

# Climatological comparison of 2011-2012 and 2012-2013 snow seasons in Central and Western Spanish Pyrenees and its relationship with the North Atlantic Oscillation (NAO)

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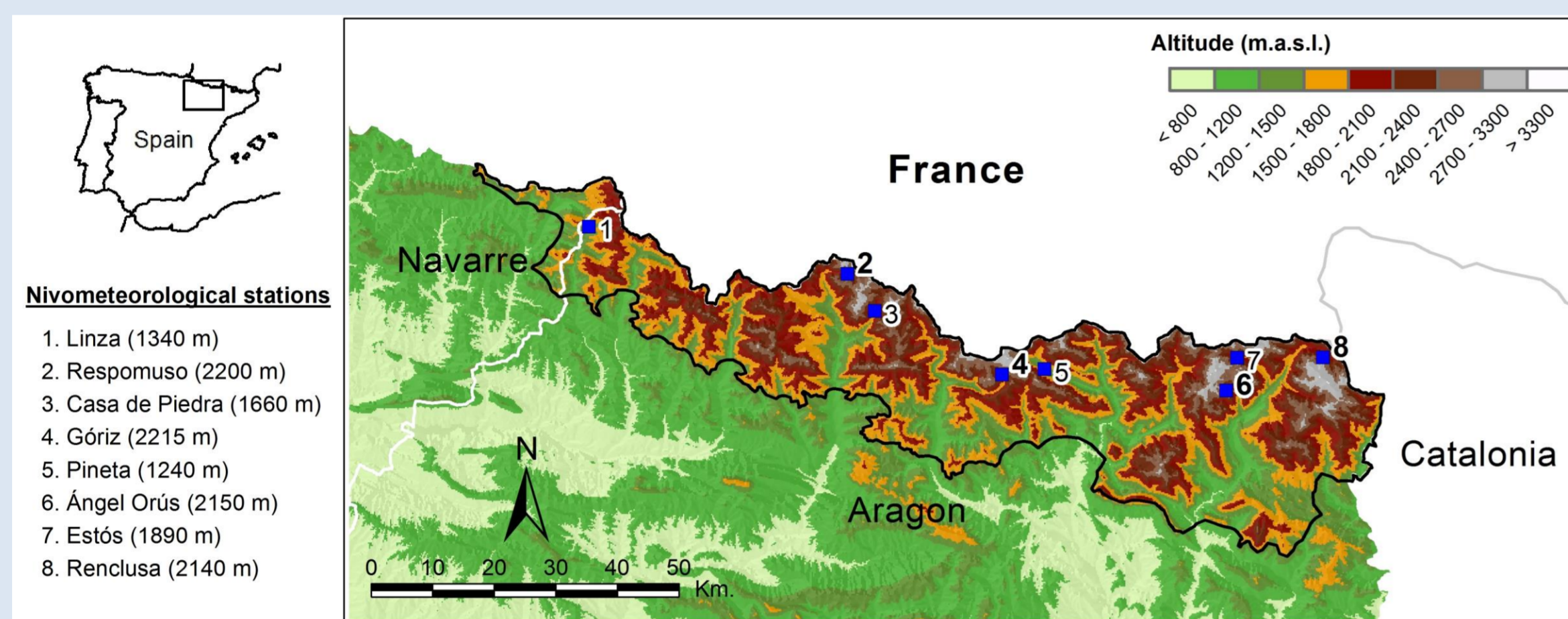
Javier Rodríguez-Marcos

## Introduction

An analysis of 2011/12 and 2012/13 seasons (NDJFMAM) has been made in the Pyrenees of Navarre and Aragon. The main objective is to highlight the contrast between the two seasons in relation to temperature, precipitation and snowpack behaviour, trying to find a relationship with the NAO.

## Study area and Data

Four high mountain manual nivometeorological stations (around 2200 m.a.s.l.) with a continuous data recording were selected for the core study. A climate reference series (1981-2011) for season precipitation and temperature is available in Góriz station. Furthermore, reference is made to other stations at lower levels to evidence the differences between the analyzed seasons.

