LOCALIZATION MAP OF AVALANCHE PHENOMENA (CLPA) AND COLLECTION OF EYE WITNESS ACCOUNTS: FIELD INVESTIGATION METHOD, BIASES, ALTERNATIVES AND LIMITS, DATA QUALITY

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ABSTRACT: A catastrophic avalanche occurred in 1970, killing 39 people in a tourist centre located in the Val d'Isère ski resort, Savoie, France. In response, the French government gave Cemagref, at this time called CERAFER (Grenoble, Isère), the responsibility of developing avalanche mapping throughout the French mountainous areas (Alps and Pyrenees). The localization map of avalanche phenomena (CLPA) was also created at this time.

CLPA planning is based on two distinct methods. The first consists in an expert approach combining photographic interpretation and field analysis on specific sites designed to determine signs of avalanche paths by landscape interpretation. The second is based on a collection of eye witness accounts. Historical information is gathered from these accounts by interviewing people who live and work in mountain areas (forest rangers, ski resort managers, inhabitants, etc.) and are likely to have seen avalanches and know the avalanche paths, and by studying available archives. Data collected from the eye witness accounts and the archives sometimes concern old, poorly known or contradictory phenomena. Therefore, the first question on the quality of the data obtained from collection of eye witness accounts was considered. We also attempted to define unbiased criteria to evaluate the data quality and to qualify the main components of a field investigation:

- Oral eye witness account data and their sources (qualifications of eye witnesses),
- Material data and their sources (written archives, pictures, maps, etc.),
- Investigation context and qualifications of the investigator.

The first part of this paper will present the actual procedure defined to manage a field investigation. It will provide a few examples of biases encountered in collecting and analysing eye witness accounts and present the alternatives now available and their limitations. In conclusion, it will suggest possible research perspectives for data quality evaluation (using different evaluation methods such as the multicriteria method).

1. HOW IS A CLPA MAPPING FIELD INVESTIGATION MANAGED?

1.1. Collecting eye witness accounts

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In contrast to a statistical investigation, a representative sample is not chosen. The information requested is so specific that it is necessary to prepare a network of informants. The investigator first meets (or contacts by phone) the mayor of the town to be investigated. This meeting is designed to inform the town's elected officials on the investigation's aim and to draw up a list of individuals to interview.
These are mainly forest rangers (in charge of a permanent avalanche survey (enquête permanente sur les avalanches, EPA) registering all events in predetermined avalanche corridors), ski resort managers and rescue ski patrols, other rescue services, road managers, local avalanche experts, natural park managers, mountain guides, ski instructors and other mountain professionals, inhabitants such as older people who have lived in the studied area for a long time, and any others who know the studied mountain area well and are likely to have information on historical and existing avalanche phenomena.

Some areas are well known because of intensive urbanisation, others are less frequented and therefore poorly known. This sample of eye witness will vary and be more or less complete depending on the area studied.

1.2. The archive document collection

Concurrently, the CLPA (carte de localisation des phénomènes d'avalanche) investigator collects archives and other materials (photos, pictures, sketches, maps, etc.) on easily available avalanche phenomena that have occurred. Following the procedure, the investigator refers to EPA event listings, Cemagref expert studies and archives concerning avalanches available at the National Forest Office. During the investigation and meetings with eye witnesses, the CLPA investigator may gain access to other archives to add to the collection.

A complete historical search is not necessary: the extent of the information composing the archive can vary.

1.3. Preliminary conclusion about the analysis of a CLPA field investigation

Since a representative sample is not used and the studied areas are not homogenous, statistical analysis cannot be carried out; consequently, a statistical analysis method specific to CLPA is needed. Furthermore, although CLPA investigations vary substantially from other investigations, several rules are nonetheless followed, in particular for the collection of eye witness accounts.

2. HOW ARE CLPA EYE WITNESS ACCOUNTS COLLECTED?

2.1. How the interview is introduced

Trust must first be established with the interviewee. The investigator therefore explains the project and its organization.
The eye witness's name, postal address and qualifications (job, age, experience, etc.) are then noted. The witness is informed that this information is not published but could be transmitted to avalanche experts if a more detailed study is undertaken.
The interview will take place outdoors in the field studied facing the avalanche path if possible. If not, good-quality photos of the field studied can be used.

2.2. The interview

After having introduced the interview, the investigator asks the eye witness several questions, generally in the following order:
Have you ever seen an avalanche here?
If so, how many times have you observed an avalanche here?
If not, have you heard about an avalanche here? Has someone recounted an avalanche to you?
In both cases:

- What were its geographical limits? Where was the triggering zone? Where did the avalanche pass? Where did the avalanche stop?
- Do you know the date of this avalanche?
- What was the snow type (powder snow, melting snow, etc.)?
- How big was the avalanche (height of the triggered line, thickness and width of the snow deposit)? For example, these values could be directly related to distance data resulting from the geographical limits recorded on the map depending on the scale of the avalanche.
- Did the avalanche cause damage? Were there any people killed or injured?
- What was the weather like before and during the avalanche?

