collected and prepared by experts to inform the public. Distributing this information means transferring rapidly changing and spatial distributed data in an efficient way. From a cartographic perspective, a regularly updated map is the best way of communicating this kind of information [1].

At the beginning the main challenge was to control the automated updating process and creation of maps. This included the transfer of data that is collected by automated weather stations in the Tyrolean Alps, the data storage in a database system as well as the visualization and distribution of the produced maps. The result was a stable database driven online mapping system for the visualization and analysis of current avalanche relevant meteorological factors. Maps can now be distributed over the WWW and via mobile devices (mobile phone and PDA).

Problems and solutions in developing the technical backbone of this mapping system are described in Kriz K., Nairz P., Kinberger M., 2004 [2]. The current work focuses on improving the cartographic design and data modeling process.

THEMATIC MAPS FOR DAILY AVALANCHE AWARENESS

Besides terrain features that are essential for avalanche awareness, weather conditions and snow pack information visualized in thematic maps are important to assess the current avalanche risk. Thematic maps that are produced with the described mapping system can be divided into two categories. On the one hand maps about the current weather conditions that are updated in defined intervals. On the other hand maps representing the regional avalanche danger levels. This information is derived from the avalanche danger bulletin produced by the experts of the Avalanche Warning Centre in Tyrol.

All depicted information is interactively accessible to the user and includes current snow depth, amount of snow accumulation within the last 24, 48 and 72 hours, temperature, wind speed and direction as well as the regional distribution of the avalanche danger levels including height and temporal dependencies. Spatial depiction of this information can help comprehend the overall avalanche danger situation of a larger region. The faster this information is made accessible, the more useful it can be. For this reason, the partners of the project decided to adapt online maps for the presentation on mobile devices such as mobile phone and personal digital assistant (PDA).

Figure 1: Maps for Mobile Devices

Today many mobile devices have a color display even if it is very small. Therefore it is possible to receive and view a simplified version of the online avalanche maps on any mobile device. However, the maps available must be optimized for small mobile device screens. It is necessary to reduce the content of the displayed graphics without loosing information. The cartographic depiction must therefore be represented on a substantially smaller area. The generated maps are integrated in a mobile information system. Through such a system members of the local avalanche committees can now receive daily updated maps of the current snow depth, amount of snow accumulation and the predicted avalanche danger scale on to their mobile phone.

Due to the small size of the display, important topographic elements that are depicted on the Internet had to be excluded from the mobile maps. In the map of the predicted avalanche danger level, the user can localize his area of interest by following the regional boundaries. In the maps of the current snow depth and the amount of snow accumulation within the last 24, 48 and 72 hours, the selected hydrographical network can be utilized for orientation.

Maps Representing the Regional Avalanche Danger

Maps representing regional avalanche danger as well as maps of selected meteorological factors can be essential within the decision-making process. They must therefore be carefully designed. The visual communication of the regional avalanche danger level is based on a worldwide standardized classification scheme with five classes and uses the colors green-yellow-orange-red-red/black.

In order to perceive the regional distribution in an efficient way it is important to choose the correct map scale and size. In most cases the area of interest represents a larger region that is divided into smaller localities so that differences can be distinguished more easily.

