# Non stationary impacts of the tropical oceans on the West African Monsoon

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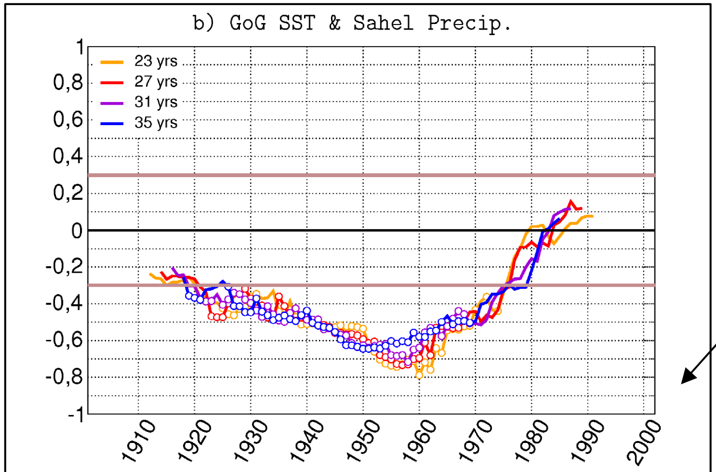
Losada, T., B. Rodriguez-Fonseca, E. Mohino, J. Bader, S. Janicot, and C. R.Mechoso (2012), Tropical SST and Sahel rainfall: A non-stationary relationship, *Geophys. Res. Lett.*, 39. doi:10.1029/2012GL052423.

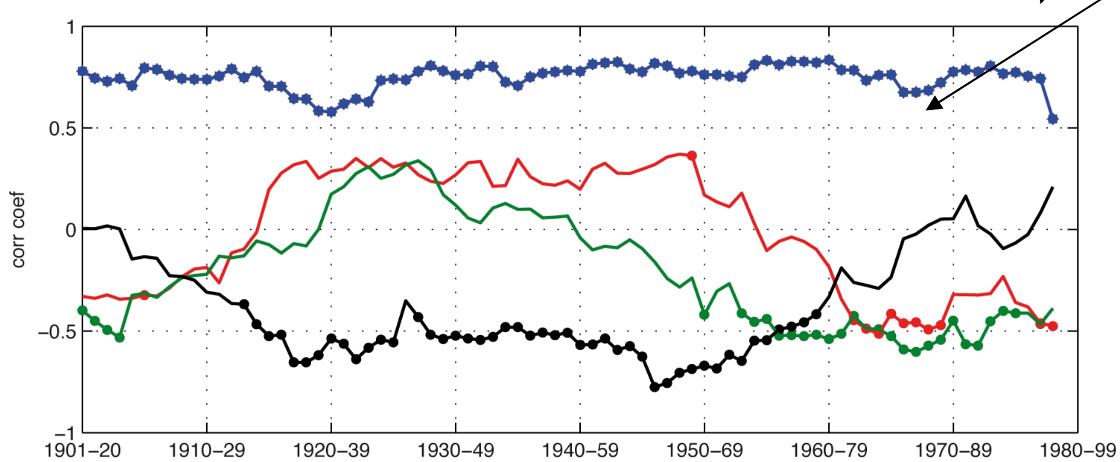
## Background




Joly and Voldoire, 2010

Change in the correlations between tropical Atlantic SST and West African rainfall after the 1970's

