Theor. Appl. Climatol. 45, 83–88 (1992)

Theoretical and Applied Climatology

551.578.48

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The Representation of Foreseeable Natural Risks: A Contribution to a New Cartography of Avalanches

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With 4 Figures

Received January 1, 1991

Summary

Research carried out on a favourable site in the Pre-Alps of Savoy has allowed the development of "risk cartography" where avalanche phenomena are defined according to three criteria: maximum extension, type of avalanche, and frequency of avalanche. The maps, composed of simple symbols, allowing easy updating, could be a useful tool for mountain professionals.

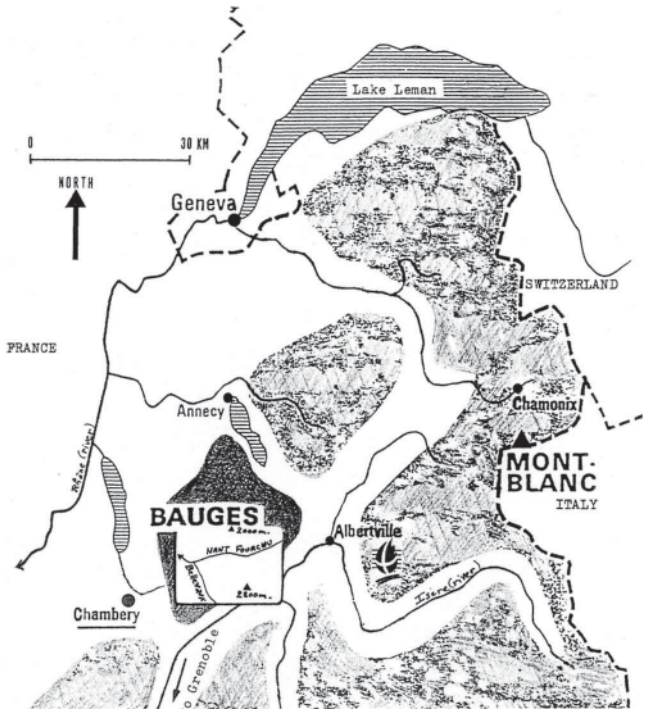
The need to map natural risks, especially avalanches, dates back to the 19th century. Real progress has been made and has allowed us to refine the different documents produced by various National Forestry Commissions and Water Authorities, for example: "Carte de Localisation Probable des Avalanches", "Plan d'Exposition aux Risques".... in France.

However, certain avalanches of the last decade have highlighted the limits to a number of these maps, which must concern the scientific specialist.

The reasons for these specific failings cannot simply be linked to the supposedly exceptional or "unforeseeable" nature of the phenomena implied. Recent articles have shown (apart from an obvious need for a general revision of the maps), a preoccupation on the part of the authorities concerned, to provide a more exact and reliable map to all the users of the mountains, whatever their activity.

I would like the following proposals to be regarded as a complement to maps already existing or under revision, as a source of additional information, in so far as they do not treat the essential parameters in the same way or the same detail.

The fieldwork for these proposals was carried out in the Massif des Bauges, in Savoy (France), in a part of the valley of the Haut Cheran, known as nant Fourchu (Appendix 1). Although of modest altitude (average 1 000 meters), the valley is a veritable avalanche laboratory. In fact, situated in the pre-alpine massif of the Franch northern Alps, the Hautes Bauges have a good snow cover in winter and receive over six meters of accumulated snow annually. The valley is oriented east-west, is very narrow and directly dominated by peaks of between 2 000 and 2 200 meters. The northern and southern slopes are steep with an average angle of more than 35° and often have a difference in altitude of more than 800 meters. The valley therefore has a high density of avalanches with nine avalanches coming from each side in a section only 2.5 km long. It is crossed by a small forest road used almost all winter by the guards of the National Hunting Office as it gives access to the National Fauna Reserve of the Bauges. It is also well-



Appendix 1. French Northern Alps and Massif of Bauges. In Hautes Bauges: velleys of Nant Fourchu and Bellevaux

used by ski-trekkiers and hikers. Furthermore given the many very compact avalanche cones at the bottom of the talweg, the risks of blocking are significant, especially in spring.

