INFORMATION TRANSFER AND CARTOGRAPHIC DESIGN ISSUES FOR AVALANCHE RISK MAPPING

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BACKGROUND

The joint project "LWD Online Maps" between the Avalanche Warning Center Tyrol (Innsbruck, Austria) and the University of Vienna, Department of Geography and Regional Research is now ongoing for several years. Its goal has been and still is to develop and maintain a complex and very powerful database driven online decision support system for cartographic visualization and analysis of current avalanche relevant factors in the Tyrolean Alps. In order to understand the avalanche situation, it is important to have real-time spatial coverage of meteorological and snow pack factors as well as information covering the avalanche danger scale. Nowadays, all information can be interactively made accessible to the user. This data can include information on current snow depth, amount of snow accumulation within the last 24 hours, temperature, wind speed and direction in addition to the regional distribution of the avalanche danger scale, including height and temporal dependencies. The crucial factor is, however, how to administrate and communicate this vital information in a sound cartographic fashion to accommodate the user's needs.

Beside cartographic design aspects, the quality and usability of a map mostly depends on the accuracy of the depicted information. The aim of the project "LWD Online Maps" is to visualize the daily avalanche report as well as the relevant meteorological factors of Tyrol with the goal to produce understandable and effective cartographic depictions. The representation of this constantly changing information demands efficient administration, high quality data and comprehensible knowledge transfer. In order to assist the data administration and production process, in particular the experts of the Avalanche Warning Center, who must work daily with the system, it was important to facilitate the user with an interactive administration tool that sensitizes the client for spatial geographic issues.

Beginning with the original weather data and resulting in the final map, in the following the mapping process will be briefly described. Thereby, the focus will be on the problems resulting on insufficient data quality and their impact on the cartographic depiction. Finally, a possible solution and its implementation for the major data quality issues will be given.

THE MAPPING PROCESS

The Avalanche Warning Center Tyrol has developed into a high-tech institution with comparatively high-quality standards. As a result of 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.

Along with 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, processed and stored together with the data from the observers in the meteorological database of the Avalanche Warning Center called WISKI. Before this data can be used for the visualization they have to be temporally discretized. This work is done by experts in Tyrol. As a starting point for the mapping application a text based file including the geographic location of every available station and the associated thematic data for a certain time is provided.

The actual mapping process can be divided into three steps. It starts with the data transfer, followed by the spatial data modeling and ends with the cartographic visualization. The following description shows that the results of the three steps are heavily dependent on the quality and representation of the data.

Data Transfer

Due to the fact that there is no possibility to access the WISKI data base directly the application is depending on the data description provided in form of a text file. This text file is parsed line by line and its content is stored in a local relational database after a

simple plausibility check. Except for the header, which contains important general information, every line describes the attributes of one weather station (see Fig.1). For every station the validity date, the unique code, the name, the geometric data (height above sea level, longitude, latitude) and the thematic data (different meteorological factors) separated by a semicolon are given. Missing or not measured values are substituted by "\N" in order to fit a specified text format.

```
DatumUhrzeit;ID_StationsNummer;Stationsname/Gde.Standortsangabe;Höhe;
Länge;Breite;Schneehöhe;24Std.Diff.Schneeh.;Lufttemp;Windrichtung;
Windgeschwindigkeit;Böe;Luft_Tmax;Luft_Tmin;48Std.Diff.Schneeh.;
72Std.Diff.Schneeh
```
```
2007-04-24 07:00:00;4307000623541;Kappl/Dias;2380;10.3461;47.0950;
\N;\N;\N;\N;\N;\N;\N;\N;\N;\N
```
```
2007-04-24 07:00:00;4307000623542;Kappl/Lattejoch;2620;10.3389;47.0850;
\N;\N;\N;\N;\N;\N;\N;\N;\N;\N
```
```
2007-04-24 07:00:00;4307000053201;Gerlos/Gmünd;1190;12.0003;47.2108;
\N;\N;\N;\N;\N;\N;19.3;0;\N;\N
```
```
...
```

Fig. 1: Extract from the text file describing the weather data

This kind of data description is inflexible, little discrepancies to the original format lead to an error in the parsing process. Therefore, a simple check proves the logical consistency of every entity mainly concerning the data type and the range of the value. If this test fails the line will be skipped and the stations data for this date are not stored in the database. Inflexibility also means that the structure of the file is static. If there is additional information to be included the parser has to be adapted. This is a time and cost consuming task. In order to improve the flexibility another way of the data description should be used.

