AUTOMATIC AVALANCHE MAPPING FOR LARGE AREAS

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PRESENTATION

The Institut Cartogràfic de Catalunya (ICC) is carrying out, in the Catalan Pyrenees (NE of Spain), a mapping project of avalanche hazard zoning “Mapa de Zones d’Allaus” (MZA) at 1:25.000 scale [1]. The methodology used is based on the French “Carte de Localisation Probable des Avalanches” (CLPA) [2] [3]. In our map (MZA) the avalanche paths determined by geomorphologic and vegetation criteria [4], historical inquiries and winter observations are represented. At present some photointerpretation tasks have been improved substantially (concerning to quality and precision), because these tasks are carried out by interpreting and digitising directly on computer, visualising on the screen digital topography, colour orthoimages and classified slope images [5]. With this method, the 46% of the area has been mapped, being the extension affected by avalanches about 780 km^2. In the other hand automatically location of possible avalanche starting zones (in function of the slope angle, convexity, vegetation, etc.) was used before in order to elaborate helpful documents for the photointerpretation in the CLPA mapping process [6].

A DEM is a numeric data structure that represents the spatial distribution of the elevation values of the terrain surface [7]. The used DEM is a regular grid (raster model) of 15 by 15 meters cell size. From DEM many models can be derivated. They represent quantitative terrain characteristics. The set of those numeric models is the Digital Terrain Model (DTM). Using DEMs, topographic attributes (elevation, slope, orientation, etc) are easily operable and can be displayed as images, which are very helpful for visual analyses.

The availability of a Digital Elevations Model (DEM) of Catalonia, and the experience of it’s application in geological mapping [8] has lead us to develop a method to generate automatic avalanche maps. The MZA is used as a pattern to generate such maps. Tools provided by the Arcinfo software (7.0.3 version) from ESRI (essentially the GRID module) have been used as a Geographical Information System (GIS).

The results of the analyses are a probabilistic model where for each pixel a probability value of being “avalanche-prone-terrain” (APT) is assigned according to its topographical characteristics. Afterwards this model has been applied to the whole Catalan Pyrenees.

METHODOLOGY

The developed methodology applies the process of supervised image classification used in multispectral classification. The goal is to obtain the spectral signature characteristic of the homogeneous training areas [9] (extracted from the MZA). In our case, the multispectral image is a set of DTMs, and the classes are obtained from the MZA. These classes are used to extract the topographic parameters (topographical signature) from the DTMs.

The main steps of this process are:

1. Selection of the pilot area (Val d’Aran).

2. Definition of the avalanche classes.
3. Calculation of the topographic parameters (DTMs).
4. Obtaining of the class signatures.
5. Testing the model.
6. Validating the model in other areas (Vall de Núria).

Once the model has been validated, it has been applied to the whole Catalan Pyrenees.

In this work the areas with a probability of more than a 70% has been considered as avalanche terrain. This percentage has been determined according to the maximum likelihood of the results of the model with the original MZA.

DISCUSSION OF THE OBTAINED RESULTS

The DTM stack that has better characterized the APT is composed by elevation, slope angle, medium slope angle accumulated along the drainage network, maximum change in elevation along flow direction, and curvature of the surface perpendicular to the slope direction.

Although the aspect seems to have an important role in avalanche phenomena, it does not have any notable effect in the results of the model, at least comparing with the other analysed variables.

Comparing the APT and the MZA from the pilot area, it is important to remark the following items:

1. The model locates the starting and the main part of the track zone in channelled avalanches. In open slope avalanches the model does not identify the path zone.

2. There are few exceptions where the model does not identify the APT. These avalanche zones have been determined by population inquiries, and their location do not obey to the classic geomorphological and vegetation criteria.

3. There have not been observed significant differences between the western part (Val d'Aran) and the eastern part (Vall de Núria) of the Pyrenees. The results are the following:

Pilot area	**Success in avalanche paths***	**Error in non avalanche paths****
Val d'Aran	84 %	23 %
Vall de Núria	85 %	18 %

Table 1: Comparison of the results in the pilot and test area.
* % of coincidence between the results of the model and the avalanche paths mapped by the traditional method.
** % of the results of the model that don't coincide with the avalanche paths mapped by the traditional method.

1. The automatic process classifies as APT some areas with forest cover. Obviously these areas are not mapped by the classic MZA, thus representing an important part of the error in non avalanche paths. Anyway it is important to remark that this is a relative error in the sense of the terrain is avalanche-prone, but the forest existence does not allow the

avalanche release. In the other hand, if the forest would be cut or burned, the avalanche release would be possible.

2. The model has been developed with a DEM 15x15 m cell size. When a DEM 100x100 m is used, the results are not satisfactory. In this case the coincidence is about 50% and it only detects starting zones. This happens because the DEM resolution is not adequated to represent the topographic parameters that characterize the avalanche phenomena. Current works show that DEMs with a resolution of 45x45 m are good enough to map areas at regional scale. In this case the success is higher than 70%.

CONCLUSIONS

This methodology gives a good approximation of all the possible extension of the areas affected by avalanches in the Catalan Pyrenees. It is important to remark the high correlation between the automatic map and the test areas.

It has demonstrate to be a useful tool in order to get a first, rapid and cheap evaluation of the snow avalanche hazard in non mapped areas, obviously if a DEM with an adequate resolution is available.

In order to obtain satisfactory results, DEM resolution has to be in agree with the dimensions of the phenomena that is going to be modelled.

From the results obtained applying the model, the extension that can be affected by avalanches in all the Catalan Pyrenees is about 1100 km^2; the non mapped extension until now is a 32%. It has allowed to manage the ICC mapping plan scheduled to finish at 2002.

The obtained images from the application of the model constitute a good additional analyses visual tool, and they have been incorporated in the MZA mapping process at a medium scale.

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