Multidecadal Modulation of the interannual rainfall variability over the Euro-Mediterranean region

Jorge López-Parages[1] and María Belén Rodríguez-Fonseca[2]
Dpto. de Física de la Tierra, Astronomía y Astrofísica I : Geofísica y Meteorología
Facultad de Ciencias Físicas, Universidad Complutense de Madrid.
parages@fis.ucm.es [1] brfonsec@fis.ucm.es [2]

INTRODUCTION

The climate variability of the Mediterranean area is influenced by the North Atlantic Oscillation (NAO, Hurrell, 2003), which frequency and positive phase intensity has suffered an increase after the 1970's unprecedented in the instrumental period, in coincidence with extreme drought conditions in the Mediterranean region. These results remark the non-stationary variability of the NAO (Vicente-Serrano and López-Moreno, 2008b) and the existence of changes in the underlying dynamics.
Tropical Atlantic Variability (TAV) and ENSO have also shown to exhibit a strong and non-linear stationary influence on Euro-Atlantic climate(Greatbatch et al. 2004). Maximun correlations in the beginning of the twenty century and since the 1970', and no influence during the 1940's-50's-60's, has been found with the Mediterranean region (Mariotti et al.2002). Unfortunately ,not always is easy to take the difference between NAO and ENSO signal over the Sea Level Pressure (SLP) . As García-Serrano et al. (2002) support, the latter could exhibit a NAO-like pattern over the Euro-Atlantic sector.

Nowadays, the underlying dynamics of these nonstationary relationships and the role of natural multidecadal variability are still unclear.

OBJECTIVES

1. To investigate the role of natural multidecadal variability in the precipitation variability over the Euro-Mediterranean region.
2. To determine the associated SST and SLP pattern related to the precipitation variability modes.
3. To investigate the non-stationary relationship between ENSO and the interannual precipitation over the Euro-Mediterranean region for the 20th century.

DATA AND METHOD

Rainfall: Global Precipitation Analysis Products (0.5º x 0.5º) of the GPCC (Schneider et al., 2008). SST: NOAA Extended Reconstructed SST V3b Data (2º x 2º). SLP: NCAR Northern Hemisphere Sea-Level Pressure (5º x 5º), (Trenberth and Paolino, 1980). Atlantic Multidecadal Oscillation (AMO) as in Enfield et al. 2000. Pacific Decadal Oscillation (PDO) as in Mantua et al. 1997. Global Warming (GW) SST signal based on yearly averaged global SST (Rayner et al. 2003). :
Methodology: Principal Component Analysis (PCA) of the winter anomalous rainfall has been done for the time period 1906-2002. The same Analysis has been done without the influence of AMO and PDO signal, and for the interannual rainfall. In the first case, a Gram-Schmidt Orthogonalization methodology has been used to generate an orthogonal base able to discriminate the AMO and PDO influence on the rainfall modes. Finally, the relationship between the Nino3.4 index and the interannual Euro-Mediterranean rainfall reconstructed with PC1 and PC2 is Analyzed with a 20-year moving window correlation. The same has been done for the Artic Oscillation Index (AO) obteined from Colorado State University and an undulatory index defined from the anomalous regression map between the PC1 and the anomalous SLP.

PC1 ~16%

1) TOTAL SIGNAL

2) INTERANNUAL SIGNAL

3) TOTAL MINUS (AMO+PDO)

pcp | slp | sst lag 0(JFM) | sst lag -3 (OND) | sst lag -6 (JJA)

1) the leading rainfall variability pattern projects onto a NAO-like signal with no clear oceanic influence

2) El Niño external influence appears, the rainfall pattern changes and an undulatory pattern emerges

3) Similar response with 2) :El Niño influence and an undulatory pattern over the SLP

−0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7

The first interannual mode is not stationary. It is related with ENSO and with the undulatory pattern before the 30's and after the 70's , but not during the 1940's-50's-60's (see figure 2).

↓

It seems to be modulated by AMO

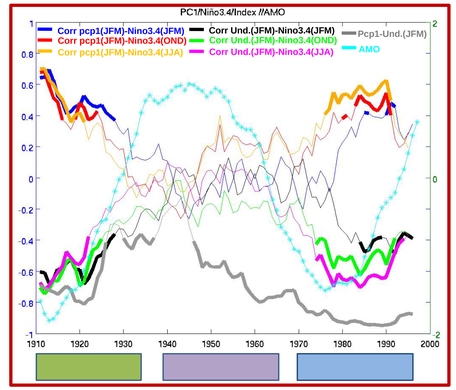

Figure 2: 20-year moving window correlation analysis between interannual pcp reconstucted with PC1 (JFM) with: Nino3.4 (JFM) -blue line-, Nino3.4 (OND) -red line- and Nino3.4 (JJA) -yellow line-. The same between SLP undulatory index (JFM) and: Nino3.4 (JFM)-black line-, Nino3.4 (OND) -green line- and Nino3.4 (JJA) -magenta line-. The grey line represent the correlation betwween the interannual pcp reconstructed (JFM) and the SLP undulatory index (JFM). In turquoise blue the AMO index , which is referenced on the right axis. Units are in std deviations. Thick lines represent periods with 90% significant correlation (monte-carlo).