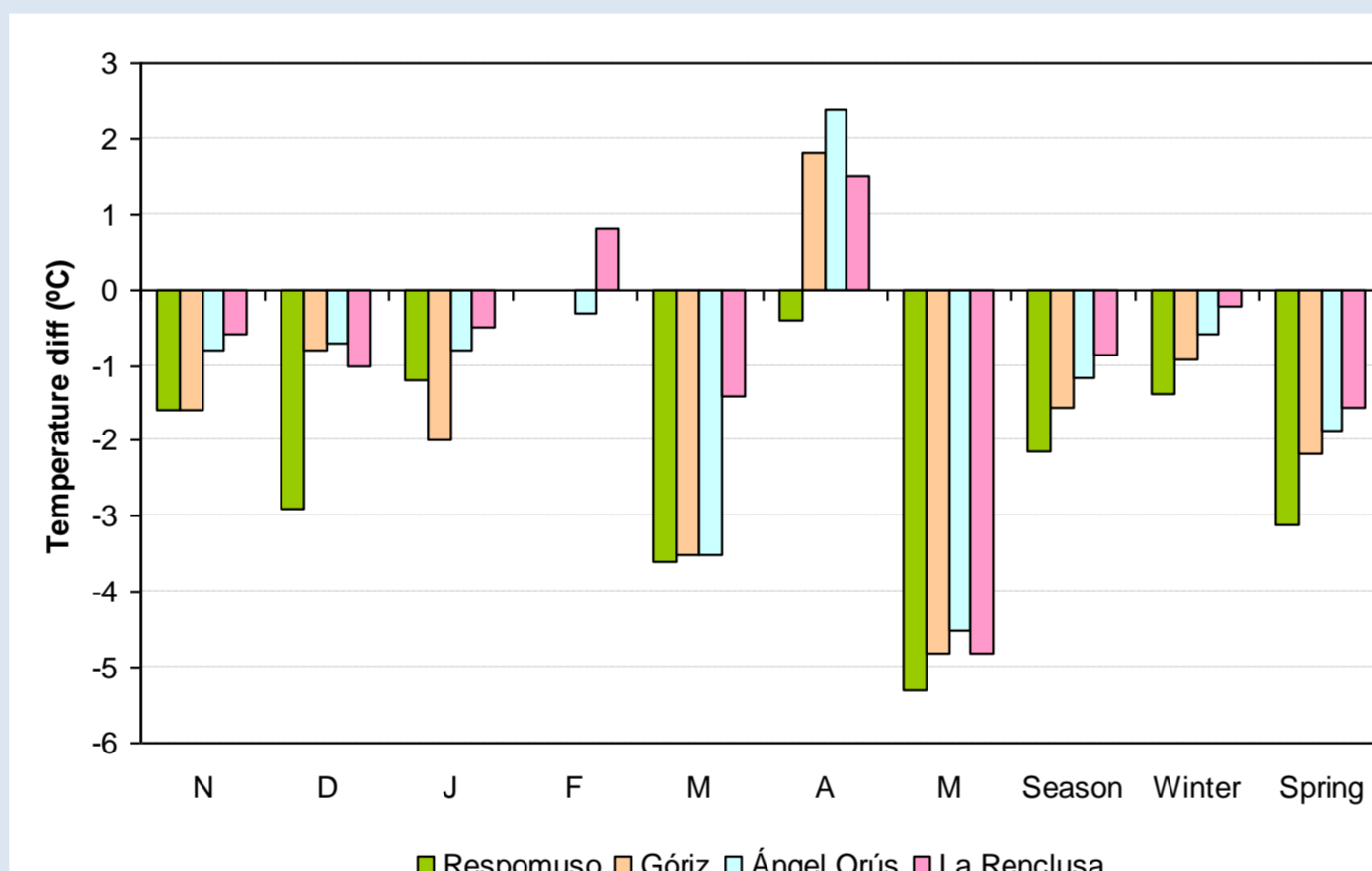


Caption 1: Location of the study area in the northern Iberian Peninsula. Numbers indicate location of analyzed nivometeorological stations.

