TOURING SNOWPACK OBSERVATIONS, A TOOL FOR AVALANCHE FORECASTING PROGRAMS - THE ITALIAN EXPERIENCE

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ABSTRACT: Accurate snowpack observations along carefully planned routes on mountain ranges are an unvaluable tool for avalanche forecasters and during the managing of civil protection emergencies to estimate the danger level. Such observations are enormously helpful in understanding and predicting snow's behaviour and in completing the avalanche scenario depicted from other's data sources as well as in accurately verify the forecasted danger level. This paper describes the techniques adopted by snow observers and the potential predictors evaluated during such activities

KEYWORDS: touring snowpack observations, avalanche forecasting, regional avalanche bulletin

1. INTRODUCTION

Nowadays the assessment of the avalanche danger level, to draft Avalanches Bulletin, still needs direct surveys to identify snowpack's characteristics and stability. These analysis methodologies are described in Conventional Method (La Chapelle 1980). In addition to the snow daily data and real time meteorological monitoring data, the Avalanche Bulletin is developed through an iterative process, day after day, based on the data really observed (Cagnati 1998).

Direct observations are still essential for a correct evaluation of the avalanche danger for the Regional Avalanche Bulletin, although advanced and complex models for estimate snowpack conditions and stability are developed. (Brun et alii, 1992; Lehning et alii, 1999; Vionnet et alii 2012). Such new automated analysis and evaluations methods take into account the snowdrift effects and the stability variations at different exposures, but still have limited capacities due to single data location snowpack spatial variability. These data are difficult to spatialize at the slope level and, even more, at the bulletin area at which scale danger level must be expressed. The experience of the forecaster to apply the inductive logic still remains the main approach to draft an Avalanche Bulletin.
However, also in this method the evaluation subjectiveness of individual situations is an intrinsic component in every Avalanche Bulletin and therefore it is necessary to establish criteria to minimize the subjectivity of the assessment.

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2. INITIAL CONSIDERATIONS

Föhn (1987), Jamienson (1992) and several other authors demonstrated the high spatial variability of the snowpack properties which leads to an equally large variability in characteristics of stability. It is well known that the precise results obtained from a stratigraphic analysis, or from the stability tests, can return completely opposite values even if they are conduct at short distances along the same slope.

The knowledge of the spatial variability of snowpack stability on a regional scale is one of the objectives for assessing the avalanche danger. The spatial contextualization of data is therefore highly important. The results of analyzes performed with standard methodologies are objective data, while the choice of the place where to make the measurements can be linked to a subjective factor and therefore it is necessary to justify each choice. To objectify the choice process, the technician should list the reasons which guided it, e.g.: snowpack condition representa-

tiveness; search for the most critical situations; etc.

Aims of these analyses are identifying the factors which control the snowpack characteristics: aspect elevation and location of the considered sector. Snowprofile or stability tests should be seen as a tool to validate/refute the estimated danger level derived from the information collected on field or from a network of automatic weather stations, or other sources.

3. APPROACH

Regional avalanche warning services of Piemonte, Valle d'Aosta and Lombardia regions adopted itinerant surveys as standard data collection process. The route selection is weekly scheduled according to the meteorological and avalanche conditions to be investigated and, first of all, the security conditions.

Avalanche forecaster, in accordance with technicians, set characteristics to be investigated during the survey, such as:

- snowpack critical issues e.g.: presence of Surface Hoar (on formation or buried); wind slabs (locations and susceptibility to trigger), cracks or settlements; weak layers, etc.;
- morphological characteristics to be investigated: elevation, aspect, slope sectors, near or far from the tree-line or from the ridges, etc.;
- natural avalanche activity: type, elevation, aspect, prevalent characters, etc.;
- stability tests: RB, ECT, PST.

Such surveys begins already during car journey, before starting the ski mountaineering route, with simple area observations.

Figure 1: a technician performing a ski mountainering route and executing observations (photo ARPA Lombardia).

The technicians (which usually operates in 2 or 3 people teams) can perform a complete snowprofile or more expeditious snow analyses, during the ski mountaneering (fig. 1 and 2), in one or more representative places in which are detected the most common or important avalanche problem situations.

Figure 2: technicians executing snowpack analysis and stability tests during a ski mountainering touring (photo ARPA Lombardia).

The technicians fill in a data form which is subdivided by main topics and the snowprofile graph. Photographs or videos made during the path or during the execution of stability tests as well as GPS tracking logs are also a very important data which complete the information gathering providing to the forecaster a better perception of the scenario.

4. DATA COSISTENCY

In the last winter seasons, the considered regional avalanche warning services (Piemonte, Valle d'Aosta and Lombardia) recorded, on average, 90 to 120 itinerant surveys (per region per season) – (Tbls. 1 and 2).

Tbl. 1: Surface of mountain territory analyzed for the avalanche bulletin (approximate values).

Region	*Area sectors avalanche bulletin km²*	*altitude average mountain areas*
Piemonte	9597	1700
Valle d'Aosta	3253	2100
Lombardia	9570	2300

Tbl. 2: Estimated number of itinerant surveys by region and density according to the area investigated.

Regione	*Numbers of surveys per season*	*Density (km²/survey)*
Piemonte	100-120	85-90
Valle d'Aosta	80-90	35-40
Lombardia	90-120	90

Such numbers allowed the services to analyse numerous very different avalanche scenarios over significant mountain area portions.

Only highly specialised and qualified avalanche technicians can perform such tasks due to their intrinsic risk exposure e.g.: Alpine Guides, Guardia di Finanza Alpine Rescue Teams and regional Avalanche Forecasters.