The site presents therefore, on a small scale, several points of great interest for applied research: an abundant snow cover, slopes with a tendency for frequent flows or avalanches of different types, according to the north or south exposure of the valley walls, and a real (albeit marginal) human activity threatened by significant risks, against which no screens have been installed.

What were the criteria and methods used to elaborate the map?

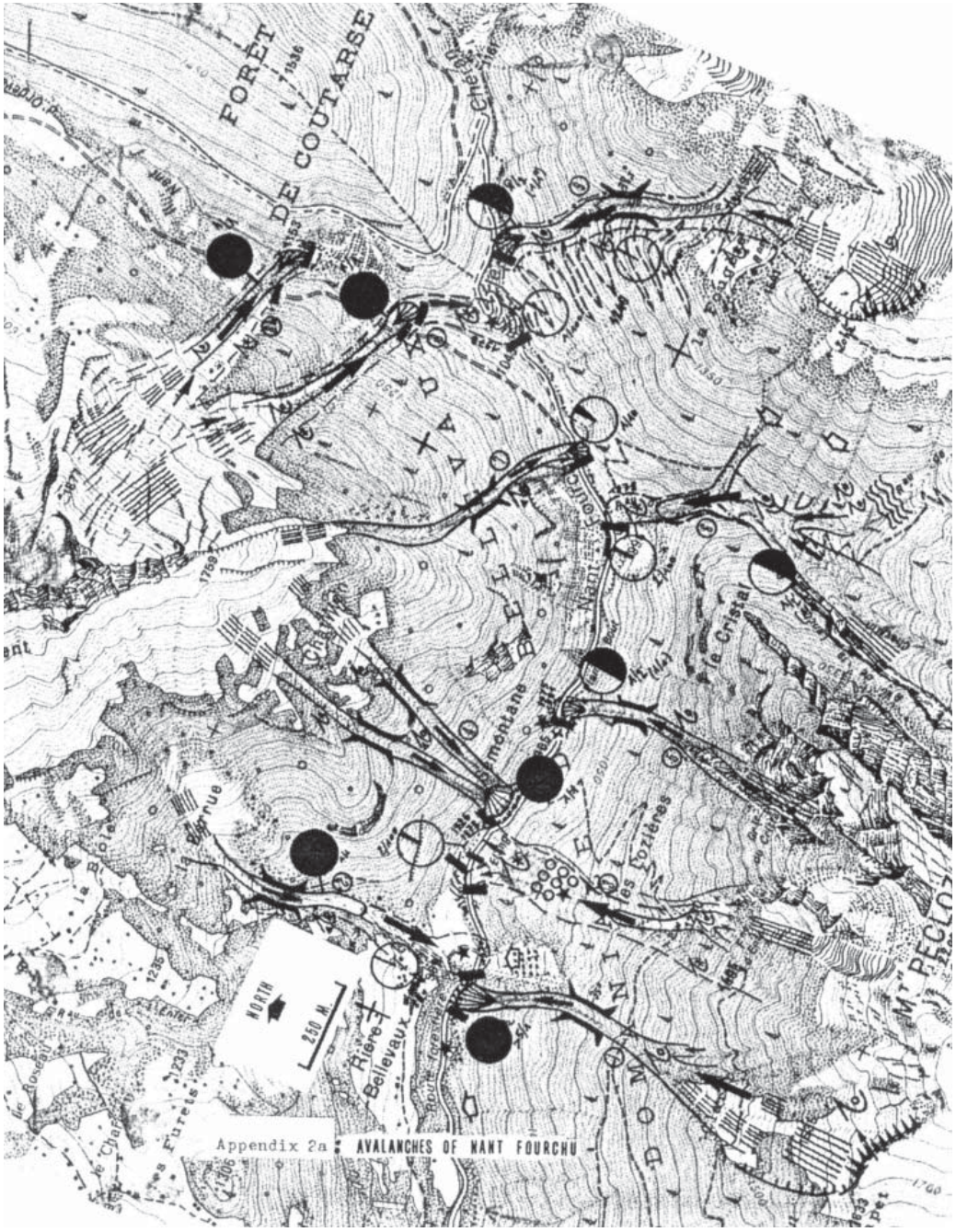
Bearing in mind the idea of a new cartography of risk and a rational use of the documents, three criteria must be adopted when dealing with avalanches:

