RAIFoS: Regional Avalanche Information and Forecasting System

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ABSTRACT: Besides the text-based and Swisswide national avalanche forecasts regional avalanche forecasts have been introduced in Switzerland in 1996. Each of the regional forecasts covers an area of about 3.000 km2 and shows the avalanche hazard in graphical form. The regional bulletins are published at 8 a.m.

RAIFoS is a computer based system that contains

- a statistical model (NXD-REG) that forecasts the avalanche hazard for Switzerland. The model is based on the nearest neighbor approach which is applied for 60 manual weather stations. The results of each station are then compiled into a map of the current and future avalanche hazard. The model results are an additional information for constructing avalanche hazard estimations and are fully integrated with BULLED.
- a GIS-based editor (BULLED) for constructing an estimation of the past or current avalanche hazard for Switzerland. The maps can be edited, copied, printed, exported in all important graphics formats and saved in a relational database.
- a text-based editor (REGBUL) for writing the forecasts for each individual region. The data of automatic stations and the official weather forecast of Switzerland are included automatically. Furthermore a set of structured sentences allows the avalanche warner to quickly compile a few sentences about the current situation. The structure of the sentences allows us to translate fully automatically into French. The hazard estimation created with BULLED is used for the region edited.

These three complementary approaches are the basis of Computer Aided Regional Avalanche Forecasts. The data of automatic stations and model calculations of SNOWPACK are further important prerequisites but are not presented here.

KEYWORDS: avalanche warning, regional avalanche forecast, statistical models, nearest neighbours

1. INTRODUCTION

Avalanche Warning has been a key task of the Swiss Federal Institute for Snow and Avalanche Research in Davos (SLF) since it has been set up over half a century ago. Since 1996 the way avalanche warning is done has gone through a major change: The project Avalanche Warning Switzerland 2000 (Russi et. al., 1998) has introduced "computer-aided avalanche forecasting" in order to cope with the increasing demand for more and more precise avalanche forecasts. The state of avalanche warning in Switzerland before this effort has been documented by Meister (1994). Stucki et al. (1998) have presented a 3-level concept for avalanche warning in Switzerland that is in use since then: The local and national level of avalanche warning have been in use since the beginning of systematic avalanche warning in Switzerland whereas the regional level has been introduced within Avalanche Warning Switzerland 2000. The national level is represented by SLF. The national bulletin, the swisswide collection of input data for avalanche warning and several auxiliary products are the main focus of the top level. At the local level local avalanche warnings are submitted in order to prevent avalanche accidents. In order to bridge the gap between local and national authorities the regional level has been introduced.

The flow of information especially about snow cover stability and local estimations of the avalanche hazard (see also Brabec et al., 1998) from the local level to SLF are the key for improving the precision of avalanche warnings. In order to motivate and include local forecasters into the construction process of avalanche forecasts a new product has been launched for the regional level in 1997: regional avalanche forecasts (see figure 1 for an example). In 1996/97 first tests of regional forecasts have been done in Grison. Since then regional forecasts have been introduced in Grison (1998), Central Switzerland (1999) and Wallis (2000). For winter 2001 two more regions are planned: Südbünden and Bern

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Oberland. After that nearly all Swiss alpine regions will be covered by regional forecasts.

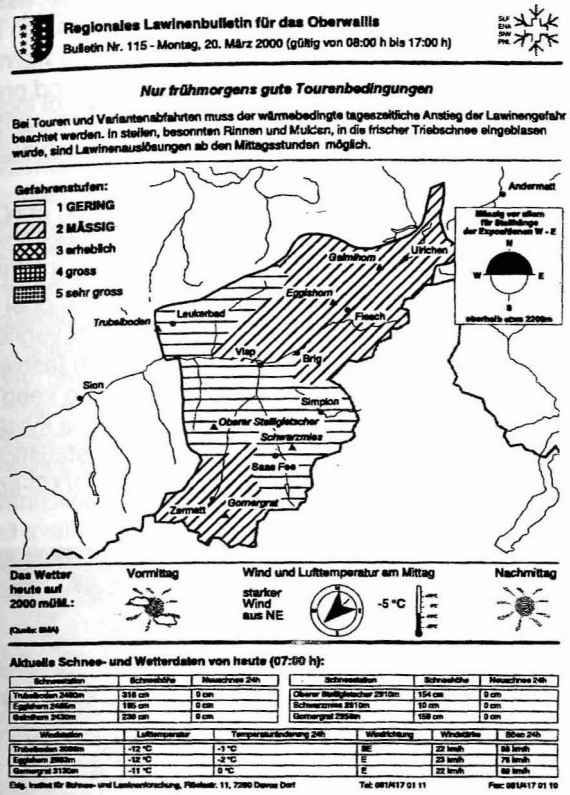

Figure 1: Example of a regional forecast for Upper Wallis: Nr 115 of winter 1999/2000.

