

Oceanic Index vs. Numerical Model to Forecast the Rainy Season in Ceará State (Northeast Brazil)

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1. INTRODUCTION

Recent studies have indicated a significant positive relationship between the equatorial Atlantic sea surface temperature anomalies (SSTA) in boreal summer and the northern Northeast Brazil (NNEB) rainfall anomalies in the following February-May. This is especially the case from the recent 1970's climate shift. The mechanism that links the ATL3/SSTA to the NNEB rainfall anomalies passes through a negative relationship between the boreal summer ATL3/SSTA and the boreal winter equatorial Pacific SSTA. This mechanism is also strongly related to the classical SST dipole pattern over the tropical Atlantic during the early months of the year.

Goal: Test the relevance of ATL3/SSTA to forecast Ceará rainfall with more than four (4) months leading time vs. the relevance of the Global Atmospheric Model (ECHAM-4.6) forecast.

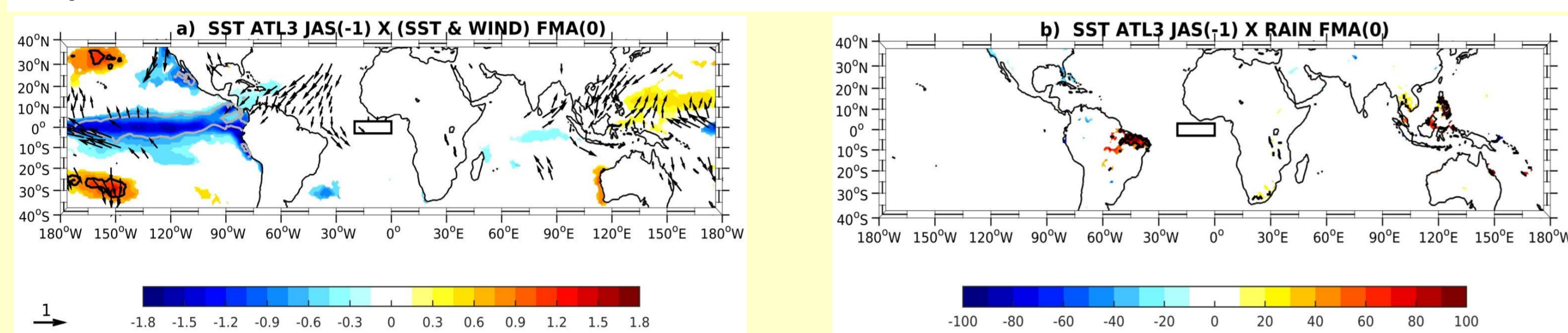


Fig.1: Lagged linear regression of the gridded: (a) SST (°C/°C, shaded) and surface wind (u and v, m s⁻¹/°C, vectors) anomalies over the global ocean in FMA(0) with SSTA inside ATL3 (oceanic black box) in JAS(-1), (b) rainfall anomalies (mm month⁻¹/°C) over the continental area in FMA(0) with the SSTA inside ATL3 (oceanic black box) in JAS(-1) during 1980-2015.

2. DATA AND METHODS

Data: 1981-2017 (37 years)

- Precipitation data from Global Precipitation Climatology Centre (GPCC); FUNCEME.
- Global Atmospheric Model (ECHAM-4.6) outputs.
- Sea surface temperature (SST) from Objectively Analyzed air-sea Fluxes Project-OAFlux.
- Reanalysis of Wind vectors from NCEP/NCAR.

Methods:

- Rainfall is predicted from the oceanic index using the Cross-validation method, i.e., calculating the regression coefficient excluding the year of predicted rainfall.
- The ECHAM-4.6 hindcast/forecast uses persisted SSTA as forcing.

3. RESULTS

3.1: July-August-September (JAS) ATL3/SSTA index prediction of Ceará State rainfall

