The avalanche events of December 2008 in Ceresole Reale (Piedmont Western Italian Alps)

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ABSTRACT: December 2008 was characterized by intense precipitations, in particular in the middle of the month (14th – 17th) throughout all the Italian Western Alps. Numerous avalanches occurred causing damages to villages and affecting the viability.
In this work we describe the meteorological situation and the intense avalanche activity that influenced the area around Ceresole Reale, a small village at 1570 m asl in the high Orco Valley in Piedmont Region.
On 17th December the snow height at the village was 250 cm, the maximum value registered in December, referring to an eighty years long snow data set. In the period between the 15th and the 16th of December many avalanches occurred. Some of them have been classified as extreme avalanches and flowed in areas where no avalanches were reported in the past, overcrossing the limits of the official avalanche map.
In particular, 4 simultaneous avalanches released from Monte Cialme and destroyed 6 houses and 12 ha of forest. The deposit and damages analysis has shown that the avalanches presented both a dense and a powder part. We estimated that a volume of snow equal to 100.000 m^3 released from 2450 m asl and flowed into the Ceresole lake at 1580 m asl. A rough estimation of the pressure of the avalanches has been done studying the damages caused to forest and buildings.

KEYWORDS: avalanche case study, extreme event, mapping, forest damage

1 INTRODUCTION

Snow avalanches are natural phenomena that might severely affect human beings. In Europe the memories of the catastrophic avalanche winter 1999 are still very fresh. In February 1999, extreme avalanches occurred on the Alps, causing fatalities and damages to villages and infrastructure. In Italy, France, Switzerland and Austria, many avalanches happened with a destructive power never seen before in some known avalanche sites (ANENA, 2000; Barbolini et al., 2000; Heumader, 2000; SLF, 2000).

Human being has developed some protection systems to face the phenomena and try to live with it (McClung and Schaerer, 1993); these measures can be constructions, as for example defence structure, avalanche tunnels, deflecting dams, or land planning procedure, as hazard maps. In Italy, there exists no homogeneous rule to create these maps: Aosta Valley is the only region where a law exists about avalanche hazard mapping (Regione Autonoma Valle d'Aosta, 1999), while in the rest of the Italian Alps and Apennines reference guide lines were adopted according to Barbolini et al.(2002).

One of the first tool to deal with avalanches was of course the Avalanche Cadastre, which is simple but very useful to record all the historical avalanche events. At the half of the 80's the AINEVA (Interregional Snow and Avalanches Association) promoted the drawing up of Probable Avalanche Location Maps - Carta di Localizzazione Probabile delle Valanghe (CLPV) - (Nevini and Sani, 1991). It is elaborated by the combination of aerial pictures analysis, cartographic maps, vegetation investigation, field work together with the information of the Avalanche Cadastre. In Piedmont a webgis system has been created by ARPA Piemonte to represent regional data related to avalanche sites (Cordola et al., 2005). These maps have to be updated whenever new events happen .

This is the case of the municipality of Ceresole Reale (Piedmont Region), where many avalanches exceeded the CLPV limits in December 2008.

This work concerns the description of these avalanche events and the damages caused to the forest and to some buildings of the Ceresole Reale village.

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2 STUDY AREA

Ceresole Reale is a small mountain village at 1580 m asl. in Piedmont Region in the North-western Italian Alps. Inhabitants are about 200 but population increase noticeably during winter and summer seasons due to tourism: it is one of the village that mountaineers cross while trekking around Gran Paradiso massif. The village lies close to an artificial lake used for hydro-power production. The municipality has a large extent where many avalanches occur, but in this study we focus on the avalanches that release from Monte Cialme, just above the village (Fig. 1).

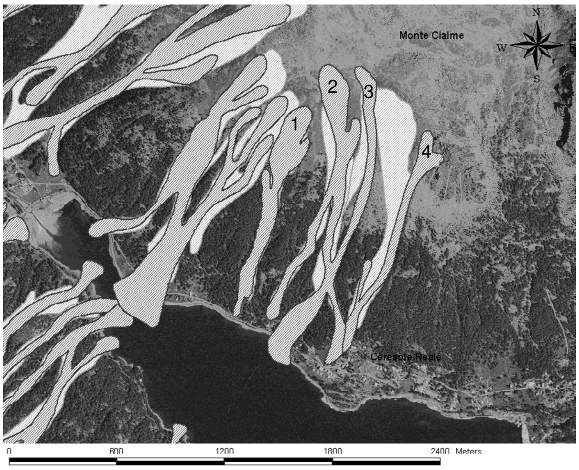

Figure 1. CLPV detail of Ceresole Reale regarding the study area. Grey areas represent the maximum extent of historical events, while light grey ones indicate avalanche areas identified by aerial photo analysis. Data from SIVA - ARPA Piedmont Region.

