RECENT DECREASE OF TEMPERATURE OVER THE EASTERN PYRENEES AND ITS RELATIONSHIP WITH THE ATMOSPHERIC CIRCULATION : PRELIMINARY RESULTS

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ABSTRACT

The present work focuses on a likely change in temperature increase detected at the end of 20th century, over high mountainous areas of the Eastern Pyrenees. The results show not only this fact but also the close relationship between the negative departure of temperature and the inflection in the dynamics of the North Atlantic Oscillation (NAO) circulation pattern.

INTRODUCTION

Although the increase of temperatures at high elevation sites along the 20th century is widely assumed by the scientific community (Beniston *et al.*, 1997; Díaz and Bradley, 1997; Vilar, 2003), there is a lack of knowledge about what is the response in the Pyrenees. This study shows preliminary results in this mountain range, in order to identify recent oscillations and its relationship with the most frequent atmospheric circulation pattern influencing western Europe, i.e. the North Atlantic Oscillation pattern (NAO).

EVOLUTION OF MEAN MINIMUM TEMPERATURE IN LA MOLINA (1960-2005)

Unfortunately, the availability of long and continuous temperature series in the Pyrenees is very poor. As a consequence, in this work two series have been combined to create a final temperature series: La Molina (1,704 m asl) and Port del Comte (1,800 m asl). Using a linear regression model and an overlapping period of 14 years between both series, a unique series has been constructed, covering the period 1960-2005. In addition, this series has been compared with a medium mountain site (Barcelona-Fabra, 413 m asl) to detect common trends (see figure 1). The main goal is to confirm the winter temperature evolution detected in other high mountain sites and analyse in detail the most recent period.

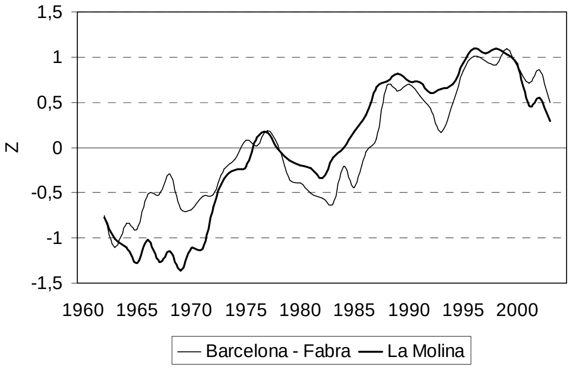

Figure 1. Standardized winter (DJF) temperature anomalies, Z in La Molina and Fabra Observatory (Barcelona), for the reference period 1960-2005. A 5-year filter has been applied to extract interannual noise.

For the whole period, 1960-2005, the temperature evolution during the winter season, December, January and February (DJF), shows an increase of 3.3ºC, which is higher than the one registered in the Fabra Observatory, 1.8ºC and in the Alps, 2.0ºC (Beniston, 2005). But from 1996 there is a clear negative evolution, that represents 0.5ºC from 1999-2005 period. A more detailed analysis of this negative inflection will be attained in the next chapters.

EVOLUTION OF DAILY MINIMUM TEMPERATURES IN BONAIGUA (1997-2006)

Minimum temperatures recorded at high mountainous areas seemed to be the variable mostly affected by climatic oscillations during the 20th century (Baeriswyl and Rebetez, 1996). Following this criterion, daily minimum temperature data collected at the automatic weather station (AWS) of Bonaigua (2,250 m asl – Eastern Pyrenees) for DJF and covering the period 1997-2006 is analysed, in order to have a more detailed view of the trend recently detected in La Molina. As a whole, from 1997, a progressive decrease in daily minimum temperatures is detected, especially evident during the 2003-2006 winters. The mean minimum winter temperature during the first half of the period (1997-2002) was of –5.8ºC, while for the second half (2002-2006) was of –7.5ºC. Actually, the 2004-2005 winter season was the coldest over Iberian high mountainous areas for the last forty years.

In a second step, the Probability Density Function (PDF) of the daily minimum temperatures was obtained for the same two different periods indicated above (figure 2). The comparison between the two curves, points out a displacement to the left of the 2002-2006 period, in relation to the 1997-2002 one. From the shape of the curves, it could be said that the decreasing in winter minimum temperatures is related mainly to a regular decrease in the frequency of values above the mean (indicated as a vertical dotted line in figure 1), while a less weight should be attributed to extreme cold spells.

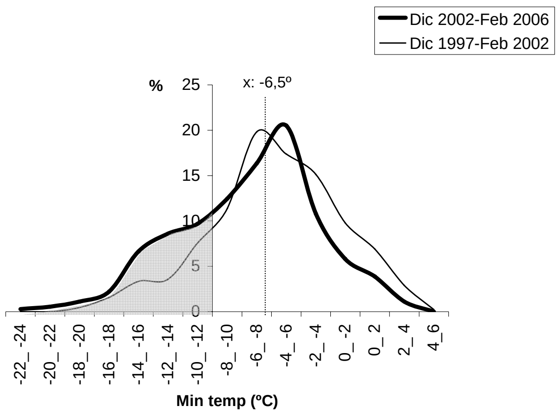

Figure 2. PDF for daily winter minimum temperature for the periods 1998-2002 and 2003-2006 registered at the Bonaigua AWS (2,250 m asl). The shaded area indicates the percentage of minimum temperatures below –10ºC, for each period.