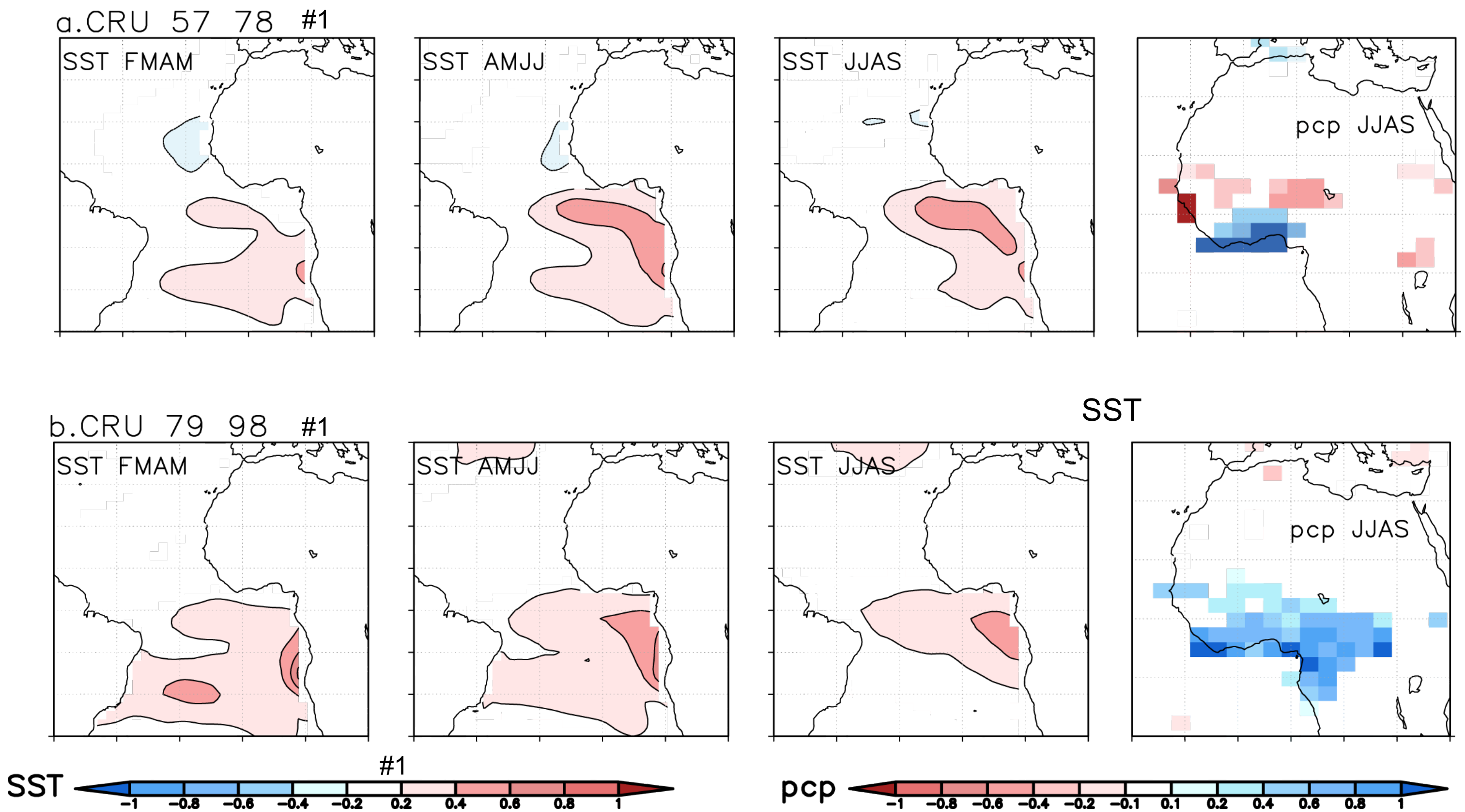
The anti-correlations between tropical Pacific SST and Sahel rainfall has strengthened after de 1970's (Janicot et al. 2001)




Losada et al., 2012

20-year running correlation from 1901–1920 to 1980–99, between observed **JJAS Atl3 index and JJAS GG precipitation index** (blue line), **JJAS Atl3 index and Sahel rainfall** index (black line), **JJAS Niño3 index and JJAS GG rainfall index** (red line) and **JJAS Niño3 index and Sahel rainfall index** (green line). Dots denote 90% significant correlations under a Monte Carlo test with 500 realizations.

**Background**




scf=41%
ruv=75%

scf=42%
ruv=66%

Mohino et al., 2011a
(Po.4C.3)

Homogeneous (SST) and heterogeneous (prcp) maps for the EMCA between JJAS WA precipitation and FMAM to SOND Tropical Atlantic SST

EMCA between JJAS WA precipitation (CRU, Hulme 1992) and FMAM-SOND tropical Atlantic SST (ERRSSTv.2, Smith and Reynolds, 2004)

