

Winter 2013/2014 on the Italian Alps

Analysis and lesson learned about avalanche risk treatment and man agement strategies

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During December and January the snowpack was composed, at its deepest levels, by persistent weak layers and slippery interfaces covered by subsequent heavy snowfalls which led to a short but intense period of instability (several provoked avalanches). As such weak base was covered by fresh snow, it no longer exerted any influence on the triggering of avalanches. Subsequent snowpack instability was first focused in the uppermost snowpack layers due to the weakening effects of further periods of precipitation and finally was extended to the whole thickness due to the exceptional overload and percolation of liquid water.

A critical avalanche situation prevailed for an extraordinarily long period along all the Alps. Spontaneous avalanches reached mountain huts, ski slopes and ropeways as well as roads and small villages. Avalanche protection measures were severely damaged and artificial avalanche release, in spite of their extensive use, were not always satisfactory in reducing the risk. Several insights arise from this recent experience.

which characterized this incredible season. The heavy snowfalls,

often mixed with rain, have piled up onto unfrozen ground. This

has promoted a strong snowpack humidification, especially in the

basal layers and also due to a lack of significant night-time

irradiation, thus encouraging a widespread avalanche activity

with medium, large and very large-sized events, mainly full-

avalanche activity has been very common on southerly aspects,

on steep grassy slopes, with events that have affected entire

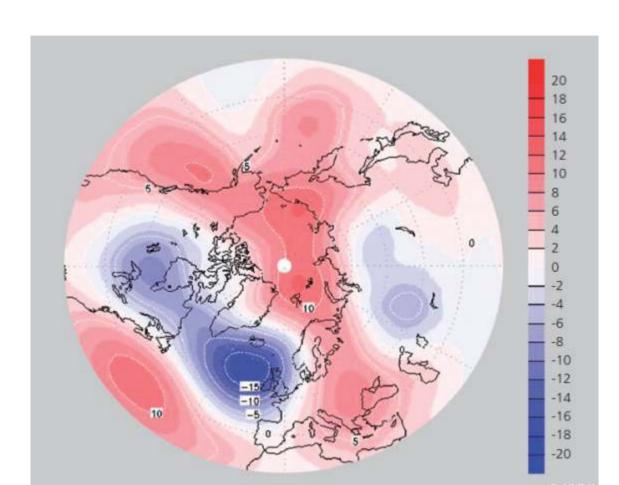
slopes reaching down to the valley floor and thus causing major

damage to infrastructure (roads, power-lines, mountain huts

past decades, had covered the old avalanche paths.

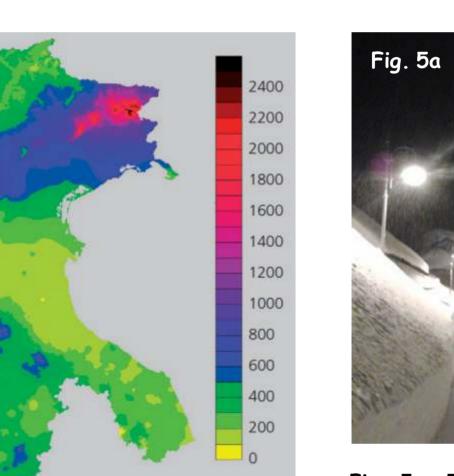
gliding, and several surface-layer avalanches. The

INTRODUCTION



height at 500 hPa for 2013-2014 winter compared to the standard 1961-2000 (data ERA INTERIM / ERA 40). Values Xpressed in dam - [after A.A., Gruppo di Lavoro ArCIS, 2014].