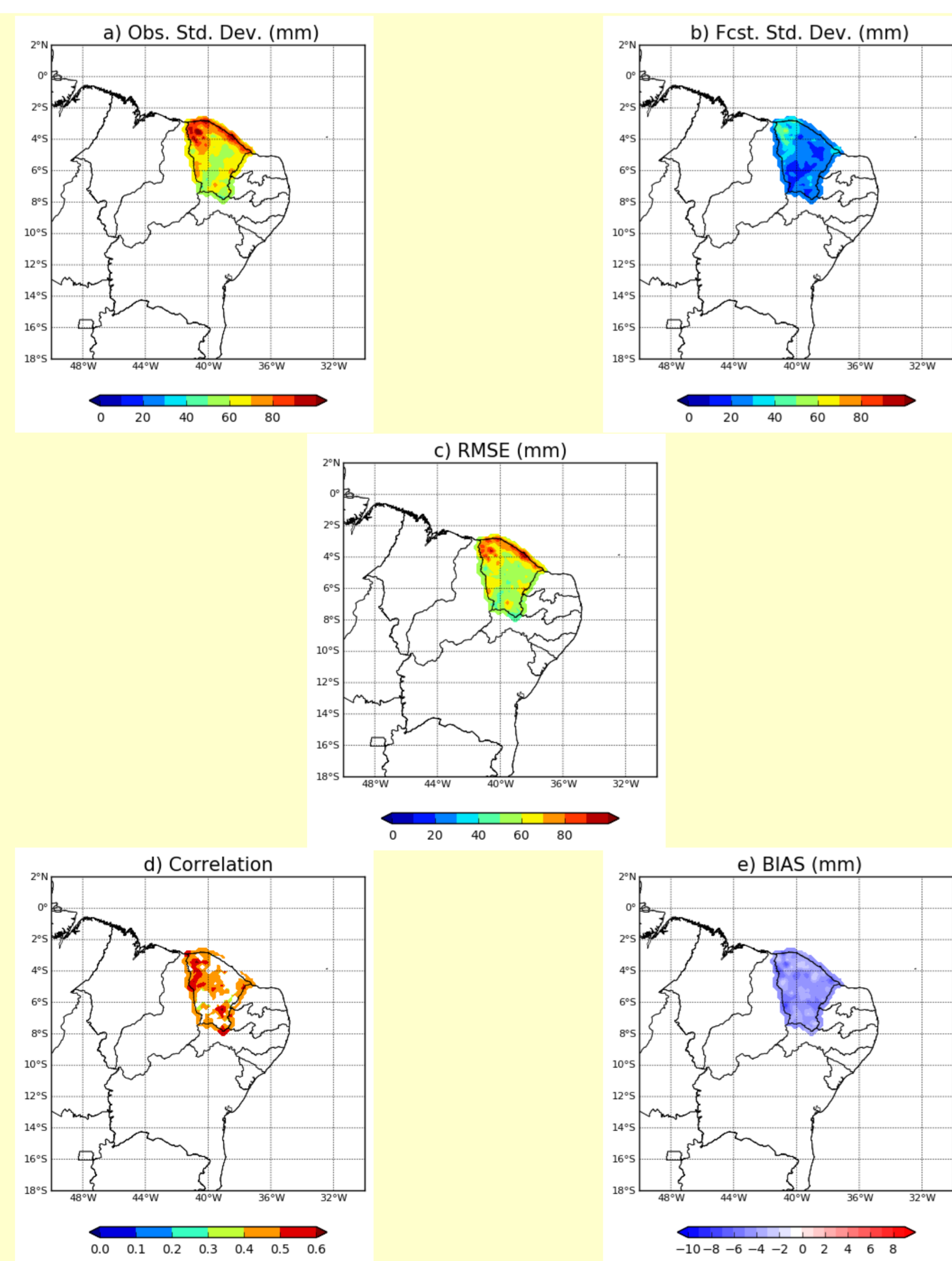


Figure 2: a) standard deviation of observed FMA Ceará rainfall; b) standard deviation of predicted FMA Ceará State rainfall by the July-September (JAS) ATL3/SSTA index (oceanic black box in Fig.1a); c) root mean square error (RMSE) of the FMA Ceará State rainfall predicted by the JAS ATL3/SSTA index; d) correlation (significant at 95% confidence level) between FMA observed and the FMA Ceará State rainfall predicted by JAS ATL3/SSTA; e) bias of the FMA Ceará State rainfall predicted by the JAS ATL3/SSTA. The study period: 1981-2017.

The JAS ATL3/SSTA index works relatively well to forecast the FMA rainfall in Ceará State. It underestimates however the rainfall along the northeastern coastal portion of the State, i.e., in the region of strong rainfall variability.

3.2: JAS ATL3/SSTA index vs. ECHAM-4.6 model

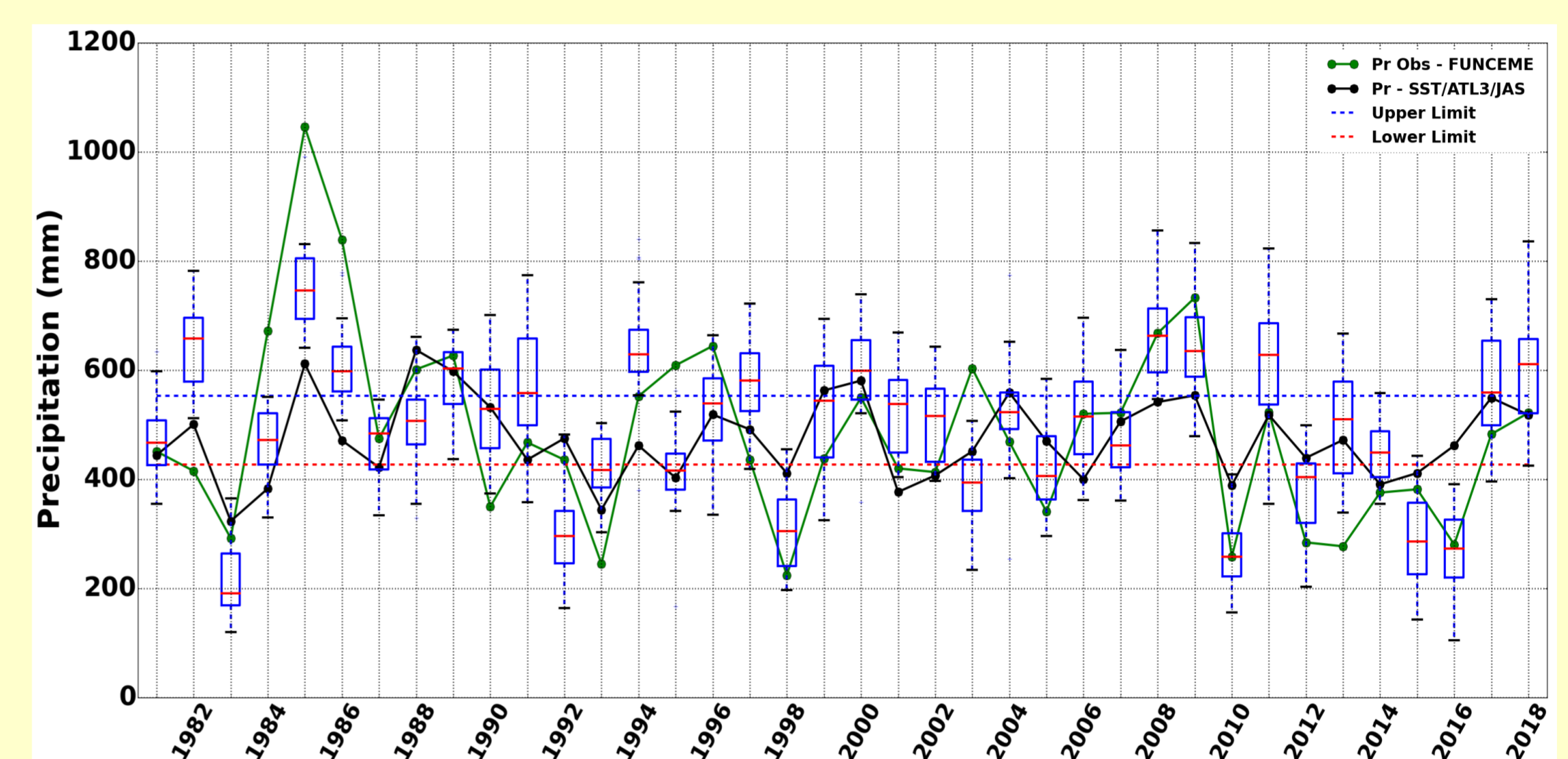


Fig.3: February-April (FMA) observed Ceará State rainfall (green line), FMA Ceará State rainfall estimated from ATL3/SSTA index (black line) and FMA Ceará State rainfall predicted by ECHAM-4.6 (red) with the upper and lower quartiles (blue box). ECHAM-4.6 is initialized in January using persistence of December SST.