## Results and Discussion

### Temperature

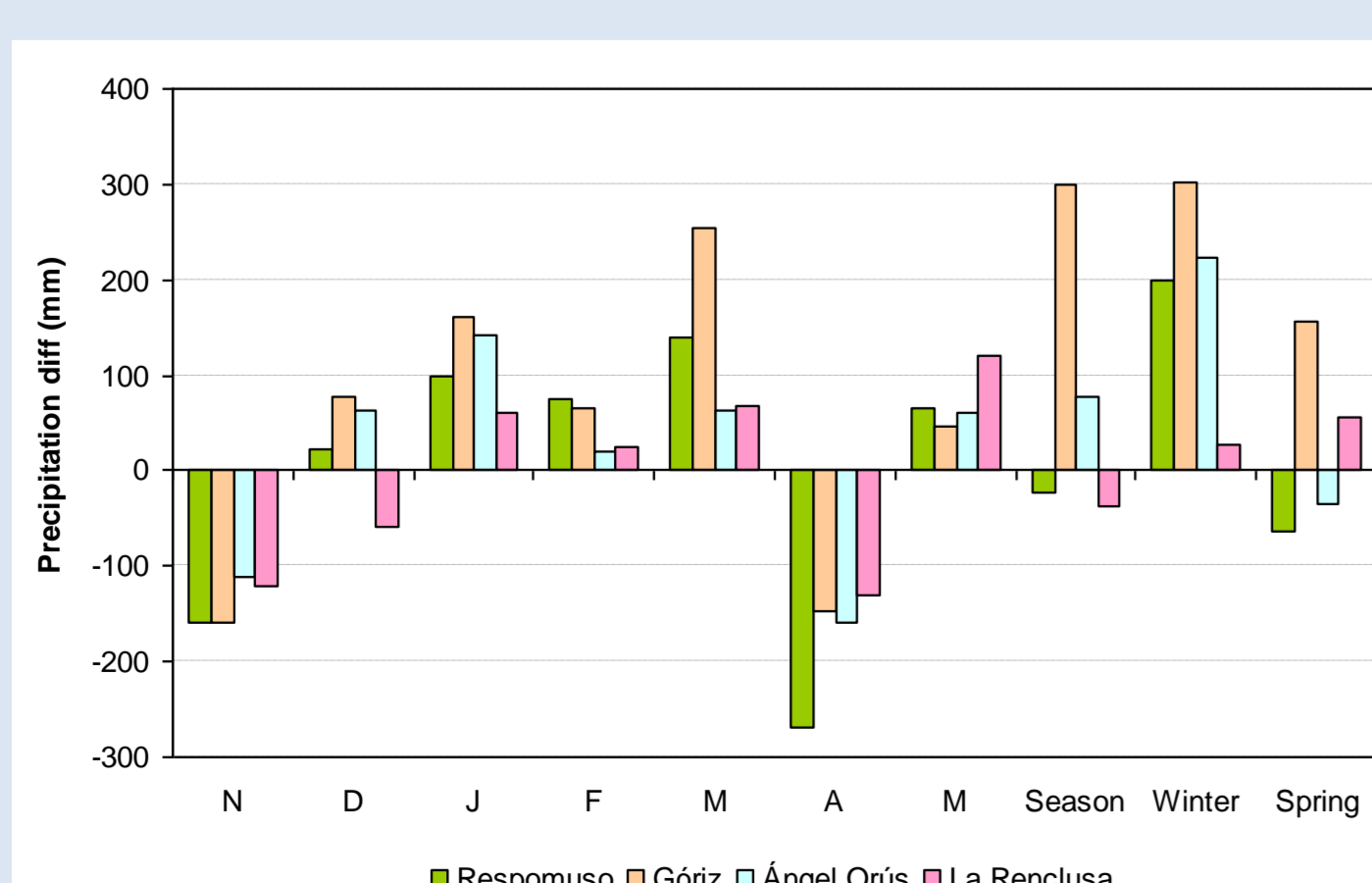
- In Góriz, the 2011/12 season was warmer than normal while the 2012/13 exhibited a clear cold anomaly.
- In all the stations, the 2012/13 season was colder than the previous one.
- Interseasonal differences were lower towards the east.