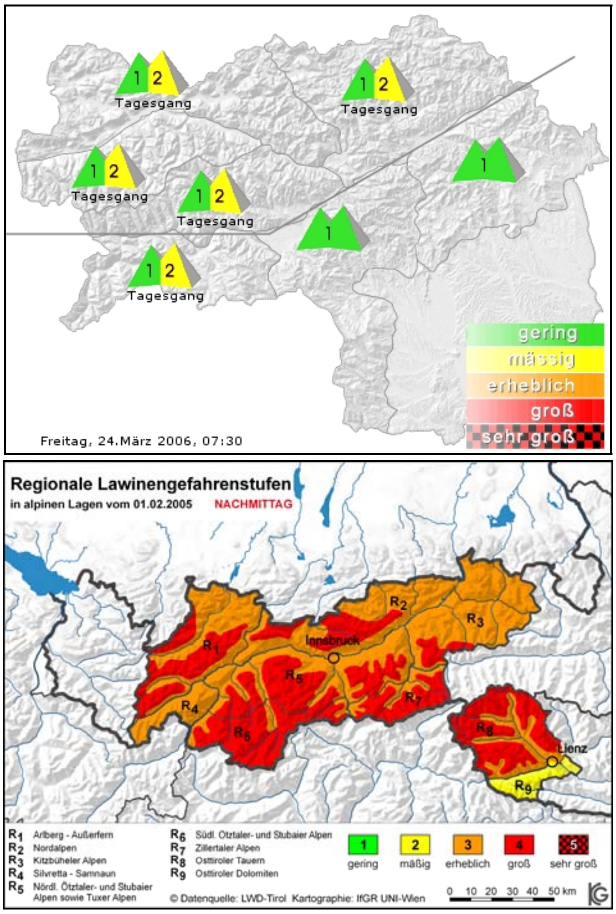


Figure 2: Maps Representing the Regional Avalanche Danger Level (Styria [5] and Tyrol [3])

Besides the depiction of basic information for a specific region, regional avalanche danger depends also on topographic as well as chronological aspects. The best way to represent height dependencies is either to subdivide the region in hypsometric fields specifying higher and lower areas or to use symbolic features.

To communicate the change of the avalanche danger scale over time it is possible to use either static and/or dynamic features. An example from the Styrian Avalanche Warning Centre, as seen on the left in figure 2, uses pictograms. The first colored double mountain peak represents the avalanche risk in the morning, the second peak the avalanche risk in the afternoon. This solution utilizes only one symbol for both time periods, but lacks to communicate the height dependency of the information. The example from the Tyrolean Alps depicts height dependency using hypsometric height fields and takes advantage of an animated second image that switches every 5 seconds to underline the connectivity of space and time.

There are also other approaches that give more thematic detail about the regional avalanche risk, the types of occurrences and their change over time. An example is given by the SFL Davos [6] that distinguishes between the risk of wet and dry slabs in connection with spatial information of the regional avalanche danger level.

Maps of Current Weather Conditions

The Avalanche Warning Center Tyrol has developed into a high-tech institution with comparatively high-quality standards. Due to sufficient financial support by the local government, there is not only an exhaustive network of observers but also one of the highest densities of high-alpine automatic weather stations in the world. This allows the usage of thematic information which can be depicted in maps. Due to the fact that the collected data is based on only discrete information, it is necessary to interpolate and classify it in order to obtain full spatial coverage.

Besides the information on the current snow depth and the accumulation within the last 24, 48 and 72 hours, the automated weather stations in the Tyrolean Alps also collect values on the current air temperature, wind speed and wind direction. All these meteorological factors are transferred and stored in a centralized database.

For the visualization of the current snow situation and current air temperature, the values of the single weather stations are interpolated, in connection with their height (mean sea level). Thereafter the spatial information is classified and colored. The class limits depend on significant values of the given meteorological factors that are important for the formation of the snow pack.

A special type of map is the visualization of the wind conditions. No spatial interpolation is needed for this depiction. Current wind speed and wind direction are represented in one map. This is realized using an arrow symbol, pointing at the geographic position of the weather station. The direction of the symbol gives information about the dominating wind direction. The wind speed is depicted by the color of the arrow – light wind is green, moderate orange, strong red.

