PROJECTS FOR PAST AVALANCHE OBSERVATION AND ZONING IN FRANCE, AFTER 1999 CATASTROPHIC AVALANCHES

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ABSTRACT: In 1999, several huge avalanches caused catastrophes in the Alps, particularly in Chamonix (France). Following these events, several programs were improved or developed in France.
Firstly, the programs of past avalanche observation have been confirmed. They concern i) the avalanche permanent survey (a past event observation on 5000 avalanche sites), ii) the past avalanche map, and iii) the selected event investigations. Important multiple year projects allow to continue, to update and to improve these programs.
Secondly, others projects have been launched concerning classification of avalanche risk areas and doctrine for land-use zoning with regards to avalanche constraints.
The article gives an overview of the projects. It details their main characteristics and show examples of methods and products.

Keywords: avalanche, observation, survey, investigation, mapping, hazard

1. OVERVIEW OF PROJECTS

In February 1999, several avalanche surges occurred in the Alps. Huge avalanches caused several catastrophes: 38 persons were buried in snow at Galtür and Valzür (Austria), 12 persons were killed in very old cabins at Evolène (Switzerland). In France, on February 12th, 12 persons were killed and 14 mountains chalets destroyed at Montroc (town of Chamonix), Rapin (2000) and Ancey (2000). People were mostly killed in or just around their house.

The French Secretary of Environment charged inspectors with establishing the conditions of the accident and the efficiency of avalanche mitigation policies.

These policies were established after the avalanche catastrophe of Val d'Isère in 1970: an avalanche hit YMCA accommodations and killed 39 persons inside. It happened while the "Snow plan" was being implemented. This "Snow plan" consisted in a redeployment of some alpine areas from traditional mountain agriculture to skiing resorts.

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Consequently, the Government started policies about mitigation against avalanche risks: structuring of avalanche forecasting, planning of avalanche mapping and risk zoning, training of avalanche dogs, planning of avalanche triggering, coordinating several services, etc., Saunier (1970).

The inspectors concluded that the Department of Environment should improve some existing programs and launch news ones, Huet (2000). Some of them relate to past avalanche observation and zoning:

- The avalanche permanent survey
- The past avalanche map
- The selected event investigations
- The classification of avalanche risk areas
- The doctrine for avalanche zoning

The article exposes what has been done in these programs over the next five years.

The Department of Environment assigned the Cemagref and the National Forest Service to develop and undertake these projects. The Cemagref is a national agency for agricultural and environment engineering research; one of its unit is specialized in snow avalanche engineering and torrent control research. The National Forest Service is in charge of the public forests and mountain risk management. It has two departments at regional level, forest agencies and mountain risk units. In these structures, many people collaborate to the projects; the works presented hereafter is the result of each and everyone's contribution.

2. THE AVALANCHE PERMANENT SURVEY

We know this program in France as "l'Enquête Permanente sur les Avalanches, EPA". It is a chronicle, which has begun in 1900 for most of the sites, describing each event that occurred on 5000 determined sites. Three hundred forest rangers have been observing these sites and writing down characteristics of each event on a template. They have sent these documents to the Cemagref, which has registered the information in a database. They have also made a copy of their observations on a notebook, of which the first ones were opened in 1900. In the past, some observations and registrations could have shown a poorer quality, as missions were not confirmed.

We improved the survey by restructuring the network of forest rangers: for each site, we identified a primary observer and a substitute one, so that no observation event could be missed. However, the survey has remained a delayed time observation (and not a real-time one).

We have been updating the list of sites, to take into account the evolution of constructions and roads. Three agents are in charge of deciding this update on the field: one is the main observer of the site, another one is a technician from the mountain risk unit, and the last one is a full-time specialized technician from the Cemagref. They decide to stop, to continue or to begin event observation on the site, and they write down their argumentation. The two main factors considered are the importance of potential and present risks, and the quality of data collected since the beginning of observation.

These three persons report on several complementary supports: a site photograph, an observation map, and a site template.

- Photographs allow observers (and especially substitute ones) to check the localization of the site on the map (see illustration 1).
- The map is drawn on a black and white topographic background, with a scale of 1/25 000. The team reports the edge of the avalanche site, open to downhill, and the avalanche main flows (see illustration 2).

The 3 persons decide some points of protocol, which are drawn on the map:

- an observation threshold: observers systematically report events which flow under the threshold; they report an event that remains over the threshold only if they estimate it has some special characteristics.
- an alert threshold: see selected event investigations described hereafter.
- a point of observation: it is a place where you can easily go most of the time and which gives you a good view of the extent of avalanche. This information is especially useful for substitute observer. Observers shall examine events at least from this place. We normally take the photograph from this place.