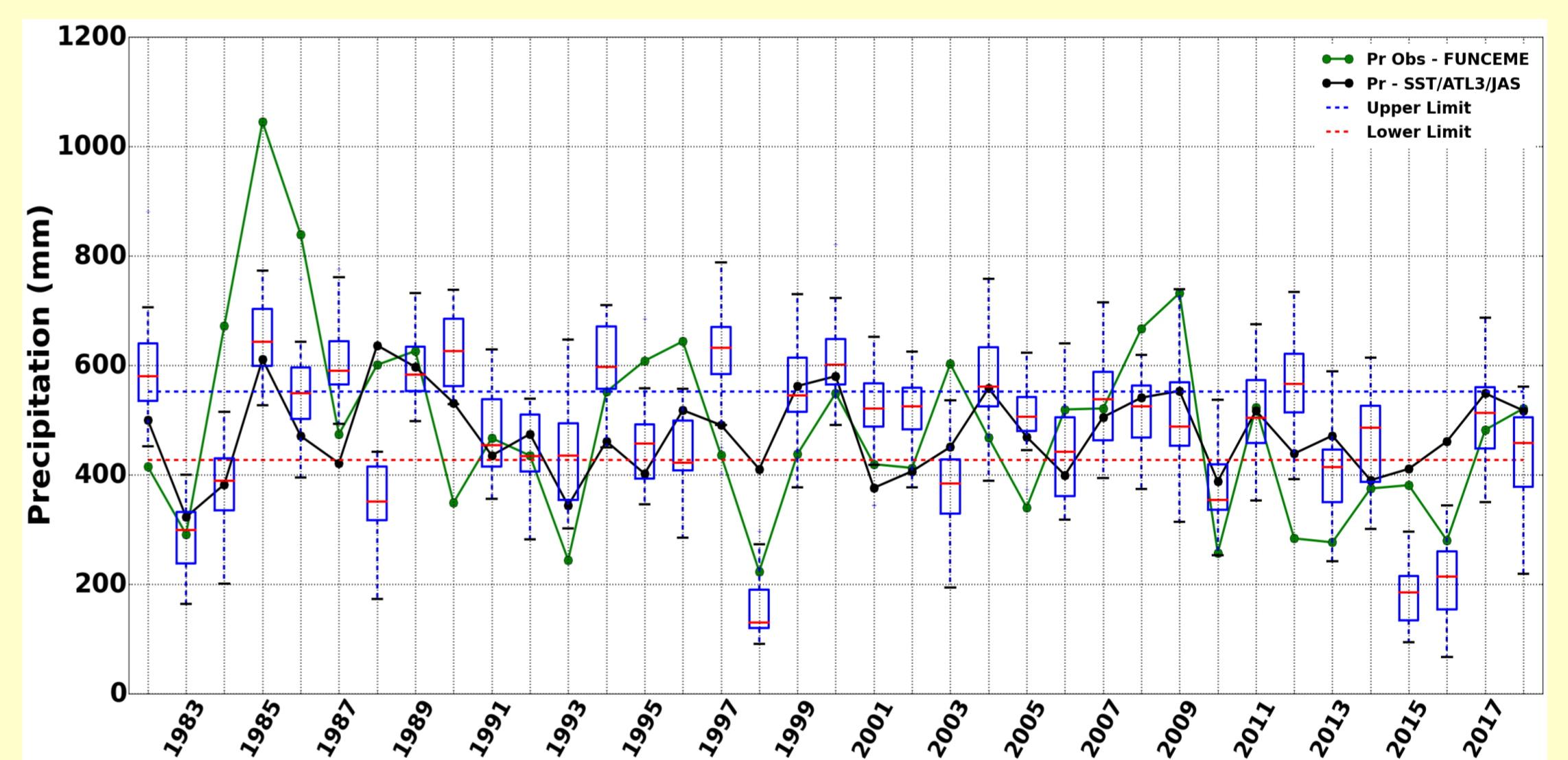


Fig.4: February-April (FMA) observed Ceará State rainfall (green line), FMA Ceará State rainfall estimated from ATL3/SSTA index (black line) and FMA Ceará State rainfall predicted by ECHAM-4.6 (red) with the upper and lower quartiles (blue box). ECHAM-4.6 is initialized in October using persistence of September SST.

	Obs. Vs JAS ATL3/SSTA	Obs. Vs Jan. ECHAM-4.6	Obs. Vs Oct. ECHAM-4.6
Correlation	0.52	0.66	0.39
RMSE (mm)	154	132	167

4. CONCLUSIONS

- When run started in January, the ECHAM-4.6 shows a **better skill** than the JAS ATL3/SSTA index to predict the FMA Ceará State rainfall.
- When run started in October, the ECHAM-4.6 shows a **weaker skill** than the JAS ATL3/SSTA index to predict the FMA Ceará State rainfall.

The JAS ATL3/SSTA index allows a simple alternative for the prediction of the NNEB FMA rainfall with about four (4) months before the peak of the rainy season with a reasonable skill.

A monitoring of SST in the two PIRATA moorings (0°N-10°W and 0°N-0°E) located in equatorial Atlantic could be so used to help in the predicting of this rainy season.

