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CMIP3 and CMIP5 representation of sea surface temperature in the Tropical Atlantic Ocean

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A B S T R A C T

This study evaluates WCRP-CMIP3 and CMIP5 representation of the Sea Surface Temperature (SST) in the Atlantic Tropical Basin. The Atlantic Ocean presents thermal variability modes on intraseasonal, interannual and decadal time-scales that affect the climate of the North Atlantic, Caribbean, Western Africa, Northeast Brazil, the Gulf of Guinea Region and Southeast Atlantic (region of the Angolan resurgence). Two main SST modes in the Atlantic are the equatorial and meridional dipoles. These principal modes of SST interannual variabilities are investigated principally by empirical orthogonal function analysis (EOFs) to periods December-January and March-May. For the period of March-May, this study too analyses the relationships of these modes from coupled models of WCRP as rainfall in Northeastern Brazil compared to the observations (1971-2000 - ERSST). This investigation showed principally that although some models showed high value correlations (above 0.8 in absolute value) for both CMIP3 and CMIP5 with observations using their first two auto values EOFs coefficients of SST in the Tropical Atlantic basin, the simulations in most CMIP3-5 models do not represented the spatial thermal configuration in the basin compared to the observations, and also largely do not reproduce the pattern of correlation between to March-May between precipitation in northern of the NEB and the TSMs in the Tropical Atlantic.

Keywords: Thermal surface variability in Tropical Atlantic Ocean, Meridional and equatorial dipoles

Introduction

Since 1990, under the auspices of the World Climate Research Program (WCRP), the main objectives of the Intergovernmental Panel on Climate Change (IPCC) Reports are analyses of studies of the past, present and future climates of Earth System. The last two IPCC Reports, i.e., the Fourth Assessment Report (AR4, 2007) and the Fifth Assessment Report (AR5, 2013), have shown analysis of results of studies from Atmosphere-Ocean Coupled General Circulation Models (AOGCMs). These IPCC ARs have related about of simulations and projections these models' projections over the 20th and 21th Century from Coupled Model Intercomparison Project Phases 3 and 5 (CMIP3 and CMIP5). These programs have analysis protocols to verify how the models agree with the current climate and can simulate future climate according to prescribed greenhouse gas emission scenarios (IPCC 2013, 2014). Several

CMIP3/5-AOGCMs use different numerical techniques and a variety of physical parameterizations to solve the physics and dynamics from subgrid processes in the atmosphere and ocean, on the land surface, in the carbon cycle, etc., and they were developed by a large set of worldwide institutions and laboratories. This great diversity allows intercomparison of the AOGCM's outputs and tests of their confidence against past and current observations. CMIP3/5-AOGCM's.

For all the tropics, the prominent forcing to the climate system in the tropical Atlantic is the sea surface temperature (SST). Two prominent interannual variability modes, the equatorial mode and the meridional mode, explain a large portion of the variance of the thermal variability in the tropical Atlantic (Servain, 1991; Chang et al., 2006). The equatorial mode is similar, although weaker, to the El Niño – Southern Oscillation (ENSO) mode in the equatorial Pacific. For ENSO, this mode is linked to a relaxation or a strengthening of the trade winds along the western Equator (Zebiak, 1993) as interannual climatic impacts on the neighbouring continental regions, namely, Northwestern Africa and South and Central America (Moura and Shukla 1981; Polo et al., 2008). SST pattern and variability are directly linked to changes in convection and wind system associated with the Intertropical Convergence Zone (ITCZ) meridional displacement (Nobre and Shukla 1998). The ocean-atmosphere interaction leads to changes in SST and low-level atmospheric circulation through the wind-evaporation-SST (WES) feedback (Tanimoto and Xie 2002).

The El Niño mode of climate variability, which results in SST anomalies in the eastern equatorial basin, has an impact on the precipitation regime over the surrounding countries of the Gulf of Guinea (Weare 1977; Servain 1991; Nobre and Shukla, 1998; Enfield et al., 1999; Li et al., 2001; Chiang and Vimont 2004). The meridional SST dipole is related to a Hadley cells system and the ITCZ latitudinal position, causing enhancement or inhibition to tropical convective precipitation, particularly over the Sahel region during boreal summer (Hastenrath, 1991) or Northeastern Brazil and the Amazon Basin during austral summer-spring (Servain 1991; Marengo and Liebmann 2001).

Ruiz-Barradas et al., (2000), presents in your results physical features on decadal and interannual time scales on variability structure in tropical Atlantic sector.