CONCLUSIONS

- **The leading EOF mode of the anomalous rainfall change when the (AMO + PDO) signal is removed. Mainly over the Mediterranean area , Scandinavia and the Iberian Peninsula (IP), where a dipolar patterns between the northwest and the southeast appears.**
- **These changes are associated with changes in the SLP patterns, from a dipolar pattern over the Euro-Atlantic sector to an undulatory pattern. The latter is related with ENSO.**
- **This undulatory response related with ENSO, which is similar to the identified for the interannual rainfall, is no stationary. It seems be modulated by AMO and it is only significative in cold pashes.**

PC2 ~14%

1) TOTAL SIGNAL

2) INTERANNUAL SIGNAL

3) TOTAL MINUS (AMO+PDO)

1) the leading rainfall variability pattern projects onto an AO-like signal with El Niño influence

2) A NAO-like signal appear and El Niño external influence disappears

3) The Aleutian centre and El Niño influence decreases, but it not dissapear at all

−0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6

The second interannual mode is not stationary. It is related with ENSO before the 40's and after the 70's , but not after(see figure 3).

It seems to be influenced by GW

↓

AO/NAO controversial?

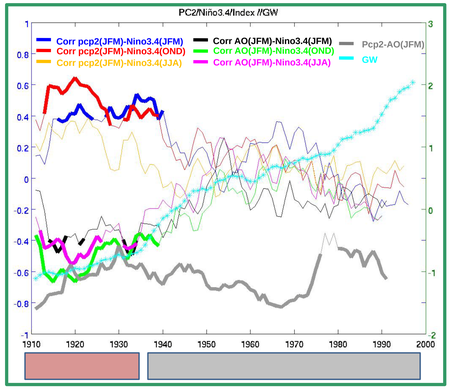

Figure 3: 20-year moving window correlation analysis between interannual pcp reconstucted with PC1 (JFM) with: Nino3.4 (JFM) -blue line-, Nino3.4 (OND) -red line- and Nino3.4 (JJA) -yellow line-. The same between AO index (JFM) and: Nino3.4 (JFM)-black line-, Nino3.4 (OND) -green line- and Nino3.4 (JJA) -magenta line-. The grey line represent the correlation betwween the interannual pcp reconstructed (JFM) and the AO index (JFM). In turquoise blue the GW index , which is referenced on the right axis. Units are in std deviations. Thick lines represent periods with 90% significant correlation (monte-carlo).

- **The (AMO + PDO) signal strengths the Aleutian centre and ENSO response associated with the second EOF mode. If only the interannual signal is preserve, a NAO-like patterns emerge over the SLP and no forcing appears from the tropical oceans.**
- **This second mode, which seems to be influenced by GW signal, could give more insight to the AO/NAO controversy.**
- **The results of the PCA should be interpreted with caution due to the length of the time period analyzed, which includes variability at interannual and decadal time scales.**

Figure 1: PCA (1906-2002).First column: Spatial regression maps of the first and second EOF mode of the winter Euro-Mediterranean anomalous rainfall. Second column: SST regression map. Units are in º per std in the PC. Third column: SLP regression map. Units are in hPa per std in the PC. 1) taking into account the whole anomalous rainfall signal, 2) only the interannual rainfall is analyzed (the differences between one year and the next), 3) only the (AMO+PDO) influence is remove. Only the areas with 90% significant correlation (monte-carlo) are shaded.

REFERENCES

- Enfield D.B.et al. (2001), The Atlantic multidecadal oscillation and its relation to rainfall and river flows in the continental U.S.Geophys. Res. Lett., 28, 10. 2077-2080.
- García-Serrano J. et al. (2010): Rotational atmospheric circulation during North Atlantic-European winter: the influence of ENSO.Clim. Din. Doi: 10.1007/s00382-010-0968-y
- Greatbatch R.J. et al. (2004): Nonstationary impact of ENSO on Euro-Atlantic winter climate, Geophys.Res. Lett., 31, 10.1029/2003GL018542.
- Hurrell J.W. et al., (2003): An overview of the North Atlantic Oscillation. In The North Atlantic Oscillation. AGU.
- Mariotti, A., et al. (2002): Euro-Mediterranean rainfall and ENSO- a seasonally varying relationship, Geophys. Res. Lett., 29, 12. 10.1029/2001GL014248.
- Mantua, N.J., et al. (1997): A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society, 78, pp. 1069-1079.
- Rayner N.A. et al., (2003): Global analyses of the sea surface temperature, sea ice, and night marine air temperature since the nineteenth Century. J.Geoph. Res. 108. doi: 10.1029/2002JD002670.
- Schneider et al., (2008): Global Precipitation Analysis Products of the GPCC. Global Precipitation Climatology Centre.
- Smith, T.M., R.W. Reynolds, T.C. Peterson, and J. Lawrimore (2008): Improvements to NOAA's Historical Merged Land-Ocean Surface Temperature Analysis (1880-2006). *J. Clim.*, 21, 2283-2296.
- Trenberth, K. E., and D. A. Paolino Jr., (1980): The Northern Hemisphere sea-level pressure data set: Trends, errors and discontinuities. *Mon. Wea. Rev.*, **108**, 855-872.
- Vicente-Serrano S.M. and López-Moreno J.I. (2008b): Nonstationary influence of the North Atlantic Oscillation on European precipitation. J. Geoph. Res-Atmospheres, 113.

ACKNOWLEDGMENTS

This research was supported by the national CGL2009-10285 (TRACS) and 2008-00050084028 (MOVAC) projects of the Spanish Government.