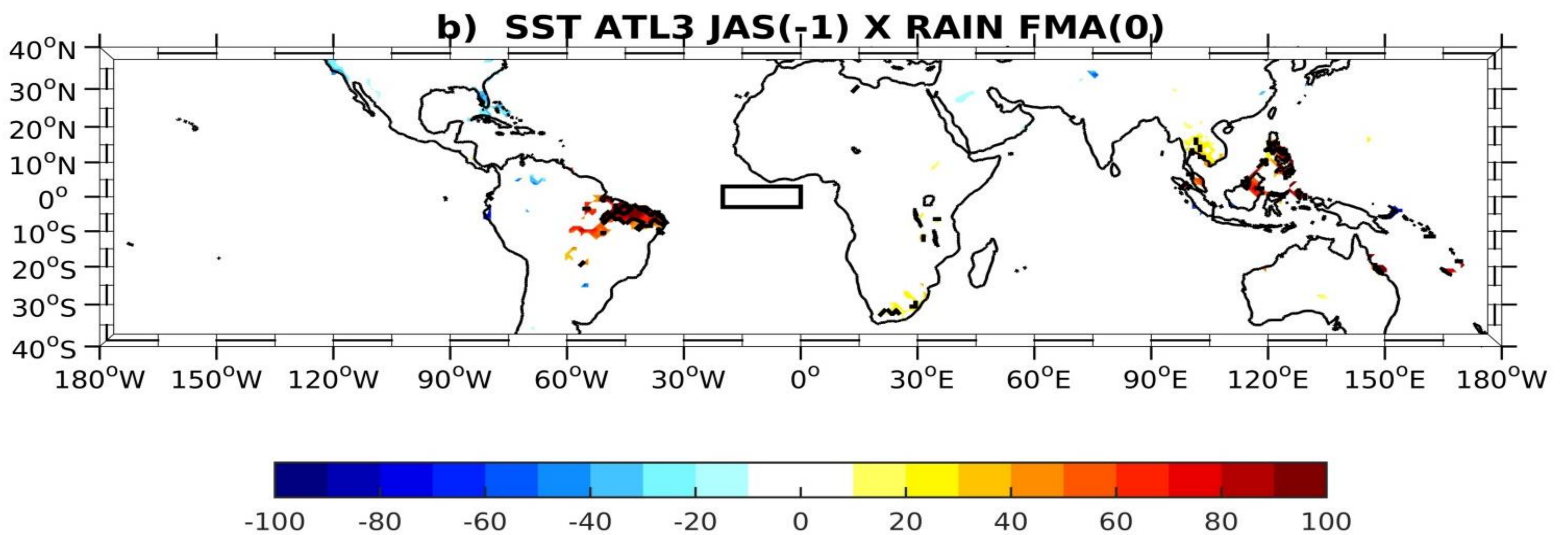
ACKNOWLEDGEMENTS: Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME) and Agência Nacional de Água (ANA) are thanked for the support of G.A. Hounsou-Gbo, D. Fontenele, J. Servain, E.S. Martins, F. Vasconcelos Júnior and J.M.R. Pereira. This work is also part of the Brazilian Research Network on Global Climate Change - Rede CLIMA and the Project CNPq-IRD PILOTE.

REFERENCES:

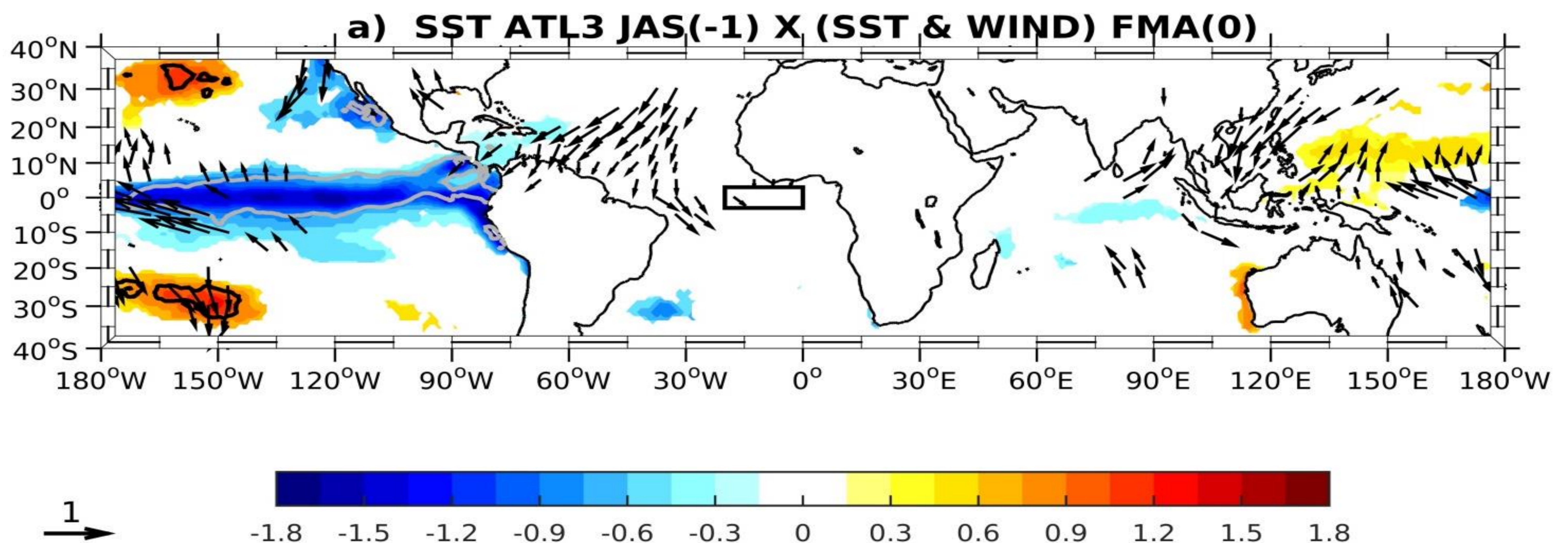
Rodríguez-Fonseca, B., I. Polo, J. Garcia-Serrano, T. Losada, E. Mohino, C. R. Mechoso, and F. Kucharski, 2009: Are Atlantic Niños enhancing Pacific ENSO events in recent decades? *Geophys. Res. Lett.*, 36, L20705
Hounsou-Gbo G. A., Servain J., Araujo M., Caniaux G., Bourlès B., Fontenele D., Martins E. S. P. R. 2018: Tropical South Atlantic Indexes for Forecasting Rainy Seasons in Northeast Brazil, *under review at J. CLIM*

Especially from the 1970-80 worldwide climatic shift ... (Hounsou-Gbo et al., 2018 submitted)

... we observed a significant positive relationship (here linear regression) between SSTa/ATL3 in JAS(-1) and RAINa/Northeast Brazil (NEB) in FMA(0) ...



This mechanism passes through a negative relationship between SSTa/ATL3 in JAS(-1) and the subsequent boreal winter SSTa/Equatorial Pacific.



The NEB rainfall is also strongly influenced by the classical SST dipole pattern over the tropical Atlantic *during the early months of the year*.

