CLIVAR-SPAIN contributions: The Atlantic impact on Pacific El Niño
A important source of predictability for the Euro-Atlantic region

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IMPORTANCE OF THIS STUDY FOR CLIVAR-SPAIN

The summer Atlantic Niño is related to the Euro-Atlantic winter anomalous rainfall since the 1970's (Rodriguez-Fonseca et al., 2009b)

-The impact of the Atlantic Niño on the rainfall in the North Atlantic region occurs through the Pacific ENSO (figure 1a and 1 b)
-The development of ENSO is accompanied by extratropical teleconnection with North Atlantic: In particular with a NAO-like pattern and a dipolar precipitation pattern over Europe (Figure 1b and 1d).

-Summer Atlantic Niño , when related with its Pacific counterpart (a) increases the predictability of Pacific El Niño impacts in 6 months (b).

This feature makes neccesary the study of this connection and related air-sea interactions.

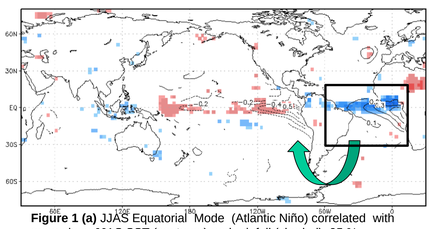


Figure 1 (a) JJAS Equatorial Mode (Atlantic Niño) correlated with anomalous JJAS SST (contours) and rainfall (shaded). 95 % significant areas are shaded.

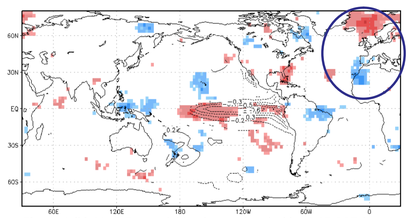


Figure 1 (b) JJAS Equatorial Mode correlated with NDJF SST (contours) and rainfall (shaded).95 % significant areas are shaded.

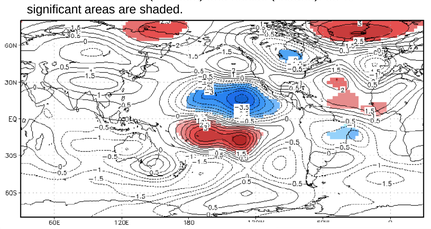


Figure 1 (c) JJAS Equatorial Mode correlated with NDJF streamfunction at 200hPa . 95% significant areas are shaded

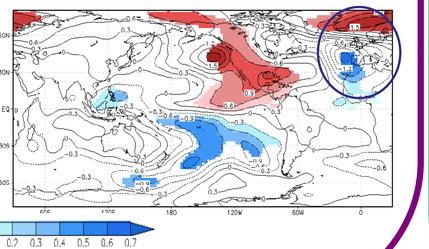
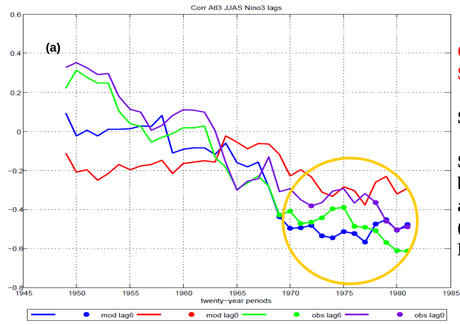


Figure 1 (d). JJAS Equatorial Mode correlated with NDJF streamfunction at 925 hPa .95% significant areas are shaded

NON STATIONARITY OF THE SIGNAL

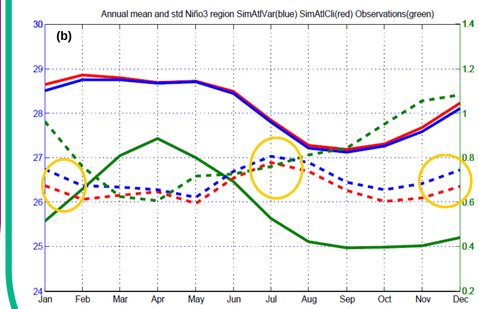
The Atlantic and Pacific Niños are connected since late 1960s in model and observations



OBSERVATIONS AND MODEL SHOW:

Since late 1960s:

Significant negative correlation between summer Atlantic Niños and winter Pacific Niños. (Rodríguez-Fonseca et al. 2009; Martin et al., 2011).



SIMULATION SHOWS:

Stronger Niño3 variability in winter and summer months (dotted red and blue lines), related to the maximum variability of Tropical Atlantic (Martín-Rey et al.2011).

Figure 2. (a) 20-year correlation from 1950-69 to 1981-00 between Atl3 and Niño3 in lag 0 (JJAS-JJAS) and lag 6 (JJAS-DJFM) from model(*SimAtlVar*) and observations. Significant values at 90% confidence level are presented in dots. **(b)** Seasonal cycle (solid lines) and standard deviation (dotted lines) of Niño3 region for *SimAtlVar* (blue), *SimAtlCli* (red) and observations (green).

