TRENDS IN CHARACTERISTICS OF DAILY RAINFALL IN NORTHERN IBERIA: IS THE NAO SIGNAL BEHIND THE OBSERVED VARIABILITY?

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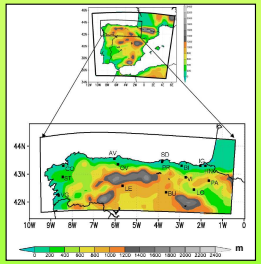
INTRODUCTION AND OBJECTIVES

The effects of global warming, if any, on the rainfall variability in **Northern Iberia** (NIB), a region of particular interest due to its location between the Atlantic and the Mediterranean, have not been examined in detail. The present study was designed to:

- Analyze the changes in the **intensity and frequency of daily precipitation** over NIB with primary focus on **extreme events**.
- Examine the potential **influence of the NAO circulation pattern** on the observed precipitation changes within this region.

METHOD

- **Precipitation data:** daily rainfall series at **14 NCDC-GSOD observatories** distributed along NIB (1973-2007). In Eastern NIB the analysis period is enlarged with two century-length time series: **San Sebastian** (**IG**, since **1929**, daily resolution, source: ECA&D) and **Bilbao** (**BI,** since **1857**, monthly resolution).
- Spatial and temporal characteristics and changes in rainfall have been analyzed using the suite of **indices** developed by the **ETCCDMI**.
- **Statistical testing** using **Mann-Kendall's** non parametric test.
- Station-based monthly **NAO index data** provided by CGD-NCAR.
- Gridded 6-hourly **NCEP-DOE Reanalysis-2** data (1979-2010).



Location of the selected NCDC-GSOD surface observatories in NIB. Shaded colours represent topography.

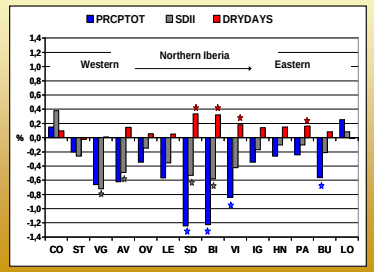
RESULTS

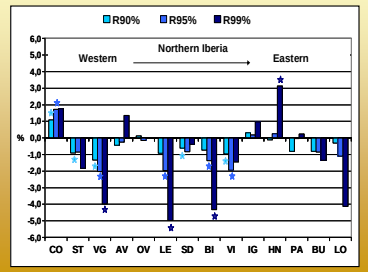
I. TRENDS AND STATISTICAL SIGNIFICANCE

SINCE 1973 in NORTHERN IBERIA (NIB)

- **Less intense rainy days** in the whole region together with an **increasing** trend in the number of **dry days** in Central and Eastern NIB.
- **Extreme rainfall events** present remarkable decreasing trends in Western and Central NIB.

Result: **decline of total rainfall**, significant in Central and Eastern NIB.

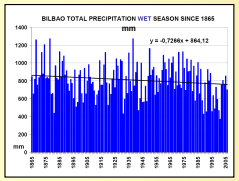


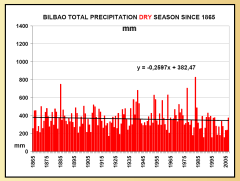


(Left) Percentage of variation of the accumulated precipitation (PRCPTOT), daily intensity index (SDII) and the number of dry days (DRYDAYS) from 1973 to 2007 in the 14 NOAA-GSOD observatories. Stars indicate trends that are significant at the 95% level based on Mann-Kendall's test. (Right) The percentage of rainfall falling on days with daily records above the 90th (R90%), 95th (R95%) and 99th (R99%) percentiles.

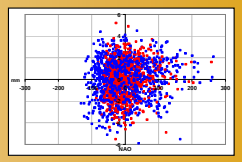
SINCE 1865 in BILBAO (BI)

- The evolution to drier conditions is observed in both the wet season, which spans from October to April, and the dry season, from May to September, statistically **significant** at the 95% confidence level for the **total annual rainfall**.