Using that particularity ...

we tested the relevance of ATL3/SSTa (JAS(-1)) to forecast the Ceará rainfall (FMA(0))

VS.

the relevance of the Global Atmospheric Model (ECHAM-4.6) yearly used at FUNCEME to forecast this Ceará rainfall (FMA(0))

Data: 1981-2018 (37 years)

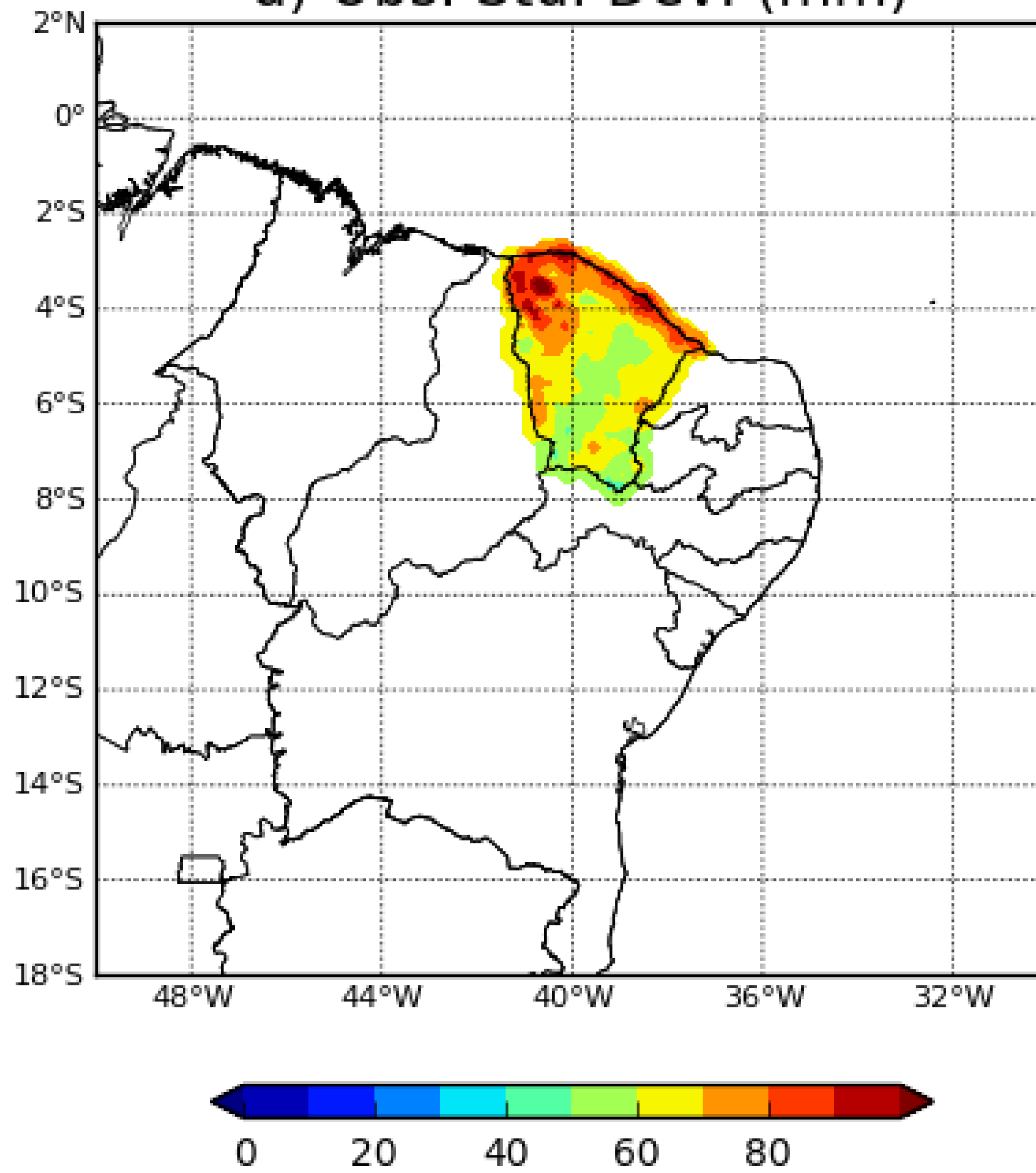
- Precipitation data from Global Precipitation Climatology Centre (GPCC); FUNCEME.
- Global Atmospheric Model (ECHAM-4.6) outputs.
- Sea surface temperature (SST) from Objectively Analyzed air-sea Fluxes Project-OAFlux.
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Methods:

