THE LOCALIZATION MAP OF AVALANCHE PHENOMENA (CLPA): STAKES AND PROSPECTS

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After almost 40 years of existence, the localisation map of avalanche phenomena (CLPA) represent now an essential element for the consideration of the avalanche hazard in developping plan in mountainous areas.

ABSTRACT: The Localization Map of Avalanche Phenomena (CLPA in French) was created in 1971 as a response to the deadly avalanche occurred in Val d'Isère (February 1970, 39 persons killed). The aim is to inventory and to memorize areas where avalanches occurred in the past in order to keep in memory precisely the greatest limits of those avalanches. The CLPA was rapidly considered as an essential element for developing plan in mountainous areas.

After the other catastrophic avalanche, which occurred in the Montroc Village (Chamonix) in February 1999, the ministry in charge of environment decided to continue and to modernize the CLPA, a mission that was assigned to the Cemagref with the ONF collaboration.
This modernization was based on digitizing maps and eye witness account records, the compilation of summary notes concerning main avalanche information in reference to a mountain massif, the institution for a durable updating of the map and the possibility of having all information on line on the website www.avalanches.fr. Information recorded in the data-base is very important for research. Now the Cemagref wants to capitalize on it with numerical models and calibrated tools. Specific parameters could be used in order to develop statistical laws which could be used for unkown sites.

Since the creation of Division Nivologie (snow study) in 1971, the entity which became later the Cemagref completed and managed two databases. The operational vocation of those is complementary of a scientific valuation of the data:
- Begun in the 19th century, the Avalanche Permanent Survey (EPA) keeps the date of events occurring in more than 4500 sites selected through the French Alps and Pyrenees, as well as some further information;
- The Localisation Map of Avalanche Phenomena (CLPA) records, on a 1/25 000 map, the greatest limits of all the known avalanches having occurred in the French Alpine and Pyrenean massifs (the CLPA covers today more of half of the corresponding surface).

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On February 9th 1999, an exceptional avalanche killed 12 persons in the hamlet of Montroc (Chamonix, Haute Savoie, France). The Ministry for the Environment decided to renew and to pursue the observation of avalanches, in particular the CLPA, and entrusted the mission to Cemagref, with the cooperation of the National Forest Office (ONF). The principles and the approach were formalized through an agreement for the period 2002-2006.
The agreement allowed in particular the recognition of public utility of the observation of avalanches. It is about the first agreement of this type who systematizes the knowledge of a natural hazard.
The renovation mainly concerned the normalization of the processes of data collection and management, the completion of the map and identification sheets of the eye witness account digitization, the compilation of massive notes synthesized for the main information on avalanches, the implementation of a permanent updating of the map and the creation of a website

(www.avalanches.fr) where all this information is online.

Since 2007, efforts are centered on the stabilization of the methods and the choice of better tools. Main evolutions today concern the implementation of a long-lasting function from 2011. This renovation opens numerous perspectives, in the data use for all projects of the mountain territories development and management and for the public information; as well as for new scientific aims: data for numerical models of avalanche flow and stop, study of regional models of avalanches, spatial analysis of the avalanche-prone zones (start zones in particular), result applications of research on information systems. The applications and the perspectives made possible by the CLPA are detailed below in parallel of the presentation.

1. WHY TO OBSERVE AVALANCHES?

The collection, the treatment and the diffusion of the known historic events are the first means of knowledge of the avalanche-prone phenomena in their spatial and temporal dimension. They are an indispensable tool for the public information; they also constitute the base of the avalanche risk consideration in the development planning.
The release and the dynamics of avalanches are physically very complex. It is generally impossible to determine the precise sites where they will start even in a term of a few hours. That is why the knowledge of phenomena on a local scale is particularly difficult.
Consequently, all the decisions of risk prevention and management concerning the stakes result from expert based knowledge of the historic events. It is necessary to have reliable, objective and systematic information.
Avalanches however often leave only discreet tracks in the environment and the eye witness account are rare and centered on the damages more than on the precise and complete description of the phenomenon. So, the observation of avalanches constitutes the first means of knowledge of these phenomena.