2.3. How to manage the interview

The questions asked during the interview must be clear and precise so that the eye witness understands exactly what is meant and can answer them precisely using landmarks and his or her own description of the field. Questions must be as unbiased as possible, so that the witness can answer them frankly. The investigator must be sure that the phenomenon studied has actually been observed. Moreover, the investigator must ensure that the avalanche description is not minimalized or exaggerated and that the eye witness is describing the largest known avalanche.
The most important feature of the interview is the precision of facts related by an eye witness, especially concerning event limits. Information such as the major event occurrence date, damage, etc. is less important and should not interfere with the search for the main information: the greatest limits known.

Witnesses are rarely able to answer all questions on every avalanche, making it difficult to assess the quality of the accounts collected. Nevertheless, the more data collected, the more one can study coherence and evaluate the avalanche limits. The event limits are drawn at the time of the eye witness interview. Each event must be defined and drawn immediately in order to solicit additional information to improve the accuracy of the event's limits. This could also avoid every disorder when the final event limits are drawn on the final map.

2.4. Preliminary conclusion on CLPA eye witness data collection

As the interview proceeds, a subjective but well-founded analysis forms for the investigator, which could modify the order of questions or how they are asked.

3. BIASES

3.1. The subjective nature of the data collected and related biases

The method chosen for data collection is concerned with the accuracy of the eye witness's account. A 1/25000 scale was chosen to alleviate certain imprecisions. The event limits uncertainty is about 30–50 m in the avalanche runout zone and usually farther for lateral limits. In the start zone, this may extend more than 100 m, because it could be difficult to see the top of slopes in poor weather. Consequently, biases directly related to subjective data are studied here.
Besides the natural characteristic of the phenomenon studied, biases are closely related to the data source and collection conditions. These biases have a direct consequence on the accuracy of collected data compared to the actual phenomenon studied.

3.2. CLPA investigation biases

The CLPA investigation is concerned by several biases related to data sources (oral and material data) and the investigation context.

The main source of these biases is the collection of eye witness accounts, including the human component. Data accuracy mostly depends on eye witnesses' memory and on many related biases (the conditions in which the recollection is acquired, individual history and memory, memory testing conditions, etc.). Data accuracy also depends on many other human aspects such as the eye witness's age, the possible presence of psychological witness account, the person's personal interest in knowledge sharing, etc. and the eye witness's knowledge of the area studied and avalanches (socioprofessional group, experience, other individual activities).
These biases are closely related to witnesses and the investigator will detect and appreciate them as they arise during the collection of eye witness accounts.

Likewise, collecting material data can also introduce biases to be considered by the investigator.

The quality of the data collected is very heterogeneous. However, this information must also be incorporated into the CLPA.

4. ALTERNATIVES AND LIMITS

Today, sufficiently detailed data are integrated into the CLPA through the map or an identification sheet. The map is updated with the appropriate information from the eye witness accounts or archive documents (photos, etc.), which may define new avalanche limits.

The investigator will be able to define avalanche limits only with accounts which clearly detail landmarks and avalanche areas. This information is then recorded on identification sheets which are linked to each numbered avalanche drawn on the map.
Both the maps and the identification sheets illustrate the main CLPA data. Certain accounts may be not sufficiently detailed and it is not possible to define and draw geographical limits on the map. In this case, the information will be recorded on identification sheets. Consequently, information is always easily available.

4.1. Alternatives

Today, the investigator can translate the precision level of the data collected in several ways.

First to be considered are the number, the precision and the physical existence of landmarks and other spatial signs described in eye witness accounts in order to represent these data on a map.
Next, the overall quality of data sources and the quality of the data collection conditions will be considered. Today, evaluating the quality of these parameters is totally subjective.

The different representations used for CLPA mapping are the following:

Definition through eye witness account collection

Avalanche (well-delimited avalanche)

Area affected by avalanches (well-delimited area exposed to avalanches varying in their extent)

Presumed area affected by avalanches (when it is not possible to define a well-delimited avalanche or a well-delimited area because the data collected is not specific enough or is contradictory)

Significant damage due to an air blast (no notable debris)

Pointed avalanche (width less than 30 m)

