Analysis of the correlation of the Indices of the North Atlantic Oscillation and Western Mediterranean Oscillation, with peak flows in Spain

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1. Introduction

The flow rates in the Spanish peninsula are characterized by large inter-annual variability and spatial. One way to identify this variation with climatic indices, that can have an impact on the study area. Were selected the two climate indices that have greater influence on the Spanish peninsula. Due to the high probability of connection of the NAO with the climatology in the Iberian peninsula, several authors have carried out studies in this regard. Since the first work done in the early nineties were able to detect the impact of monthly NAO and winter precipitation in the pennisula (Hurrell 1995, Zorita et al. 1992), the role of this mode of movement on the peninsula has exhaustively investigated, including a daily scale (Gallego et al. 2005).

The weak correlation between the NAO index and the rainfall in the eastern façade of the Iberian Peninsula (Guijarro, J. 1999, Martin, V. et al 1999) explains that although much of the monthly rainfall in Spain (Martin V. et al 2001), these results led to study models of variability characteristic of the Mediterranean. As the proposed development of low-frequency index WeMO Mediterranean with its application in its influence on rainfall in eastern Spain (Martín, V. 2002). Finding the results of the index a significant correlation with precipitation for the month of January showed a greater influence than the NAO index.

This work discusses the possible influence of the levels of the North Atlantic Oscillation (NAO) which has been shown in various studies presented a domain in climate regimes in the region and Western Mediterranean Oscillation (WeMO) in the caudal maximum instantaneous in several basins of Spain.

2. Hypothesis

The main hypothesis was established for the development of this research is the view that the teleconnection indices used in the same NAO (North Atlantic Oscillation) and WeMO (Western Mediterranean Oscillation) showed significant correlations with instantaneous peak flows in the Spanish mainland, and these in turn have spatial and temporal patterns.

3. Case of Study

The study aimed to 80 gauging stations distributed throughout the Spanish territory, the selected sites should have the requirement to natural regimen.

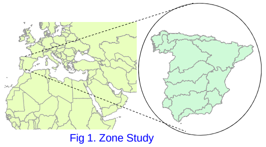


Fig 1. Zone Study

4. Information

Hydrometric Information:

Monthly and Annual instantaneous peak flows of 80 hydrometric station in natural regime. CEDEX (Centro de Estudios y Experimentación de Obras Publicas), (http://hercules.cedex.es/anuarioaforos/)

Teleconnection indices:

NAO monthly series of the Climatic Research Unit (CRU) (1821 – 2009). http://www.cru.uea.ac.uk/

WEMO monthly series of the Climatology Group Research of the Barcelona University (1821-2009). (http://www.ub.edu/gc/English/wemo.htm)

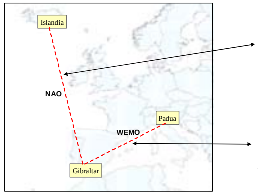


Fig 2. Dipoles of the teleconnection indices

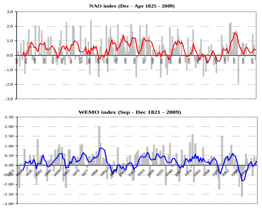


Fig 3. Monthly teleconnection indices

With the information flow analysis was performed of the seasonal timing of these, of what it was observed that peak flows occur mostly in winter on the Western Front in Spain, while in the eastern front tend to occur during the fall and in the central part of Spring (fig. 4).

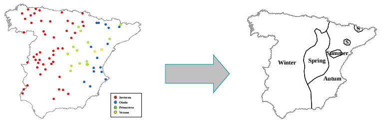


Fig 4. Seasonal distribution peak flows in Spain

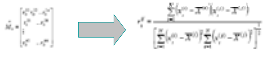
4. Methodology

The guidelines followed in developing the next job consisted primarily in a literature review in relation to teleconnection indices and their influence on climatic variables. This was an important part to establish the vision of the subject treated and the lines could be followed and teleconnection patterns with which it could work. And understand their behavior.

I then took the collection and analysis of information, both hydrometric and teleconnection indices. One way to analyze the influence of teleconnection indices flows in calculating the correlation is linear time series. It took place the calculation of correlation matrices annual and monthly in order to identify delays in the correlations, which was used to test significant Pearson correlations for establishing a confidence level of 95%.

$$r = \frac{\sigma_{XY}}{\sigma_X \cdot \sigma_Y}$$

Pearson Coefficient



I y *j* represent two station
Cross-correlation

From the known values were interpolated fields of annual and monthly correlation using Kriging with which we obtained the raster images and contours could be obtained, which could identify the areas where they had more influence the various indices used. It is a comparison between the areas of influence of each index.