2. THE CLPA, AN INVENTORY MAP OF AVALANCHES

2.1. Origin

Further to the murderous avalanche of February 10th 1970 in Val d'Isère (39 persons killed), the report of the Interministerial Mission of Study on the Mountain Resorts Safety, recommended "the establishment (…) of an inventory map of avalanches". This mission was entrusted to the Division Nivologie (snow study) of the CERAFER (became CTGREF and then CEMAGREF) in association with the IGN (french National Geographic Institute). Called then, Map of Probably Localization of Avalanches (already CLPA in French; with the more recent evolutions of the concepts bound to the risk management, this qualifier became ambiguous compared to the exact meaning of the CLPA), the objective of this map was to assess known historic phenomena or tracks of which are visible on the field. The planned vocation was to keep a precise memory of the places where avalanches effectively occurred in the past.
The CLPA was mainly constituted by a A0 size paper map, first on a 1/20 000 scale and then on a 1/25 000 scale, where they were collectively put back the greatest limits of avalanches recognized by photo-interpretation (represented in orange) as well as by investigation on the field (represented in magenta). Afterward, the main structures of protection realized in the date of the investigation were added in black. Identification sheets were already established to describe avalanches being from the investigation on the field and appointed on the map by a number.The first maps were established since 1970 to 1980s. From 1990s, thanks to the intervention of the concerned Regions, the existing maps were updated for the first time and new zones were studied. At the same time, the appearance of Geographical Information Systems (GIS) allowed the digitization of the whole CLPA.

2.2. Description

The Localization Map of Avalanche Phenomena (CLPA) is a descriptive map of the observed or historic phenomena, which vocation is to inform the population on the existence of zones where avalanches effectively occurred in the past. The greatest limits are represented.
The CLPA is not a prospective analysis. It does not take into acount the potential risk considering return period and power of the avalanches in the studied zone.

2.2.1. Principles of CLPA mapping

2.2.1.1. The past events interpretation

The photo-interpretation consists of a stereoscopic study with pairs of black and white and 1/30 000 scale summer aeral photos. The objective is to

determine physical tracks left by the past avalanches. The main clauses are the deposit (debris rocks, snowy morains), the marks in the vegetation: broken forest, according to the line of bigger slope, more scattered zones, line of trees seeming younger (size different from that of the surrounding plants) or partially torn away, presence of shrubs (alders, birches more or less buissonnants, sorbs), and tracks of destruction (hoarse trees, sometimes ruins of houses). This allows characterizing essentially the path and sometimes the runout zone of avalanches, but not defining closely their limits on the map, particularly for the start zones.
That is why the person in charge of the interpretation have to make a complementary analysis of photos to end its work. The stereoscopic study also allows a meticulous examination of the topography and the search for diverse geomorphologic indications favorable to the release of avalanches : steep slopes (30 - 50°), with sufficient vertical fall distance, especially those of convex longitudinal profile, smooth ground (fine mass of debris rocks, paving stones, glacier, slept grass), presence of sources or shrubby vegetation. So, it is possible to specify essentially the start zones situated over the treeline.

Concerning the runout zone, the photo-interpreter often has only to use his own experience "to stop" avalanches, because of the frequent absence of evident tracks.
The photo-interpretation allows finding either evident demonstration of the studied phenomenon, or establishing simple assumptions. It allows finding former phenomena taken out of memories and takes all its importance in areas little or not known. One of its big advantages lies in its independence towards any human, economic or political constraint. This advantage cannot regrettably mask the incapacities and the subjectivity of the interpretation of the air pictures, more particularly in the runout zones.
That is why this work is henceforth completed by a careful route on the field, made rather by the author of the photo-interpretation, to specify this last one by the search for details which would have been able to pass unnoticed on examination of air photos. The observation of field aims, besides the control of the validity of the photo-interpretation, at the search for additional obvious indications that this last one would not have created, such as branches broken on the sides of a path, the trunks broken remotely, damages under forest place setting, the existence of microreliefs or changes very localized by the plant place setting or by the ground, for example.
This contribution of complementary data takes all its importance when the studied area is badly known, or where the collection of testimonies is insufficient or not reliable. As regards "interpreted" data, they appear on the map in the layer of the interpretation of the past events.

