SNOW PRECIPITATION IN THE LAST YEARS ON ITALIAN ALPS

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Abstract: Recent papers showed a general decrease of winter precipitation in the last years on Italian Alps and particularly snowy precipitations, both in the Western Italian Alps and in the Eastern part. In the Dolomites snowfall decreased of 28% during the period 1988-2003, comparing with average precipitations in 30 years (1971-2000). In this paper it is carried out an analysis of seasonal snowfall in the Dolomites and first results of a regional climatic evolution using the adimensional index SAI (Standardized Anomaly Index) for 40 nivological stations on the Alps. Furthermore decreasing snow precipitations corresponds to a strong reduction of Dolomites' glaciers (-24% of the surface during the period 1980-2000).

Keywords *– Mountain climate, Snow, Glaciers*

1. INTRODUCTION

Recent papers showed a general decrease in winter precipitations in the last decades on the whole southern slope of the Alps (Cacciamani and others, 2001, Quadrelli and others, 2001) and particularly snowy precipitations, both in the western Alps (Mercalli, 2003) and in the eastern part, and in the Dolomites too (Fazzini and Gaddo, 2003). However all these works concerned a limited number of stations. In order to trace out a balance of the snowfalls, as seasonal fresh snow amounts, for all over the southern slope of the Alps, 40 measurement stations data were considered; the stations are mostly located in Italy and a little part on the Swiss Alps (Fig. 1). In this work the results of the first elaborations about the cumulated snowfalls trend in the nearest period (1971-2000) are carried out, with an analysis referred to the medium-long period (1920-2004), where it is possible. Besides a general characterization, 3 different trends are proposed for the 3 big Alps' sectors (western, central and eastern Alps); about the eastern Alps also the correlations with the phase of reduction of glaciers are considered.

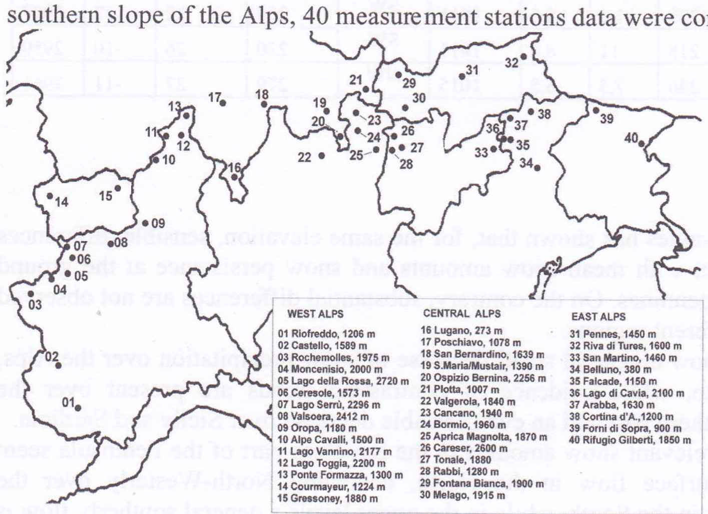

Fig. 1: Measurement stations

2. DATA SOURCE

This work was possible with the collaboration of all the Avalanche Offices agreed to AINEVA (Associazione Interregionale Neve e Valanghe), which gave part of their databases, and of SLF Davos (Ch), for the Swiss stations.

The larger part of the historical data were derived from Hydrological Annals published by the Ministry of Public Works (1927-1996), which maintained for a long period a dense network of thermo-pluviometrical stations. Other data came out from daily measurements made by Electrical Companies nearby the dams, from the manual nivometeorological network managed by the Hydrographic Office, Avalanches Prevention and Meteorological Service of the Bolzano Autonomous Province, from the Snow, Avalanches and Meteorology Office of Trento Province, from the Avalanches Office of the Autonomous Friuli Venezia Giulia Region and from ARPAV- Avalanches Centre of Arabba.

Seasonal snowfall data are the results of the single daily values summation, usually measured in cm at 8 o'clock every day (Cagnati, 2003). All the graphs and the tables are referred to the hydrological year (for example 2003 means the period between 2002 October 1st and 2003 September 30th). However the only October-May precipitations were considered for this work. For some stations the monthly and seasonal values were already available as tables in the papers looked up; for the others ones the summations has been made fro m the daily values.

3. METHODS

To point out the regional climatic evolution with an only one series, the adimensional SAI Index (Standardized Anomaly Index) has been used (Giuffrida and Conte, 1989), which expresses the anomaly of the studied parameters, through the contribution of the monthly and the seasonal average values of the single one station. An annual anomaly index with value 0 means a year lined up with the reference average, a positive or negative anomaly value means respectively an overplus or a deficit more or less large compared to the normal value (Mercalli and others, 2003).