- The surface area of the avalanche, with its possible trajectories, its maximum known observed extension; and its probable maximum extension.
  Large powder snow avalanches and certain large avalanches of wet snow sometimes have, for different reasons, surprising trajectories and longitudinal developments and, as far as possible, these must be taken into account. It is here, with a view to accident prevention, that risk-mapping is most justifiable.
- The types of avalanche, defined by two main types of flow (powder snow and dense snow), which can influence our appreciation of the extension.
- The frequency of the phenomena with three thresholds:
  - rare avalanche: a weak frequency with a probable occurrence of 1 in 100 years
  - frequent avalanche: annual or even several times a year
  - medium frequency (once a decade).

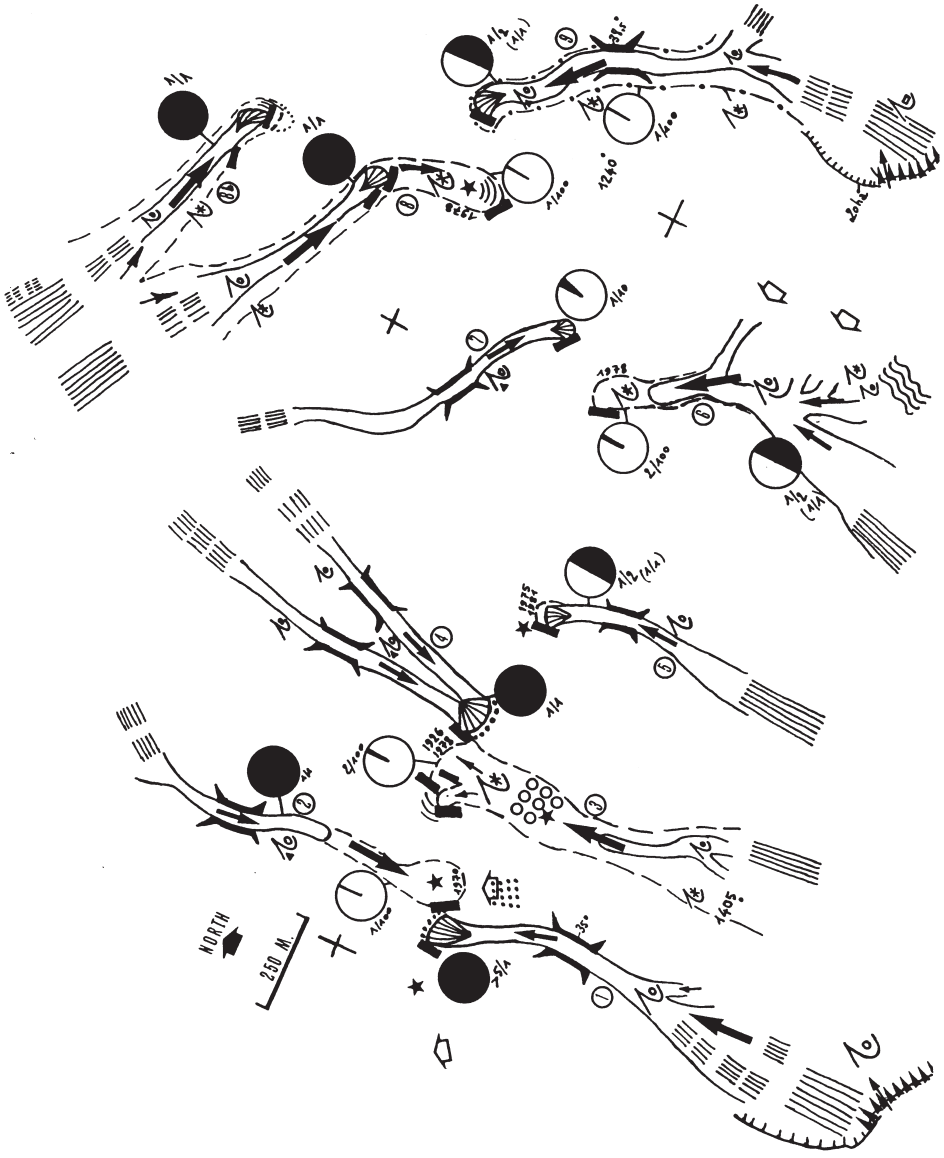
The third criterion is important for accident prevention in inhabited areas with traffic, but it is difficult to judge scientifically without historical data over a long period, so that it can only be completed by future research into vegetation in avalanche zones.