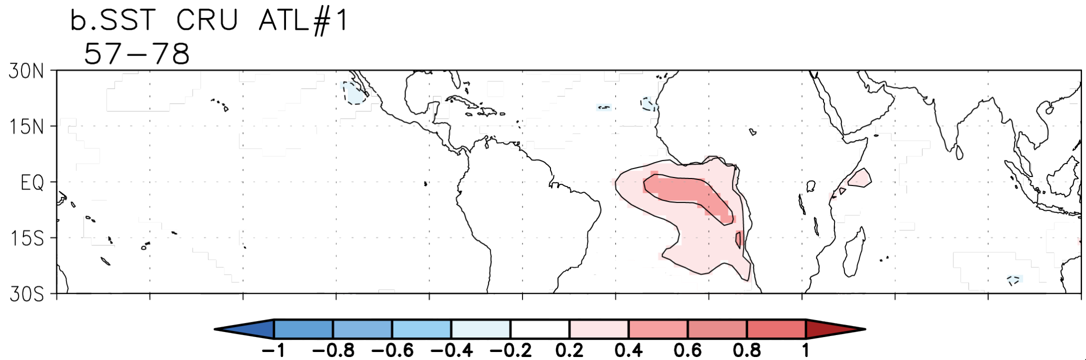
**Statistical significance:**

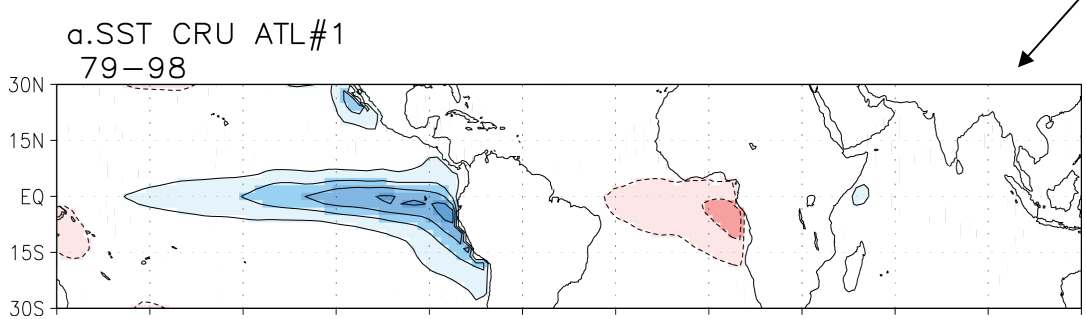
Regressions: t-test of correlation (95% confidence)

EMCA and difference maps: MonteCarlo test (95% confidence)

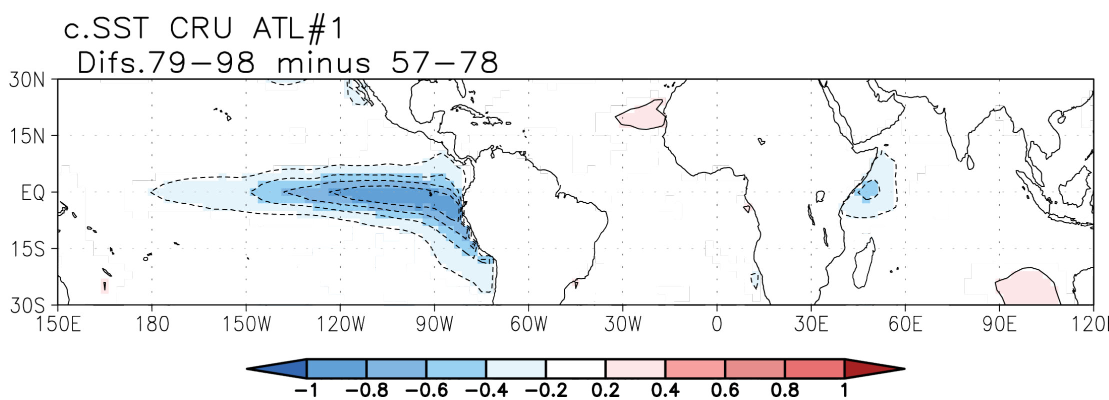
## Background

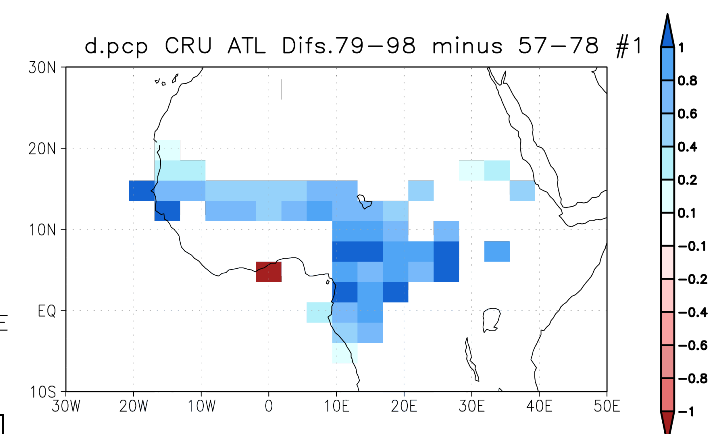
Tropical Atlantic-Pacific connection after the 70's (Polo et al, 2008; Rodríguez-Fonseca et al., 2009)