DATA

AOGCM: The AGCM is the ICTP (Kucharski et al.2008) and the OGCM is described in Chang 1994.Two groups of simulations:
(i) SimAtlVar: 9 simulations fully coupled in the Tropical Indo-Pacific basin and climatological SSTs elsewhere except for the Atlantic Ocean, where observed monthly varying SSTs are prescribed .(Rodriguez-Fonseca et al., 2009)
(ii) **SimAtlCli: 5 simulations** fully coupled in the Tropical Indo-Pacific basin and climatological SSTs elsewhere for the period 1981-1990.

THE ATLANTIC IMPACT ON THE EQUATORIAL PACIFIC VARIABILITY

Atlantic Niño influences on Pacific Niño, but, how is the influence of the Atlantic on the whole variability of the Pacific Ocean?

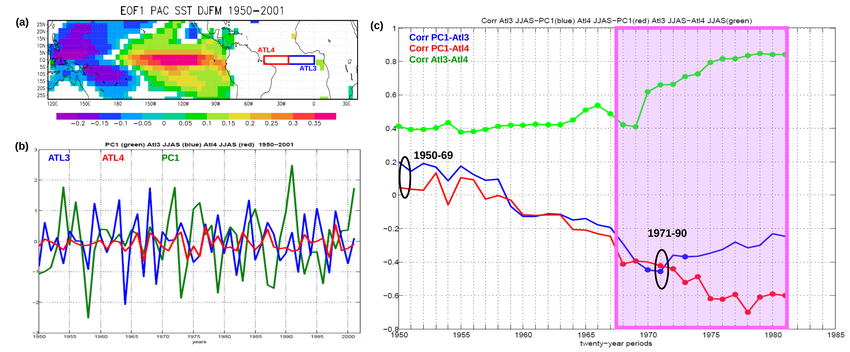


Figure 3.(a) Main variability mode of winter (DJFM) SST of the Tropical Pacific for the period 1950-2001.It explains 37,7% of the total variance. **(b)** PC1(green), summer Atl3 (blue) and Atl4 (red) indexes for the period 1950-2001.**(c)** Correlation in 20-yr windows, running one year from 1950-69 to 1981-2000 between PC1-Atl3 (blue), PC1-Atl4 (red) and Atl3-Atl4 (green). Significant values at 90% confidence level are presented in dots.

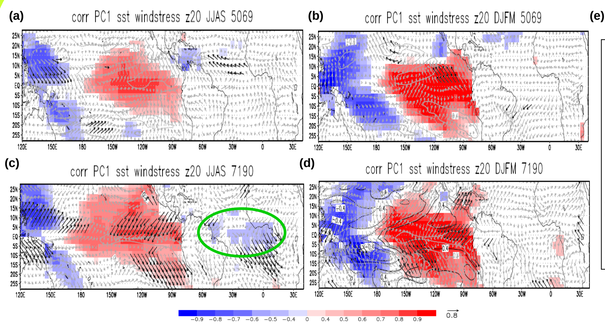
(a) Leading EOF of the Tropical Pacific SST forced by the Atlantic: <u>El Niño-like pattern</u>.

(b-c) <u>The mode is anticorrelated with Atl3 and Atl4 indexes since 1970s.</u>
It suggests that the influence of the Atlantic is not restricted to Atl3 and how the entire equatorial Atlantic impacts on ENSO phenomena from the 1970s (Martín-Rey et al.2011)

(c) <u>Prior contribution of the Atl4 region</u> : important role played by the western tropical Atlantic in the beginning of the interbasin connection.

(c) The correlation between Atl3 and Atl4 indexes reaches 0.8 in the last three decades. It could be due to the homogeneous warming in the tropical Atlantic observed in the last decades (Tokinaga et al. 2011)

How are the ENSO associated with the Atlantic Niños?



(e)

STATISTICAL ANALYSIS

	SimAtlVar 1950-2001	SimAtlCli 130 years
Ratio Niños/Ninas	0.97	1.06
Ratio EP/CP	3.81	4.01
Skewness	0. 01	0.25
Related to TA	Atl4	No related
Variance explained (DJFM)	37.7%	35.9%
Periodicity (from peaks of power spectrum)	[6-8] yr [4-5] yr	[6-7] yr 3.5 ; 5.5 yr

Figure4. (a-d) Correlation between PC1 and anomalous SST(shaded), wind stress (vector) and thermocline depth (contour) for summer (JJAS, left) and winter (DJFM, right) in the periods 1950-69 (without interbasin connection) and 1971-90 (with interbasin connection). A Monte Carlo test has been applied and significant values at 90% confidence level are shown in shaded and black vectors and contours.(e) Statistical analysis of el Niño events in *SimAtlVar* and *SimAtlCli*.

(a-b) Weaker ENSO are shown in the period 1950-69, only characterized by a warming in the eastern Pacific, without modifying wind stress or z20.

