Multidecadal Modulation of ENSO influence on the interannual Euro-Mediterranean rainfall

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INTRODUCTION

El Niño-Southern Oscillation (ENSO) is the globally dominant mode at interannual timescales. However, its influence over the North Atlantic sector is less well understood than those influencing on the Pacific due to the highly variable extratropical circulation of the Atlantic basin [Trenberth et al., 1998]. Over the North Atlantic, most of the studies point out to the North Atlantic Oscillation (NAO) as the leading pattern controlling the atmospheric variability. An interesting point is that, at interannual timescales, the regional atmospheric spatial pattern at surface levels over the Euro-Atlantic region associated with the Pacific El Niño presents a similar structure to the one associated with the NAO [Brönnimann, 2007, García-Serrano et al., 2011]. In this way, although most of the NAO signal has an internal origin, external contributions associated with Sea Surface Temperature (SST) changes in the Pacific can have a determinant impact on the centers of action of the NAO.

Over Europe, previous studies have found nonstationary features of ENSO and NAO impacts along the 20th century. These studies include interdecadal shifts in the location of NAO centers [Vicente-Serrano et al. 2008], different impacts of ENSO on the Euro-Atlantic winter climate before and after the 1970s [Greatbatch et al. 2004], multidecadal variations in the relationship between ENSO and the western Mediterranean rainfall [Mariotti et al. 2002], or a changing ENSO impact depending on the NAO and multidecadal oscillations of the SST over the Pacific [Zanchettin et al. 2008]. However, none of these studies has restricted the analysis to the internannual signal, distinguishing in this way the multidecadal modulation of the interannual variability from the purely multidecadal variability not removed in the analysis.

GOALS

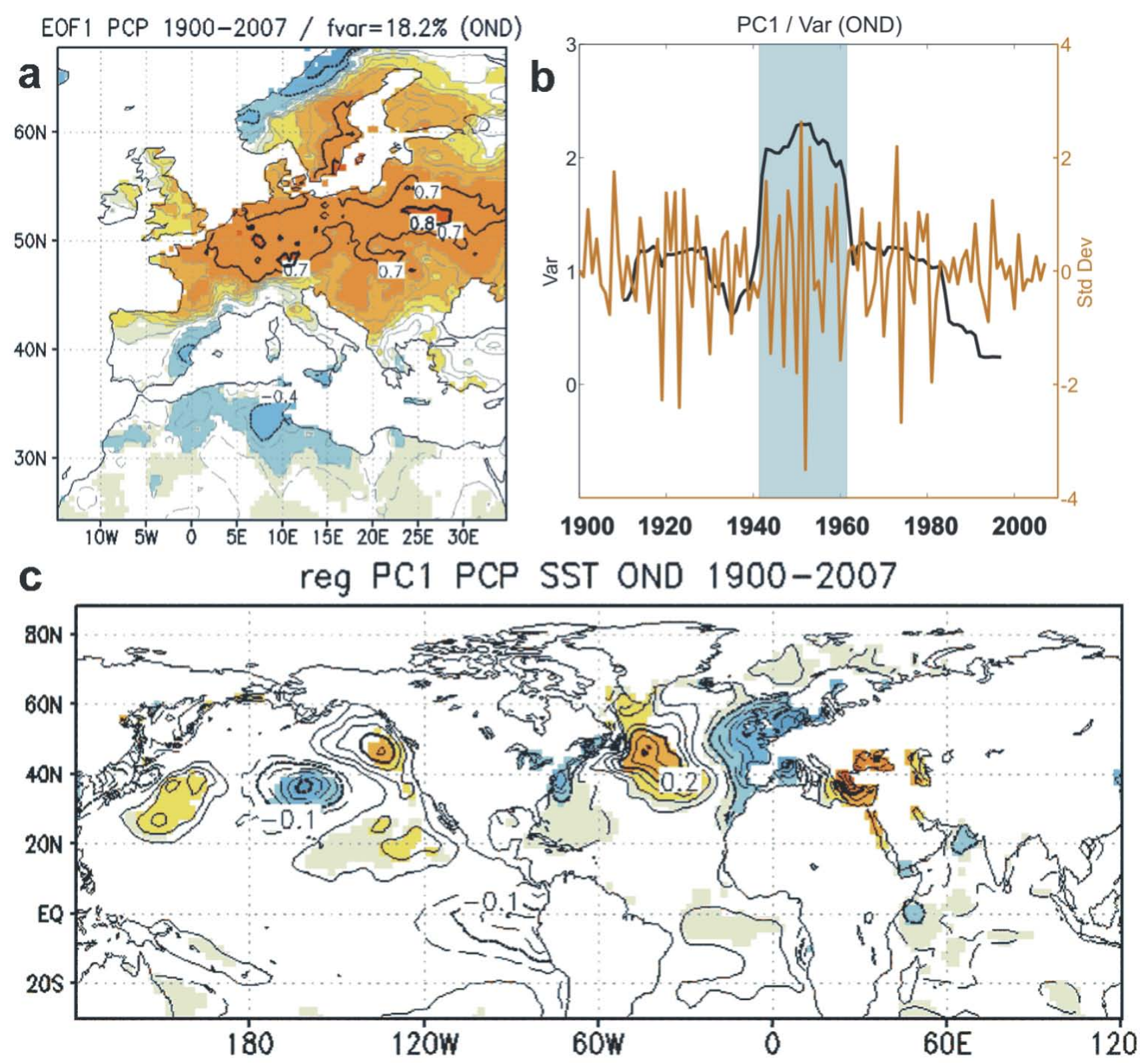
1. To investigate the El Niño impact over the Euro-Mediterranean climate variability at interannual timescales.
2. To analyze the stationarity of this El Niño impact and related sources.