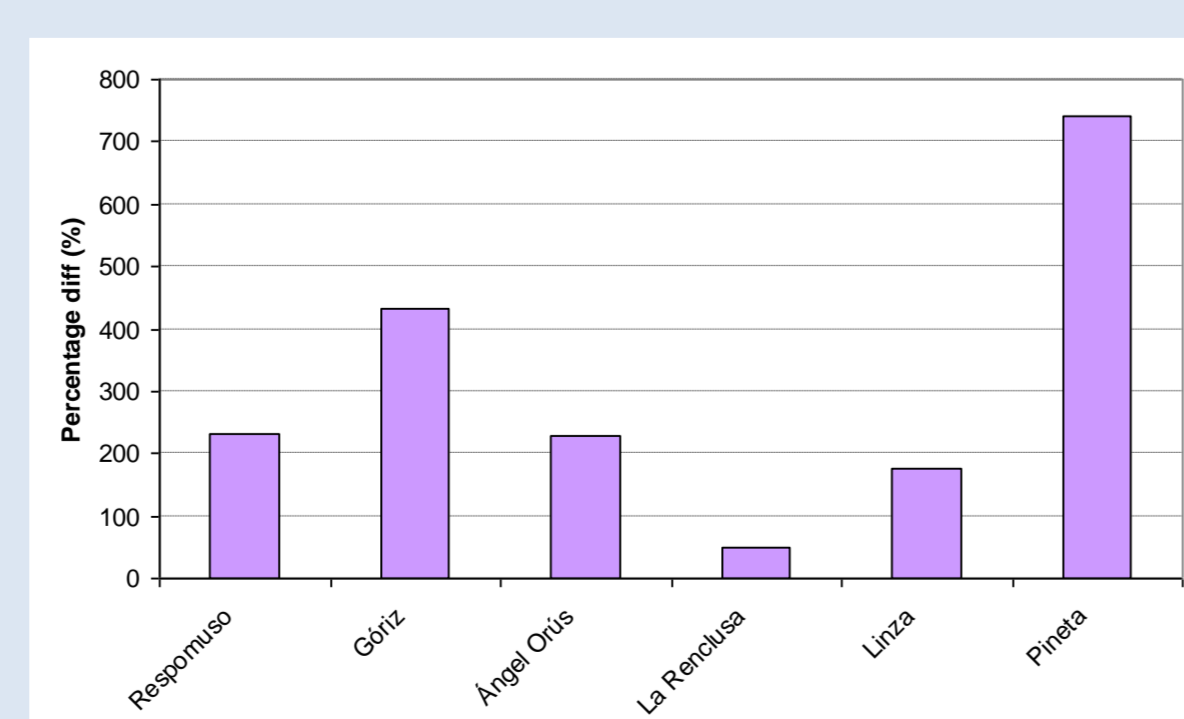
Caption 2: Average monthly, winter, spring and seasonal temperature interseasonal differences (2012/13 minus 2011/12).

### Precipitation

- Total precipitation registered in both seasons was very similar in stations with the exception of Góriz, where there was a dry and a wet anomaly in 2011/12 and 2012/13 respectively.
- The key factor was its temporal distribution: a higher precipitation in the 2012/13 winter season (DJFM) caused a higher snowfall.
- In stations more exposed to south flows much higher precipitation was observed in the 2012/13 winter and winter season.