2.2.1.2. The eye witness account collection

The study by photo-interpretation remains however incomplete; everything is not detectable on photos or even after a complementary examination of the field. That is why it is indispensable to appeal to the memory of the concerned areas inhabitants and the mountain professionals, quite as the contributions of texts which could specify the events of the last century.
The investigation led on the spot thus contains the collection of eye witness account (forest rangers, ski patrollers, rescue services, roads managers, shepherds, mountain guides and old persons) and the perusal of archives easily accessible and indicated by these witnesses.
All the information obtained with these persons during a confrontation in the field, of the entire zone to be studied, is analyzed. The eye witness account collected with the advisers or the connoisseurs considered the most reliable are faithfully reported. Only what witnesses communicate is precisly noticed. It is the same with archive documents if they are exploitable. All the structures of protection realized in the working zone are added (gas exploders, avalanches gallery, others active protections…).
This type of investigation brings an indispensable complement and insurances.
Regrettably, it does not allow informing correctly the map in the low frequent zones. Near the inhabited places, avalanche paths are more sharply individualized and bounded by witnesses, because their activity having had effects particularly easy to specify on a territory where tracks are many and the impacts noticed by all. On the other hand, it is sometimes harder to get information from those who are mostly concerned: economic interests and land pressure are sometimes too important so that the investigation benefits of the best honesty conditions.
However, a clear evolution of the mentalities in front of the revealing of existence of avalanche areas was noted during the last years: the CLPA is now considered as a tool indispensable for the territory management, rather than as a heavy constraint.

2.2.1.3. Presentation of the document project before official distribution

When the work of investigation and mapping is ended, and before official distribution of the CLPA, the project is presented to Mayors and concerned municipalities, technical services and all others invited persons.
During the presentation, a brief explaination is made for the frame of realization of the presented works and the principles of elaboration and use of the CLPA. Then the main part of the presentation consists in a cartographic presentation of avalanches being from the eye witness account collection and recently postponed or modified, and a reading of the corresponding identification sheets.
Persons of the auditory are then invited to express their observations, in particular on the part "eye witness account collection", which Cemagref will take into account. Cemagref remains the only one responsible for the definitive edition of the CLPA.

2.2.2. Associated uses

The CLPA is an informative document conceived to inform all the persons interested in the existence of avalanches in an area. It has no statutory value itself.
The CLPA contains essential elements of information, helping against avalanches problems in equipment and development projects in mountain areas (communications, skilifts). It can avoid many errors in developments from the beginning of studies. Indeed, the least expensive solution in the fight against avalanches risks consists in avoiding their paths from the roots of a project. The CLPA is particularly important during the establishment of an Intervention Plan of Releasing Avalanches with explosives (PIDA in french) as reference document where appear all the known sites. The PIDA often details limits of avalanches zones with a larger scale, because the essential purpose is to specify the place of the points of explosions.
The CLPA is a technical informative document which particularly concerns the Mayors and administrative or technical departments concerned by natural hazards problems in mountain areas. It is drawn up in order to be read and used by specialists who have to know well how it was realized and to understand the nature of the information contained, in order to use it correctly. It has an important role in the establishment of evacuation and crisis management plans, risk mapping (risk prevention plan or PPR) and urbanism and preventive information documents, as informative document defining zones where avalanches already occurred.
However, the map cannot be directly used as a hazard map. Indeed, there is a fundamental difference between the collection of historic events and the prediction of danger zones. The establishment of a hazard map requires the drawing of a different document where return period and power of the known or possible phenomena are considered through a fine analysis of the field led by an expert. However, the CLPA remains a very important element of appreciation in the realization of these hazard maps.
The number and the importance of its use have largely balanced on the will of the improvement of the CLPA.

3. IMPROVE AND RENEW THE DEVICE

3.1. Why to renew the CLPA?

Several decades after the definition of the CLPA, a confirmation of the Government command and of operators' mission entrusted to the ONF and to Cemagref became necessary.
Further to the avalanche of Montroc (Chamonix), in 1999, where 12 persons died, a mission of experience feedback was confided to the General Inspectorate of the environment. The resulted report (Glass and al., 2000) proposed improvements in the CLPA elaboration, concerning the data collection as well as their distribution.
Cemagref in association with the ONF were entrusting, by the Ministry for the Environment, through an agreement for the 2002-2006 period (Bélanger and al., 2002). This convention confirmed that this program found attributions of the Ministry loaded with natural risks, and fixed the frame of the modernization: approach-quality of the processes, structuralization of databases, data distribution.
The main improvements were the following ones.