Regresion of the global SST onto the EC of the EMCA between JJAS WA precipitation and FMAM to SOND Tropical Atlantic SST



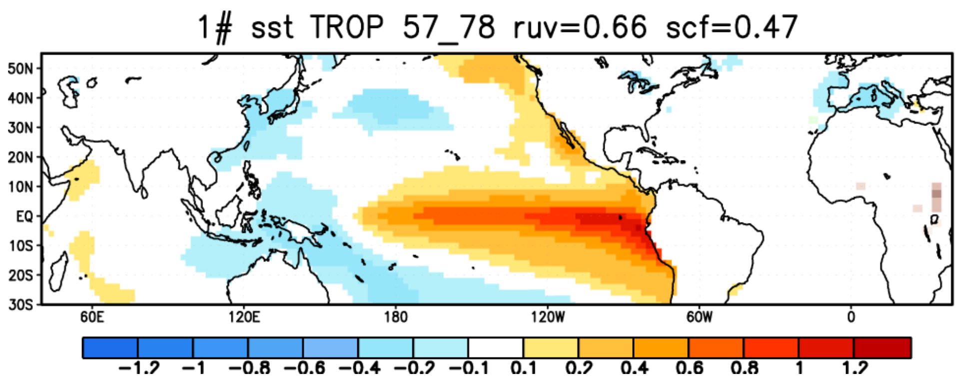



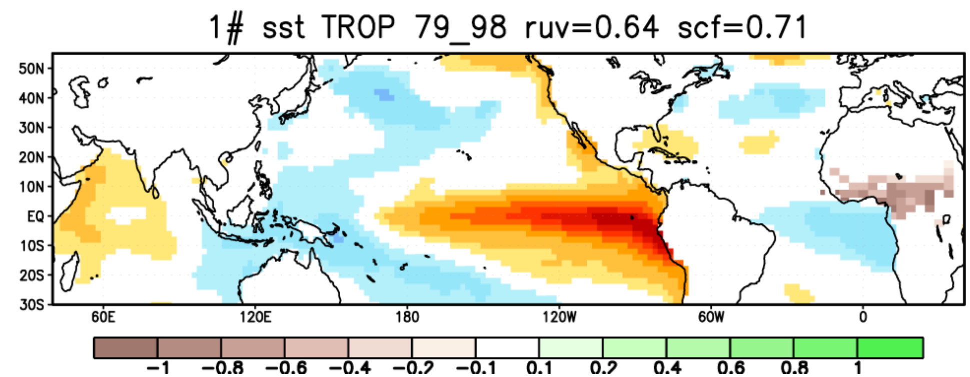

Tropical Pacific (Rowell, 2001; Joly and Voldoire, 2009) and Indian (Bader and Latif, 2003) influence on Sahelian precipitation.

Differences between the two periods global SST( left) and precipitation (right) pattern.

Mohino et al., 2011a (Po.4C.3)

## Background




Leading EMCA mode of variability between the FMAM to SOND SST anomalies in the global tropics and JJAS WA precipitation

Rodríguez-Fonseca et al., 2011

**After the 1970's, there is a coupled mode of co-variability between the global tropical SST and the WAM.**

## Objectives

**What are the characteristics of such global pattern?**

**Is this SST pattern the responsible for the described non-stationarities between Sahel rainfall and tropical SST anomalies?**

