DEVELOPMENT OF A GIS SUPPORTED TOOL FOR THE CARTOGRAPHIC REPRESENTATION OF THE AVALANCHE HAZARD BULLETIN

Moner, I.; Marturià, J.; González, J.C.; García, C.; Martí, G.; Oller, P.; Martínez, P.; Roca, A.

Institut Cartogràfic de Catalunya, Parc de Montjuïc, s/n, 08038 Barcelona, Spain

www.icc.es/allaus imoner@icc.es

Key words: Avalanche Forecasting, GIS, Raster Modeling

1.- Presentation

In the frame of the PARAMOUNT project (Marturià et al. 2003), a GIS-based tool for the improvement of the regional avalanche forecasts is being developed. PARAMOUNT is a IST Program project, and its aim is to develop an information and navigation system focused on mountaineers, by combining telecommunications (GSM, GPRS, UTMS) and satellite navigation (GPS) with geographic information systems (GIS), based on a Mobile Client / Server architecture.

2.- Objectives

The main objective of the so-called Cartographic Avalanche Forecasting (CAF) is to solve the spatial interpretation difficulties detected on the users of the Avalanche Hazard Bulletins (AHB). Deficiencies on the understanding of the AHB geographical parameters lead to wrong interpretations of the avalanche hazard spatial distribution.

In the way to that goal we have achieved two other important objectives: to include in the regional forecasting the information currently provided by the Avalanche Path Maps; and to systematize the making-up of the AHB and store it in a Database.

3.- Methodology

The development of the CAF could be divided in the following steps:

- AHB Database design: Its aim is to systematize the Bulletin making-up, to store it, and to allow the automation of both a text bulletin and a cartographic representation of the forecast. It includes the main expressions used in the fifteen years of AHB in Catalonia. A data form allows to fill-up the Database daily in a easy and user friendly way.

- The creation of the text format AHB has already been automated. Starting on the data stored on the AHB Database, an application generates the framework of the bulletin, containing the characteristics and distribution of the forecasted avalanches.

- The next step was the generation of the graphical AHB. The main result is a map that shows the distribution of the avalanche hazard, the CAF map. It is impossible to include all the textual information in a single understandable map, specially taking in account the small size of the PDA screen where it will be displayed. This problem is solved by the CAF diagram: it contains further information on the characteristics of the snow surface and the spatial distribution of the avalanche hazard (figure 1).

  In the CAF map, the avalanche hazard levels are represented with the colours of the European Avalanche Hazard Scale. The distribution of the avalanche triggering prone areas is shown using a grey scale with three levels of probability: possible (less than 30%), probable (30-70%), very probable (more than 70%).

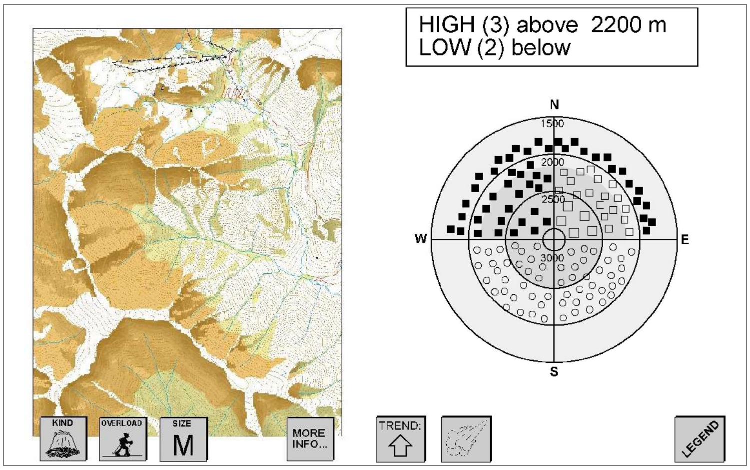

Figure 1: example of a CAF map & diagram, with some icons complementing the information

Raster modelling has been performed on a 15 m cell DEM of a selected test area, in order to automatically recognize the morphologies described in the AHB and stored in the Database. For achieve this aim derivate raster variables have been generated. Some of them are directly derived from DEM. Others have been generated by the combination of several variables and functions (see figure 2).

In this step, the relation between the avalanche hazard distribution and each one of the variable has been qualitatively analysed, on the basis of bibliography and expert criteria. After this, a more reduced group of variables has been found to be significant an will be taken in account (highlighted in figure 2). The choice of variables can be modified after the first results of the field tests in an iterative process.