3 SNOW AND METEOROLOGICAL CONDITIONS

Winter 2008-2009 started early all over the Italian Alps. In Ceresole Reale the first snowfall was registered on November 24th, bringing 30 cm of new snow (Fig. 2).

In December heavy snowfall brought more than 300 cm of new snow, more than four times greater than the monthly average, referring to the historical data of the nivo-meteorological station placed at the Serrù Lake, 2296 m asl, for the period 1966-2009 (Fig. 3). In the week 10th-17th of December the cumulative amount of new snow was 240 cm, increasing the snow depth from 60 cm to 250 cm: 160 cm fell in three consecutive days (Fig. 2).

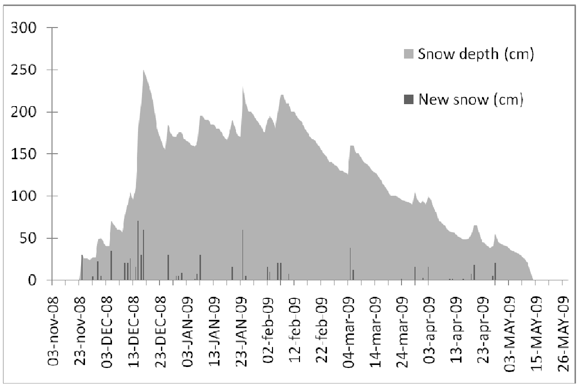

Figure 2. Snow data from the automatic nivo-meteorological station located at Ceresole Reale Villa (1581 m asl).

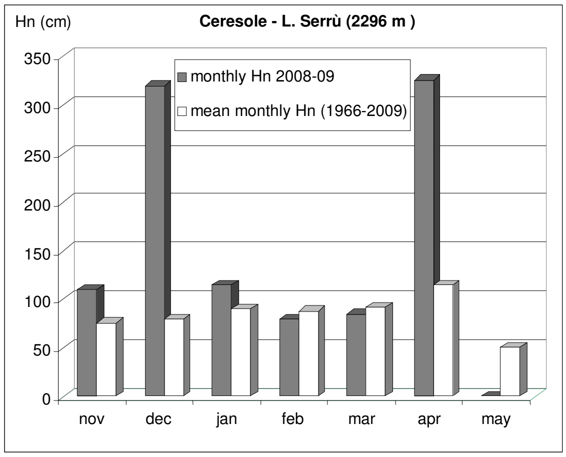

Figure 3. Monthly cumulated new snow compared to historical data (1966-2009) from the automatic nivo-meteorological station located at Serrù Lake (2296 m asl).

4 AVALANCHE DATA

The avalanche map CLPV of Piedmont Region indicates that the whole basin of Ceresole Reale is influenced by avalanches. Several avalanche paths are identified and most of them interact with human activity (viability and/or buildings); in particular, in the CLPV are drawn 22 avalanche paths that end into the lake or close to villages.

4.1 Historical data

The Regional Avalanche Cadastre contains a lot of data about the avalanche activity in the study area. The avalanches from Monte Cialme are well known (Fig. 1) and caused damages to forest, roads and buildings in the past.

The most important avalanche events were registered in January 1885 and in February 1972, when avalanches reached and damaged the church of the village and some buildings.

4.2 The avalanches of December 2008

During the intense snowfall of the middle of December, numerous avalanches occurred. The two small villages located on the left side of the lake west of the main village of Ceresole Reale were isolated until the end of December. The nordic ski track developing around the lake was closed because of very high avalanche danger.

Eight extreme avalanches occurred in the surrounding area of the village mainly on December 16th affecting the viability and causing severe damages to forests and buildings.

Fortunately, no victims were registered because the destroyed buildings were empty.

5 THE "CIALME" AVALANCHE

The avalanches we consider in this work run along known paths, as shown in the CLPV (numbers 1,2,3,4 in figure 1). The release zones are located at an altitude of about 2500 m asl and are covered mainly by grass and rocks of small size. The release area of path number 2 is covered partially by defence structures, such as snow bridges and snow nets. The difference in height is around 900 m, as the avalanches flow to the lake at 1580 m asl. The tracks are well visible through the forest, which is made mainly of *Larix decidua*.

The avalanches usually cross the main road and a secondary one and can reach several houses (Figs. 1 and 4). Dense and powder snow avalanches occurred in the past.

5.1 The event

On December 16th at 1:30 p.m. a big avalanche released from Monte Cialme down to the lake.

The release area was very wide, about 600 m, as the avalanche numbered as 2,3 and 4 in figure 1 released simultaneously; moreover the avalanche n. 1 had a separate release area but overlapped with the others in the deposition zone. Therefore, in this work, what we call avalanche "Cialme" is a unique event that includes all the four avalanche paths. We estimated a release volume of about 100.000 m^3.