The choice of these criteria determines the research methods in the field, which have been known, in most cases, for at least twenty years. Observations both during and after the winter precede an in-depth study to find traces left in the vegetation (scars; the stages of repopulation by colonizing species, homogeneous reafforestation) or geomorphology (soil erosion, allochthonous rocks, whose presence could not be explained by supposing an obvious trajectory). These investigations provide a first evaluation of the size and frequency of the phenomena. This was carried out mostly on the lower slopes which explains why the present map is incomplete on certain higher slopes. Finally a study of each recorded avalanche slope was carried out from the opposite valley wall to appreciate the general topography, size, trajectory and possible longitudinal development of each flow. This essential survey from the opposite side of the valley complemented the study of aerial photos taken by IGN (Institut Géographique National, Paris) and revealed additional details.

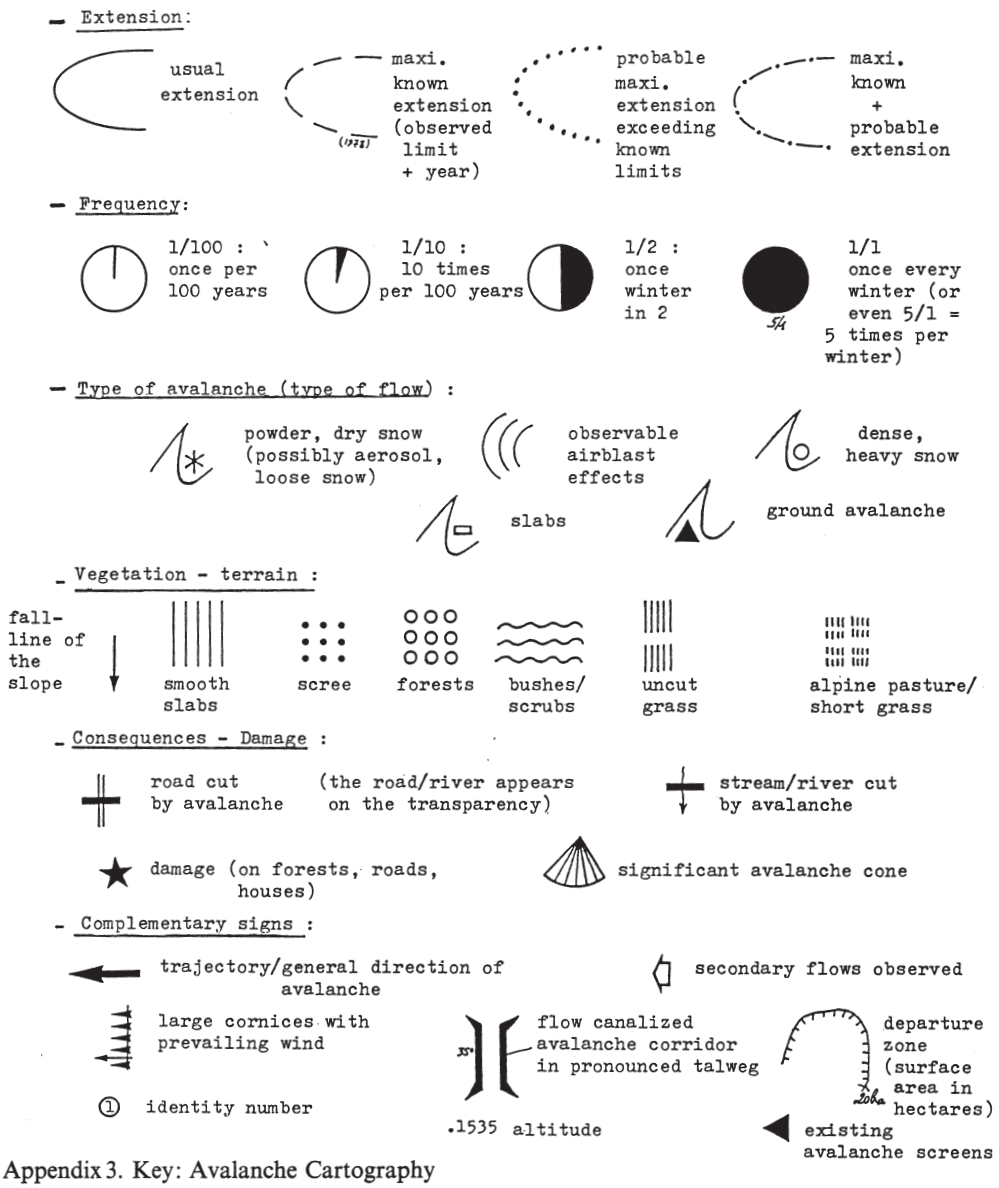
Results of this research, over several years, were collected into a dossier and a first draft of a simplified map was presented to the National Hunting Office Guards of the Bauges for comparison with their own files. They have been recording systematic observations of significant factors for over twenty winters, of which 1970, 1978, 1981, and



Appendix 2a : Avalanches of Nant Fourchu



Appendix 2b : Avalanches of Nant Fourchu



Appendix 3. Key: Avalanche Cartography

1984 were particularly rich in avalanches. Certain exceptional events dating back over 70 years were also recorded, and this comparison enabled the testing of the validity of the methods outlined in the previous paragraph.