Italy experienced a persistent and intense climatic anomaly associated with persistent abnormalities in the large-scale atmospheric circulation which involved most of the Northern Hemisphere compared to climate 1961-2000 - (Fig. 1, 2 and 3) -

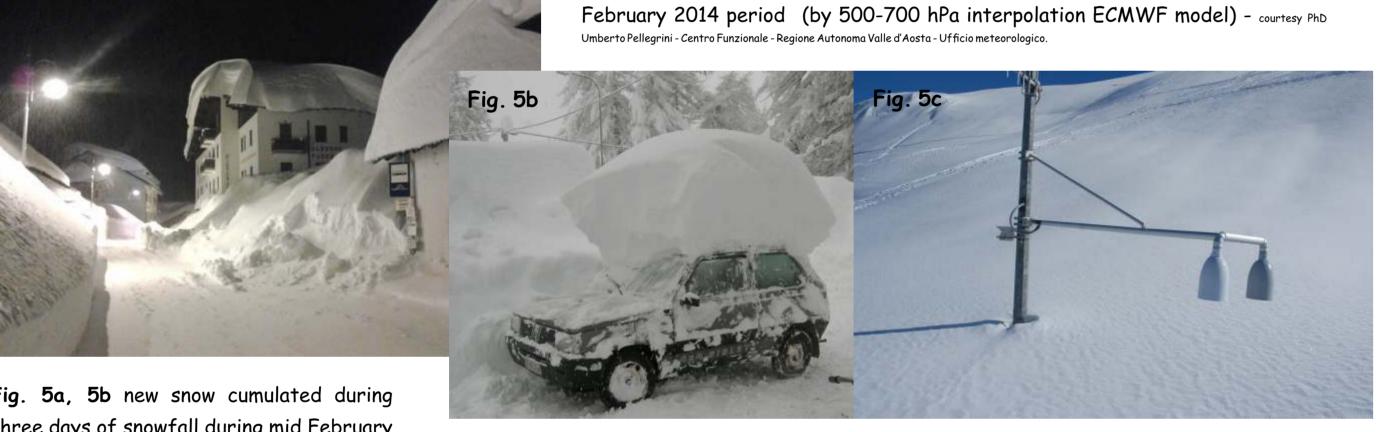


(A.A., Gruppo di Lavoro ArCIS, 2014).

ABSTRACT: Winter 2013/2014 in Italy was the second warmest since 1800. At low elevation it was characterized by frequent as well as abundant rainfalls (>62% above the

average value for the reference period). At high elevations (above 1500 m a.s.l.), on the other hand, the winter season recorded remarkable amounts of snow on the Italian side of the Alps:

exceptional values of snow cover, up to more than 800 cm, has been cumulated at 2000 m a.s.l. (around twice the long-term average) and fresh snow fell for single event up to 150 cm/24 h.



weather station at Livinal Lunc (eastern Alps - Friuli Venezia Giulia Region) almost submerged. The ultrasonic snow depth sensor is located at 6,5 m o height on the mast - [courtesy Avalanche Forecasting Service Autonomous Region Friuli Venezia Giulia, 2014]

courtesy PhD Umberto Pellegrini - Centro Funzionale - Regione Autonoma Valle d'Aosta - Ufficio meteorologico.

Precipitations (liquid and solid) were extremely abundant (Fig. 4 and 5), reaching in some regions cumulated values (December, January and February) ever observed during the last 90 years - and temperatures were mild, with positive anomalies more intense and widespread in the minimum values other than in the maximum (A.A., Gruppo di Lavoro ArCIS, 2014)

lecember january february march april april ovember lecember january march april march april

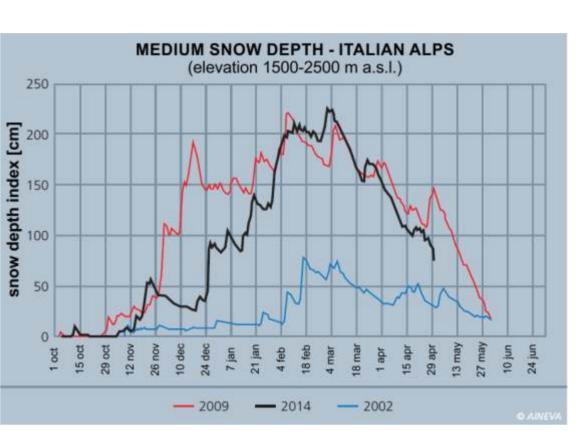
the norm, while in April they were significantly lower than the average reference (1975 - 2009) - (Valt and Cianfarra,