Data Modeling

In order to obtain full spatial coverage, it is necessary to interpolate the sample data from the weather station. This concerns the information on the current snow depth, the amount of snow accumulation within the last 24, 48 and 72 hours, and the air temperature. The values of the single stations are interpolated in connection with their height (mean sea level). The result of this calculation is an unclassified surface. The interpolation method and the problems concerned with this process are described in detail in KINBERGER M., KRIZ K. (2006).

Besides the utilized interpolation method which is used the density and the distribution of the sample data have a strong impact on the quality of the resulting surface. Therefore, it is important not to loose any information during the transfer process due to wrong data descriptions.

In addition, the accuracy of the surface is dependent on the quality of the individual values. Incorrect values on basis of a measuring error or incorrect geographic reference distort the final surface. Due to this fact the quality of the thematic and the geometric data has to be guaranteed for a sound cartographic depiction.

Cartographic Visualization

In the final step of the mapping process 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. After this the surface is colorized according to associative cartographic color principles – e.g. blue-green-red color scheme for air temperature.

Summing up, we could point out three major flaws in order to produce a sound cartographic depiction. First, there is an inflexible form of data description used for the data transfer. Second, although a simple plausibility check is done there are still wrong data because of measuring errors. Third, not all stations are assigned to the correct geographic location.

SYSTEM IMPROVEMENTS

In order to improve the quality of the visualized information a new kind of data description, a station administration tool, a geographic location verifier and a new map design have been implemented in the application.

Flexible data description

As already explained the current text file is static in its structure and inflexible. As an alternative a new XML description - similar to the one already used for the information transfer about the current avalanche danger scale – has been defined (see Fig. 2). Now it is

possible to leave or add information if it is necessary without interrupting the parsing process. If it is required the measured data of more than one date can be assigned to a station without repeating the geometric information.

The new, more flexible, XML data description could be used to include other local, but also international stations into the system independent from there used data base management system.

```
<METEO>
    <METAINFORMATION> //general Information, Metadata
        ...
    </METAINFORMATION>
    <STATION> //data
        <ADMIN_GEOM> //geometric and administrative data ()
            <ID>2222</ID> //Station-ID (required)
            <STAT>Mut/Imst-Muttekopfhüs</STAT> //Station-name(optional)
            <HEIGHT>1935</HEIGHT> //height of Station (required)
            <GEOL>10.6697</GEOL> //longitude of Station (required)
            <GEOB>47.2632</GEOB> //latitude of Station (required)
        </ADMIN_GEOM>
        <METEOINFO>
            <METEODATA> //meteorologic data from Station
                <TIME>2006-09-06 11:40:00</TIME> //data-timestamp(required)
                <TEMP_CEL></TEMP_CEL> //temperature(optional)
                <SABS></SABS> //snow absolute (optional)
                <SDIF_24></SDIF_24> //snow difference 24H (optional)
                <SDIF_48></SDIF_48> //snow difference 48H (optional)
                <SDIF_72></SDIF_72> //snow difference 72H (optional)
                <WIND_DIR></WIND_DIR> //wind direction(optional)
                <WIND_KMH></WIND_KMH> //wind speed [km/h](optional)
                <WIND_BOE></WIND_BOE> //gust of wind (optional)
            </METEODATA>
            <METEODATA>
                ...
            </METEODATA>
        </METEOINFO>
    </STATION>
    ...
</METEO>
```

Fig. 2: XML data description

Station Administration Interface

Currently there are more than two hundred stations included in the mapping application. To administrate this huge amount of weather data it was necessary to use a data base management system like PostgreSQL. To select the relevant stations for the cartographic visualization, and to exclude incorrect values, a location independent user interface was needed.