The initial mass divided then into the usual couloirs concerning the dense part. The powder part flew with a wider section into areas not classified as avalanche terrain in the CLPV. The dense deposit was well visible especially for the couloir n. 4, while in the other ones the powder component was the predominant part.

In the deposition zone there was an overlaying of the avalanche masses coming from the different couloirs. During the surveys, in the area (a) and (b) of Figure 5, we could find very clear clues of different flows direction: some trees were bended in direction NW-SE and some others in direction NE-SW.

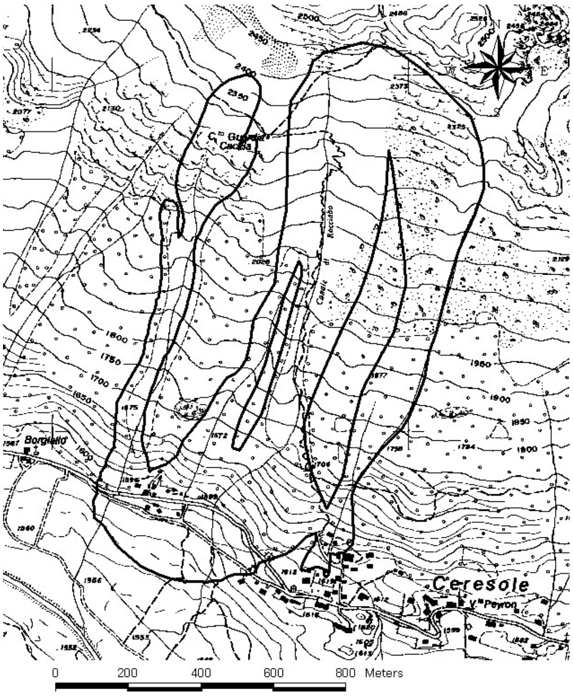

Figure 4. Outline of the "Cialme" avalanche occurred on December 16th 2008.

5.2 Analysis of the damages

Six houses were destroyed or heavily damaged and a dozen slightly damaged; some gates and fences and electricity pylons were damaged along the roads; the forest was strongly destroyed along the tracks and mostly in the run-out zone between couloirs n. 2 and 4 (Fig. 5).

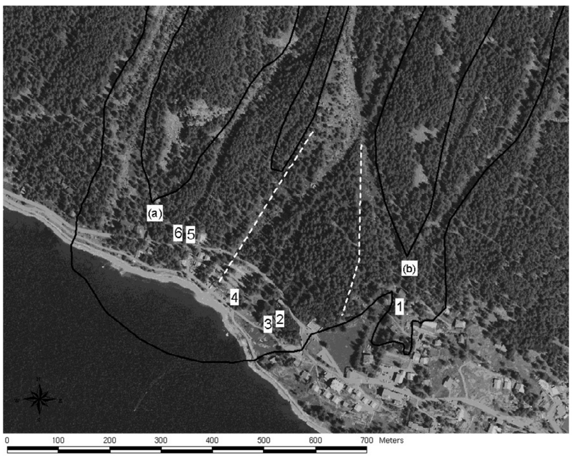

Figure 5. Zoom on the run-out zone of the "Cialme" avalanche of December 16th. The numbers indicate the 6 houses highly damaged or destroyed, (a) and (b) areas where different avalanche flows converged and the white lines the most damaged forested area.

Forest damage was evaluated with some field works. In the run-out zone of couloir n. 4 the tree-ring analysis revealed signs of frequent avalanches, while in the large area between couloirs n. 2 and 4 the avalanche frequency is lower, as fallen trees of almost 200 years were found. Trees with broken branch up to 20 m are signs of a flow height up to that value; surely this damages were caused by the powder part of the avalanche.

Concerning structural and building damage, the greatest damage was observed in four alpine-type houses placed the run-out zone of the avalanche. Typically, these traditional constructions present the ground floor with a reinforced concrete frame coupled with bricks and mortar walls and the first floor and roof in wood. All wooden parts of these 4 houses are totally destroyed by the impact of the avalanche (Fig. 6). The wooden roof of house n. 3 was found about 30 m below, on the lake. Thanks to the presence of a local defense structure (a concrete spur) for house n. 6 in couloir n. 2, the part close to the spur has not been damaged, while the rest was completely destroyed. For all four houses, the direction of the avalanche impact was frontal.