Winter and snowpack evolution

The 2013-2014 winter season showed a similar trend, in all areas of the Alps, but characterized by different intensities of some snowfalls (Fig. 16, 17). The early winter snowpack evolution, characterized by alternations of "cold" and "warm" intense snowfalls, favored the development of persistent basal weak layers (MFpc, MFsl, FCxr, DHxr) and slippery interfaces (crusts - MFcr, IFil, IFrc) followed by short but intense periods of instability. During and immediately after the main snowfalls, snowpack instability was first focused in the uppermost snowpack layers due to the weakening effects of several periods of precipitation but gradually it was extended to the whole thickness due to the exceptional overload and percolation of liquid water towards the ground. A period of strong warming and subsequent snowpack ablation immediately followed the snowfalls from February 26th to March 5th, thus significantly increasing the percolation of liquid water towards the ground - (Valt and

The average index value of the HS was 117 cm (calculated for the Italian Alps for the November - April period over a altitudes range of 1,500 up to 2,500 m a.s.l.) - (Fig. 13 and 14).

Such value was the second one, in average, between 2002-2013 and was preceded only by the 2009 value of 138 cm. The same indices calculated for the February and March were also higher than 2009 ones, while December 2008 and January 2009 values were higher than this season - (Valt and Cianfarra, 2014).



of elevation. The Index is compared with two winter seasons

northern Apennines for winter 2013-2014 using NASA/GSFC EOS

(LANCE) system Rapid Response MODIS public images (subset MODI

The snowpack duration has been strongly influenced by the mild

winter temperatures which favored heavy rains at low altitude.

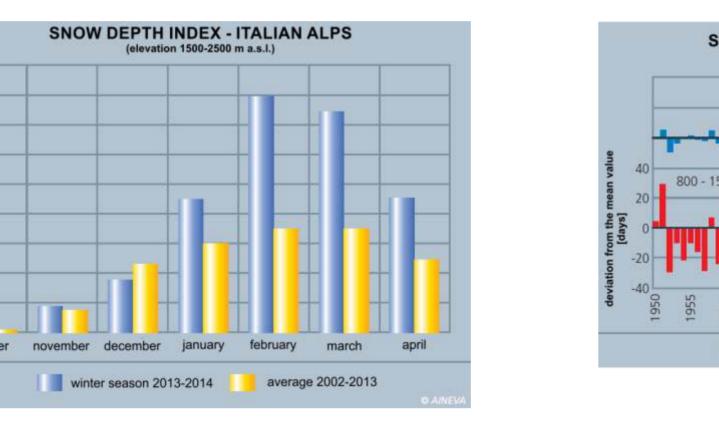


Fig. 14 - index of average HS for winter 2013-2014 drawn, b month, on a selected data set of 20 representative station above 1500 m of elevation. The Index is compared wit average value for the period 2002-2013 - [after Valt and Cianfarra

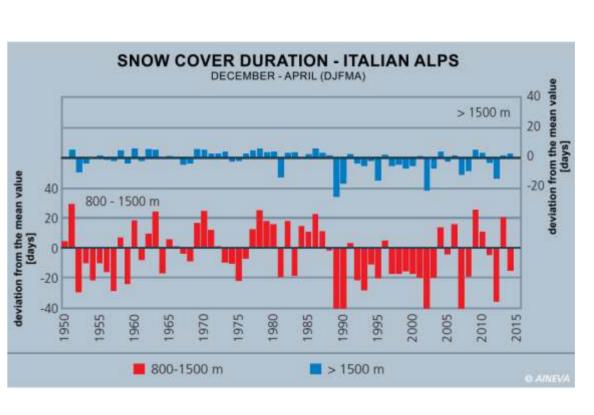
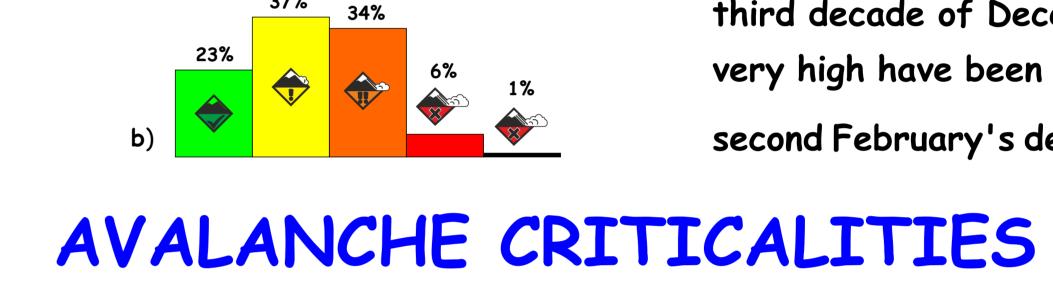