5. Results

Annual

Highest correlations presented a 1 lag month between Maximum instantaneous peak flows and NAO index. The WEMO index didn't show a delay in the calculation of correlations (fig.5). The NAO index shows a significant influence only in its negative phase, while the index WeMO has it in his two phases positive and negative (fig. 6).

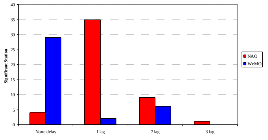


Fig 5. Station significant un the annual cross-correlation

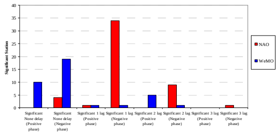
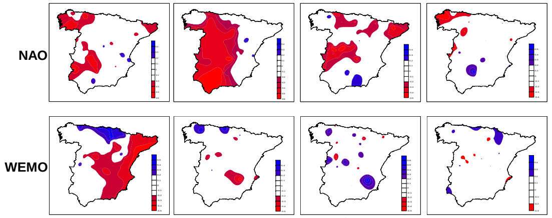


Fig 6. Stations significant for each phase of the indices

In the analysis of the annual correlation matrices was observed that after two lags, the correlation is lowered.



None delay in the signal
1 Lag
2 Lag
3 Lag

The NAO index in her negative phase showed significant correlation in the southern and western of the Spanish Peninsula. The NAO index in her negative phase showed significant correlation in the southern and western of the Spanish Peninsula. The WEMO index showed significant correlations in their two phases (Positive and Negative). In the positive phase the significant correlation are in the north of the peninsula. In her negative Phase the significant correlation are in the eastern of the peninsula (fig. 6).

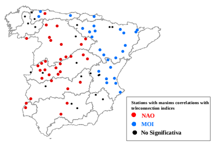


Fig 7. Highest correlation index (annual)

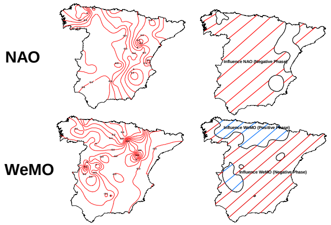


Fig 8. Isopleths of correlation and areas of influence of the teleconnection indices

Monthly

The results show as in the annual analysis of the effect on flow rates of the negative phase of NAO index. As the months from December to February (during winter) months with the greatest influence of the index (fig. 11). The highest correlations for the months of October to February and August there were no delays in the correlation matrices. For the months of March to July and September showed the highest correlations with one lag (fig. 9 and 10).

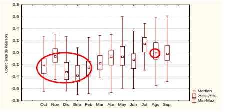


Fig 9. Interannual coefficient of Pearson without delay (NAO vs Qmax)

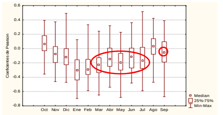


Fig 10. Interannual coefficient of Pearson with 1 lag (NAO vs Qmax)

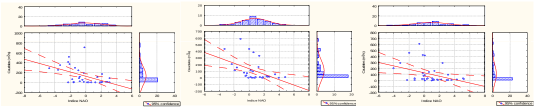


Fig 11. Months with more influence of the NAO index (December to February) example station 3161 Tajo Confederation

The results of this WeMO index showed the highest correlations in the great majority for the maximum monthly without delay (January, March, April, June and August to December) showing the greatest influence in the months of September to January in its negative phase especially in the eastern front of the peninsula and the center, the correlation showed positive phase in the months of December through May, particularly in the north of the peninsula.

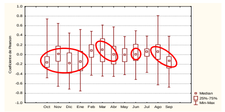


Fig 12. Interannual coefficient of Pearson without delay (WeMO vs Qmax)

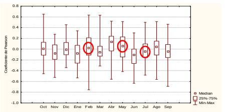


Fig 13. Interannual coefficient of Pearson with 1 lag (WeMO vs Qmax)

The variance represented by the NAO index in the Confederations most influential (Tajo, Duero, Guadiana, Guadalquivir y Miño-Sil) shows that this is more important for the winter months with average values of 20 to 25% for the Confederations Tajo, Duero , Guadiana and Guadalquivir (fig. 13). In the case of index WeMO explained variance is lower than in the NAO, and is even greater during the months of August to January, and showed a greater influence in the confederations Cantabrico, Tajo, Ebro and Jucar (fig.14).