The Cemagref registers all these data, and then publishes them in binders. They include maps, photographs and site bills. We distribute them to the observers and to the technicians from the mountain risk units. In 2003 and 2004, we have updated half of the 5000

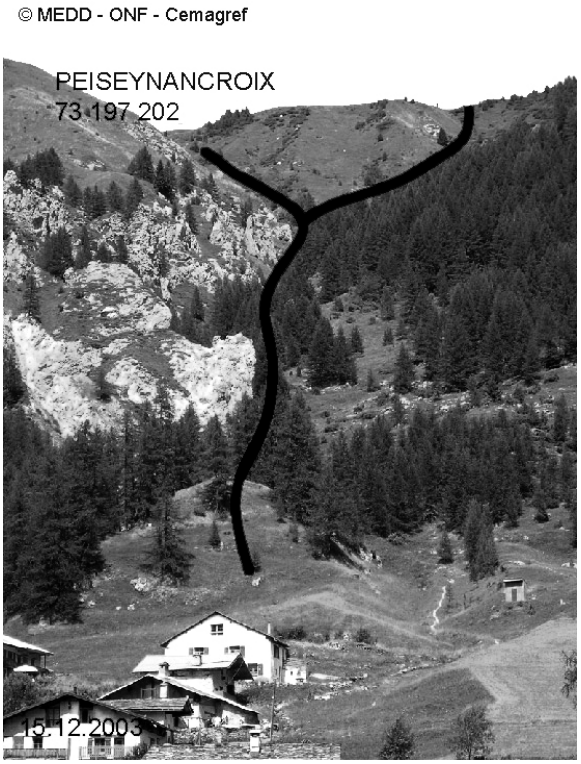

Illustration 1: Example of site photograph. It reports from top to bottom, the name of the village, the zip code and the site number, as well as some red lines for the avalanche main flows. Finally, forest rangers are able to archive their notebooks.

sites. We will update the remaining half in 2005 and 2006.

We have re-edited the full protocol of observation much more precisely. However, the bases of reports still rely on an adaptation of the International avalanche atlas, De Quervain (1981). We describe and illustrate this protocol in an observation handbook, given to all observers, Garcia (2003).

Finally, we registered data of all events in a database since our first computers in 1970. However there were some intermediate supports (both on paper and computers), and we might have made some transcription or migration mistakes. Therefore, we have decided to scan all the observation notebooks that were completed. After scanning the notebook, we provide the users with the databases together with the scans, as complementary information and crosschecking tool for the older events.

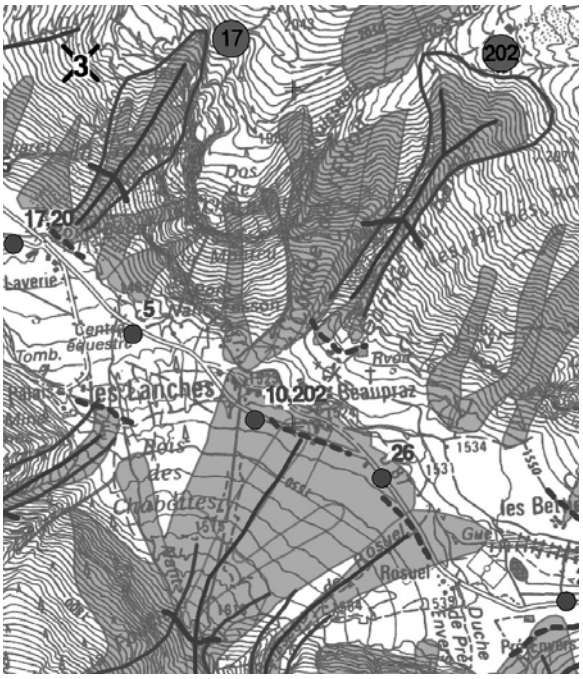

Illustration 2: Example of the observation map for the avalanche permanent survey. It reports for site # 202 from uphill to downhill: the reference number of the site, the edge of the avalanche site open to downhill, the avalanche main flows, the observation and alert thresholds, and the observation point. Moreover, the grey areas report witness testimonies from the past avalanche map.

3. THE PAST AND GEOMORPHIC AVALANCHE MAP

Since 2002, we have called this program in France “Carte de Localisation des Phénomènes d’Avalanches” but it is still rather better known under its older name “Carte de Localisation Probable des Avalanches”, the abbreviation remaining CLPA. The Government decided to launch this program in 1970, after the catastrophic avalanche of Val d’Isère, and it assigned the Cemagref. The map has reported, with a 1:25,000 scale, the envelope of event areas, by two independent methods:

- an analysis of archived newspapers, photographs and technical reports as well as witness testimonies. We collect the information through field investigations. The purpose is to inventory exhaustively past avalanche area, and the key point is to get facts.
- an interpretation of stereo-aerial photographs, to find avalanche marks on vegetation and relief.