DATA AND METHOD

Rainfall: Univ. of Delaware (Matsuura and Willmott, 2009) and GPCC data (Schneider et al., 2008). Resolution : (0.5º x 0.5º).
SST: ERSSTv3 [Smith et al. 2008] and HadISST1 [Rayner et al. 2003] data, with (2º x 2º) and (1º x 1º) of lag-long resolution.
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.

Methodology: Principal Component Analysis (PCA) of the interannual seasonal rainfall over the Euro-Mediterranean region [iEMedR, [24ºN-68ºN, 15ºW-35ºE]. Regression maps are computed projecting the iEMedR, SST, and SLP, onto the leading Principal Components (PCs). Looking for the stationarity of ENSO impact, sliding windows correlation analysis between the leading PCs and the Nino3.4 index is applied. Finally, periods with or without significant correlations are analyzed separately.

Mode 1 iEMedR

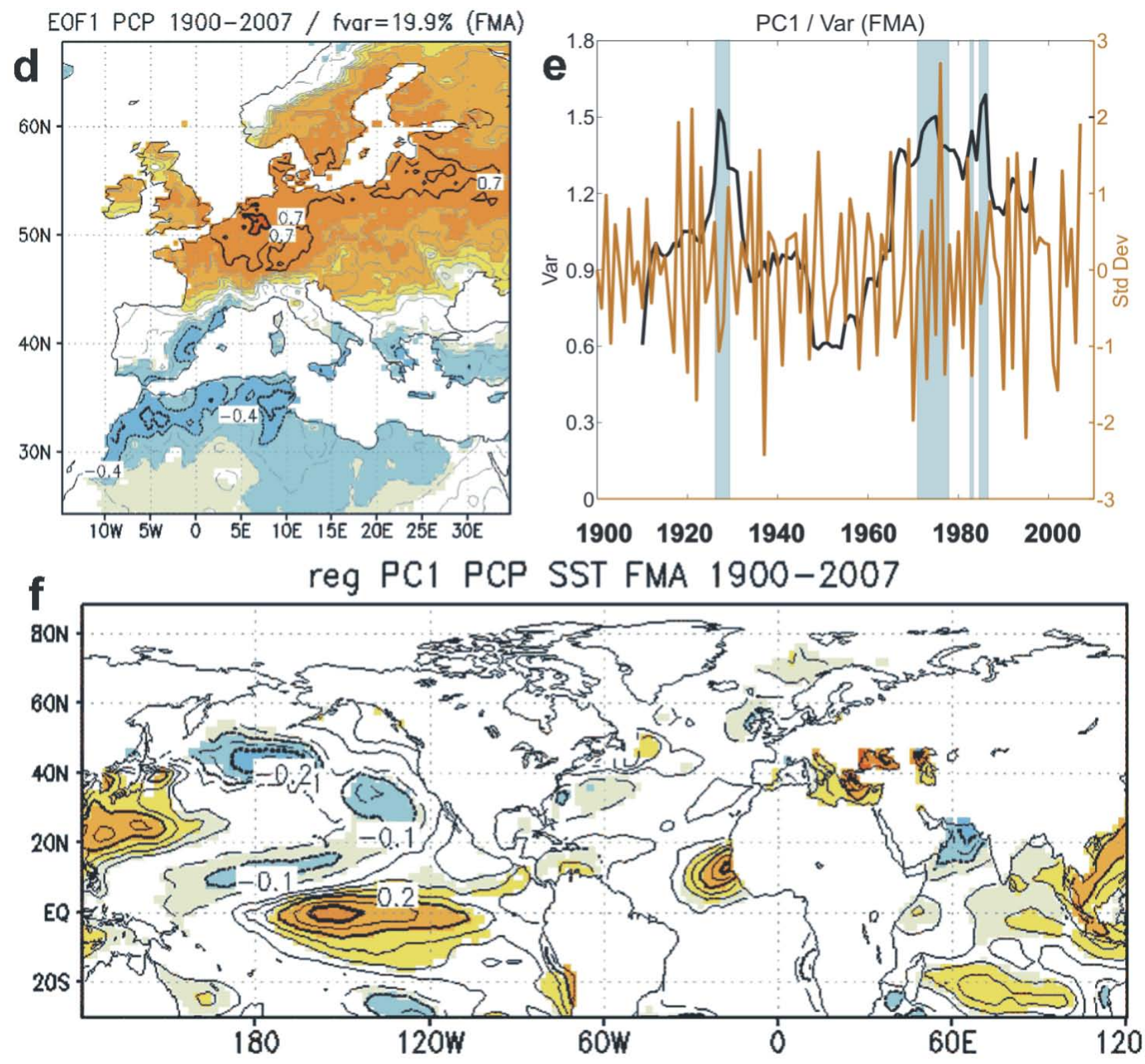


OND

Figure 1: OND mode: a) Leading EOF (contours, ci= 0,1 mm per std in the PC) of the OND anomalous rainfall over the EMed region (24.25– 67.75ºN/14.75ºW-34.75ºE). b) Associated standardized principal component (PC1, referenced on the right axis) and its variance (black line, referenced on the left axis). c) Regression map of anomalous SST onto the PC1 (ci= 0,05 º per std in the PC) . In all the maps, shading represents statistical significant areas, according to a Monte Carlo correlation test at 95% confidence level. Blue band in figures 1b represent significant changes in the PC variance using the same test and threshold as in the maps.

(OND)
Non stationary iEMedR-El Niño relationship → evolves in phase with the PDO

- **Similar iEMedR pattern for FMA and OND, but different projection of the anomalous SST onto the leading PC, mainly over the tropical Pacific.**
- **1º PCs → statistically significant changes in its variance along 20th century.**



FMA

Figure 4: FMA mode: the same as in figure 1 but for FMA.

(FMA)
Non stationary iEMedR-El Niño relationship → evolves in phase with the AMO

Sliding window correlations (PC1-Niño3.4)