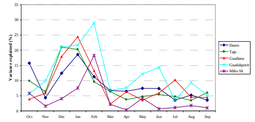


Fig 11. Variance explained by the NAO index in the Hydrologic Confederations

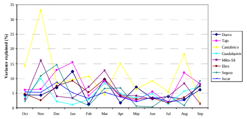
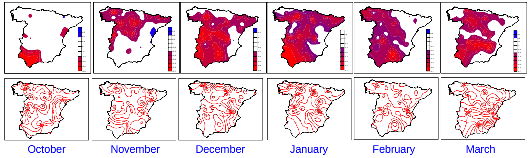


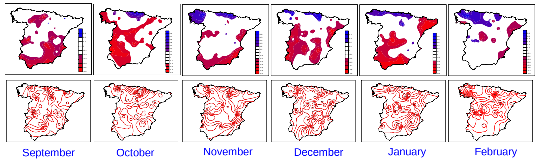
Fig 12. Variance explained by the NAO index in the Hydrologic Confederations

The following figures show the results for the spatial distribution of significant stations for month with significant correlations. Stations showing significant for each phase of the index, as well as areas of significant influence to the stations by using Kriging interpolation space.



October
November
December
January
February
March

Fig 13. Area of influence and Isopleths of correlation for months with significant influence of the NAO index



September
October
November
December
January
February

Fig 14. Area of influence and Isopleths of correlation for months with significant influence of the NAO index

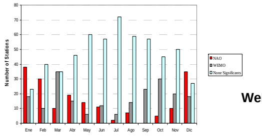


Fig 15. Significant gauging station for each month

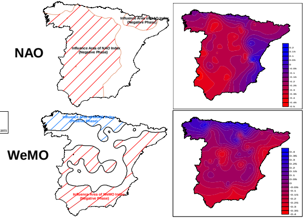


Fig 16. Results of spatial analysis in influence of the teleconnection indices

6. Conclusions

- ➢Exist a significant correlation between Maximum instantaneous peak flows and teleconnection indices in some areas and seasons in the Spanish Peninsula. The NAO index showed a more extensive area of influence.
- ➢In the analysis of highest correlations the NAO have more area of influence in the months December, January and February (Winter) and the WEMO index in September, October, November (Autumn). June, July and August present very few stations with correlations significant.
- ➢ These results are in agreement with results obtained by different researches who have relied in the analysis the influence of the teleconnection indices in the rainfalls and temperatures in Spain.

7. Acknowledgments

This study was supported by a grant provided by the National Council for Science and Technology of Mexico (CONACYT) and by the Spanish Ministry of Science and Innovation through the projects CGL2008-06474-C02-02/BTE and Consolider-Ingenio CSD2009-00065

8. References

- ➢ Hurrell, J. W., (1995), *Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation, Science*, 269, 676– 679.
- ➢ Guijarro, J., (1999), *Teleconexiones climáticas y precipitación en la España mediterránea, La Climatología española en los albores del siglo XXI*, pp. 243-251, Barcelona.
- ➢Martín, V., Barriendos, M., Peña, J., Raso, J., Llasata, Ma., y Rodríguez, R., (1999), *Potencialidad del índice NAO en la previsión de episodios de alta pluviosidad en España*, Gerencia de Riesgos, Madrid.
- ➢Martín, V., (2002), *Ensayo sobre la oscilación del mediterráneo occidental y su influencia en la pluviometría del este de España*, El Agua y el Clima, publicaciones de la AEC, serie A, nº3, Mallorca, pp. 35-42.
- ➢Martín, V. y Fernández, D., (2001), *El índice NAO y la precipitación mensual en la España peninsular*, Investigaciones Geográficas, nº26, Universidad de Alicante, pp35-42.
- ➢Zorita, E., Kharin V. y Von Storch H., (1992), *The atmospheric circulation and sea surface temperature in the North Atlantic area in winter: Their interaction and relevance for Iberian precipitacion*, Jounal of Climate, 5, pp. 1097- 1108.
- ➢Gallego, M.C.; Garcia, J.A. and Vaquero, J.M. (2005): The NAO signal in daily rainfall series over the Iberian Peninsula. Climate Research, 29, 103-109.

European Geosciences Union
General Assembly 2010
Vienna, Austria, 02 – 07 May 2010