Fig. 3: Extract from the Station Administration User Interface

6	4300151220031	Alpbach/Kleiner Beil	12.0183	47.3506	1920	☑	☑	☐
7	4307151220032	Alpbach/Saupanzen	12.0078	47.3656	1957	☐	☐	☑
8	4307000000051	Alpein/Alpein	11.7439	46.9592	1170	☐	☐	☐
9	4307000000031	Alpein/Alpein (TIWAG)	11.1781	47.09	2020	☑	☑	☐
10	4307090351001	Amlach/Beobachter Dolomitenhütte	12.7842	46.7903	1616	☐	☑	☐
11	4307000069012	Bach/Jöchlspitze_Gipfelstation	10.3597	47.2822	1740	☐	☐	☑
12	4307000069013	Bach/Jöchlspitze_Liftstation	10.3653	47.2753	1740	☐	☐	☐
13	4307000069011	Bach/Jöchlspitze_Schneestation	10.3675	47.2733	1680	☑	☑	☐
14	4900000693901	Berchtesgaden/Jen.-Hauptstation	13.0193	47.5865	1200	☑	☑	☐
15	490000069390	Berchtesgaden/Jenner-Schneestation	13.0193	47.5865	1200	☐	☐	☐
16	4900820004372	Berchtesgaden/Reit.Schneestation	12.8098	47.6495	1670	☐	☑	☐

The new online interface lists the stations with their unique identifier, name longitude, latitude, sea level and the usage for the visualization for the maps (air temperature, snow and wind). Stations can easily be included or excluded for the next mapping process by marking a check box.

Geographic Location Verifier

As previously described, a wrong geographic location has a crucial impact on the interpolation and the cartographic visualization. Accordingly, the information the user receives from the map is incorrect. Due to the fact, that it is not possible to measure all geographic locations with a GPS, a location verifier tool was developed for data acquisition. This was done by using Google Earth as visualization and editing tool for geographic point information (see Fig. 4).
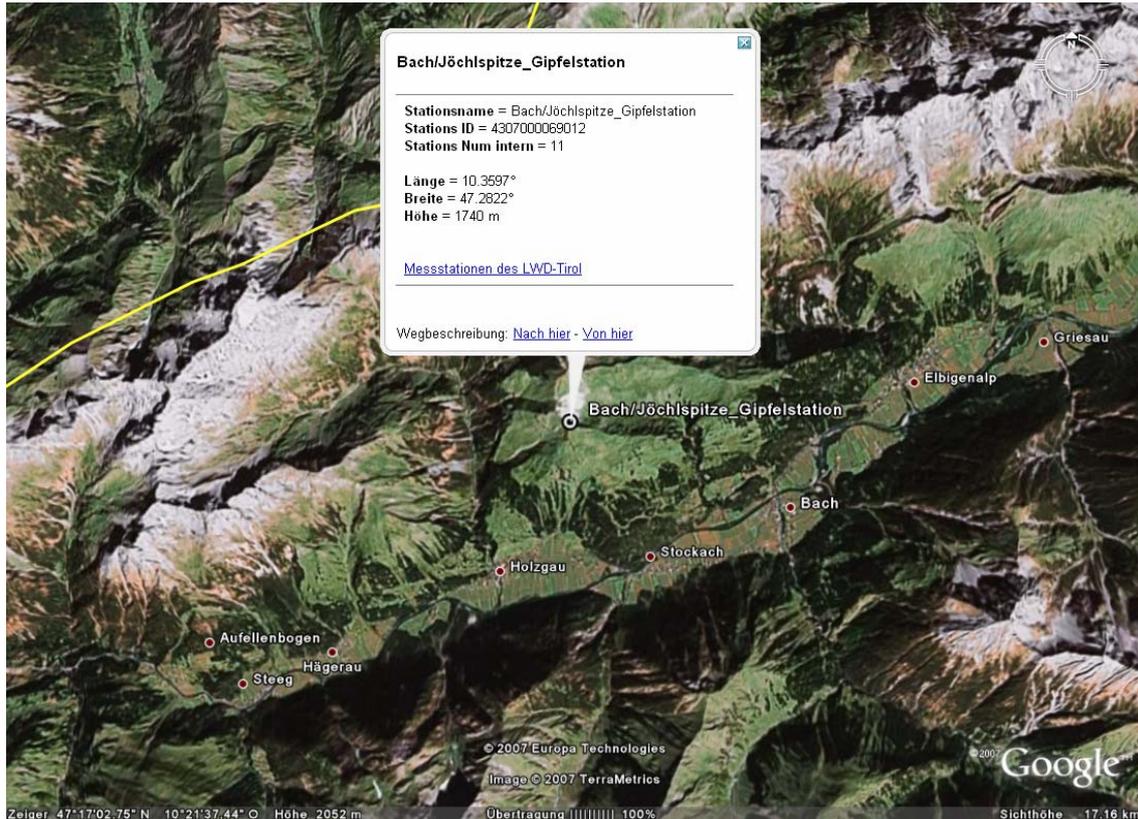
Fig. 4: Geographic Location Verifier