In the work of Keenlside and Latif (2007), these authors present results over the variability interannual in equatorial Atlantic and SST modes variability. SST modes variability and its influences in West African rainfall were too investigated by Polo et al., (2008). On Atlantic El Niños, Rodriguez-Fonseca et al., (2009) presents a possible increase in first decades of years 2000. Connections between Pacific and Atlantic El Niños as decadal modes were related in results of Martin-Rey et al., (2014).

Deppenmeier et al., (2016), show as Bjerknes feddbaks is represented in Atlantic basin in CMIP5 models and it influence in thermal conditions in the basin. Amaya et al., (2017) using CMIP5 data made an analysis show the mean feedbacks between the wind and evaporations in equatorial Atlantic region. The SST dipoles in tropical Atlantic were related on climate in surroundings during summer and autumn seasons were investigated in the studies of Kayano et al., (2018). Dippe et al., (2019) in your study presents results of a comparison of Bjerknes feedbacks between Atlantic and Pacific oceans in relation the seasonality and characteristics of symmetry and stationarity. The control by seasonal cycle in interannual variability in equatorial Atlantic region was investigated in the studies of Prodhomme et al., (2019).

As climate of a given region is determined by a set of several factors, such as its distance to the ocean, and its altitude and latitude. The atmosphere and hydrosphere, with their distinct physical and dynamical characteristics and interactions, are determining factors for the Earth's climate and modulate its variability. Thus, analyses of studies exploring the atmospheric-ocean of the Atlantic Ocean and how reliable the models simulate these features and thermal variability in the ocean. Projections of the ocean modes are also important to estimate the climate impacts and may guide planning in economic, social and policy decisions.

The paper aims to investigate how fairly the AOGCMs from CMIP3 and CMIP5 represent the two main tropical Atlantic SST modes by comparison with the 1971-2000 observed SST. This study is based on Empirical Orthogonal Function (EOF) analyses through their seasonal characteristics, principally during austral fall (March-April-May - MAM), which comprise the cores of the rainy seasons in South America and Northeast Brazil. The study is led first with an SST analysis inside the whole tropical basin, and then we focus on the ability of the AOGCMs to represent the equatorial and meridional SST dipole. A difference from this study was the proposal of investigate the type of meridional and equatorial dipole in three categories (positive, negative and neutral) in the CMIP3-5 simulations compared to the observations. The paper is structured as follows: The data and methods are described in the next section, and section 3 shows results and presents the discussion. Summary and main remarks can be found in the last section.

Data and Methodology

Monthly SST data from Extended Reconstructed SST version 3 (ERSST) are utilized in this study (Smith et al., 2008). This SST dataset is available on regular grid points of 2.5° x 2.5° comprising the period from 1971 to 2000. This period was chosen due to increase in the number of oceanic observations from the 1970s and because of the consistency of the period regarding AR4 and AR5 experiments. The SST data from the IPCC AR4 and AR5 models are also for the period 1971-2000. Details of these models in relation to physical features and spatial resolution, providing Meteorological Center, and other characteristics are shown at http://cmip-pcmdi.llnl.gov/. Details regarding Greenhouse Gas (GHG) concentrations during simulations can be found at http://www-pcmdi.llnl.gov/. The SST data of the ERSST and coupled models were interpolated into a linear grid of 2.0x2.0 degrees in a selected area of 90°W to 10°W and 25°N to 25°S. EOF analysis (Were, 1977) is performed to objectively find the principal modes of monthly SST anomalies (1971-2000) for DJF and MAM over the Atlantic Tropical from observations and model outputs and thus identify which of the models are able to simulate at least qualitatively the tropical Atlantic variability. We calculate the Pearson correlation between the time series of the two leading modes obtained from observations and from models to evaluate the association between them. After identifying the models that better simulated the two principal modes of Atlantic variability, they were chosen to be considered in the following steps of the methodology. The selection criterion is defined by correlation values greater than or equal to 0.50, which explain more than 25% percent of the thermal variability in the Tropical Atlantic Basin, between the time coefficients of the SST EOF analysis in the Tropical Atlantic from models and observations (Table 1).