5. OUTCOMES

5.1 *Example of data collection form*

As already stated, this process of information collection from itinerant survey aims to obtain key and necessary data for drafting avalanche bulletin.
The process, therefore, after the field phase needs also an active involvement of the technicians in data evaluation process and a discussion with the avalanche forecaster in order to jointly evaluate the avalanche danger level to be assigned to the area. In order to facilitate the achievement of such goal, the avalanche warning services structured the data collection form in such a way which simulate the bulletin structure that will be produced, even if the expressed synthetic evaluation should be more correctly defined as a local scale avalanche bulletin.

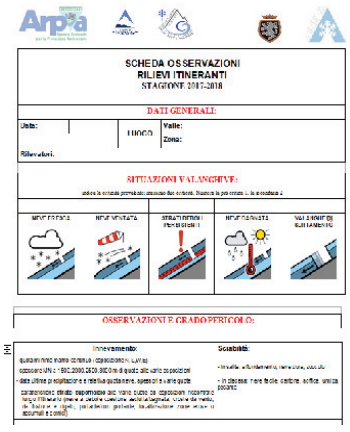

Figure 3: example of survey form compiled by the technicians (source Regione Autonoma Valle d'Aosta – Fondazione Montagna Sicura).

Following the example of figure 3, the technicians are expected to specify the avalanche problem and to describe textually its spatial distribution and location. Furthermore, the technicians are requested to rate the local danger level for the surveyed area following the criteria used in the European Matrix.

5.2 *Archive and visualization on WebGis*

All the information collected during each single itinerant survey, to enhance the data usability and its spatial analysis, are inserted into a WebGis platform which enable a real-time use.

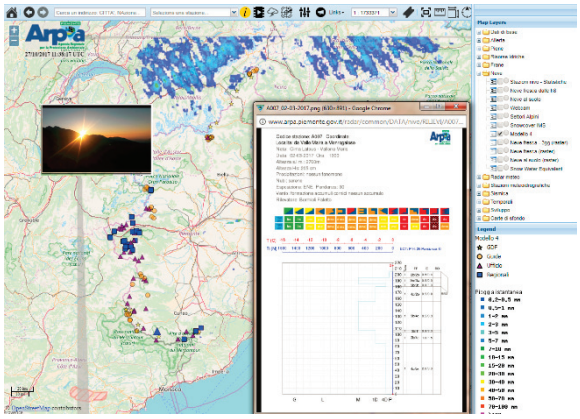

Figure 4: screenshot of IRIS web-platform with snowprofile, photos, automatic weather stations values and meteorological radar output displayed (source ARPA Piemonte – Dipartimento Rischi Naturali).

ARPA Piemonte avalanche warning service has developed a platform (IRIS Integrated Radar Information System) where forecasters and technicians can access, in real-time, to all data from automatic weather stations, meteorological radar outputs, HN and HS distribution maps, snow climatological values and snowpack profiles. In addition to such data, all survey forms (see previous paragraph), geo-referenced photos or videos, gps track logs and other metadata are available (fig. 2).

6. CONSIDERATIONS

Information collection in a systematic and objective way is useful to finalise the avalanche bulletin drafting phase. Such process is subject to an urgent need to optimize resources and time spent, but it is also necessary to ensure a good or excellent quality of the products and to provide a service in line with more and more demanding end-users.

The active involvement of the technicians in a joint evaluation, together with the avalanche forecaster, of the avalanche danger level has

progressively improved the final quality of the bulletins. Such outcome has also caused a greater diffusion and use of the forecasting products, thanks to the increased avalanche bulletin usability by professional and non-professional end-users.

6.1 Open questions

As the touring snowpack observations can be performed following several different methodologies, in order to achieve a better standardization of the process, we have asked ourselves some open questions that we hope will spark a debate in the technical community:

- Which is the number of surveys necessary in each areas for an optimal data collection?
- What kind of observations are necessary and essential to draft a regional avalanche bulletin?
- What are the main tasks which need to be standardized in the process of drafting an avalanche bulletin?
- Nowadays, is it possible to objectify a process that is still largely subjective/empirical? If so how?

REFERENCES

Brun, E., David, P., Sudul, M., and Brunot, G., 1992, A numerical model to simulate snow-cover stratigraphy for operational avalanche forecasting: Jour. Glaciol., V. 38, pp. 13 – 22.

Cagnati, A., Valt, M., Soratroi, G., Gavaldá, J., and Sellès, C., 1998, A field method for avalanche danger-level verification: Ann. Glaciol., Vol. 26, pp. 343–346.

Föhn, P., 1987, Avalanche Formation, Movement and Effects - volume 162, chapter: The rutschblock as a pratical tool for slope stability evaluation: IAHS-AISH, pp. 195–211.

Jamienson, B., and Johnston, C., 1992, Experience with rutschblock: Avalanche Review, Vol. 11(2), pp. 4–5.

La Chapelle, E.R., 1980, The fundamental processes in conventional avalanche forecasting: Journal of Glaciology, Vol. 26, n. 94, pp. 75-84.

Lehning, M., Bartelt, P., Brown, B., Russi, T., Stöckli, U., and Zimmerli, M., 1999, Snowpack model calculations for avalanche warning based upon a network of weather and snow stations: Cold Reg. Sci. Technol., V. 30, n. 1-3, pp. 145-157.

Vionnet, V., Brun, E., Morin, S., Boone, A., Faroux, S., Le Moigne, P., Martin, E., and Willemet, J.-M., 2012, The detailed snowpack scheme Crocus and its implementation in SURFEX: Geosci. Model Dev., V. 7.2, N. 5, pp. 773–791, doi:10.5194/gmd-5-773-2012.