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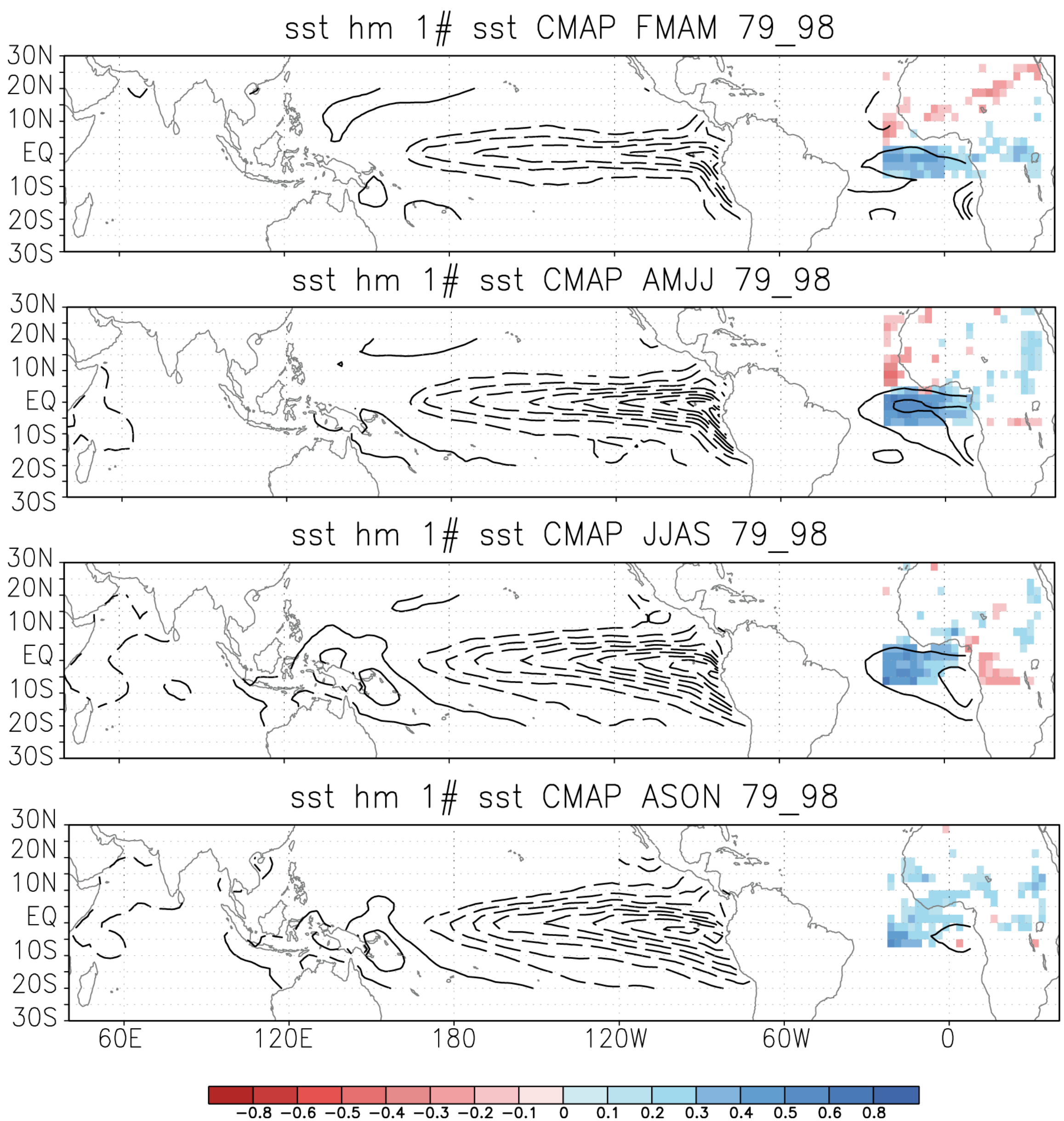
## Global tropical Mode




Before the onset the anomalous pattern of precipitation shows a dipole with positive anomalies in the Gulf of Guinea and negative anomalies to the north.

After the onset de anomalous dipole dissapears and the whole WA region shows an incerase in precipitation for a warming in the TA.

Homogeneous (SST) and heterogeneous (prcp) maps for the EMCA between JJAS WA precipitation and FMAM to SOND Global Tropical SST

Losada et al., 2012

**Observations:** CMAP (Xie and Arkin,1997) precipitation and ERRSSTv.2 (Smith and Reynolds, 2004) SST

What are the characteristics of such global pattern?

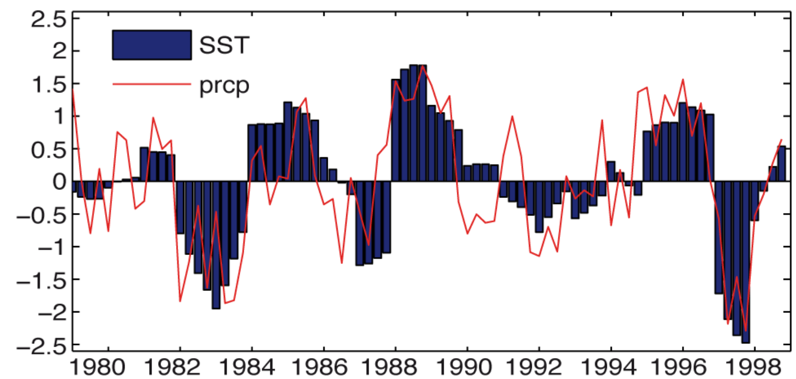
**Is this SST pattern the responsible for the described non-stationarities between Sahel rainfall and tropical SST anomalies?**