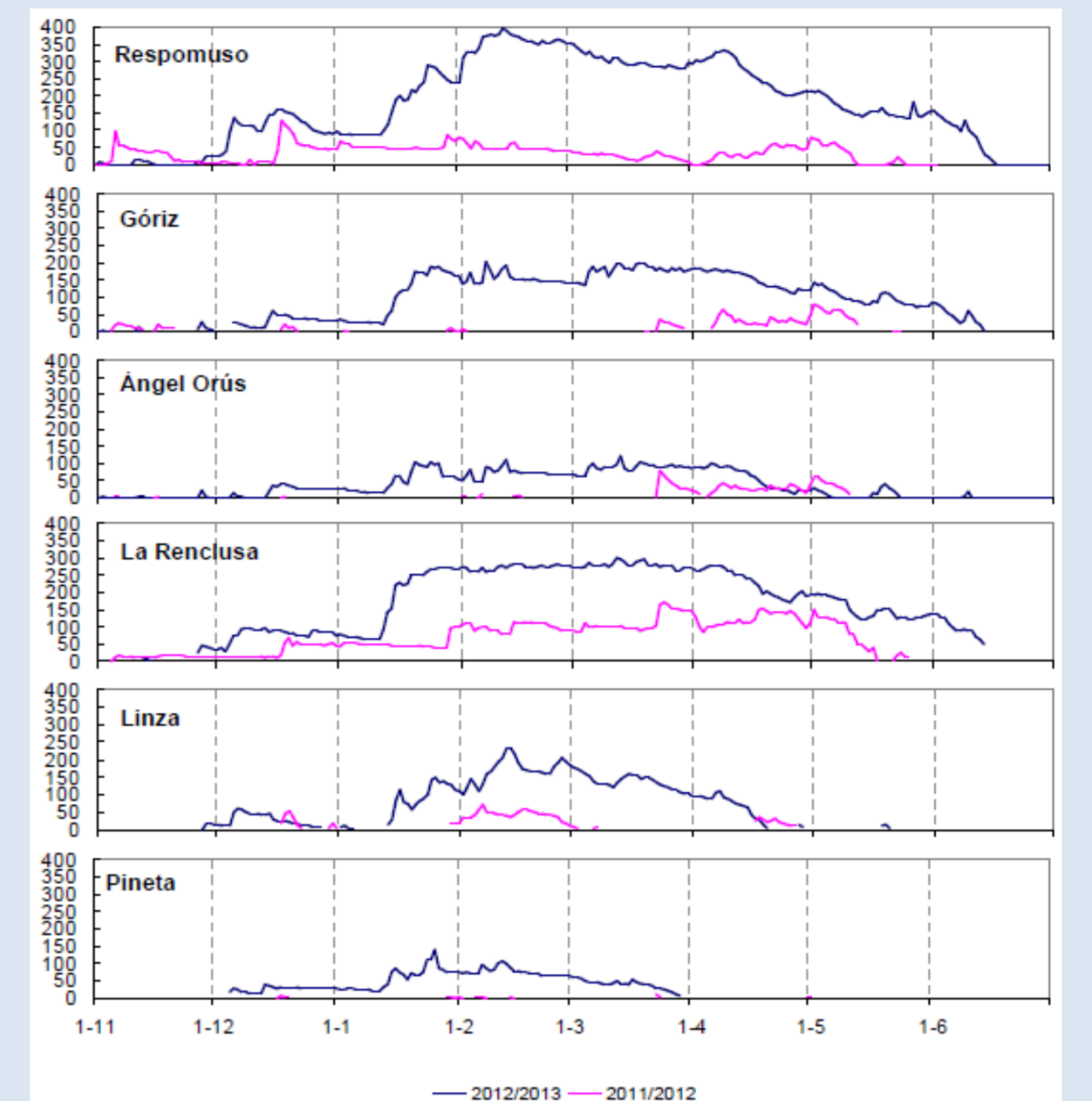
Caption 3: Total monthly, winter, spring and seasonal precipitation interseasonal differences (2012/13 minus 2011/12).



Caption 4: Percentage difference of 2012/13 winter season (DJFM) snowfall with respect to 2011/12.