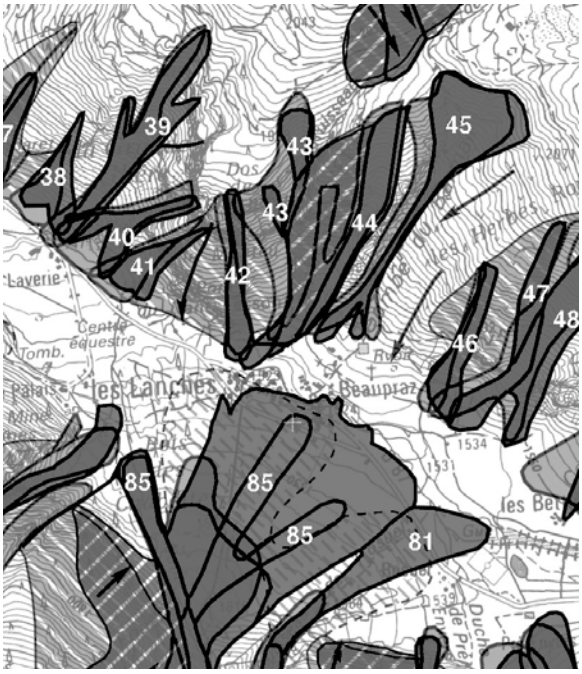

Illustration 3. Example of the past avalanches map. It reports witness testimonies in dark gray and photo-interpretation in lighter gray (respectively magenta and orange in original colored map)

We report both areas, respectively in magenta and orange. We do not distinguish the boundaries of the different events known on an avalanche site: we draw only the global envelope of all the events.

Before publishing, we show the map to local representatives for information and comments. Since 1970, we have studied 7,000 square km of valleys and their neighborhoods.

We improved the map by adding two documents to the map that we now systematically distribute.

- Since the beginning, we have kept tracks of testimony references and main facts on a paper file for each avalanche. We have digitized these data in a database, and we have published them, to the exception of witnesses' names.
- For each mountain massif, we have edited a synthesis of the main avalanches that happened. It also includes descriptions of mountains, geomorphology, environment, and it will integrate climate and precipitation data in relation with snow and avalanche. French Meteorological departments will write these last two parts.

We have also implemented regular update processes:

- Since the last edition, ten to thirty years ago, new events have occurred, and some of them may have been bigger than the ones known before: the envelope of past events shall be extended. Each year, we make a full investigation on ten percent of the studied valleys, searching for such big events. It is the decennial update.
- In addition, there is an annual update. It is limited to places where professionals send the Cemagref some information about events exceeding the drawing of avalanche on the map. We collect part of this information thanks to the selected event investigations described hereafter.

We complement the photo interpretation with a field analysis, to find evidences of avalanche on the vegetation and relief, because some of them cannot be seen on aerial photographs: for example, a narrow corridor where avalanche has destroyed trees, but which is still hidden by neighboring trees.

In addition, news valleys or parts of valleys are studied.

The Cemagref registers all these data, and then publishes them in binders. They gather maps, testimony references and main facts, as well as massif synthesis. We distribute them to leaders, professionals, forest rangers and witnesses. All professionals appreciate this map for its precision and its exhaustiveness: It is The reference map for avalanche in France. However, nobody shall forget that this is not a full prospective or hazard map (even if it is an essential part of it).

4. COMMON POINTS

Someone may ask why there are two different programs:

- The avalanche permanent survey efficiently collects textual information about events, but not geographical information. On the contrary, the past avalanche map collects geographical information about sites (and not each event that occurred).
- The map of the avalanche permanent survey reports observation areas where events shall be observed, and not event areas.

Therefore, the survey and the map are fully complementary. They share some common characteristics:

- Both focus on areas where there are constructions or roads. They are not adapted to mountain sport activity, which need short-time analysis of the snow stability.
- All technicians use both of them as references about past avalanches, as opposed to the broader public. These people do not know avalanche observations well, nor do they understand their precise meaning. To inform people about natural risks, the Department of Environment asked us to widely spread data. It requires that we vulgarize the above notions about avalanche observation, such as differences between past avalanche and hazard identification, or avalanche forecasting.
- From this purpose, we shall put the data on an Internet site, with a geographical interface. A temporary web site already allows consulting the past avalanche map. The address is

http://clpa.grenoble.cemagref.fr/

- To make it possible, we have put all the data about events, sites, and observation network on databases. They are on the software Microsoft Access for textual parts, and ESRI ArcGis station for geographical data. They will be migrated on Oracle, with the connection Arc SDE for geographical data.
- We publish all maps on A3 sheet (approximately 420 x 280 mm). The cutting grid is regular and it uses the same base for the map survey and the past avalanche map. There are approximately 300 tiles for the survey and 500 tiles for the past avalanche map.
- We distribute the products (maps, cards, photographs) in formal binders. It allows easier fillings and updates.