3.2. Adopt better adapted methods of treatment…

The current name of the CLPA is "Localization Map of Avalanche Phenomena". This modification is intended to assert better the factual character of the document; it is about an informative map, recording facts turned out. The "probably" term has been banned, of the CLPA's name, this term evoking the probability in the statistical sense, and the idea that the document would present a

forward-looking character, which is not the aim of the CLPA.
For the same reasons, the graphics standards of the document were revised. Indeed, the symbology could inconveniently let suppose a difference of intensity or frequency between the represented phenomena. The CLPA is the object of no forward-looking analysis as for the intensity or the frequency of phenomena. The figurative of the CLPA allows only taking into account various types of phenomena in their known maximal limits and their translation through the received eye witness account.
Besides, the principles of realization of the CLPA were enriched.
During the field investigation, zones of significant damages due to the breath of an aerosol are henceforth clearly postponed of snow deposit of the avalanche. On the other hand, the looked tracks left by the avalanches run, which could not be reported during the investigation field with witnesses, are integrated in the layer of photo-interpretation appearing in orange on the map.
Finally, the normalization of the processes of data collection and management was begun and is the object of the implementation of a quality approach in finalization progress.

3.3. … by making a regular data updating

Since the creation of the CLPA, the mapped area has grown and the data were updated according to the acquired financing. An important evolution of the CLPA is the fact that data are today regularly updated.
Indeed, new avalanche limits fathered by new or more important events are recorded every year by the ONF services as an annual updating of the CLPA. The main interest is to capitalize as quickly as possible the maximum of information on these events, before they are forgetten. Besides, any testimony enough supported brought to Cemagref is also integrated into the CLPA as an annual updating. So, 20 to 30 updating of the CLPA are made every year by this way.
The winter 2008/2009 will be particularly rich with more than 80 main modifications recorded. The last avalanche-prone floods of December 2008 came to remind us the vulnerability of the man towards the mountain and the relevance to keep in memory, and so to pull teachings, such events.
On the other hand, every studied zone is also updated every 10 years with the decennial updating. It is the opportunity to control and complete the annual updating, to find possible new avalanches limits which would not have been recorded in the annual updating, and to renew in a homogeneous way all CLPA studied areas. This updating is made since 2003 on every zone bounded and studied until then. It will be made from 2011 municipality one by one.
New avalanches limits are rapidly integrated into the database in order to give available to users the most recent data. These are then settled on a web site (www.avalanches.fr), managed by Cemagref for the Ministry of the Environment, where it is possible for each to consult them.

3.4. … in the objective of a larger and more appropriate data distribution

The CLPA is distributed as an atlas assembling several documents and mainly those following one : a 1/25 000 scale map, where are postponed the confirmed limits of the biggest historic events, a user-key and a collection of identification sheets concerning every avalanche numbered on the map. The map is broadcasted like a set of A3 sheets, which are referenced according to a regular and unique railing for Alps and Pyrenees, in order to give easier the updating. The atlas includes a departemental assembly plan of sheets, a user guide concerning its realization, its use and its limits of use, and a descriptive note of the context concerning avalanches in the studied areas, called "massif note" in reference to massif bounded by Meteo France for the avalanches risk forecast (PRA) (33 massif notes were drafted this time).
Atlas is largely broadcasted in concerned municipalities and technical services in charge of the avalanche risk management.

The CLPA contains geographical data geolocalised and keyed on a unique reference topographic plan, and tables assignees where is kept the further information of the simple geolocalised objects.
The content of identification sheets concerning every avalanche numbered on the map has been specified and is at present digitized; existing identification sheets have been numerised, and the information contained has been integrated into the new presentation of the document.
All the maps and identification sheets are available as images and GIS data on the web site www.avalanches.fr. Other documents (user guide, use-key, massif notes, assembly plans) are also avalaible on the site.

4. INCREASE THE STUDIED AREA, IN ORDER TO IMPROVE THE TERRITORIAL KNOWLEDGE OF THE DANGER ZONES

The renovation of the existing maps concerns, at this time, 556 000 ha on 725 000 ha of the CLPA which will entirely be updated before 2011.
The evolution of the stakes creates new needs of avalanches knowledge. Approximately 93 000 ha have already been studied, through to financial participation of communities in Alps and Pyrenees.
Finally, 380 municipalities of Alps and Pyrenees are concerned by the CLPA. It represents more than 25000 recorded avalanches and more than 13000 collected testimonies.
In the future, every A3 sheet will be updated every 10 years. Studies on other massif including stakes (Massif Central, Corsica) will also be envisaged.