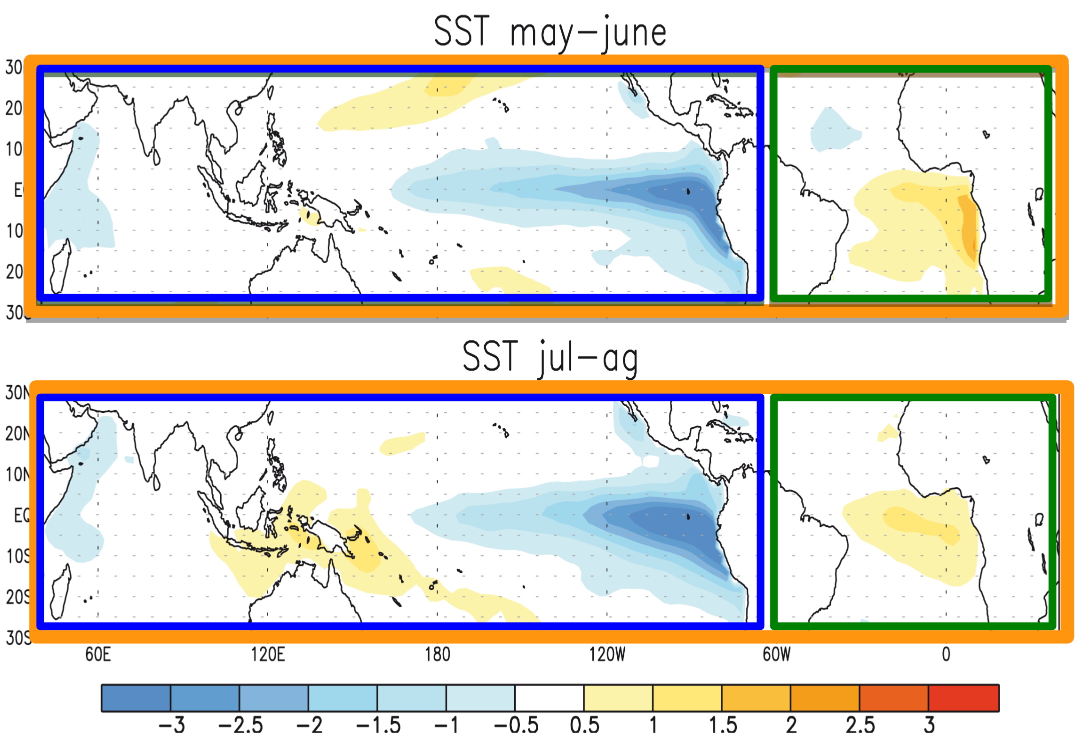
# AGCM EXPERIMENTS: UCLA & LMDZ

**BOUNDARY CONDITIONS:** Composites from EMCA results:

Positive yrs: 1982, 1983, 1997

Negative yrs: 1985, 1988, 1989, 1996




**SENSITIVITY EXPERIMENTS:**

- SST anomalies Tropical Atlantic **(TA)**
- SST anomalies Indo-Pacific **(IP)**
- SST anomalies Global Tropics **(GT)**