The compilation of the map, from all of the collected data, was determined by precise cartographic requirements. The map had to be visual and informative. The choice of scale and of graphics was most important. A tracing-paper or a plastic transparency fixed over the topographical map allows the user to superimpose (and thus to visualize simultaneously) the topographical data with the nivological details. The scale is that of IGN maps at 1/25 000 with the possibility of enlarging the map with a colour photocopier to produce a backing map of 1/12 500. (It would be preferable to work with 1/5 000, if the site was covered at this scale, which is not the case in the Bauges.)

Appendices 2 a, 2 b, 3 show the maps drawn for the central section of Nant Fourchu, with and without the backing IGN map, and the corresponding key. The graphics were chosen for their ease of design and their visual impact. The three fundamental criteria are:

- The size, trajectory and longitudinal development which are immediately seen by the user and allow to visualize at a glance the entire

avalanche zone. The distinction between the different observed and possible limits can be made from fieldwork, or research into the archives which established the precedents.

To proceed by stages, the usual extension of the avalanche is represented by a solid line; its maximum observed extension by a brocken line; and its probable maximum extension (which could exceed its maximum known extension given the comparatively short period of observation, less than 80 years) by a dotted line. This sign, little used on the site in question, would be very useful in Bellevaux, a neighbouring section of Nant Fourchu. The avalanche from "La Lanche" regularly descends to the 1090 m contour. In 1980, it reached 1 000 m, and, in 1981, it descended as far as the 980 m contour, its maximum observed limit. But some evidence, especially from oral tradition, would suggest a probable limit of the 930 m contour, a place marked by a small chapel built as an outpost uphill of the ancient monastery of Bellevaux where there is now a forest nursery (Appendix 4). Note that methods similar to those of the historian allow us to find important information in the study of local archives, "cahiers de raison", or in place-names, evidence of probable maximum limits dating back over several centuries.