The regional avalanche forecasts are published during the main winter season every day at 8:00 a.m. The main target group of the regional forecasts are out-of-bounds skiers and snowboarders who usually do not have a lot of avalanche education. The data of automatic snow and weather stations, precise weather forecasts and the feedback of local avalanche forecasters are compiled to the new bulletin. Additional information comes from SNOWPACK (Lehning et al., 1998) and NXD-REG (Brabec et al., 2000). This paper focuses on a system for decision support and the construction of regional avalanche forecasts. Three complementary modules (NXD-REG, BULLED and REGBUL) are the parts of this system.

Similar software systems are in use at all modern avalanche warning services around the world. The main differences are in the amount of integration that is provided and the number and kind of models that are in use. Williams (1998) has presented an overview of tools and systems that are in use in North America. Before that Tremper (1992) focused on computer applications for avalanche warning. Durand et. al. (1999) present the state of the French avalanche forecasting chain SAFRAN-CROCUS-MEPRA. McClung et al. (1993) introduce conventional and numerical avalanche forecasting. Gabl et. al. (1994) present an introduction to avalanche warning in Austria. The current state of avalanche warning in different countries can be derived from the annual winter reports of each avalanche warning service.

2. ARCHITECTURE

Russi et al. (1998) have presented the architecture of Avalanche Warning Switzerland 2000. Here we focus on the Regional Forecasting Module and present details of the implementation. Figure 2 shows the general architecture of RAIFoS, the Regional Avalanche Information and Forecasting System, containing all modules and information paths.

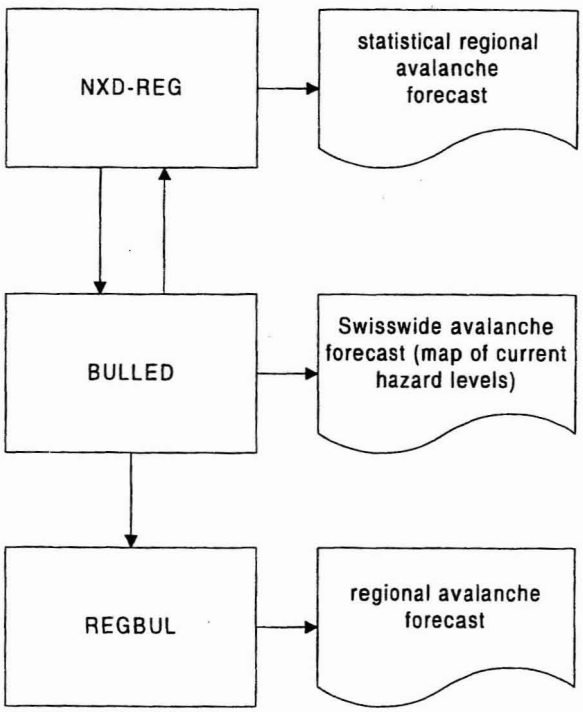

Figure 2: General architecture of RAIFoS (Regional Forecasting Module of Avalanche Warning Switzerland 2000).

2.1 NXD-REG

The abbreviation NXD-REG stands for Next-X-Days-Regional. It is a nearest neighbors based model that has been generalized to the task of regional avalanche forecasting (see Brabec et al., 2000). The results of 60 nearest neighbor calculations based on the Swiss manual observer network are compiled to a map of averaged hazard levels called hazard values and a second map of hazard levels. Both maps are presented to the avalanche warners as a suggestion for a new avalanche forecast. Besides the data of 10 years of manual observation stations BULLED has been used to construct a database of past avalanche forecasts. Both databases are integrated into the official SLF snow and avalanche database. The evaluation of NXD-REG has shown that the system is in agreement with the conventionally estimated hazard levels in about 52% of the cases. It has to be noted that the system does not yet include data about the current snow cover stability. By downscaling weather forecast models to the location of the weather stations a true forecast for the next day can be derived.