Fig. 15 - snow cover duration calculated as a standard deviation from the mean value (period 1961-1990) for two altitude ranges: 800-1500 m (8 stations - red color) and above 1500 m (8 stations - blue color) - [after Valt and Cianfarra, 2014]



a 1 - low 2 - moderate 3 - considerable 4 - high 5 - very high

considering the 47 AINEVA forecasting zones - [after Valt

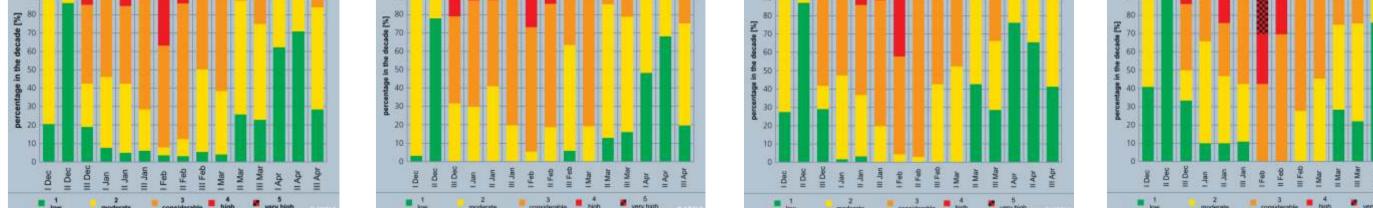


Fig. 23 - % usage of the danger levels for the different winter decades: a) in the 7 regional avalanche bulletins (47 AINEVA's forecasting zones); b) in the western Alps regional avalanche bulletins (17 AINEVA's forecasting zones); c) in the central Alps regional avalanche bulletins (17 AINEVA's forecasting zones); d) in the eastern Alps regional avalanche bulletins (21 AINEVA's forecasting zones) - [after Valt and Cianfarra, 2014].

The danger level 1 - low was often issued in December, and then it was increasingly used Fig. 22 - % usage of the danger levels: a) in the 7 regional by the end of March to mid-April. The danger level 2 - moderate was scarcely used value; b) during the last winter season along the Italian Alps especially during the first two decades of February and mainly in the western and central alpine sectors. The danger level 3 - considerable was often issued between the third decade of December and the first of March. The danger levels 4 - high and 5 very high have been issued more often between the third December's decade and the second February's decade - (Valt and Cianfarra, 2014; A.A., Servizi Valanghe AINEVA, 2014).

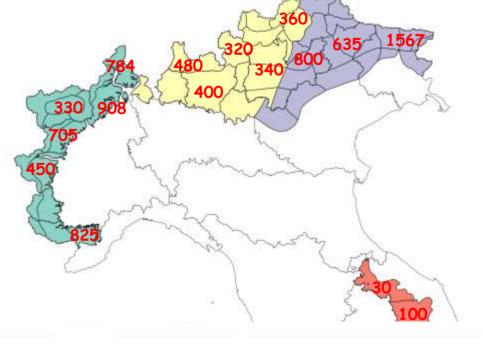
ANALYSIS



A dimensionless SAI index (Standardized Anomaly Index) has been used to investigate the magnitude value anomalies: this Index has been compared with annual or seasonal average values of the individual stations along the Italian Alps (Fig. 7).