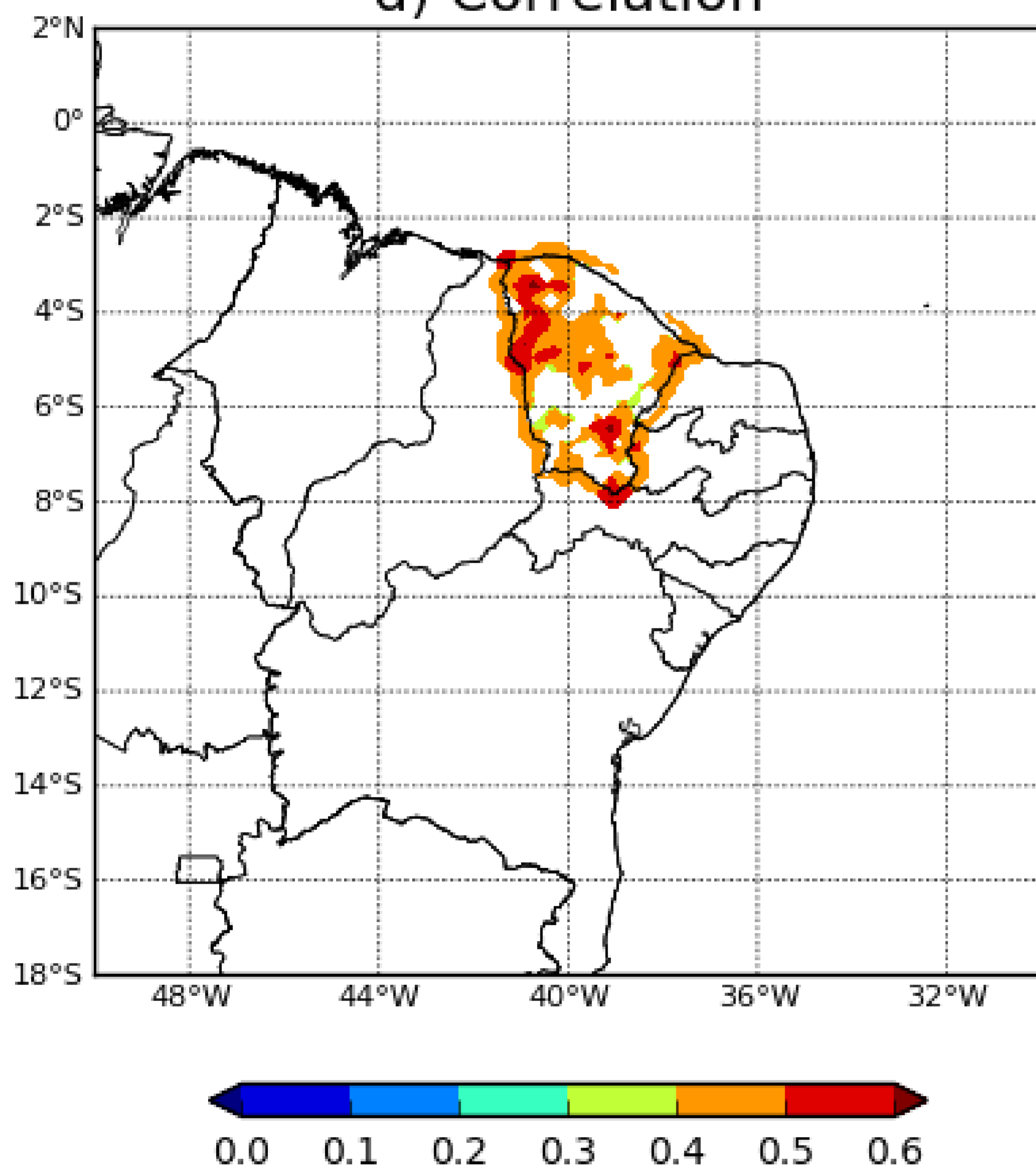
- Rainfall is predicted from the oceanic index using the cross-validation method, i.e., calculating the regression coefficient excluding the year of predicted rainfall.
- The ECHAM-4.6 hindcast/forecast uses persisted SSTa as forcing.

JAS(-1) ATL3/SSTa index prediction of Ceará State rainfall

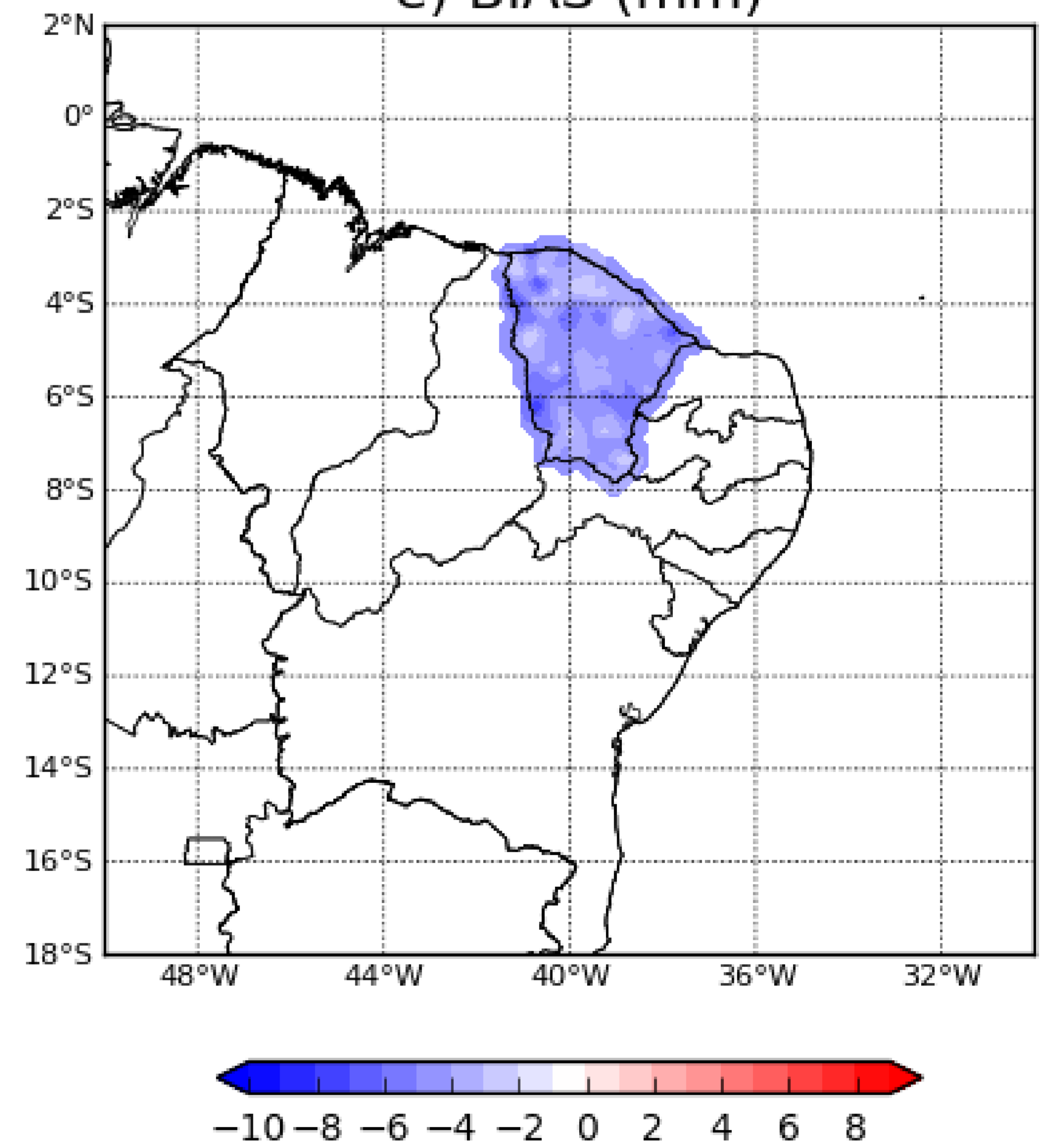
a) Obs. Std. Dev. (mm)