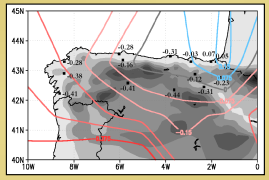
- The scatter plot substantiates the lack of correlation between the monthly NAO signal and the precipitation anomalies (mm) in Eastern NIB, during the wet and dry seasons.

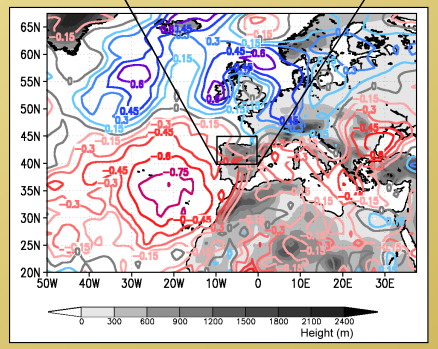


II. CORRELATION NAO-PRECIPITATION ANOMALIES FROM THE REGIONAL TO CONTINENTAL SCALE

At the regional scale (NIB). Low and non-significant correlations between the wet season precipitation anomalies and the NAO signal. Local variations: **west-to-east coastal decrease** of the (negative) correlation, with highest (negative) values at the south-western margins.

Pearson correlation coefficients (r) between the mean wet seasonal NAO index and the relative precipitation anomalies (%) from the NCEP-Reanalysis-2 data (1979-2010) in contour lines. On the enlarged figure the numbers correspond to the correlation for each NCDC-GSOD observatories (1973-2007). Shaded colours represent topography.



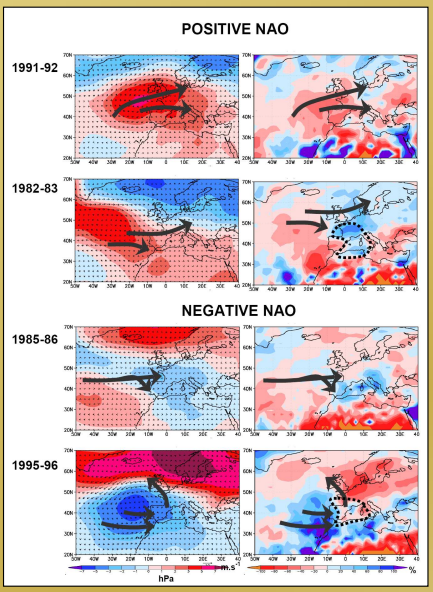


At the continental scale, the eastward propagation of the NAO signal is **influenced by mountain barriers and water bodies**: propagates along the main water bodies and stops and/or changes the correlation sign at mountain ridges. Lower correlation values at mountain barriers and the lee side of moisture-laden winds from the Atlantic Ocean.

III. ATMOSPHERIC CIRCULATIONS

Pressure-wind (left) and precipitation (right) anomalies for a selection of four wet seasons of the Reanalysis-2 series. Black arrows illustrate main moisture transport pathways during each season. Top-to-bottom panels: the Azores anticyclone shifts position to the south-west and weakens, following NAO changes from positive to negative modes.

The **Bay of Biscay**, including Central and Eastern NIB, and the **Western Mediterranean** (dotted line) can show reversed rainfall anomalies for each NAO mode, explaining the lack of correlation.



CONCLUSIONS

- There has been a generalized **decreasing trend of the accumulated precipitation** in all NIB since the 70s, more pronounced and statistically significant **in Central and Eastern NIB** due to simultaneous decrease both in the intensity of the average wet day and in its frequency.
- The evolution of the NAO signal shows **no correlation** with precipitation anomalies. This lack of correlation, confirmed from the century-length time series of Bilbao and San Sebastian, is more evident for Central and Eastern NIB. This region shows significant trends to drier conditions and, in consequence, **the NAO signal can not be behind the observed negative trend.**
- NCEP-Reanalysis-2 series show for the last two decades an **increase in the frequency of *extreme* circulation patterns** during the wet season, attending the location of the Azores High (top and bottom panels of the Figure with atmospheric circulations). Both extremes cause negative precipitation anomalies in the NIB region.

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