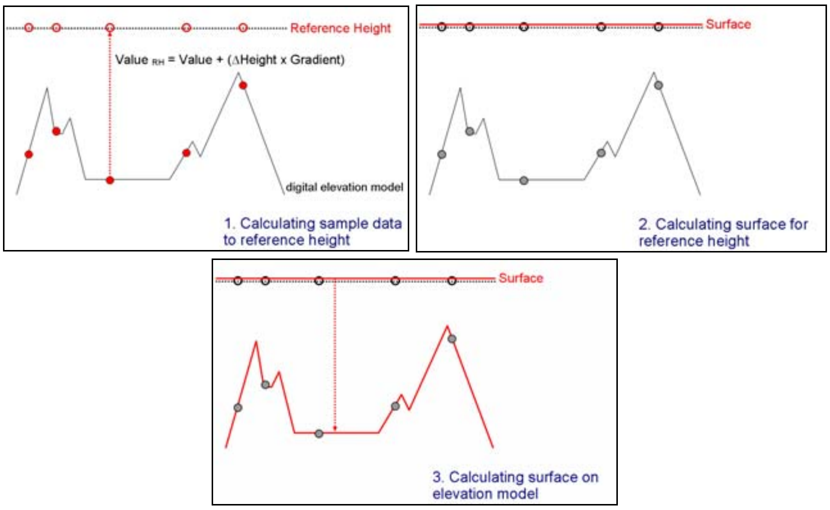
MODELING METEOROLOGICAL CONDITIONS

In a first approach for the defined map scale it was assumed that it would be sufficient to interpolate the values with a linear interpolation method without considering the mean sea level of the weather stations. Combing the colored surface with the hill shading showed that the height dependency of the meteorological phenomenon, such as air temperature and snow pack, is too significant to be ignored. The height dependent interpolation was realized in three steps – the calculation of the sample data to the reference height, the interpolation of the surface for the reference height and the calculation of the surface for the digital elevation model.

In order to consider the mean sea level of the station, the sample data surface was calculated with a uniform reference height of 4000m above sea level. The first step was to adjust the sample values according to the following formula:

$$\text{Value}_{\text{Reference Height}} = \text{Value}_{\text{Station}} + (\Delta\ \text{Height x Gradient})$$

The gradient in the formula defines the rate at which the value of the meteorological factor changes per 100m. For the air temperature a gradient of -0.7 degree Celsius is used. Δ Height is the difference between the reference height and the actual height of the weather station. Step two calculates an interpolated surface at the defined reference height.



1. Calculating sample data to reference height

2. Calculating surface for reference height

3. Calculating surface on elevation model

Figure 3: Steps for Interpolation

Interpolation of the adjusted sample data is calculated using the Inverse Distance Weighting (IDW) method. This interpolation process uses a numerical approximation technique based on distance squared weighting utilizing the values of nearest data points. The result is an unclassified surface for the defined reference height. Thereafter, the surface values are reduced according to the underlying digital elevation model to get the approximated values for the terrain. Finally, the surface is classified and colorized according to associative cartographic color principles – e.g. blue-green-red color scheme for temperature.

The quality of the interpolation results depend mainly on the defined gradient and the availability of evenly distributed data values. This is unfortunately not always the case. Furthermore, for special weather conditions, such as temperature inversion, the value of the meteorological factor does not always change in a linear way. Temperature inversion is a meteorological phenomenon that often occurs in mountainous regions. Air temperature increases for a certain altitude, as opposed to the normal decrease by height. For this occasion it is necessary to use a dynamic gradient in connection with terrain information.

OUTLOOK

The dynamic gradient for the air temperature is not the only problem that has to be solved in the near future. Gradients for the current snow depth and the snow accumulation within the last 24, 48 and 72 hours have to be also adjusted. To experiment with gradients for different altitudes, the development of an online user interface is being planned. The interface will be ready for the next winter season.

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Projekt Partners:
[3] Avalanche Warning Centre Tirol: http://www.lawine.at/tirol
[4] University of Vienna, Department of Geography and Regional Research, Cartography and Geoinformation: http://www.gis.univie.ac.at/karto

Examples:
[5] Avalanche Warning Centre Styria: http://www.lawine-steiermark.at/
[6] Eidgenössisches Institut für Schnee- und Lawinenforschung Davos: http://www.sfl.ch

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Karel Kriz, born 1962, studied geography and cartography at the University of Vienna and graduated in 1989. For 3 years he worked in the fields of digital cartography, GIS and computer science developing various scientific and commercial applications. Since 1992 he is an Assistant Professor at the Department of Geography and Regional Science at the Department of Geography and Regional Research. In 1994 he completed his PhD on the topic of “Requirements on Digital Cartographic Systems”. His major areas of interest lie in web-based cartography, GIS and thematic aspects of mountain cartography.