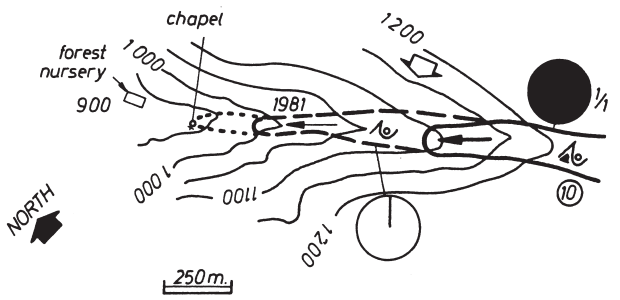
- The type of flow is represented in a simplified way by a symbol linking the idea of an avalanche to the type of snow in motion. The sign "slab" is kept so as not to confuse the reader used to the 3-type classification.
  The sign "ground avalanche" is useful to show the significant geomorphological role that can be seen in certian cases. Notice that a mixed avalanche can easily be shown by superimposing different graphics. On the map only the dominant type of flow for each path has been marked unless another type causes a well established modification (frequency, trajectory and/or maximum extent) which is worth recording.
- Frequency is represented by a system of circles proportionally shaded and completed by figures giving the probability of re-occurrence of the phenomena. Appreciable variations in the probability of re-occurrence can appear according to the type of flow observed for the same path. Remember, however, that these notes do not aim to give the probability of re-occurrence determined statistically and that the values here are only an indication.

On the map, avalanche 8 is a good example of the simultaneous use of the three criteria and their utility in a concrete evaluation of risk. According to the type of flow, not only he frequency but also the longitudinal development and trajectory are quite different and can be rather surprising, however well-known the frequency and extension of the avalanche has been.

To give the most comprehensive range of symbols useful for this type of cartography, other signs have been used in the key without necessarily being employed on this first map. They were chosen for their simplicity and ease of visual comprehension.

For example:

the sign "cornice" with the direction of the prevailing wind to better localize the formation of wind slabs; the sign "avalanche cone" with the date of the final melt (an important factor at the bottom of the valley); the detail for the average inclination of the avalanche corridor; the indication of the total surface area of the departure zone with the possible dimension of the catchment area, can give an idea of the amplitude of the avalanche if everything fell. Finally with the types of vegetation, it is possible to map and demonstrate the



Appendix 4. Avalanche from "La Lanche" Valley of Bellevaux (Bauges)

correlation between the agro-pastoral changes in alpine or sub-alpine zones and the evolution of avalanche risks.

In effect, with the desired aim of constantly updating this kind of map, the simplicity of the figures and symbols gives a certain freedom of use for the person in the field who has to consult and correct the maps themself according to his own observations.

We have, therefore, a permanent working tool for professionals in the mountains, foresters, road surveyors, resort and building-site managers, consultants and other experts.

There are two main limiting factors to these propositions:

- Preliminary investigation is time-consuming. This could be reduced by using helicopter surveys, Spot Imagery, IGN documents, by referring to the archives of communities in the high valleys and massifs where a veritable "collective memory"has been recorded, and by simulating the phenomena with models.
- Ease of reading could be compromised by an overload of detail on a small scale map (1/50 000) or by "black and white". Optimal reading demands large scale maps (1/10 000 or even 1/5 000) and the use of coloured backgrounds.

These maps, thus made more readable, would provide a foundation to a systematic representation of the avalanches at a given site. Later, by taking into account new information and updating the maps, they would become a support within a general framework for the mapping of natural risks.

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