The results of NXD-REG are directly written to the database of BULLED which allows the avalanche forecaster to directly access them. Of course NXD-REG is only an extension of the information that the Swiss avalanche warning service uses. The conventional method presented by Meister (1994) still plays a predominant role. It will be supported by computer aided avalanche forecasting more and more.

The software implementation of NXD-REG is based on a combination of database (Oracle), GIS (ArcView) and statistical software (S-Plus). All data, results and parameters of the model are stored within the database. Different versions of the model and all calculations (even testwise runs) are also kept there. This allows us to keep track about the historic development of the system. The statistical part is used for doing all statistical estimations, implementation of the NXD-approach

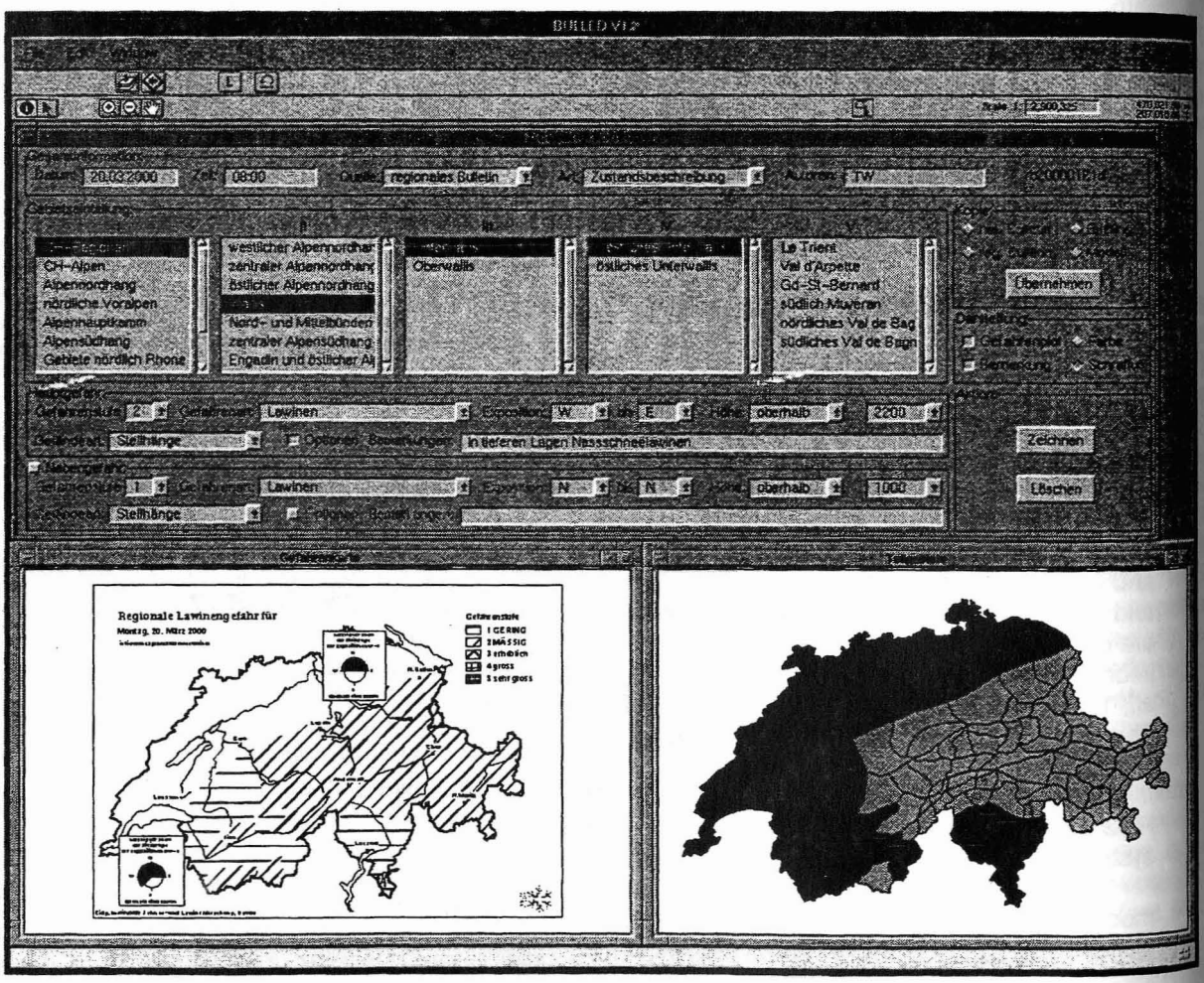

Figure 3: User interface of bulletin-graph-editor (BULLED).

for each station and comparison to other statistical approaches. The GIS software produces all maps.