5. APPLICATIONS AND PERSPECTIVES

The effort of improving and large distribution of data had for essential objective to give easier the work of technicians and the information access of everyone, which is necessary for an improvement of the dangers connected to avalanches prevention.
The informative nature of the data excludes any forward-looking aim: only a detailed knowledge of the mountain and the phenomenon "avalanche" allows drawing from those conclusions concerning the threat degree on the stakes. By the knowledge improved by the past, those data can give easier the work of the experts, as well as that of the researchers.

5.1. At the technical level

Those data are used for majority of decisions taken in avalanche risk prevention and management: town planning (prevention plans of natural risk, evacuation); communications (closure and opening in the traffic, choice of place); infrastructures (dams and restraints of heights, electric lines, development of ski resorts)…
Those numerous data concerning existing avalanches phenomena is a set of information largely envied.
However, it still remains the need to organize the numerical link between geographical data and textual data in order to improve the data traceability. Finally, other complementary databases are developping and it would be interesting to associate our reflections in the current objective to improve the public information.

5.2. At the scientific level

The skills acquired since the implementation of the device, allow today our teams thinking about a methodology recovering from an expert approach of the events statement. Besides a continuous improvement of the data quality it can bring, this reflection will bring elements to the elaboration and the improvement of decision-making tools.

The CLPA database is unique in the world. It covers a big part of the French mountainous built territories and it contains rich spatial integrated information. If we manage to extract and to formalize this information, we can exploit it to transfer the information towards passes not covered by the CLPA on the one hand and to compare CLPA avalanche limits between them in the same area and detect the possible abnormalities on the other hand. A way of realizing this formalization will consist in exploiting one of the products of our researches on the dynamics of avalanches. It is about distribution models which allow reaching sizes of an avalanche flow on its whole route. One of the releases of these models is the maximal extension of the avalanche and the limits of the deposit. The application of these models on a given pass requires a fine knowledge of its topography (under the shape of a digital field model or numerical field model, for example), the identification of the limits of the start zone, and the knowledge of the thickness and the rheologic properties of the mobilized snow. For rear-view mirror to analyze every CLPA avalanche limits, it is necessary to define initial conditions and to compare the releases of the model with the CLPA avalanche limits.

As the CLPA avalanche limits correspond to rare to extreme events, we can choose to fix the start zone to its maximal extension and the thickness of snow in a rare reference such as the centennale reference. For the lines limits of the start zone we can translate the existing expert rules as algorithms in a geographical information system, which will allow an automatic gratitude of the start zone limits from the digital field model.
According to the results, the start zone limits contained in the CLPA can be exploited to refine or force the expert rules. The following stage, the stage of inference, will consist in looking for by an iterative process the friction parameters which minimizes the difference between the historic influence and the influence obtained by models. This procedure is to be applied by homogeneous sector to the climatic plan and it will be necessary,

to estimate the predictive capacity of this method, to realize the phase of learning on a part of the CLPA and to keep a part of paths for the test. The statistical distribution, the spatial variability, within the same massif and between massifs, parameters of friction will be used and parameters of possible climates correlations will be looked for.

This project of research will allow us the extraction and the formalization of a part of the knowledge contained in the CLPA (model + statistical distribution of its parameters) which could be used to the predetermination of the CLPA avalanche envelops on paths situated out of CLPA studied zones.
All the works which we can envisage on the CLPA data require the mastery and the implementation of manipulation tools of vectoriels objects and require the development of a specific mathematical environment allowing the manipulation of spatial objects.

This project will certainly take several years before succeeding. In the meantime, the CLPA data are already used by the RTM services in predetermination of start zones limits and by ourselves for the study of building intercepted by the CLPA avalanche limits. The CLPA offers possibilities of diverse and varied applications as well for the expertise as in town planning, in avalanche risks zoning and in economic evaluation of the risk.

6. CONCLUSIONS

The multiple applications and interests should allow, or already allow, improving the available tools for the avalanches knowledge. They undertake to continue the observation activity, begun more than a century ago as for the EPA and confirmed those last years with the CLPA, the necessity of which will remain indisputable as long as the phenomena release and dynamics will not be controlled. In the meantime, the renovation of the global device allows the concerned services and now all the public, to have essential data for the risk prevention of avalanches.

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