For comparative analysis between the observations and the models' data, the following measurements were calculated: spatial means of SST anomaly in the tropical North and the South Atlantic areas, representing the inter-hemispheric SST anomaly gradient (North area: 60ºW-30ºW and 5ºN-20ºN and South area: 30ºW-10ºW and 5ºS-20ºS) beyond the zonal gradient in the Tropical Atlantic (west area: 50ºW-35ºW and 0º-5ºN and east area: 20ºW-0º and 5ºN-5ºS); these areas are shown in Figure 1a. By using these time series, the meridional and zonal gradient indexes from the difference between northern (eastern) and southern (western) areas are computed. The categories of gradient were defined as a negative dipole (DipNeg) when the difference reaches 0.2ºC, a neutral dipole (DipNeu) when the index exceeds -0.2ºC and is less than 0.2ºC, and a positive dipole (DipPos) when the index exceeds 0.2ºC. These areas of zonal and meridional anomalies SST gradients and its categories were defined in (Alves et al., 2009).

Meridional and zonal gradients were calculated and classified into DipNeu, DipPos and DipNeg for the AR4 and AR5 models, and they were compared against observations during austral summer and autumn (1971-2000). The choice of the southern summer season for the analysis of the two modes of variability, including the equatorial one that is most active in the southern winter (Chiang et al., 2006), was due to some studies showing a direct relationship of these two modes in their evolution and summer phases for the southern autumn (Breuguem et al., 2006).

The Pearson correlation coefficient between mean rainfall in the MAM austral period over the Northeastern sector (15ºS-2ºS e 45ºW-37ºW) called the Northeastern Brazil Precipitation Index –

IPNEB, which is provided by the Global Precipitation Climatology Project (GPCP), and the SST anomalies on the Tropical Atlantic was computed for austral autumn only, which is the season when the thermal variability is the major influence on precipitation anomalies of northern NEB (Uvo et al., 1999). This coefficient was computed for the previously chosen CMIP3 and CMIP5 models.

Results and Discussion

EOF's first and second modes of SST variability

EOF analysis shows that of the CMIP3 and CMIP5 models used in this study, few qualitatively capture the leading modes of SST Tropical Atlantic variability. Table 1 presents the models chosen by the criterion described in the methodology section. The explained variances of the two leading modes of SST monthly variability in the Tropical Atlantic are 31.5% of the equatorial mode and 28.4% of the meridional mode. As shown in Table 1, GIS_MODEL_ER was among the CMIP3 models that had better simulation results for the equatorial mode, having a coefficient of correlation of 0.91, and explained the variance of 36.1%. For the meridional mode, some of the CMIP3 models had good correlations, such as BCCR_BCM2_0 (0.94), CCCMA_CGCM3_1 (0.93), CNRM_CM3 (0.83), GISS_AOM (0.86) and INGV_ECHAM4 (0.88).

Table 1 – Selected CMIP3 and CMIP5 by Pearson correlation between the time series of the two leading modes obtained from observations and from models. In parentheses are shown correlation coefficient and explained variance for each model.

CMIP3		CMIP5	
Equatorial Mode	Meridional Mode	Equatorial Mode	Meridional Mode
BCCR-BCM2 (0.59, 26.6)	BCCR_BCM2_0 (0.94, 15.0)	Bcc-CSM1-1 (-0.82, 27,0)	Bcc-CSM1-1 (-0,92, 19.1)
GISS_AOM (0.69, 27.9)	CCCMA_CGCM3_1 (0.93, 19.0)	FGOALS-G2 (-0.86, 35.7)	BCC-CSM1-1-m (0.93, 17.4)
GISS_MODEL_E_R (0.91, 36,1)	CNRM_CM3 (0.83, 16.3)	HadGEM2-AO (-0.80, 22.6)	FGOALS-g2 (-0.83, 13.6)
INMCM3_0 (-0.67, 35.0)	GISS_AOM (0.86, 17.3)	HadGEM2-CC (-0.69, 25.4)	HadGEM2-AO (0.86, 15.7)
UKMO_HADGEM1 (-0.67, 22.8)	GISS_MODEL_E_R (-0.89, 18.0)	HadGEM2-ES (0.78, 20.6)	HadGEM2-CC (0.64, 14.9)
-	IAP_FGOALS1_0_g (-0.82, 14.6)	-	HadGEM2-ES (0.86, 13.3)
-	INGV_ECHAM4 (0.88, 12.0)	-	-
-	MPI_ECHAM5 (-0.81, 16.9)	-	-
-	NCAR_CCSM3_0 (-0.94, 12.6)	-	-
-	NCAR_PCM1 (0.67, 9.5)	-	-
-	UKMO_HADGEM1 (-0.87, 17.0)	-	-

However, the explained variance of these models underestimated the ERSST observations. For the CMIP5 models, regarding the equatorial mode, the majority of the models present negative correlations, with absolute magnitudes comparable to those of the CMIP3 models. The model that presented a positive coefficient correlation was HadGEM2-ES (0.78). The variance explained by FGOALS-GS had a value more similar to a proxy of observations (35.7). For the meridional mode, a great proportion of the CMIP5 models had a correlation with positive and high values including Bcc-CSM1-1-m (0.93), HadGEM2-AO (0.86), HadGEM2-CC (0.64) and HadGEM2-ES (0.86). As also observed in the CMIP3 models in both modes, the explained variance to the meridional mode underestimated the ERSST variance.