2.2 BULLED

The bulletin-graph-editor (BULLED) is a tool to construct past, current and future avalanche hazard maps. Figure 3 shows the user interface of BULLED. The software has been implemented using ArcView and a database for storing all maps. For each map date, time, authors, origin and type are stored. For the origin national forecasts, regional forecasts, models and questionnaires are distinguished. For the type forecast for the next day, now-cast for the current day, check of the forecast and verification can be chosen. Check of the forecast and verification are distinguished because one is interested in checking the forecast on a daily basis whereas a verification is usually done several days later when all available information is available (see Föhn et al., 1995).

Maps can be constructed in two ways: Either a region is selected via a menu or a map and the hazard estimation for that area is done afterwards or vice versa. To make the map-based bulletins compatible to the text-based national avalanche forecast a new division of Switzerland into subareas of about 50-1000 km^2 has been derived. Figure 3 bottom right shows these 100 subareas that can be selected individually by clicking on the map *Teilgebiete* or via a dynamic menu (see part *Gebietseinteilung* of user interface). Besides the names of the subareas 70 additional geographic terms have been introduced and organized into five levels, e.g. *CH-Regionen* covers the whole alpine area of Switzerland.

For each subarea the hazard estimation is given by the hazard level, according to the European Avalanche Hazard Scale, type of danger, aspect, height and type of endangered terrain part. The result of the map construction is shown in the left bottom window. Black and white as well as color are supported.

The system is in operational use since winter 1998/99 at SLF. During two years about 500 maps of the avalanche hazard for Switzerland have been constructed. As a database for NXD-REG the bulletins of 10 winters have been brought into the new formalized form. There were only few situations that were difficult to transform especially when the hazard estimation was rather vague and depended on weather factors.

2.3 REGBUL

The Regional Bulletineditor REGBUL is used to efficiently construct regional avalanche forecasts for Switzerland. It can easily be extended for new regions that can also overlap. Consistency for the hazard estimations of subareas that appear in several regional forecasts is guaranteed. The hazard estimation which is the main part of the product (see Figure 1) is done using BULLED. REGBUL has an interface to the BULLED database that allows to fullfill the constistency requirement.

Figure 4 shows the user interface of REGBUL. The structure is similar to the document that is published (see Figure 1). At the top one can find the input fields for general information. Next is the Flash (german and french) and a 3-line textfield that can be generated using a sentence generator. This generator allows the forecaster to create the most important sentences for REGBUL in german. These sentences are automatically translated into french (for regional bulletin Unterwallis). The sentence generator can easily be extended to further languages. The weather forecast from MeteoSwiss is included. The data of automatic stations is also automatic input that only has to be checked by the forecasters. The resulting document is created using ArcView. ArcView automatically reads the input of the hazard map from BULLED where a hazard map has to be constructed before starting REGBUL.

The dissemination of the bulletin is highly integrated. From one matrix of targets (printers, internet, fax and fax on demand) several options can be selected.

3. EVALUATION

In this paper we focus on the evaluation of the system from a consumer perspective. The evaluation of NXD-REG can be found in Brabec et al., 2000. To quantify the interest in products of SLF two complementary approaches have been applied: on the one hand we have submitted a questionnaire to a group of security personnel and mountain guides to ask them which information and which products are most useful for decisions concerning avalanche questions. This inquiry has shown that for this group the regional avalanche forecasts have become as important as the swisswide national forecasts within a few years. On the other hand detailed information about the amount of information and products that have been requested from SLF have been collected. In winter 1996/97 the national avalanche forecasts have been requested 212'386 times from SLF. This number has increased up to 501'004 in winter