**CONTROL SIMULATION:**

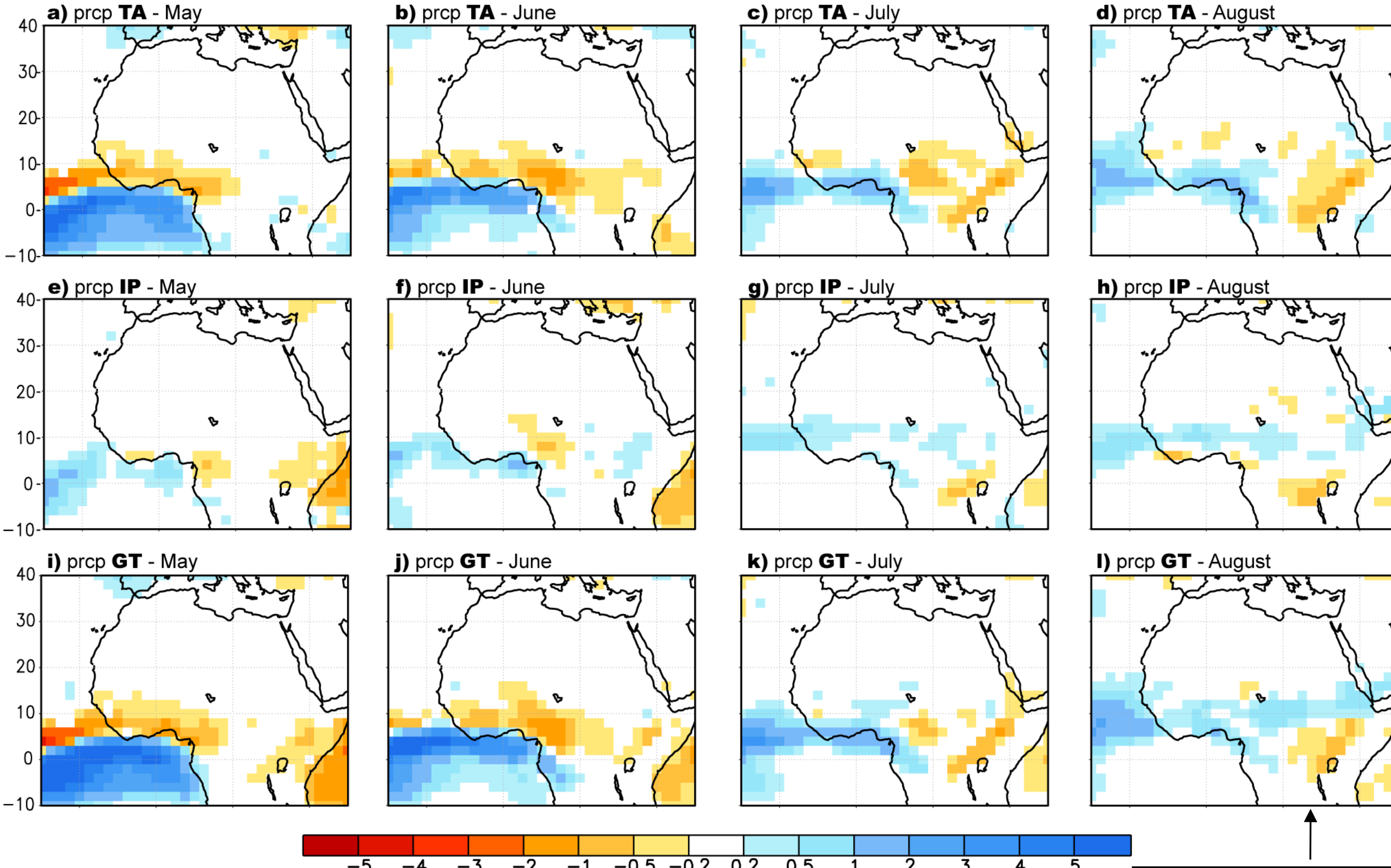
- Monthly climatological SST (1979-2005)

**RESPONSE:**

Difference between the mean of the sensitivity experiments from the two models and the control simulations.

## Results

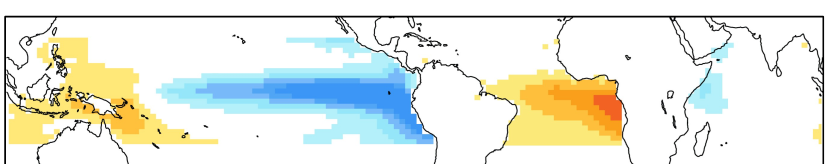
## Precipitation




May to August monthly-mean anomalies of precipitation (mm/day) for TA; IP and GT experiments;