Figures 1 and 2 presents the leadind variability mode from observations and from the CMIP3 and CMIP5 models given by Pearson coefficient linear correlation between the PC1 and SST anomalies over the Tropical Atlantic Ocean sector. Spatial patterns and intensity from observations of the equatorial mode simulated by models are barely represented. To CMIP3 models, the better representation this mode was BBCR_BCM2_0 (Fig. 1b) and GISS_Model_ER (Fig. 1d). The others models not get represent the zonal gradient from the west to the east in the equatorial region. In the models' simulations, meridional anomaly gradients northward frequently occur along the Tropical Atlantic patterns (Chiang et al., 2004; Richter and Xie 2008; Richter et al., 2014), which disagree with observations. Those characterize problems of air-sea interactions associated with heat and momentum fluxes in the models, leading to the models to lack the ability to represent thermal variability properly and, consequently, the position and intensity of the ITCZ over the Tropical Atlantic.

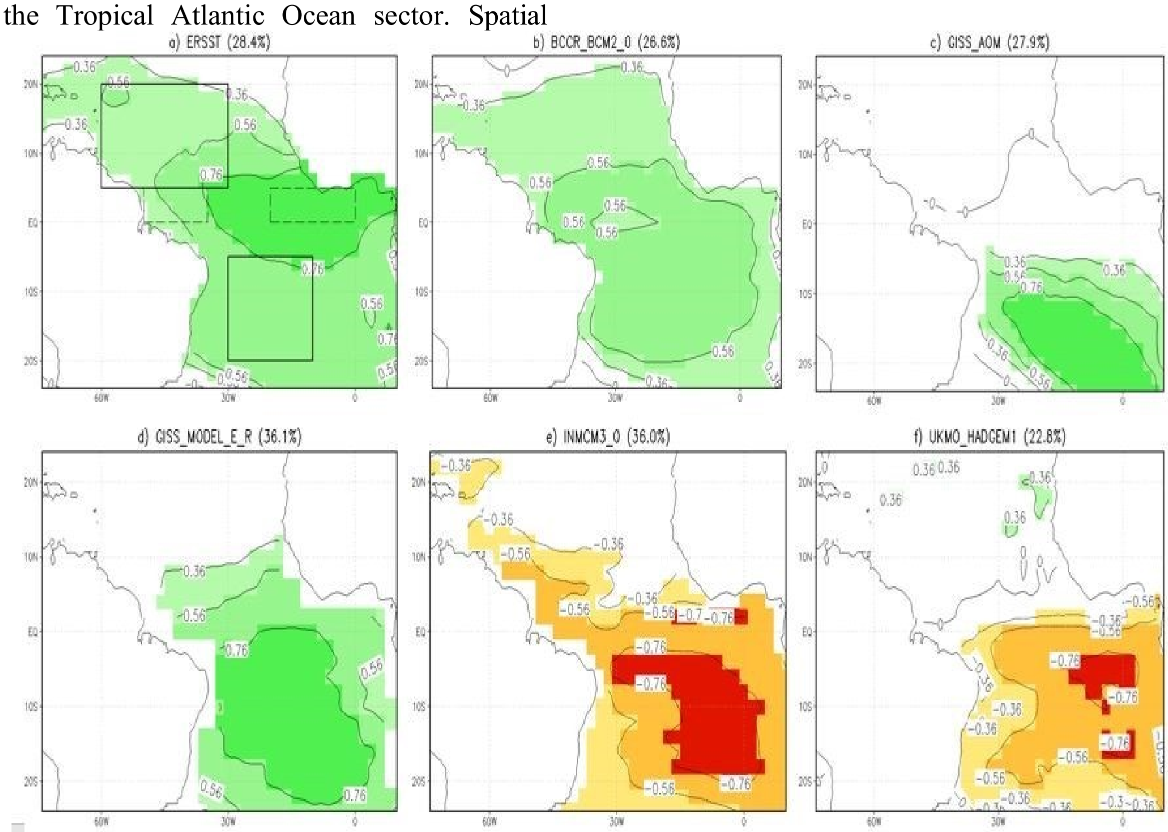

Figure 1 – Tropical Atlantic equatorial mode (leading first EOF) in observation and in selected CMIP3 models. Leading variability mode from observations and from the CMIP3 models given by Pearson coefficient linear correlation between the PC1 and SST anomalies over the Tropical Atlantic Ocean sector a) ERSST observational data, b) BCCR_BCM2_0, c) GISS_AOM d) GISS_MODEL_E_R, e) INMCM3_0 and, f) UKMO_HADGEM1. Correlation coefficient greater