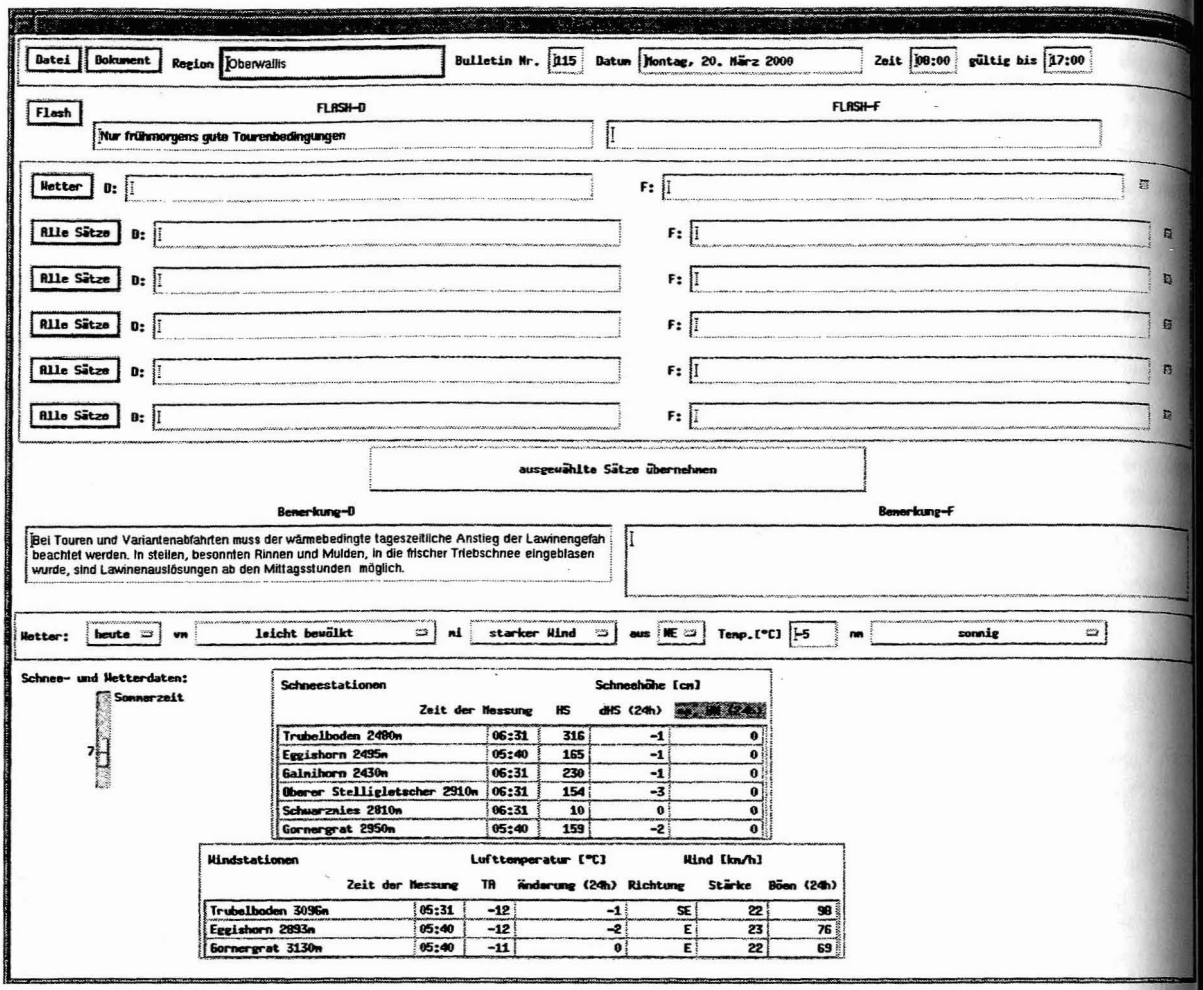

Figure 4: User interface of the regional bulletin editor (REGBUL).

1999/2000. At the same time the requests for regional forecasts increased from 0 to 277'557. All SLF products have been requested 1'453'630 times by internet, fax, InfoBox (see Russi et al., 1998) or telephone during winter 1999/2000. 80% of the information have been disseminated by internet.

4. CONCLUSIONS AND OUTLOOK

In this paper three complementary software packages for regional avalanche forecasting are described: NXD-REG is a nearest neighbor based statistical model that allows the SLF to calculate a forecast for the complete alpine area of Switzerland. BULLED includes the results of NXD-REG and is used for constructing maps of the current avalanche hazard. REGBUL is an editor for editing Swiss regional avalanche forecasts for several regions. All three packages are highly integrated but also offer open interfaces. The system is in operational use since winter 1999/2000 and has proven to be useful and stable. Internet hits and user inquiries indicate that the new products are well accepted and are a true need.

For the next years it is planned to actually cover all areas of Switzerland with regional bulletins. Furthermore several analysis tools will be developed to compare different hazard assessments within BULLED. NXD-REG will be extended by input data from automatic weather stations, snow cover stability and output from NXD2000 (Gassner et al., 2000). Furthermore several other approaches for statistical models will be applied to the task of regional avalanche forecasting.

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