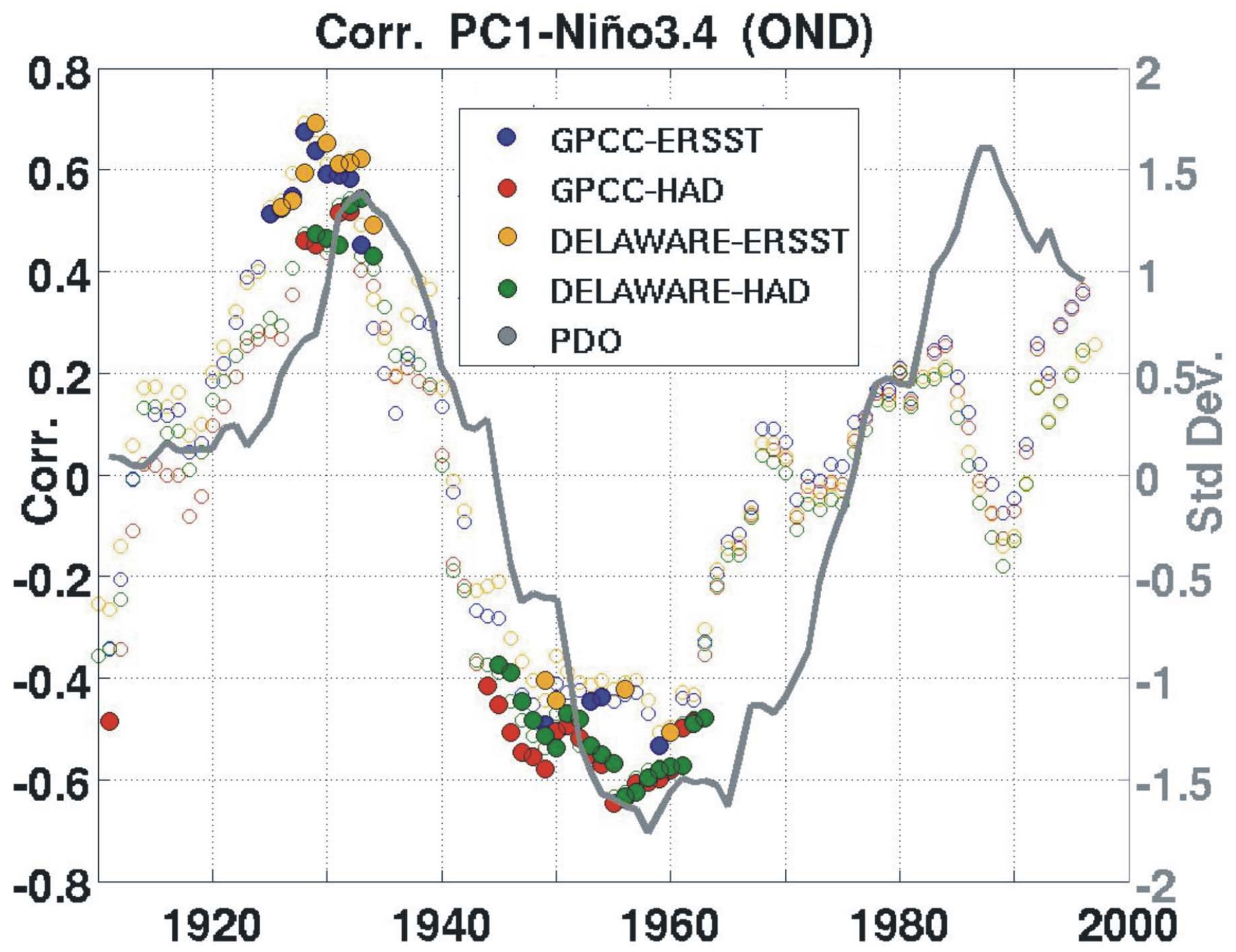


Figure 2: 21 year moving window correlations (left axis) between the leading iEMedR PC and Nino3.4 in OND for different PCP and SST dataset according to the legend. In grey line, the PDO index based on Mantua et al. (1997) definition is plotted, referenced on the right axis. Fill dots represent periods with a 95% significant correlation according to a Monte-Carlo correlation test.

OND → Significant correlations for negative and positive phases of PDO.