than absolute value of 0.36 is statistically significant follows t-Student test. Between parentheses in each figure means the explanation of the variance. The rectangles with solid and dashed lines in Figure 1a are indicative of the north and south, east and west areas of the meridional and equatorial

dipoles in the Tropical Atlantic.

The selected CMIP5 models (Fig. 2) also had difficulty representing the equatorial mode of SST anomalies in the Tropical Atlantic. Even the models underwent an important evolution of physical parameterization and new approaches to represent other earth system components, which are the schemes that drive SST changes comprising heat fluxes and horizontal and vertical advection in superficial layers of the oceans. Considering the pattern this SST mode shows in Fig. 2a, the model that better performance in simulation this mode as HadGEM2_ES (Fig. 2f).

The variability of the equatorial mode has strong oceanic-atmospheric coupling, leading to changes in sea level pressure, regional circulation over the Tropical Atlantic and, consequently, to water vapor transport towards the South American continent (Xie and Carlton 2004). The lack of coherence for this mode can make it difficult to capture the pattern of Tropical Ocean forcing represented by the models, producing noise at different time scales.

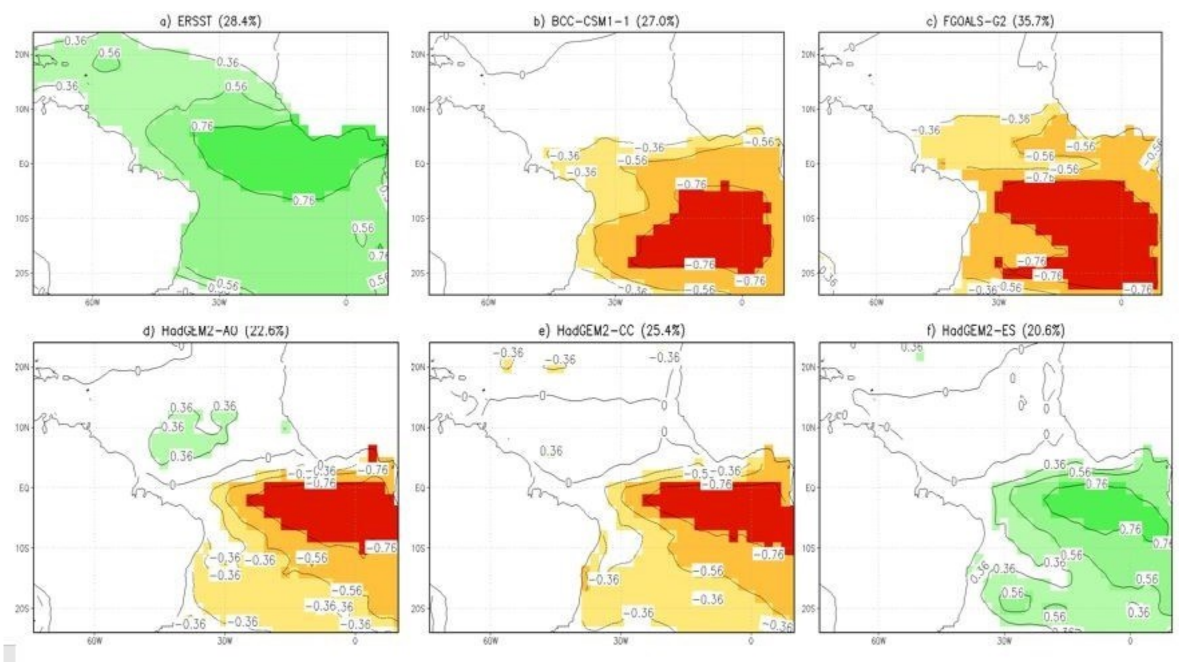

Figure 2 – As Figure 1, but to selected CMIP5 models. a) ERSST observational data, b) BCC-CSM1-1, c) FGOALS-G2, d) HadGEM2-AO, e) HadGEM2-CC and, f) HadGEM2-ES.