## Snowpack

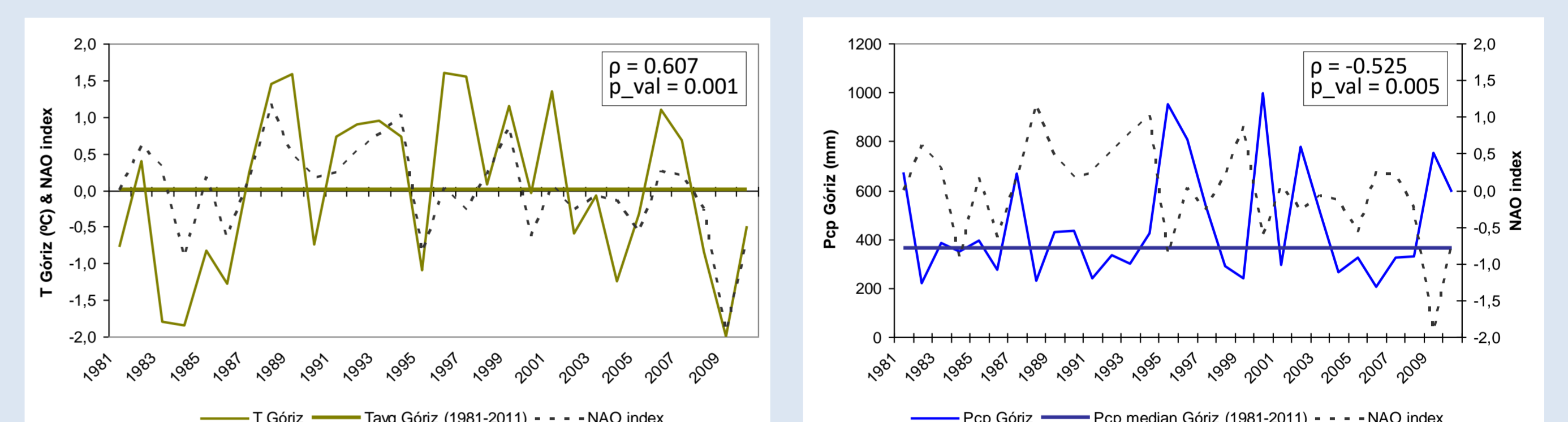
- In the 2011/12 season it is only possible to identify a consolidated snowpack in areas more exposed to north flows above 2000 m.a.s.l.
- The 2012/13 season was characterized by a well consolidated snowpack since early December.
- At stations more exposed to south flows and at lower altitudes the percentage of days with snow on the ground was much higher in the 2012/13 season.



Caption 5: Temporal evolution of snowpack depth (cm).

## Relationship with the NAO

- Statistically significant correlations between the winter season NAO and temperature and precipitation have been demonstrated in the series of Góriz, and in the last two winter seasons.



Caption 6: Temporal evolution of the average winter season (DJFM) NAO index, average temperature (left) and precipitation (right) in Góriz station (1981-2011). The thick line represents the average temperature and the median precipitation in all the period.

Winter season (DJFM)	NAO index	Behaviour Temperature / Precipitation
2011/2012	1.02	Normal / Extremely dry
2012/2013	-0.77	Very cold / Very wet

- A good relationship between the winter season NAO and weather variables has been detected in the rest of analyzed stations, with lower influence in those ones more exposed to north flows.

## Conclusions

- The 2012/13 winter season (DJFM) was the main period which made the difference between both seasons due to a lower temperature, a higher precipitation and consequently a higher snowfall.
- In Góriz, temperature and precipitation exhibit statistically significant correlations with the winter season NAO in the reference period.
- The NAO acted as a good thermopluviometric indicator in the last two winter seasons, with lower influence in those stations more exposed to north flows.
- A more complete study taking into account other teleconnection patterns and more stations with a longer period of data available would be necessary in the future.

## References and Acknowledgements

- <http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml>.
- For all references see the proceeding.
- We would like to thank the keepers of mountain refuges and ski staff for their task collecting daily nivometeorological data, and also the AEMET staff in Aragon for the receipt, review and incorporation into databases and climate data treatment.