FMA → Significant correlations only for negative phases of AMO

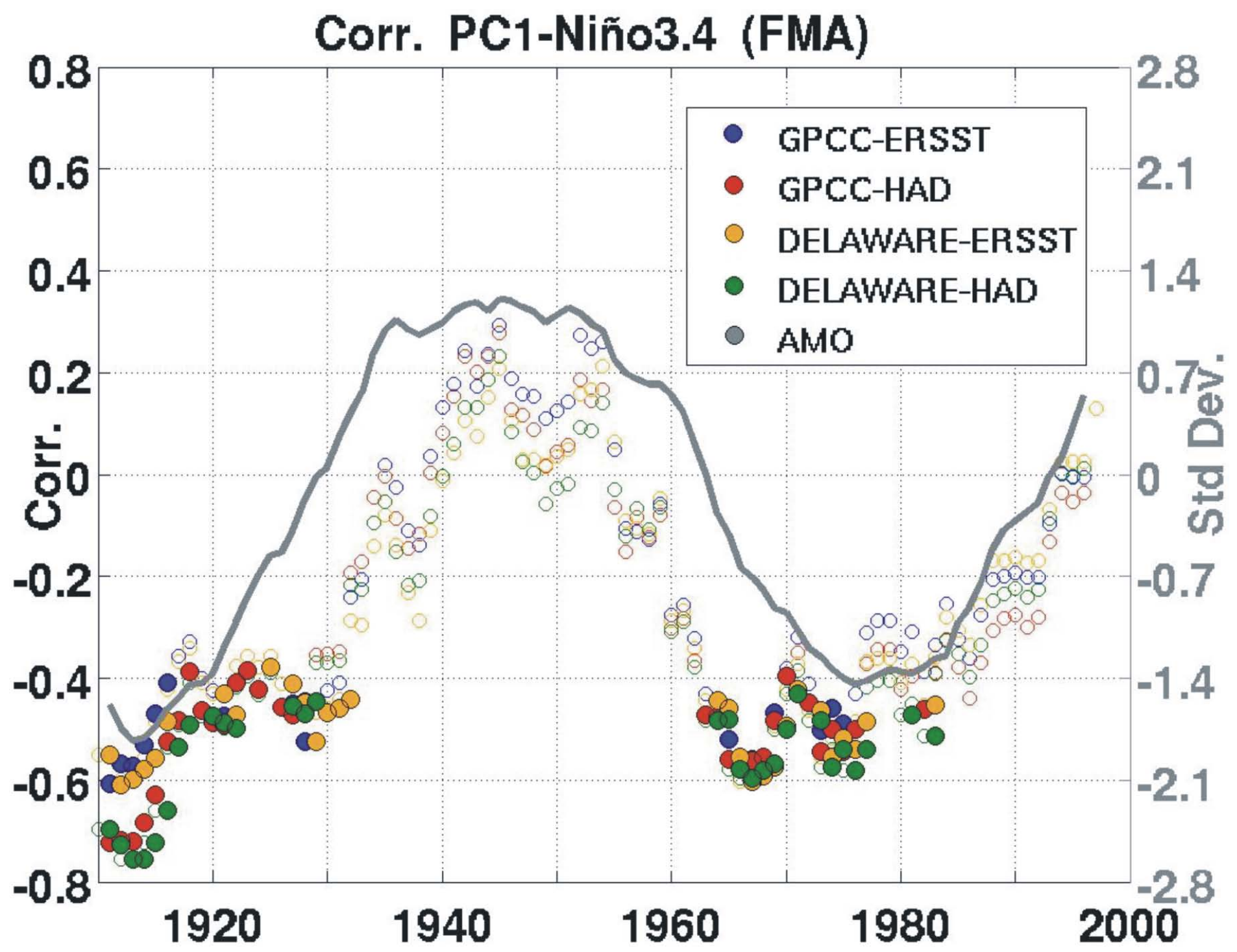


Figure 5: the same as in figure 2 but for FMA. In grey line, the AMO index based on Enfield et al. (2001) definition is plotted, referenced on the right axis. The sign of the correlation has been changed to better show how the evolution of the correlations is in phase with the AMO.