HN - height of new snow, depth of snowfall

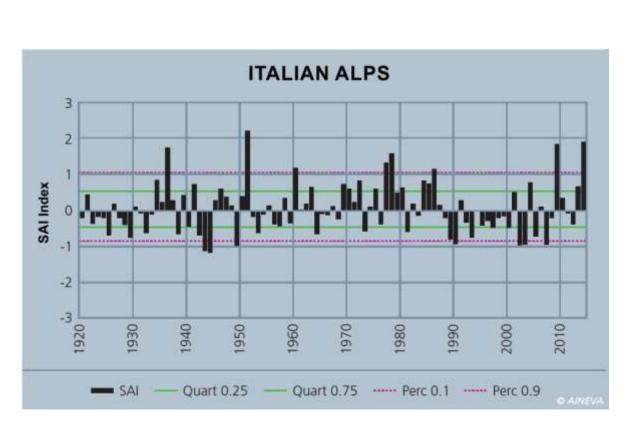
As seen in Fig. 4, the largest peaks of precipitation were recorded in the Friuli-Venezia Giulia Region (eastern Alps), where the cumulated values over three months exceeded 2500 mm (a value 4 to 5 times larger than the climatic norm for the reference period and a new record over the last 50 years for January and February) - (Valt and Cianfarra, 2014).



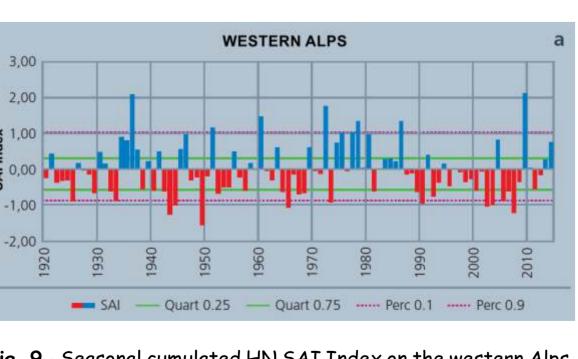
winter 2013-2014, on the Italian Alps mainly at 2000 m of altitude - [after A.A., Servizi Valnghe AINEVA, 2014].

The analysis shows values above average reference (1975-2009) for the cumulated HN values (Fig. 8; on a monthly basis for the three different alpine areas - Fig. 12), but to a different extent depending on the domain (Fig. 9, 10 and 11). The SAI Index value, calculated throughout all the Italian Alpine regions, indicates a value higher than the 0.90 percentile and therefore the

2013-2014 winter is defined as "extreme or rare" for its snowfall amounts. Only the 1950-1951 winter shows higher values - (Valtand Cianfarra, 2014).

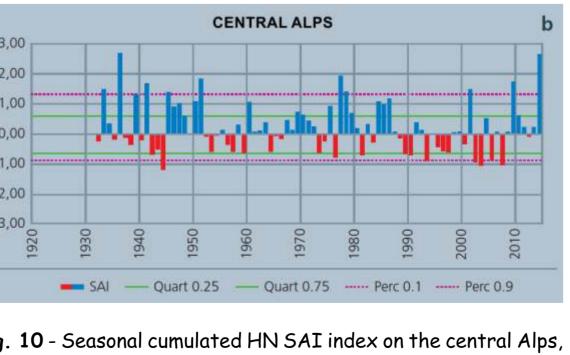


on the Italian Alps [SAI Index] for the period 1920



period 1985-2014 it was only lower than 2008-2009, 2003-200

and 1985-1986 winters. [after Valt and Cianfarra, 2014]



only by 1936, and by being higher than the 0.90 percentile this

winter is classified as "extreme or rare". [after Valt and Cianfarra,

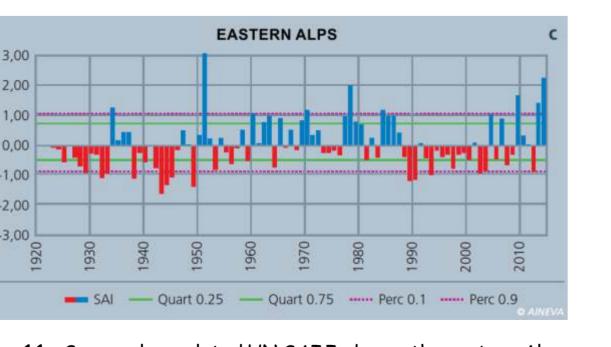


Fig. 11 - Seasonal cumulated HN SAI Index on the eastern Alps the this winter season may be classified as a "rare and extreme" like winter 1950-1951, which recorded an higher value. [after Valt

Fig. 19 - Avalanche activity index compared with snow cover duration and cumulated HN [SAI Index] for each winter (period 1980-2014) onto a data set of 12 significant stations [after Valt and Cianfarra, 2014].