Presumed pointed avalanche

Presumed link between avalanches

Fig. 1. Extract of the CLPA key

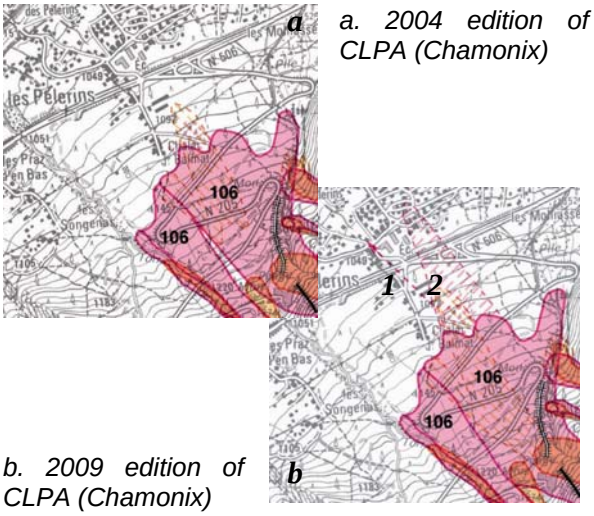
These different representations are assembled in what is called a representation class. Representations 1, 2 and 4 will be put in the “appropriate area limits” class; representation 3 in the class called “uncertain area limits”; representation 5 in the “appropriate linear route” class; and representations 6 and 7 in the “uncertain linear route” class.
The following table presents several rules assisting the investigator in choosing the mapping representation.

		Number and precision of geographical marks collected		Existence of geographical marks collected (2)		Connection between testimonies	
		Sufficient and precise	Insufficient and imprecise (1)	Present and identifiable marks on the field	Old and/or unidentifiable marks on the field (1)	Corresponding testimonies	Contradicting testimonies (3)
Width of the studied avalanche (ratio between avalanche sizes and the 1/25000 map scale)	Upper than 30 meters	Appropriate area limits	Uncertain area limits	Appropriate area limits	Uncertain area limits	Appropriate area limits	Uncertain area limits
	Lower than 30 meters	Appropriate linear route	Uncertain linear route	Appropriate linear route	Uncertain linear route	Appropriate linear route	Uncertain linear route
Geographical marks collected enabling definition of lateral limits of the studied avalanche (4)	Sufficient, precise and known	Appropriate area limits	Uncertain area limits	Appropriate area limits	Uncertain area limits	Appropriate area limits	Uncertain area limits
	Insufficient, imprecise and/or badly known	Appropriate linear route	Uncertain linear route	Appropriate linear route	Uncertain linear route	Appropriate linear route	Uncertain linear route

(1) This category mostly represents archive data, poorly localized and described, which do not correspond to oral testimonies or for which no legible plans or pictures give detailed limits.
(2) Geographical marks used in an avalanche description could be identified if the corresponding field has a few such marks or has not changed since the event occurrence date.
(3) This characteristic is important for the investigator when choosing between contradicting testimonies for which what is true or false is not clear.
(4) Without enough detailed information on the lateral limits of an avalanche, area limits cannot be defined. A possible path to the known point affected is still drawn. *N.B.: in this case, drawing area limits requires an expert methodology which does not correspond with CLPA mapping.*

Fig. 2. Table using in the definition of eye witness account data

If the data collected cannot be represented by means of CLPA mapping (because the eye witness accounts are not clear or are disconnected and the investigator cannot define event limits), they may simply be recorded on an identification sheet if it has been established for the studied avalanche. In other cases, the account will be considered nonworkable and nonrecordable.



a. 2004 edition of CLPA (Chamonix)

b. 2009 edition of CLPA (Chamonix)

Between the 2004 and 2009 editions of the CLPA for the Chamonix area, the limits of the 106 avalanches were updated. Two new outlines were added.
*The first one (**1**) stems from an oral account: around 1936, a family member of the eye witness was blown over by the air blast of an avalanche near a farm. This farm was filled in with a sizeable snow depth. This account concerns an old event and was given by an indirect witness. Furthermore, the sole known and clear mark is the farm. This information was recorded on the "presumed pointed avalanche" drawing.*
*The second one (**2**) results from an 1818 document discovered in 2008. This very old archive recounts an area where inhabitants could collect wood destroyed by an avalanche that occurred at the beginning of 1818. Some of the marks described in this document have disappeared since 1818 but have been approximately localized by the person who found the document and several old topographic maps. The data were recorded here with the "presumed area affected by avalanches" drawing.*

Fig. 3. An example of eye witness account collection data definition (Pélerins corridor, Chamonix, France)

4.1. Limits

In spite of rules established to help the investigator in CLPA mapping (see previous table), this decision remains subjective.
First, the choice results from a human decision and therefore introduces biases. In addition, established boundaries are not tightly closed and do not objectively discern ambiguous cases. Moreover, each class covers a large group of quality values from eye witness accounts and the investigator may use the same representation class for several different values. These slight quality differences will not be directly readable by CLPA users.