d) Correlation

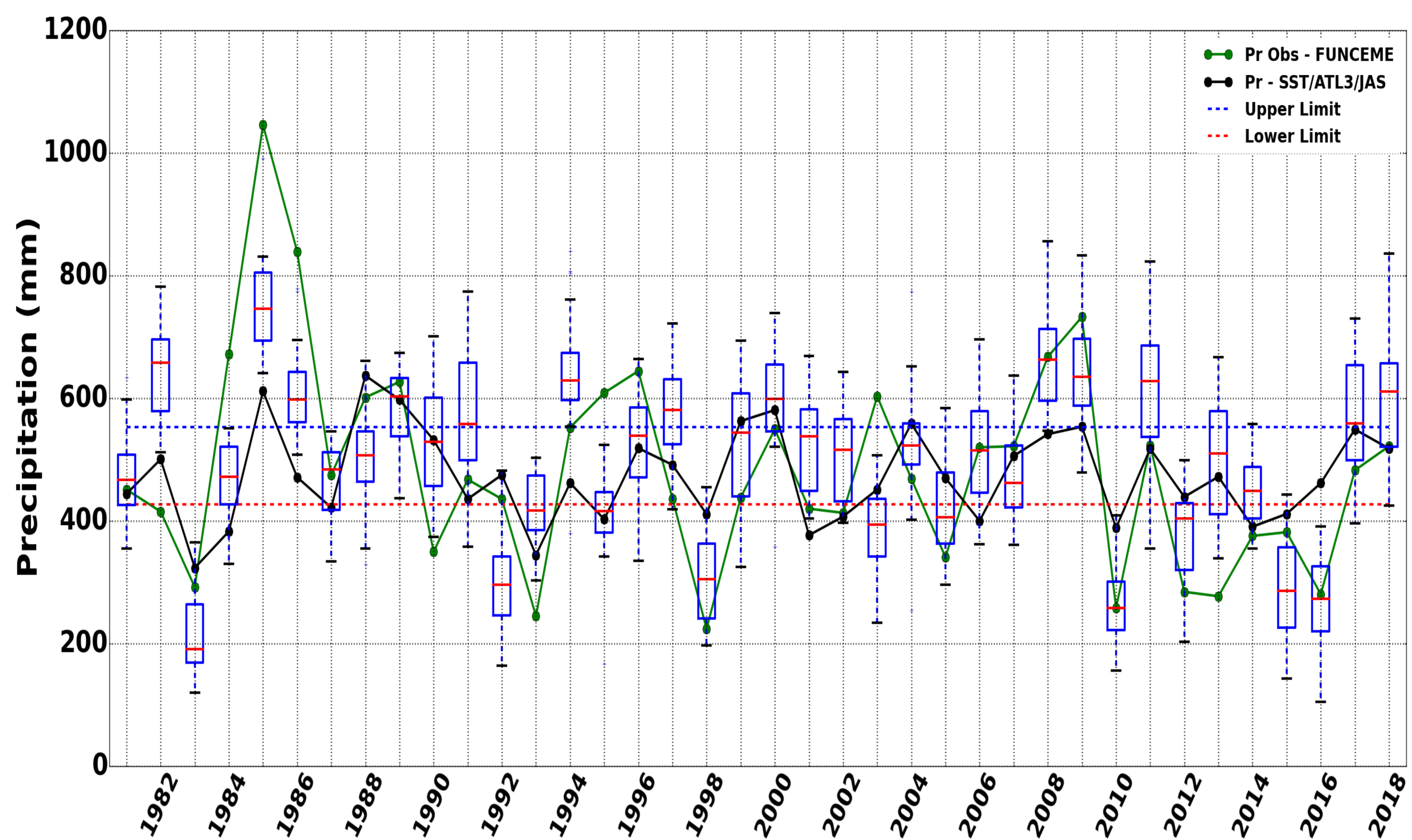


e) BIAS (mm)



The JAS(-1) ATL3/SSTa index works relatively well to forecast the FMA(0) rainfall in Ceará State.

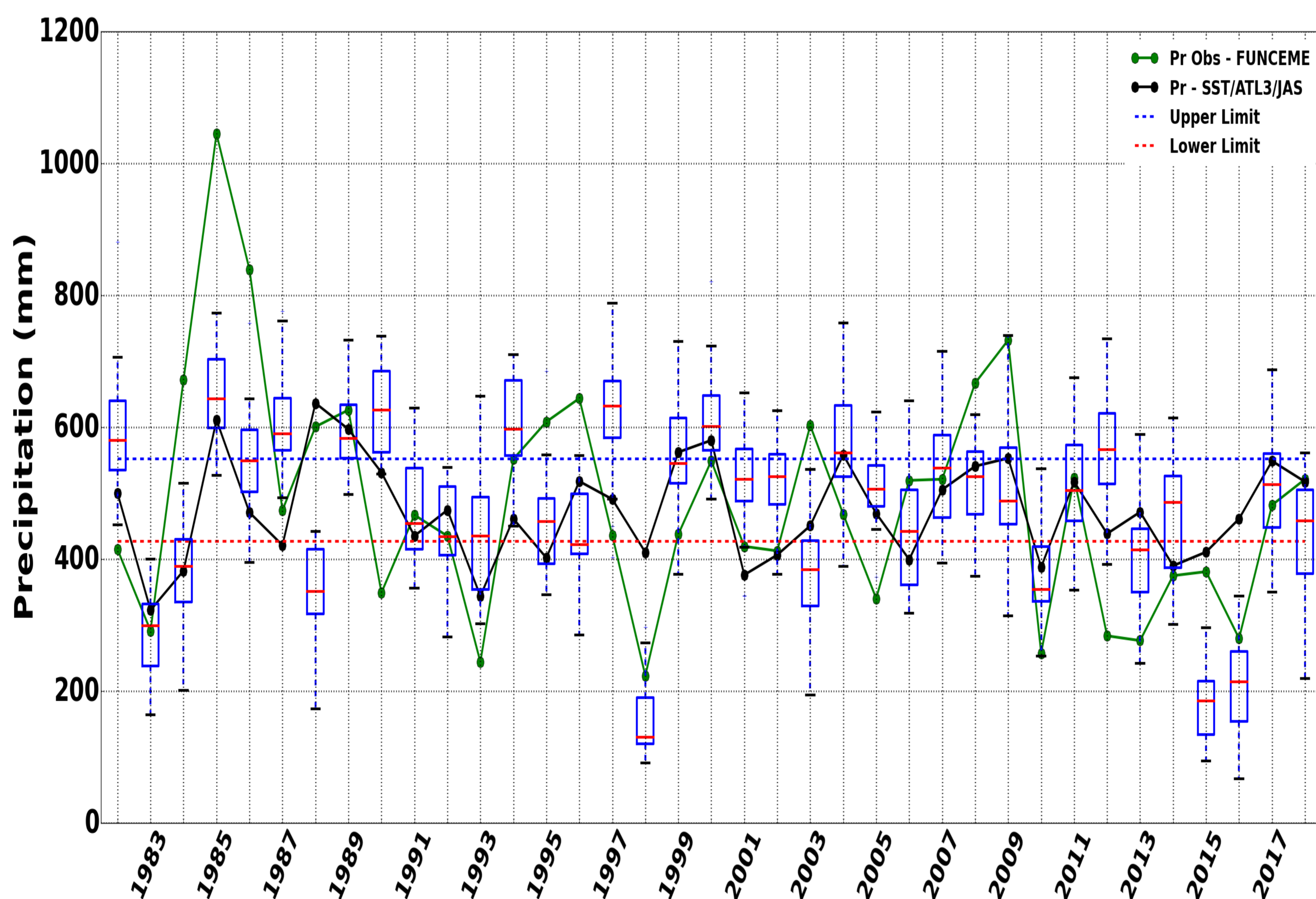
It underestimates however the rainfall by 4-6 mm.