To characterize the different trends of the historical series, the average value has been calculated referred to the 1971-2000 reference period (WMO, Climate Normals, CLINO, technical note 847), and the departure from this average value has been calculated too.

In particular, to define the exceptional (extreme or rare) events, the 0.10 and the 0.90 percentile have been determined referred to the 30 years reference period. The average departures which are over this threshold have been considered rare events (IPCC, 2001). The values located between 1 and 3 quartile (25% e 75%) have been considered included in the medium variability. The average departures which are inside 1 and 3 quartile to 0.10 and 0.90 percentile have been defined non-normal events. Many authors use different thresholds and more developed statistical methods to analyze precipitation and temperature data, but this characterization method has been used due to its simplicity.

4. SAI INDEX RESULTS

In Fig. 2 the trend of the snowfalls on the southern slope of the Alps is shown, expressed like SAI anomaly index, calculated about the reference climatic period (1971-2000) for the 40 available stations. The reference thirty-years period 1971-2000 is checked by 2 periods with different trends. A first period, from 1971 to 1986, is characterized by a sequence of positive SAI index values, with 6 non-normal values (1972, 1975, 1980, 1984, 1985 and 1986), and 2 exceptionally snowy winter (rare) in 1977 and 1978. In this period only two are the particularly not very snowy winter, 1973 and 1981. A second and well different sequence of winters characterized by negative SAI values