Directly derivated	Directly calculated	Multi-calculated
Aspect Slope Curvature (long, perfil, pla) Roughtness Hydraulic (flow direction, flowaccumulation...) ...	Average slope Sin of slope Sunshine ...	Ridge distance Deflation areas Accumulation areas Wind-shelterd areas

Figure 2: Raster variable generated for the analysis

All the processes involved in the CAF, from the fill-in of the data form to the generation of the CAF map, the CAF diagram and the AHB framework are being automated.

- Field tests: In the winter of 2002/2003, field observations are being carried out in a selected area of the Catalan Pyrenees, the Ulldeter Valley. Apart from offering diverse morphologies and aspects this valley also meets the requirements of safety and accessibility necessary for the implementation of a winter field campaign.

Natural hazard is evaluated by the occurrence of avalanches, which are mapped and checked with the danger level given by the CAF map. The evaluation of the accidental hazard (man induced) is done by the collection of stability tests. We have chosen the “Stuffblock” test due to its dependability and the short time it consumes (Birkeland, 1996). “Ruschblocks” are also included in the analysis. The results have to be reclassified in the same three levels of the CAF map before contrasting them (figure 3).

	Height	Thickness	Height	Thickness	Height	Thickness
Very Probable (>70%)	<20	>20				
Probable (30-70%)	30-40	>20	<20	<20	>50	>20
Possible (<30%)	>50	<20	30-40	<20		

Figure 3: Conversion table for the results of the Stuffblock stability field test.
Both height and thickness are in cm

4.- Preliminary results

The evaluation field campaign has not been completed yet, but it is possible to present some preliminary results:

- About the field campaign: The Stuffblock stability test can be a useful tool for our kind of analysis. The correct choice of the test sites is crucial: to the usual requirements of the test slopes (to be safe and representative), it is necessary to add another one: it must be close to a major avalanche slope, with enough area to be recognised by the model (15 m of cell size). Avalanche events recording is also a good way of verifying the natural hazard level.
- About the avalanche hazard mapping: Avalanche hazard levels are correctly shown in the map. The avalanche hazard distribution map is still in progress, but based on the results of the field campaign we can conclude that:
  - the adjustment of the model to the field results is around 90% for the natural hazard
  - and around 60% for the accidental.

  A lower rate of adjustment in the accidental hazard is due to the difficulty in modelling wind effects (which create wind slabs) and the problems of testing a latent hazard.

5.- Conclusions/Perspectives

The first conclusions on the development of the CAF are:

- At the present stage of development, Cartographic Avalanche Forecasting is a useful tool for avalanche forecasting teams. It allows to standardize and to store the AHB in a database which can be consulted.
- The graphical interface (CAF map & diagram) is a good way of solving the topographic and morphologic interpretation difficulties of the avalanche forecast users.
- The integration of the Avalanche Path Maps in the forecasts give mountaineers useful information.
- CAF map will be delivered to the user at 1:50000 scale, while the development is made at 1:20000 to 1:5000 digital maps. At user scale the results are almost satisfactory.
- Due to the anisotropy of the snow cover and the complexity of the wind effects on the snow in a mountain environment, we conclude that a longer and more intensive field campaign will be necessary. Possibly, the results could be improved also by the use of a more detailed Digital Elevations Model. With such a field campaign it is possible to apply geostatistical methods in the choice and combination of the variables.

6.- Acknowledgements

PARAMOUNT (www.paramount-tours.com) is a EU funded project under contract IST-2000-30158

7.- References

Birkeland, K.; Johnson, R.; Herzberg, D. (1996): The Stuffblock snow stability test. Technical report 9623-2836MTDC. US Dept of Agriculture, Forest Service. http://www.csac.org/Professional/papers/stuffblock-fs/

Bolognesi, R.; Denuelle, M.; Dexter: Avalanche forecasting with GIS. Management and analysis of snow, avalanche and climate data. http://www.avalanche.org/~issw/96/art_1_.html

Coléau, C. and others (2002): Les tests de stabilité du manteau neigeux. Rev. Neige et Avalanches, N. 99, pp 8-25. ANENA. Grenoble, France

Galanda, M.(2000): Online (cartographic) Visualization of the Avalanche Bulletin. High Mountain Cartography 2000. pp 207-214. Dresden, Germany

Leutholdand, H.; Allgöwer, B.; Meister, R.: Visualization and Analysis of the Swiss Avalanche Bulletin using GPS. http://www.avalanche.org/~issw/96/art-7-.html

Marturià, J.; Moner, I.; Roca, A. (2003): PARAMOUNT project: an information and navigation system for mountaineers. Proceedings of the 4th Congress on Regional Geoscientific Cartography and Information Systems. Bologna 17-20 June 2003.