Regression maps in different temporal intervals

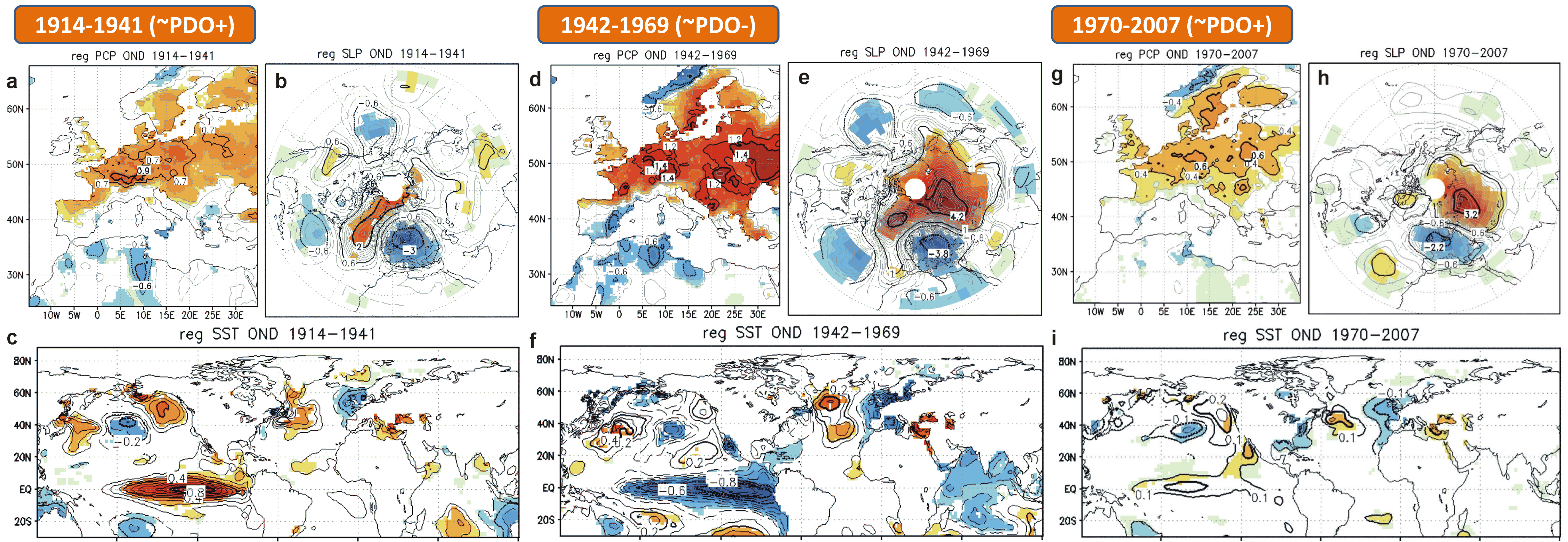
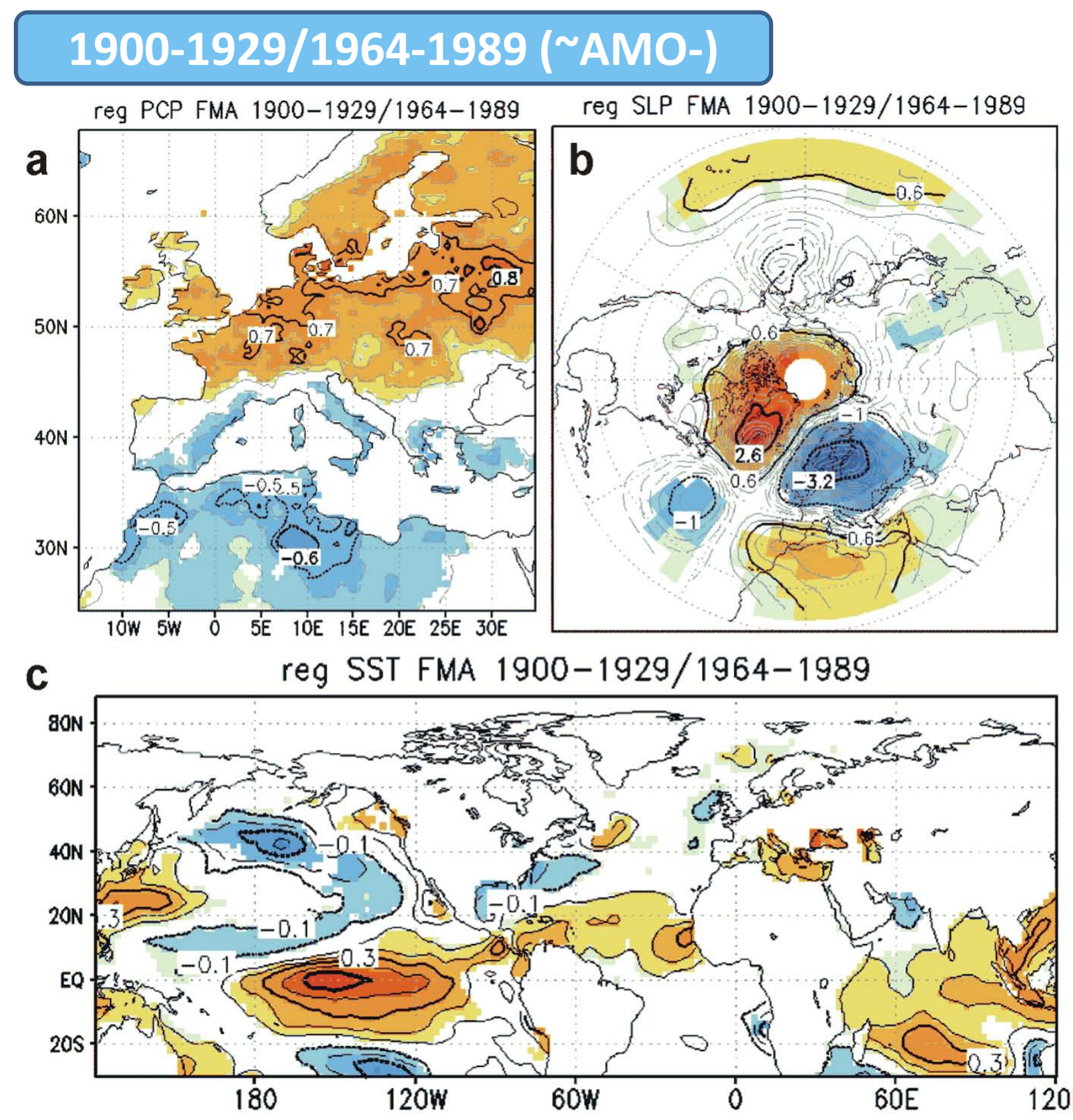