**TA warming**: Dipole of anomalous precipitation (Losada et al. 2010)

**IP cooling**: Increased Sahel precipitation after the onset (Mohino et al. 2011b Po.4C.2)

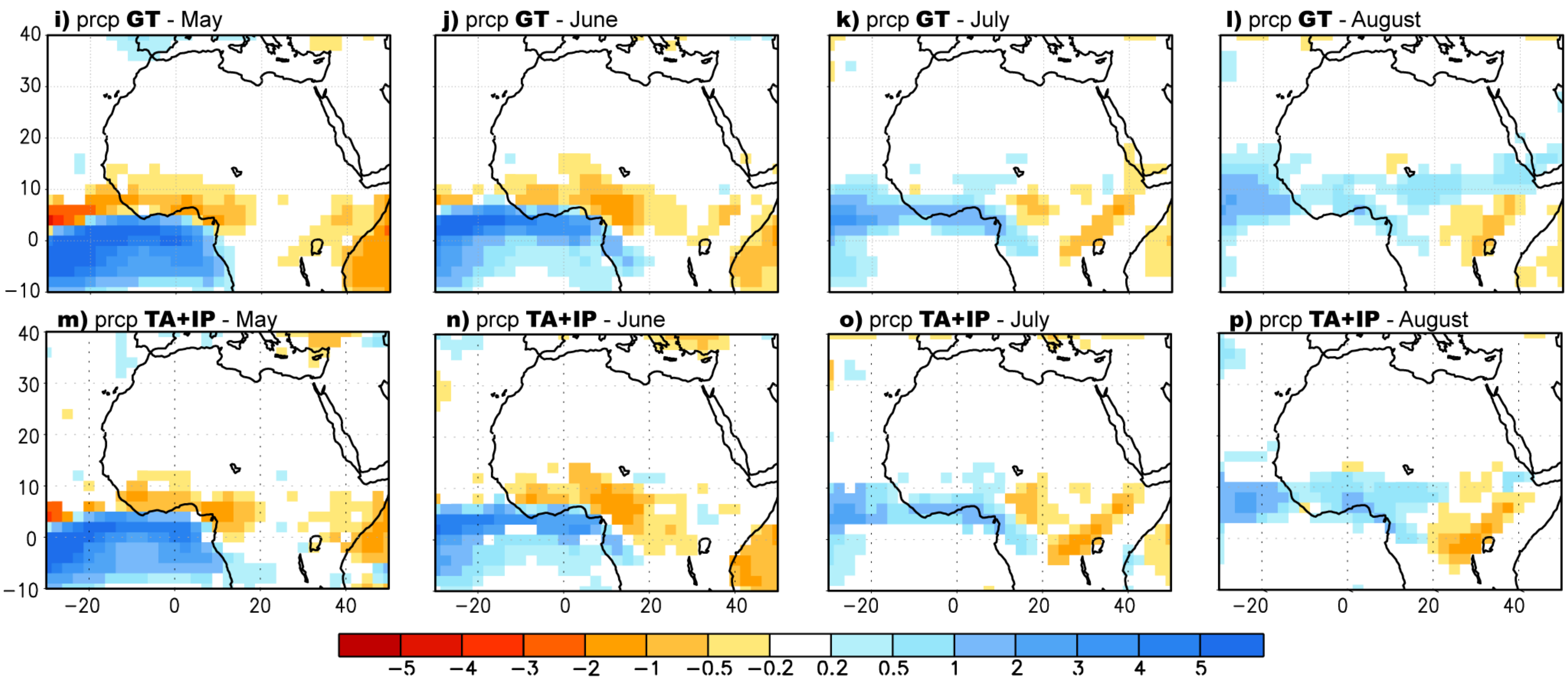


May-June mean anomalous SST pattern used in the GT experiment

**GT SST anomalies**: Dipole of anomalous precipitation before the onset. Increased precipitation in all West Africa after the onset.

Response similar to EMCA results

## Precipitation




GT

TA + IP

May to August monthly-mean anomalies of precipitation (mm/day) for GT and TA + IPexperiments;

The WA **precipitation response** to SST anomalies in the Global Tropics is **primarily linear**:

The sum of TA and IP experiments clearly resembles the response obtained in the GT experiment.

## Conclusions

- **After the 1970's**, there is an **SST anomalous pattern over the tropics** that co-varies with precipitation anomalies in West Africa.
- This pattern does not hold before the 1970's, giving rise to **non-stationarities** in the links **between WA rainfall and tropical SST anomalies**.
- The **impact of each of the individual ocean basins** is relatively **stationary** over time.
- **After the 1970's**, constructive and destructive **interferences** between the impacts of **TA and IP SST** change the pattern of anomalous WA rainfall.
- **Before the onset** TA and IP add their effects → well defined **precipitation dipole**.
- **After the onset** TA and IP counteract their effect over the Sahel, with a dominance of the IP influence → Weakening and **disappearance of the the anomalous dipole**.
- The WA **precipitation response** to SST anomalies in the Global Tropics is **primarily linear**.

The results provide a quantitative confirmation of conjectures on the linearity of the impacts of tropical SST anomalies on WA rainfall raised in previous works (Joly et al., 2007; Joly and Voldoire, 2010; Mohino et al. 2011a; Rodríguez-Fonseca et al., 2011).