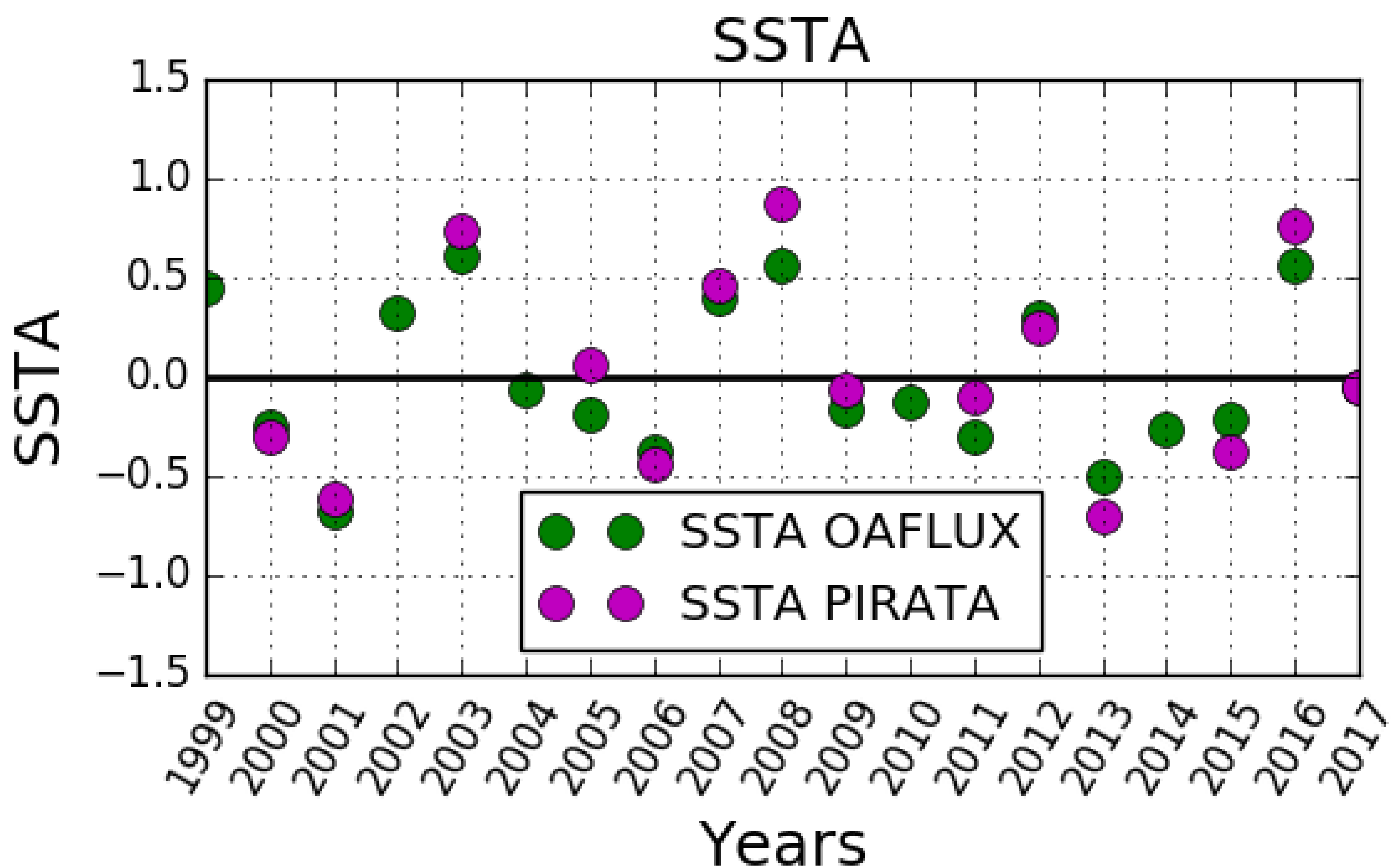
- ECHAM-4.6 started in **January(0)** (with December(-1) SST forcing) shows a **better skill** than the JAS(-1) ATL3/SSTa index to predict the FMA(0) Ceará State rainfall (**0.66 vs. 0.52**)

	Obs. Vs JAS ATL3/SSTA	Obs. Vs Jan. ECHAM-4.6	Obs. Vs Oct. ECHAM-4.6
Correlation	0.52	0.66	0.39
RMSE (mm)	154	132	167

- ECHAM-4.6 started in **October(-1)** (with September(-1) SST forcing) shows a **weaker skill** than the JAS(-1) ATL3/SSTa index to predict the FMA(0) Ceará State rainfall (**0.39 vs. 0.52**)



The JAS(-1) ATL3/SSTa index allows a **simple early alert** (*i.e. a few months before the classical dipole over the tropical Atlantic*) for the prediction of the NNEB FMA(0) rainfall.



A monitoring of SST in the two PIRATA moorings (0°N - 10°W and 0°N - 0°E) located in equatorial Atlantic (ATL3) could be so used to help in the predicting of this rainy season.