(c-d) Anomalous cooling (warming) and wind divergence (convergence) in the equatorial Atlantic during the summer seems to be related with wind convergence in the centre- east (180-150ºW) of the Tropical Pacific since 1970. the thermocline perturbation suggests active thermocline feedbacks, enhancing the winter SST in the eastern basin after the 70s.

(e) The Atlantic forcing is associated with an increase of ENSO periodicity in the 4-5 years band, and with an increase of the number of events, in particular the number of Niñas and favoring the CP ENSO versus EP (Martín-Rey et al. 2011)

Is the interbasin connection related to changes in the mean state of the Atlantic and Pacific Oceans?

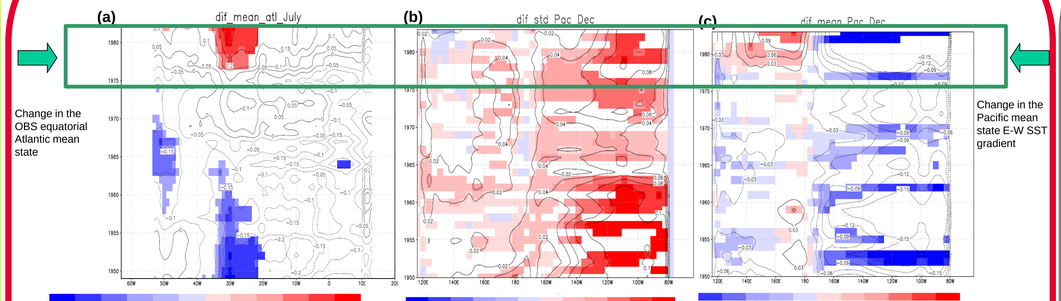


Figure 5. (a) Differences between mean observed equatorial Atlantic SST from 1950-69 to 1981-2000 in July. **(c)** As (a) but for the mean simulated (from *SimAtlVar*) equatorial Pacific SST, *SimAtlCli* for the total period are used as reference value. A t-test of equal means has been applied and significant values at 90% confidence level are presented. **(b)** Differences between the standard deviation of the equatorial Pacific SST, considering all the members for SimAtlVar, with respect to the standard deviation of the total period from *SimAtlCli*. A F-test of equal variances has been applied and significant values at 90% confidence level are shown.

(a) A shift in the equatorial Atlantic mean state is observed in July since late 1960s, so a cooling of the Atlantic turns into a warming from that period. In particular, a significant warming appears in Atl4 region (40ºW-20ºW) since mid 1970s. This homogeneous warming of the Tropical Atlantic in the last decades (Martín-Rey et al.2011) has been also reported in previous works (Tokinaga etal.2011).

(b) The observed warming of the summer equatorial Atlantic since the 1970s could be acting on the Pacific Ocean, increasing equatorial Pacific variability in the central and eastern part of the basin from summer(not shown) to winter months.

(c) East-West SST gradient similar to la Niña like-pattern, with negative anomalies in the centre-east (170ºW-80ºW) and positive ones in the west of the equatorial Pacific, is shown during the winter since mid 1970s

Hypothesis: A warmer Tropical Atlantic could alter Walker circulation and link the Atlantic Niños (Niñas) with the Pacific Niñas (Niños) since 1970s. Finally, these phenomena could be gradually modifying the mean state, becoming statistically significant several years later.

Are the subtropical highs involved in the creation of the Atlantic Niño since 1970s?

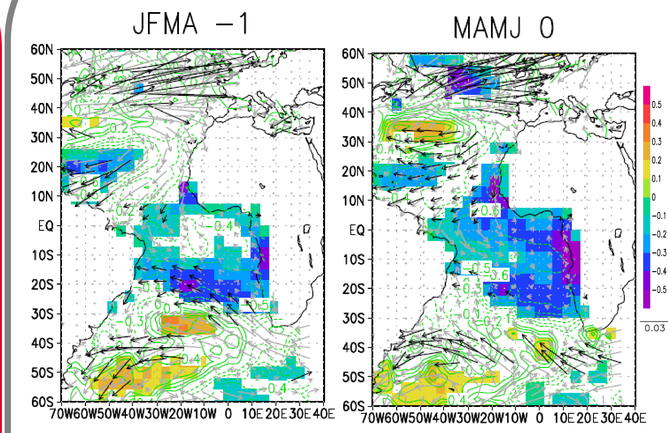


Figure 6. Regression of the time series of the summer (JJAS) Atlantic SST pattern (Figure 4c) over the anomalous SST and wind stress in JFMA and MAMJ in the Atlantic Ocean for the period 1971-90. A Monte Carlo test has been applied and significant values at 90% confidence level are shown in shaded (SST) and black vectors (wind).

(a) A strengthening of Sta Helena High could favor the upwelling in the Benguela area, cooling this region during winter months.

(b) The subtropical high in the North Atlantic seems to be also altered, contributing to the cooling of the western and north of the Tropical Atlantic in spring.

Additional sensitivity experiments with OGCM are designed to be performed in order to understand the origin and development of the Atlantic Niños associated with the Pacific variability since 1970s.

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