In spite of the short period treated in the analysis and the use of just one series, the results are in agreement with those published by the NASA (2006). According to their data, the decrease in winter mean temperature for the period 1990-2005 is between –0.5ºC and –1.0ºC over the Pyrenees.

RELATIONSHIP WITH THE ATMOSPHERIC CIRCULATION DYNAMICS: THE NAO INDEX

North Atlantic Oscillation (NAO) is the main circulation pattern that rules most of the temperature and rainfall variability over Europe (Osborn *et al*., 1999). Many authors have succeeded in establishing a close relationship between temporal NAO series, expressed as an index, and regional and local climate time series. The analysis of the NAO index (NAOi) during winter months from 1950 to the 1990s, shows a progressive increasing of the index (meaning a higher frequency of westerly circulation), while an opposite trend is clear during the last years.

In this step, the main goal is to establish a relationship between the NAOi and the temperature behaviour in winter over the Pyrenees, using the data from Bonaigua AWS. For this purpose, the method follows that proposed by Beniston and Jungo (2002) for the Swiss Alps.

The PDF curves of daily maximum and minimum temperatures for the Bonaigua sample (DJF, 1997-2006) are represented jointly with the lowest NAOi values (below the 10th percentile) (figure 3) and the highest ones (above de 90th percentile) (figure 4). This approach, allows the analysis of atmospheric circulation extremes over the area, filtering the noise induced by mean values.

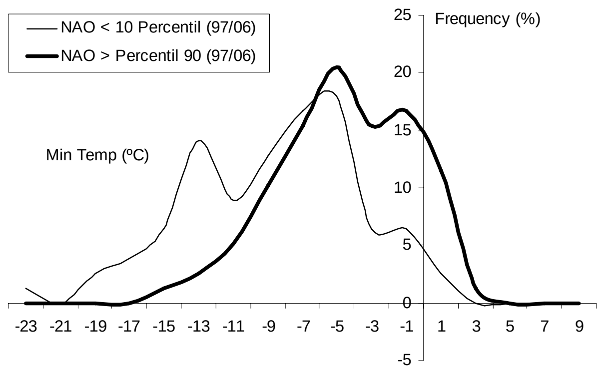

Figure 3. PDF curves of daily winter minimum temperature in Bonaigua (1997-2006) for those days with the lowest NAOi values (<10th percentile) and for the highest ones (>90th percentile).

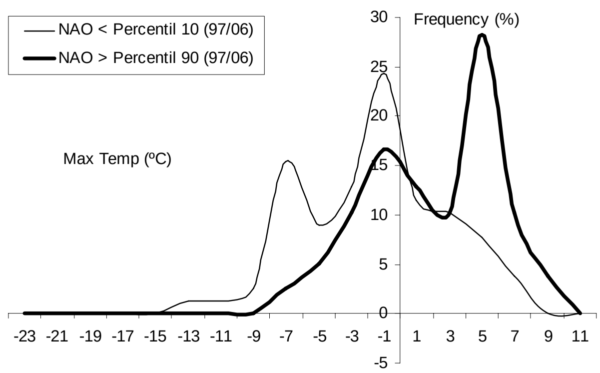

Figure 4. The same as in figure 2 but for daily maximum temperatures.

From figures 3 and 4, some interesting results are obtained:

- For both minimum and maximum daily temperatures, lowest values are linked with the lowest values of daily NAO index, while the opposite is found for the highest positive NAOi, especially for the maximum temperatures.

- Most of the days with high positive NAOi show positive (>0ºC) maximum temperatures. For minimum temperatures, lowest NAOi are associated with frost days.
- The decrease in NAOi values detected in the 1990s has a close relationship with a decrease of maximum and minimum temperatures.
- With highly positive NAOi, not only the number of days registering negative values increases, but also the internal variability grows clearly up.

To reinforce the results, it should be said that for the period 2002-2006, those days with negative NAO index have registered temperatures below 0ºC, indicating the cooling reported during the last years.

CONCLUSIONS

From 1997-1998 up to now a change in the temperature trend has been detected over Eastern Pyrenees, showing a high and positive correlation with the NAO index. This temperature decrease over high mountainous areas deals with the low values of NAO index. Nevertheless, not only negative phases of NAO let to extreme negative temperature departures. It should not be ruled out that NAOi close to zero could also produce negative temperature anomalies. For this reason, deeper studies must be carried out in order to demonstrate if negative values of NAO index mean a temperature decrease in an unequivocal way.

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