The CLPA representation used today facilitates the investigator's work of translating the data collected into a form that can be used by other users. However, a detailed analysis of CLPA geographical data quality is not sufficient, so identification sheets are now an important component of the CLPA. Actually, identification sheets may contain information on further mapped avalanche limits which could give greater detail on avalanche limit quality for the CLPA user. These identification sheets remain incomplete, mostly based on investigations since the beginning of 2000s. As for older investigations, the data collection methodology was different. Consequently, the corresponding mapped data cannot be analysed in the same way. The content of the identification sheets also carried greater uncertainty than for recent data.
The representation of the quality of the data collected requires further investigation, possibly including new ways to analyse the quality of the existing as well as the old data.

5. PROSPECTS AND CONCLUSION

5.1. Present considerations

At present, the investigator evaluates the accuracy of the data collected based on his or her own judgement. This analysis, even if done quickly, is highly rational and deductive and important to describe. First, the criteria influencing the data accuracy were identified. These criteria were defined with all the investigators and validated by all. Analysis of these criteria remains subjective because it is specific to each investigator, which is why biases concerning the investigator's description and the investigation context were also studied.
The method listed all the final criteria, in as much detail as possible. Each criterion belongs to one of the three following components:

- Oral eye witness data and their sources (eye witness qualification),
- Material data and their sources (written archives, pictures, maps, etc.),
- Investigation context and investigator qualifications.

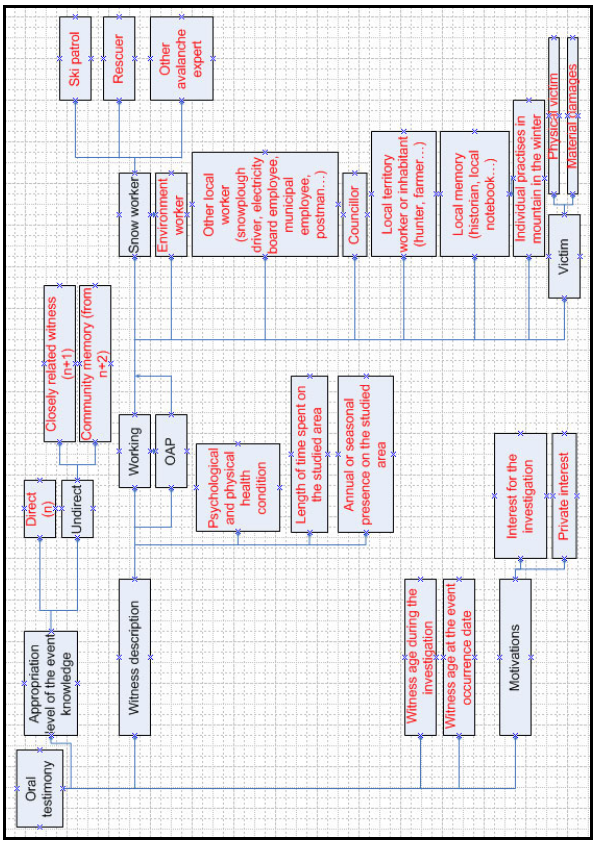


Fig. 4. Example of the eye witness oral criteria listing

CLPA avalanche limits often result from combining several event limits resulting from several different, oral or written, eye witness accounts collected during consecutive investigations (by consecutive investigators). The more numerous the biases, the more the accuracy of each avalanche limit point will be difficult to analyse. However, the more numerous the corresponding accounts concerning avalanche limits, the more these avalanche limits may be considered reliable. Nevertheless, the utility of systematically collecting corresponding accounts may be reconsidered at times. For example, a clear, precise and coherent account can be considered as reliable as a testimony shared by several persons.

Therefore, it is very important to evaluate an account as objectively as possible. If possible, the goal today is to weight the criteria listed below and to find the best methodology to aggregate them. Finally, the summation of the weighted value given during the study by the investigator will give a preliminary idea of the corresponding quality of the accounts.

5.2. Future considerations

It would be very useful to define a methodology that can describe the subjective analysis of the accuracy of the eye witness accounts collected based on the interview and later when data is transferred to the map.
Moreover, improving the methodology of data transfer seems to be necessary in order to retain the slight differences in quality between the data collected and to keep the resulting avalanche limit uncertainty.
Finally, the CLPA would be easier to use if the map could express this uncertainty. The uncertainty could be directly joined to the data, in xml structure, for example. The CLPA user would have to refer to this structure explaining the uncertainty description in order to use the data properly. Studies have already been conducted on this topic (Burnet 2004) and could facilitate this reflexion.

5.2. Conclusion

These reflections could assist the CLPA investigator in the analysis of data collected and also improve the quality of the CLPA product.
Furthermore, a precise evaluation of data quality could aid the CLPA use and the work of CLPA users such as individuals and services concerned by avalanche risk. In the future, all these methods could also be employed in most natural hazards studies.

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