Of models from CMIP3 (Fig. 3) selected by methodology only four was capable of in simulation capture similar configuration SST meridional mode pattern of Fig. 3a, with as BCCR_BCM2 (Fig. 3b), CCMA_CGCM3-1 (Fig. 3c), CNRM_CM3 (Fig. 3d) and ING-ECHAM4 (Fig. 3h). In relation selection of CMIP5 models (Fig. 4) too was observed a difficulty in representation of the meridional mode of SST anomalies in the Tropical Atlantic. In terms of configuration compared the same of Fig. 4a, the models that presents configuration as some similarity was HadGEM2_ES and HadGEM2_CC, principally in north sector of basin (Fig. 4e and 4f).

The capture of this variability mode is performed is a scanty manner and arises predominantly from the improper solution of the Tropical Atlantic Ocean dynamics and thermodynamics in the coupled models. The meridional mode has a dipole-like pattern, as studied by Servain (1991). Although ocean-atmosphere coupling is weak or is reserved to North Atlantic sustained pattern SST anomalies (Xie and Carlton 2004), it is an important climate driver for the Sahel of Africa, northern South

America and northern Brazil. Across-equator Atlantic SST anomalies modulate the position of the ITCZ towards the warmer hemisphere (Nobre and Shukla 1996). The inability of the CMIP5 models to reproduce this mode could be pointed out by the lack of interaction between SST/U-wind components on the Tropical North Atlantic assuming WES feedback (Amaya et al., 2017).

Addressing yet about poor representation of two models to represent the configuration of two meridional and equatorial modes, this question may be related to thermodynamics of these modes due to the models was not able better represent both modes in summer and autumn austral. Breuguem et al., (2006), Richter and Xie (2008), Richter et al., (2014), in results of your studies, show that the winds of east in the equatorial region and its configurations presents many errors in simulations of CMIP models compared to the observations, as well as the regions of the wind-evaporation mechanism in the tropical Atlantic surface. These factors second these authors are crucial for the development and interaction of modes between the summer and autumn seasons of south Hemisphere.

SST Dipole events from Equatorial and Meridional Modes of SST: Observations and Coupled Models

In this section, we selected only models in CMIP3 and CMIP5 that had better performance in simulated at least hit a frequency of the equatorial and meridional dipole categories between 1971-2000 during austral summer and autumn in 3 categories (positive, neutral, or negative). It is noted by Figures 5, 6, 7, and 8 that for all the models from CMIP3 and CMIP5 in summer and autumn, the highest matches occurred for neutral dipole categories. Specifically, CMIP5 models simulated more neutral dipoles, agreeing with observations. This result indicates the inability of the models to represent opposite signals of the meridional dipole events in seasonality.

Correlation between IPNEB (March to May) and SST anomalies

The Fig. 9 and 10 show the correlation pattern between IPNEB for the northern NEB region and the observed SST anomalies in the Tropical Atlantic for models selected by EOF analysis criteria. The majority of the CMIP3 models did not capture the negative (positive) correlation signal over the Tropical North (South) Atlantic (Fig. 9b-9g), which is highlighted by the observations (Fig. 9a). This indicates the small ability of the models to reproduce correct signals of the SST anomalies throughout the Tropical Atlantic.

The correlations values are quite low in the results from the models and not significant. The BCCR-BCM2_0 (Fig. 9b), CRN_CM3 (Fig. 9d), GISS_AOM_H (Fig. 9e) and INV_ECHAM (Fig. 9f) models capture negative correlations over the Tropical North Atlantic, which is an important driver of ITCZ position and, consequently, of rainfall on northern NEB (Nobre and Shukla 1996). The Fig. 10 shows similar features for CMIP5 models. Most of the models did not simulate the linkage between rainfall on the northern NEB and SST anomalies of meridional dipole in the Tropical Atlantic. All the models showed a predominance of positive SST anomalies in the Tropical North Atlantic, which is an inverse pattern to that of the observations. The model that presented a certain similarity of pattern was HadGEM2-ES (Fig. 10e). The BCC_BM1_1M (Fig. 10b) and HadGEM-CC models (Fig. 10d) showed negative correlations that were weaker in magnitude in the South Atlantic, which is consistent with the observations (Fig. 10a).