5. THE THREE OTHER PROJECTS

Another program concerns investigations about selected events, wherever they happened. This program covers all mountain risks: avalanches, torrents, rock falls, landslides, etc. The criteria to select these events are: special size or characteristics, damages or proximity to constructions or open roads. Mountain risk technicians have reported the descriptions of the context, the event and the damages. Then, these event investigations are registered in a database.

For avalanches, the investigations are connected to the avalanche permanent survey and the past avalanche map:

- All observers of the permanent survey have to alert mountain risk units if the event goes over the alert threshold predefined for each site of the avalanche permanent survey; or, for all avalanche sites, if the event exceeds the drawing on the past avalanche map.
- A technician investigates the event. Besides his report, he draws a map of the event, and sends these documents to the Cemagref.
- The Cemagref integrates these information to the past avalanche map, in the annual update.

The Department of Environment has started several other projects, but they concern temporary studies rather than permanent programs.

One of the projects is the inventory and classification of avalanche risk areas. Its purpose is to identify the most dangerous sites in order to focus the mitigation risk efforts.

- In 2002, mountain risk units inventoried avalanche risk areas.
- The Cemagref has developed a method of classification according to the risk level, Rapin (2002). For each area, there are 38 questions about past events, risks, avalanche knowledge and meteorology. The answers should be selected in lists of 2 to 8 defined items per question, with a weight associated for each item. At the end, all the weights for a site are summed, and the total allows the classification of the area into strong, middle or less important risk. The key points of the method are to be as objective as possible, and rather quick to answer (one day per site for a person who knows the place).
- In 2004, the Department of Environment assigned mountain risks units to apply this classification method to approximately 500 sites. With these results, we will be able to test the adequacy of chosen weights and we will update the classification accordingly. Another challenge will be to establish what shall be done for the most dangerous areas.

Another important project concerns avalanche risk zoning. The main tool in France is Risk Prevention Plan. Mountain risk units establish it for each village. The plan includes past avalanche analysis and hazard identification, and it establishes prescriptions and rules for local planning. From 2001 to 2003, we investigated and defined the doctrine. The result is an official handbook that is about to be published, Lievois (2004).

- For buildings, we still base safety on centennial hazard in land-use zoning. We considered three avalanche pressure zones: lower than 1 kPa, between 1 and 30 kPa, higher than 30 kPa.
- For people, we introduce prescriptions to village council regarding people safety plans (by example, evacuation or confinement plan). It concerns areas of potential maximal hazard (in French “avalanche maximale vraissemblable, AMV”). We aim for an estimated tricentennial event, or at least the biggest known avalanches.
- Finally, we define the departure area of avalanches, where forests are protected.

6. CONCLUSIONS

Several projects have been launched after the accident of Montroc to increase avalanche risk mitigation.

Avalanche hazard identification, and consequently risk mitigation, is essentially dependent on the information about past avalanches. All new projects of building or land-use have a crucial need of this information to take avalanche risk into account. Therefore, the Cemagref and the National Forest Service have taken care for a long time of the avalanche permanent survey, the past avalanche map and the selected event investigations. Nowadays, we take great benefit from having so many systematic collections of data about past avalanches as far as a century old.

After the catastrophe of Montroc, the Department of Environment confirmed the missions of the Cemagref and the National Forest Service, and gave important resources to continue and upgrade the three programs with multiple year projects. It will be necessary to keep on updating these data, and to increase or update the observed areas according to the evolutions of land use. Our challenge is to plan these programs as permanent works, with regular resources, for the long-term needs.

Another subject is better information to the public about avalanche hazard and risk. Ours maps and data are mostly unknown or misunderstood outside avalanche expert world. We are undertaking communication and information actions, mostly through Internet sites. Some of them are especially designed for leaders and professionals, according to their specific responsibilities. However, we have a general challenge to vulgarize our knowledge in an adapted way to the needs of different public.

Moreover, we have to value people reactions on our data shown on Internet site. How to collect testimonies about past avalanche from this public to complement the avalanche survey and maps? How to cross testimonies and check author's identity? This will be future jobs for avalanche mitigation.

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