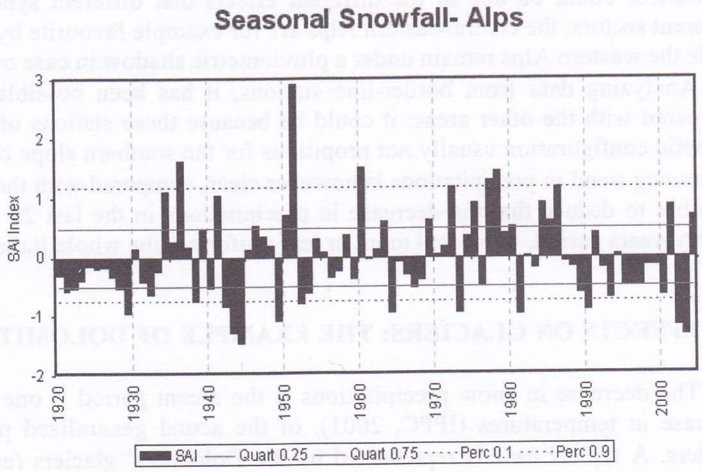

Fig. 2: SAI Index Southern Alps

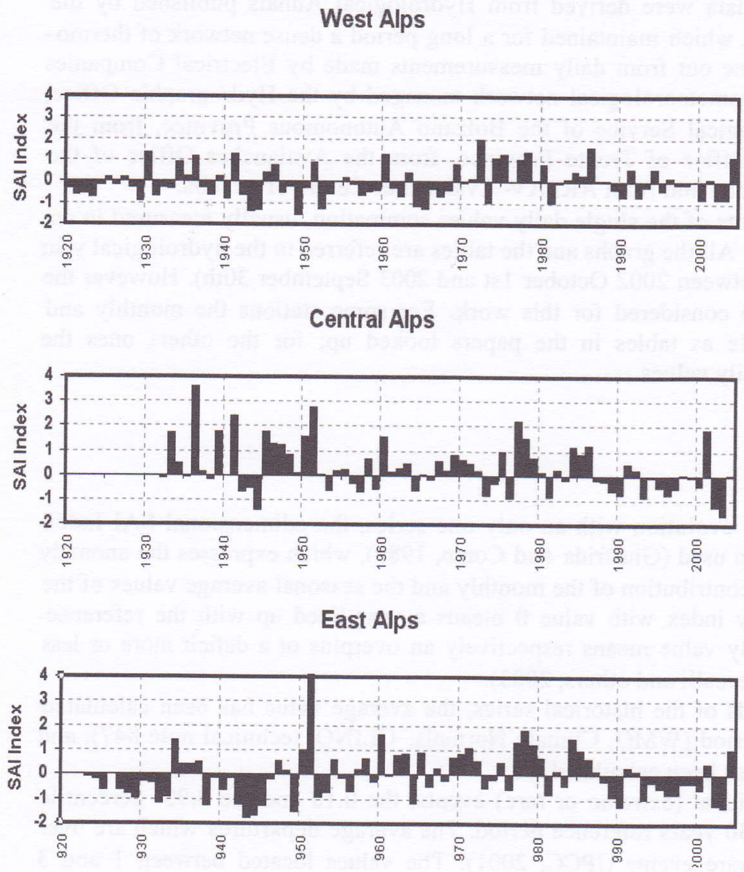

Fig. 3: SAI Index 3 sectors of the Alps

follows (1987-2000), with 5 non-normal winters (1989, 1993, 1995, 1996 and 2000) and only the 1990 exceptionally dry. Negative SAI index values can yet be found in recent winters, as 2002 and 2003, but included between 2 snowy seasons as 2001 and 2004. About the period before 1971, it is possible to observe 3 very snowy winters (1936, 1951 and 1960), a sequence of 3 dry seasons during the second world war (1942, 1943 and 1944) and a period characterized by winters near to the norm between 1951 and 1970, with just a pair of extreme seasons (1960 and 1964). Considering that the disturbed flows which interest the southern slope of the Alps determine different precipitation's amounts in different sectors due to their origin and magnitude, to verify the variability of the snowfalls the SAI index has been calculated for the 3 big areas, in which the Alps are divided (western, central and eastern Alps) (Fig. 3).

For central and eastern Alps the anomaly index looks like the general SAI index, confirming a decreasing of the snowfalls in the last 20 years (1985-2000), comparing with the previous decades. About western Alps, the trend presents some significant differences, with many winters countertendency. In particular, in the period 1995-2000, the SAI index value results equal or near to 0, while it is negative for the central-eastern areas. The differences could be due to the different effects that different synoptic configurations produce over different sectors: the central-eastern Alps are for example favourite by flows between W-S-W and E-S-E, while the western Alps remain under a pluviometric shadow in case of western flows.

Analyzing data from border-line stations, it has been possible to verify a more constant trend, compared with the other areas; it could be because these stations often receive precipitations also with synoptic configuration usually not propitious for the southern slope of the Alps; also for these stations a decreasing trend in precipitations is however clear, compared with the previous twenty-years period. It is possible to deduce that the decrease in precipitations in the last 20 years, compared with the previous twenty-years period, interested more or less uniformly the whole Italian Alps.

5. EFFECTS ON GLACIERS: THE EXAMPLE OF DOLOMITES

The decrease in snow precipitations in the recent period is one of the causes, associated with the increase in temperatures (IPPC, 2001), of the actual generalized phase of the withdrawal of alpine glaciers. A typical case is represented by the Dolomites' glaciers (eastern Alps), which, due to limited extension, have a very fast reaction to the on going climatic changes.

Recent papers about Dolomites' glaciers (Cagnati and others, 2002), showed, on 27 glaciers which represent 78% of the whole glacialized area on the Dolomites, that in the period 1910-1999 the decrease of glaciers' surface has been 43%; this value is higher than the average area decrease of the alpine glaciers, estimated in 38%. In the period 1980-1999 the decreasing phase has particularly improved; in fact, while between 1910 and 1980 the decrease was 25,7%, between 1980 and 1999 it has been 24,3%.

Comparing the SAI index trend of the eastern Alps with the evolution of the glaciers' surface (Fig. 4), it's possible to note a connection between the decrease in snow precipitations in the last twenty-years period and a strong reduction of the glaciers' area; the previous period (1970-1985), characterized by many snowy winters, has been signed by a significant slowdown in decreasing phase.

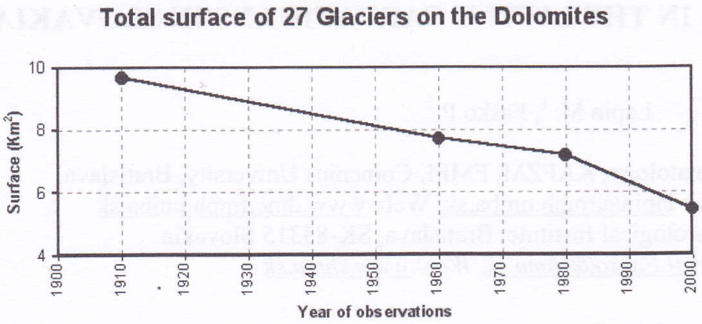

Fig. 4: Surface of 27 Dolomites' glaciers

6. CONCLUSIONS

From the analysis of the historical series of 40 stations, made using the standardized index SAI, a general decrease in snowfalls on the southern slope of the Alps has been pointed out in the nearest period (1985-2004). The reduction tendency is evident particularly in the central and eastern Alps. The effects of this tendency are very clear about the glaciers situation, especially concerning the smallest ones, which quickly answer to climatic changes. Concerning the Dolomites' glaciers, a direct correlation between the snowfalls trend and the variation index of glaciers' surface has been verified. In future the causes of this decrease are going to be analyzed, about the temperature, which could influence the fresh snow amounts at medium-low altitude, and about the synoptic configurations too; in fact from a preliminary study it appears that also the stations along the border-line, interested by different kind of flows, show a decrease in snow precipitations.

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