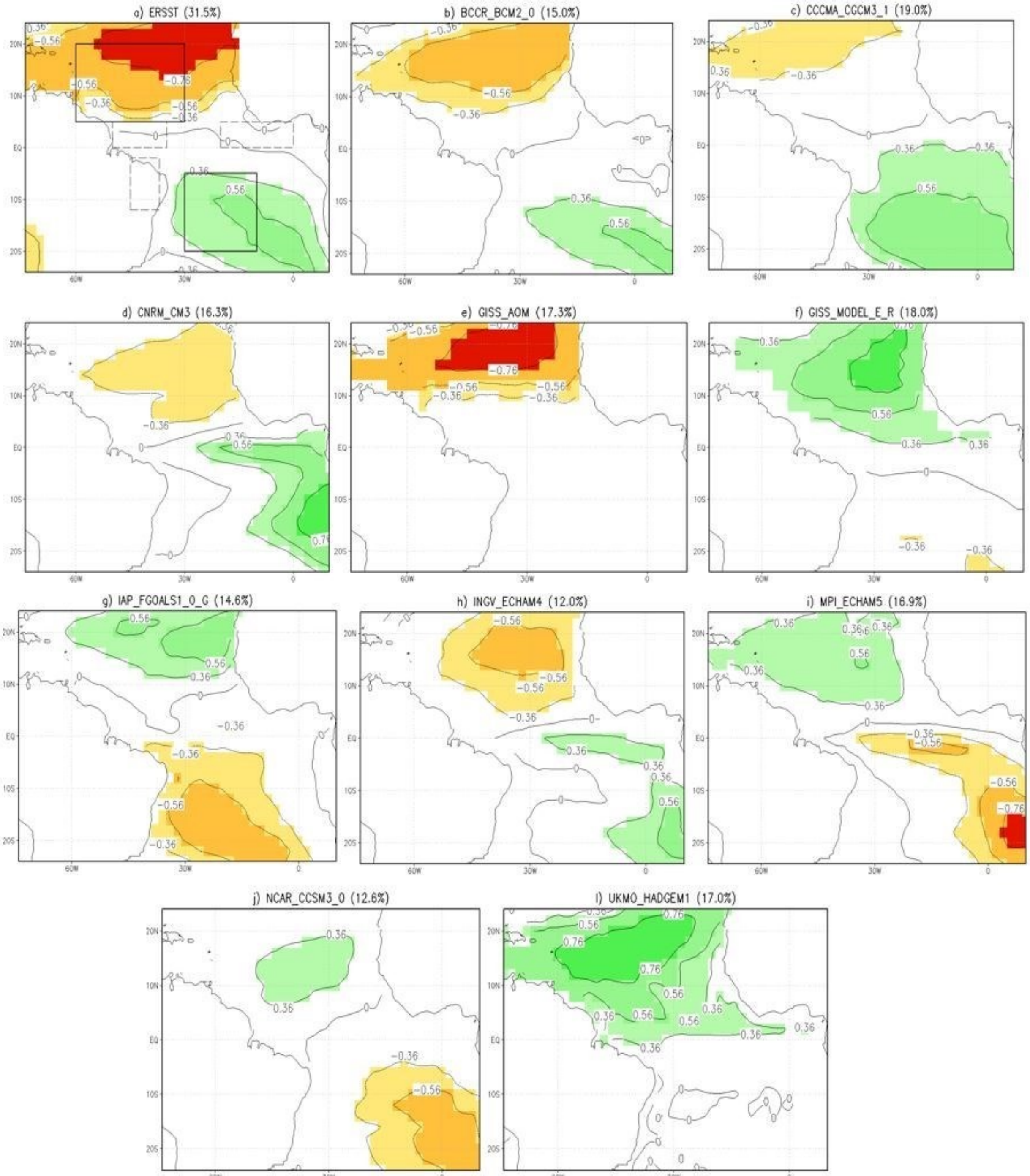

Figure 3 – As Figure 1, but to selected CMIP3 models. a) ERSST observational data, b) BCCR_BCM2_0, c) CCCMA_CGCM3_1, d) CNRM_CM3, e) GISS_AOM and, f) GISS_Model_E_R, g) IAP_FGOALS1_0_G, h) INV_ECHAM4, i) MPI_ECHAM5, j) NCAR_CCM3_0 e l) UKMO_HADGEM1. In this Figure is shows area on northern of Northeast Brazil used to calculate the IPNEB.