New Map Design

To give the user the possibility to evaluate the quality of the interpolation and the resulting visualization the stations and the according values where depicted in the new map design (see Fig. 5). It is important to avoid an overcrowded presentation; therefore, all maps for mobile devices, like mobile phone or PDA, lack this additional information.

RESUMÉ

The aim of the system improvements - increasing the quality of the information depicted in the regularly updated weather maps - has been reached. This has been achieved by planning and implementing a more flexible kind of data description, a station administration tool, a geographic location verifier and a new map design. Now it is up to the persons responsible for the data administration to use these new tools.
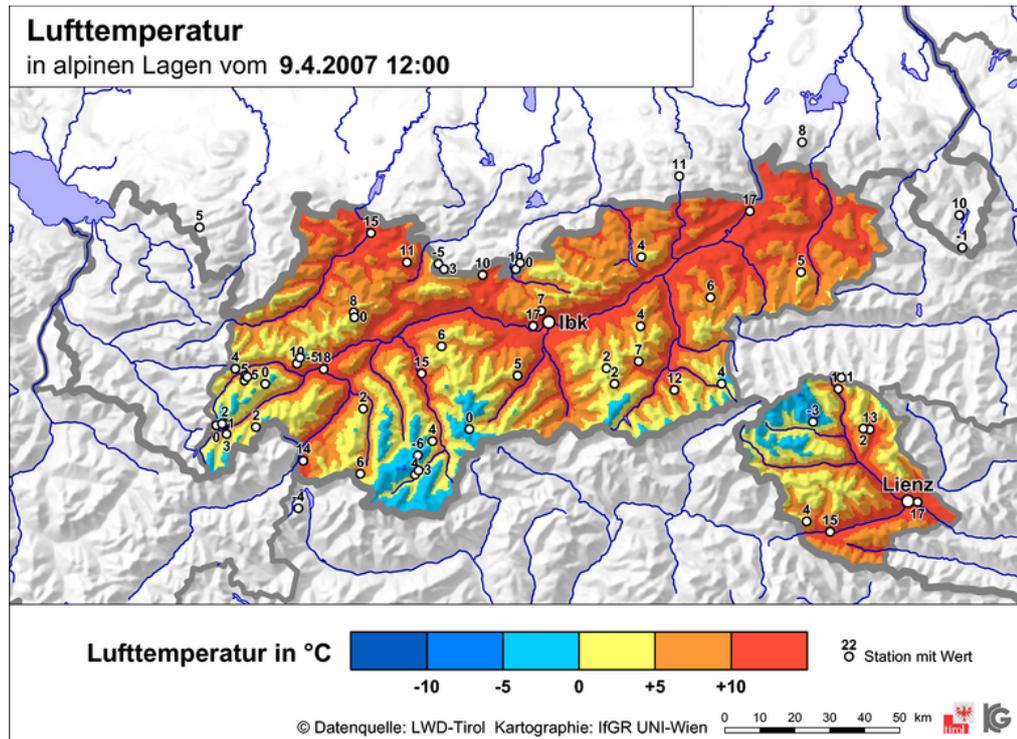
Fig. 5: Map of the air temperature with station values

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Kriz K., Nairz P., Kinberger M. (2004): LWD-Infosystem Tirol: concept and design of an avalanche decision support system. Proceedings, 4th ICA Mountain Cartography Workshop, Vall de Núria, 30th September - 2nd October 2004, Barcelona.

Kinberger M., Kriz K. (2006): Geo-Communication And Daily Avalanche Awareness. Proceedings, 5th ICA Mountain Cartography Workshop, Bohinj, 29th March – 1st April 2006, Slovenia.

Project Partners

Avalanche Warning Centre Tirol: http://www.lawine.at/tirol

University of Vienna, Department of Geography and Regional Research, Cartography and Geoinformation: http://www.gis.univie.ac.at/karto