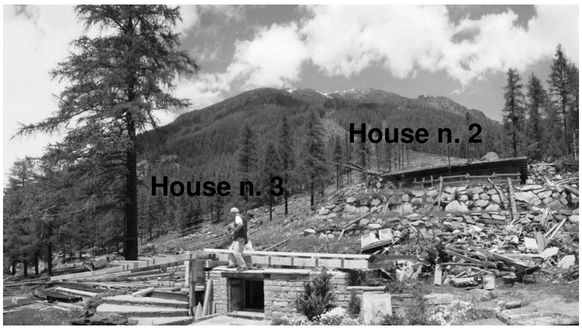

Figure 6. Houses n. 2 and 3 on the run-out zone of couloirs n. 2 and 3 after the event of December 16th: only the ground floors in reinforced concrete frame are survived.

Some other buildings with different architectural design (reinforced concrete frame, bricks and mortar walls, concrete or metal sheet roofs) and with a different orientation towards the avalanche flow were less damaged. A lot of damages on ancillary works were detected: chimneys, balconies, stairs and stone-iron stairs, iron or wooden railings.

The avalanche of couloirs n. 2 and 3 also destroyed the perimetral walls of the cemetery.

Thanks to the survey of the structural and wooden damages, the impact pressure could be estimated. To scrape away an ancient tree the necessary pressure is estimated around 100kPa (McClung and Schaerer, 1996), whereas to destroy a wooden house, the impact pressure varies from 5 to 30 kPa (McClung and Schaerer, 1996). The minimum pressure to induce the reported damages on the roofs was estimated around 2 kPa for metal sheet ones and around 4 kPa for concrete ones.

The field observations showed that most of the damages on the buildings were caused by the debris of rocks, trees and houses carried downstream by the force of the avalanche, while the damage to the forest was due mainly to the powder component of the avalanche flow.

6 CONCLUSIONS

The present work had the aim to simple describe the events that happened in December 2008 along the “Cialme” avalanche path.

Combined analysis of historical events, aerial pictures, topographical maps, damages to forest and buildings, field works and information from the inhabitants helped us to reconstruct the event, which is classified as extreme. In tracks n. 1 and 2 the avalanche overpassed the limits drawn in the CLPV of about 100 m; in the run-out zone (below 1700 m) the avalanche widening involved 10 ha of terrain beyond the limit of the maximum recorded historical event (dark shaded area in figure 1 compared to dark outline in figure 4).

The effect of the powder cloud was very destructive, never observed before on the same paths.

The forest felling has created new open spaces where future avalanches might more easily flow, therefore a good protection plan should be developed for the village of Ceresole Reale.

7 AKNOWLEDGEMENTS

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8 REFERENCES

ANENA, 2000. L’avalanche de Péclerey. Neige et avalanche. December 2000.

ARPA Piemonte. SIVA Sistema Informativo Valanghe. http://gisweb.arpa.piemonte.it/arpagis/index.htm

Barbolini, M., Ceriani, E., Del Monte, G., Segor, V. and Savi, F., 2000. The “Lavanchers” avalanche of February 23th 2000, Aosta valley, Italy. Proceeding ISSW 2000. International Snow Science Workshop, Big Sky, Montana, USA, 1-6 October 2000, 519-527.

Barbolini, M, Natale, L., Tecilla, G. and Cordola, M., 2002. Criteri per la perimetrazione e l’utilizzo delle aree soggette al pericolo di valanghe.

AINEVA e Dipartimento di Ingegneria idraulica ed ambientale dell'Università degli Studi di Pavia.

Cordola ,M., Prola, M.C., Bonansea, E., Pispico, R., Papa, G., Rostagno, C., 2005. SIVA. Il sistema informativo valanghe del Piemonte. Neve e Valanghe, 55.

Frigo, B. 2003. Effetti sulle strutture della componente aerosol delle valanghe: il caso della Valle d'Aosta. Tesi di Laurea. Politecnico di Torino.

Heumader, J., 2000. Die Katastrophenlawinen von Galt¨ur und Valzur am 23. und 24.2.1999 im Paznauntal/Tirol, Proc. Internationales Sympos. Interpraevent – Villach, Austria, 26–30 June 2000, 2, 397–410.

McClung, D.M. and Schaerer, P.A., 1993. The Avalanche Handbook. Seattle, WA, The Mountaineers.

Nevini, R. and Sani, M., 1991. C.L.P.V.: un tematismo fondamentale. Neve e Valanghe, 13.

Regione Autonoma Valle d'Aosta, 1998. Legge Regionale 6 aprile 1998, n. 11. Normativa urbanistica e di pianificazione territoriale della Valle d'Aosta. Art. 37: Classificazione dei terreni soggetti al rischio di valanghe o slavine e relative disciplina d'uso.

SLF, 2000. Der Lawinenwinter 1999, Eidgenoessisches Institut fuer Schnee- und Lawinenforschung (Ed), Davos. pp 588.