Figure 3: OND Regression maps, for selected periods of the PDO, calculated between the PC1 and: Left panel, a) PCP (contours, ci= 0,2 mm per std in the PC) , b) SLP (ci= 0,2 hPa per std in the PC) , c) SST (ci= 0,1º per std in the PC) for the period 1915/1942 . **Middle panel** the same as a), b) and c) but for the period 1943-1970. **Right panel:** the same as a), b) and c) but for the period 1971-2008. In all the maps,magnitudes correspond to one std dev of the PC. Statistical significant areas, according to a Monte-Carlo correlation test at 95% confidence level, are shaded.

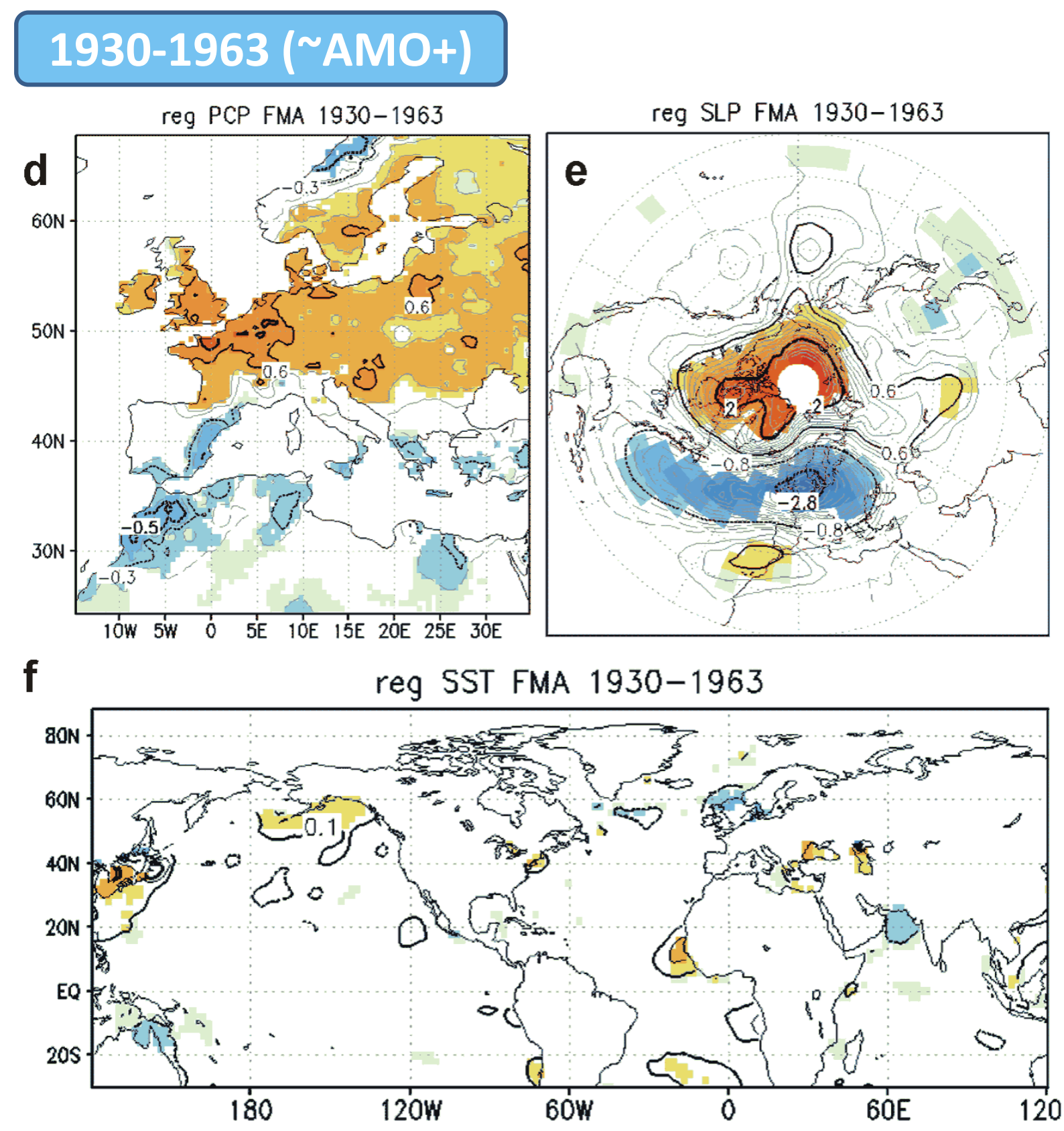
- **Same precipitation pattern related to opposite phases of El Niño (stronger for negative PDO).**
- **SLP pattern is broadly similar over the Euro-Atlantic sector but not so over the western Pacific and Asia.**

- **No significant ENSO signal appears and the rainfall pattern decreases with respect to the one identified in the positive phase of PDO before the 1940s.**

Opposite phases of El Niño are giving a similar impact over the Euro-Atlantic sector depending on the phase of the PDO.



- **SLP pattern shows a quadrupolar structure in the North Atlantic and a significant centre over the tropical Pacific → Gill-type response?**
- **El Niño pattern over the Pacific SST**



- **SLP pattern is confined to the Atlantic-European region**
- **No El Niño signal is found**
- **Internal variability?**

Figure 6: FMA Regression maps, for selected periods of the AMO, as in figure 3) but for selected periods of the AMO**. Left panel:** a) , b) and c) correspond to the period 1900-1929/1964-1989. **Right panel:** d), e) and f) for the period 1930-1963.

Negative AMO → significant iEMedR-El Niño relationship through an enhanced Walker-Hadley [Wang et al., 2002] mechanism?

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These results are recovered in the article title “Multidecadal modulation of El Niño influence on the Euro-Mediterranean rainfall”, that has been recently submitted to Geophysical *Research Letters* and it is currently under review (2011GJ050049).