- cumulated HN

Pol. (snow cover duration)

Pol. (spontaneous avalanche activity)

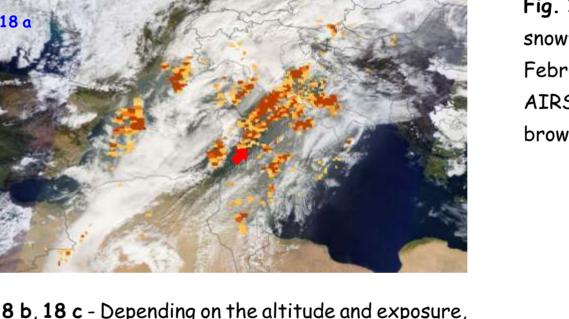
Avalanche activities and danger levels

value since 1980 - (Fig. 19).

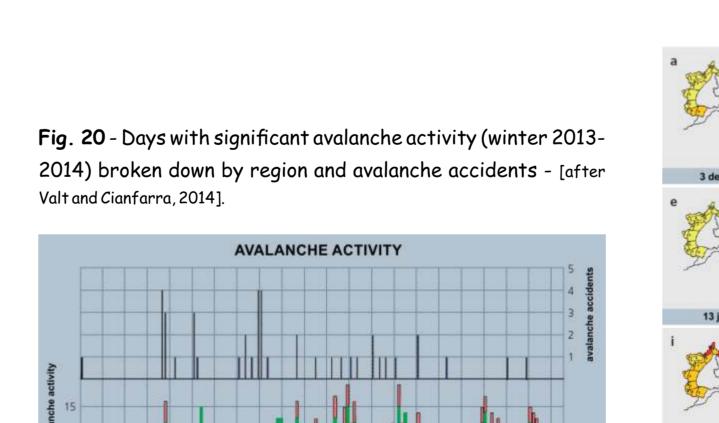
spontaneous avalanche activity

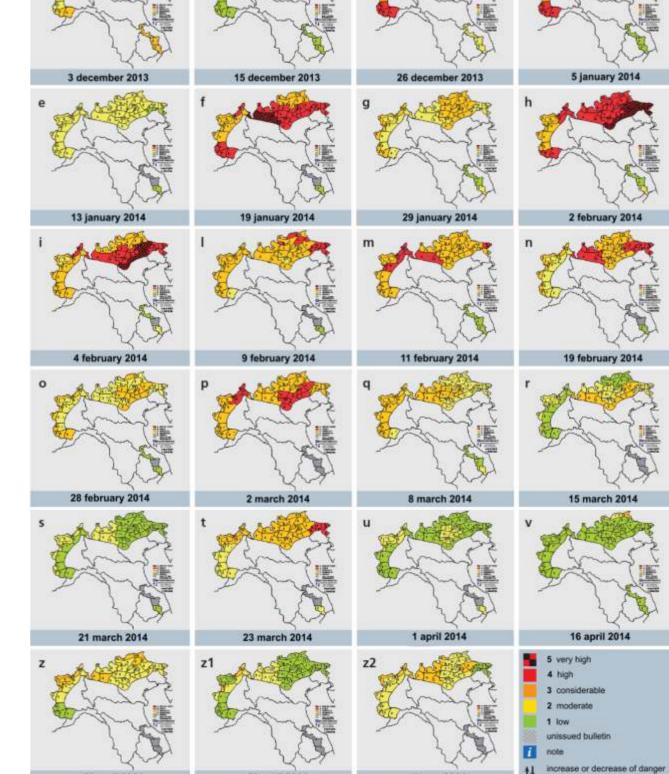
By examining the daily observations data (Fig. 20), using the AINEVA's Model 1 codes (many medium-sized avalanches - cod. 3 group L1; single large natural avalanches - cod. 4, group L1) it is observed that along all the winter season was characterized by spontaneous avalanche activity and especially during the periods: 27th December; 7th January; 2nd-6th February (intense snowfalls); 16th-24th February (snowfalls and wind); 10th-16th March (major rise in temperature); 5th-13th April (new rise in temperature); 20th-22nd April (snowfalls). The spontaneous avalanche activity can be compared with the number of avalanche accidents

snowfall with wind); 6th Feb.; 2nd and 16th Mar. (snowfalls with wind) - (Fig. 20) - (Valtand Cianfarra, 2014; A.A., Servizi Valanghe AINEVA, 2014).



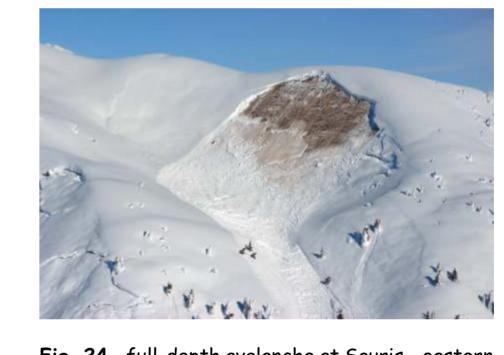
oped allowing the growth of faceted crystals above and below the crust itself (Fig. 18 b, 18 c). After the first decade of March, this horizon has enhanced, due to its low albedo, the absorption of heat in the snowpack and its strong wetting, thus favoring the full depth and gliding





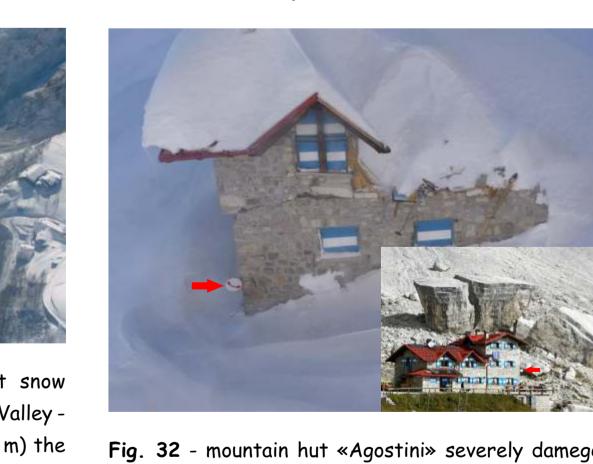
The highest concentration of accidents occurred: 26th-27th Dec.; 5th Jan. (during a snowfall mixed with rain); 25th-26th Jan. (after a

The spontaneous avalanche activity was a common phenomenon











and 11th Mar. 2014) - [courtesy Avalanche Forecasting

13th-25th Feb. and during the first two decades of

scraped the turf (locally starting significant

interrupted the 16th Mar. 2014 by several large

rvice Veneto Region, 2014]. The full depth and glidino

closed due to avalanche danger for several days (up to a maximum, in the Dolomite area, of 83

Management of avalanche criticalities

The management of avalanche criticalities was carried out by local avalanche commissions or by groups of professional in close collaboration with the forecasting offices. Those activities were mainly observations, data collection, local forecasting, monitoring and management interventions. Loose dry snow avalanches or surface-layer slab avalanches were handled properly and timely (road closures and artificial triggering) if the scenario was easy to detect and monitor (heavy snowfall, significant wind activity with slabs formation). However, due to frequent poor weather conditions or too high HN amounts, employment and effectiveness of such measures were, often, hampered. Full-depth avalanches or gliding ones have been poorly managed as the scenario was more difficult to detect, forecast and monitor (due to the exceptional HS). The only most effective management measures were prolonged closures and evacuations. Artificial triggering, by any means, has often proved totally ineffective due to the high HS and its significant plasticity able to absorb artificially induced stresses - (A.A., Servizi Valanghe AINEVA, 2014).











Fig. 12 - In the western Alps, the cumulated HN value was higher than the average reference (between November and February). In the Central Alps, the cumulated HN value was

much higher than average and has increased from November to February. In the eastern Alps, the cumulated HN value was above average in the months of November, January. and

February, while in December (due to the high elevation of the freezing level) the value was around average. For the three sectors, the cumulated HN values of March were around

















The winter season has been characterized by frequent avalanche activity from late December to

late April. Due to succession of snowfalls and continued basal snow cover instability, a high number

of days with avalanches occurred in almost all regions. In general, the SAI Index analysis of daily

avalanche observations (avalanches present, versus avalanches absent), has shown the highest