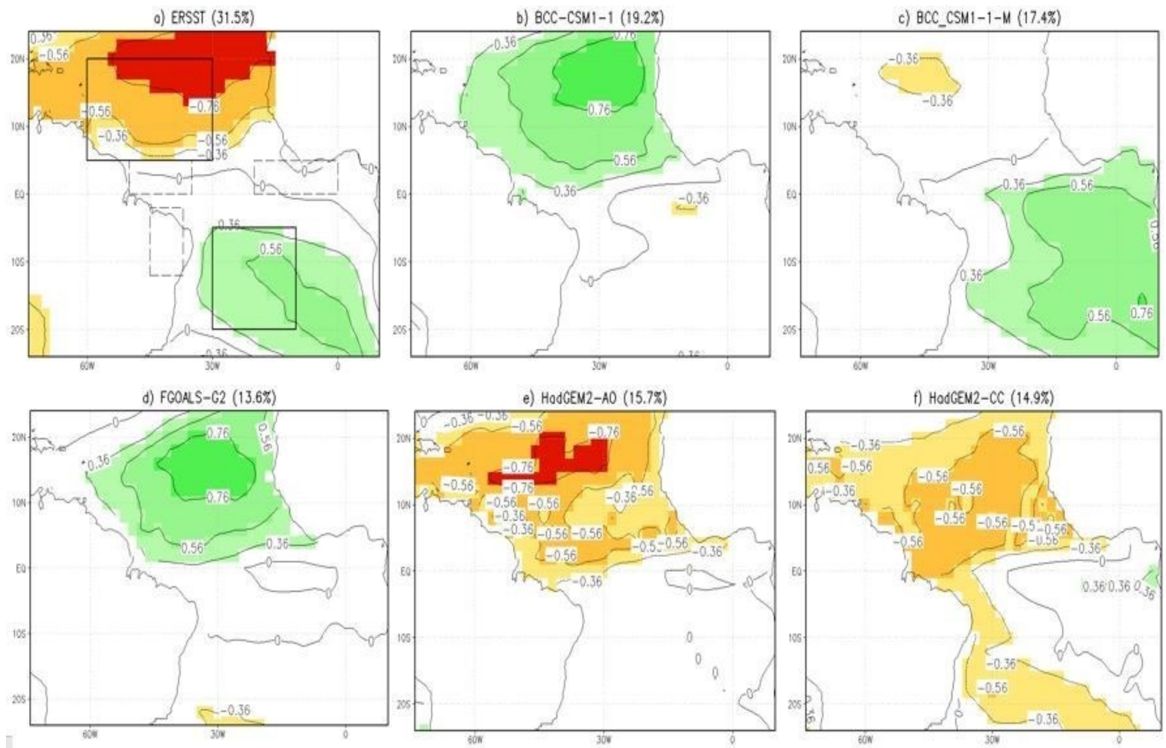

Figure 4 – As Figure 3, but to selected CMIP5 models. a) ERSST observational data, b) BCCR_CSM1-1, c) BCC_CSM1-1-M, d) FGOALS-G2, e) HADGEM2-AO, f) HADGEM2-CC.

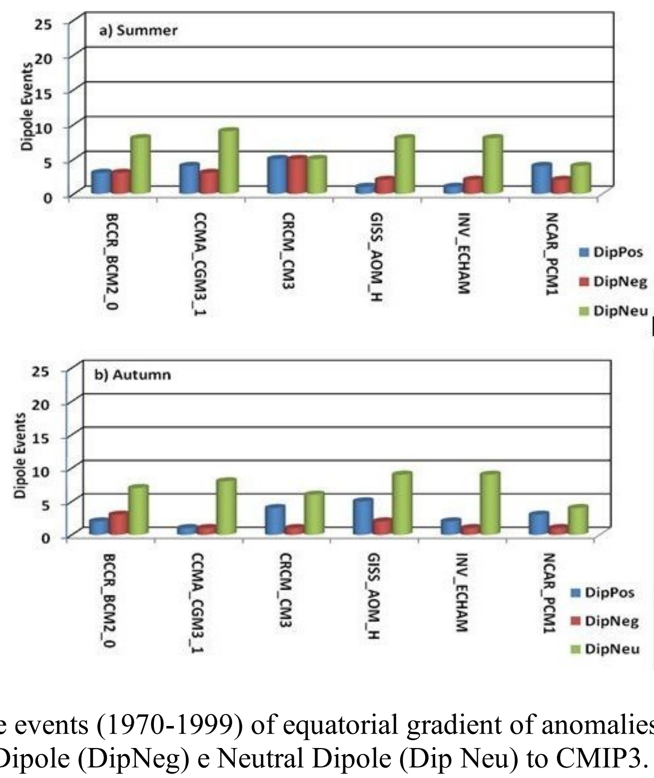

Figure 5 – Coincident dipole events (1970-1999) of equatorial gradient of anomalies SST classified as Positive Dipole (DipPos), Negative Dipole (DipNeg) e Neutral Dipole (Dip Neu) to CMIP3. a) Summer and b) Autumn.

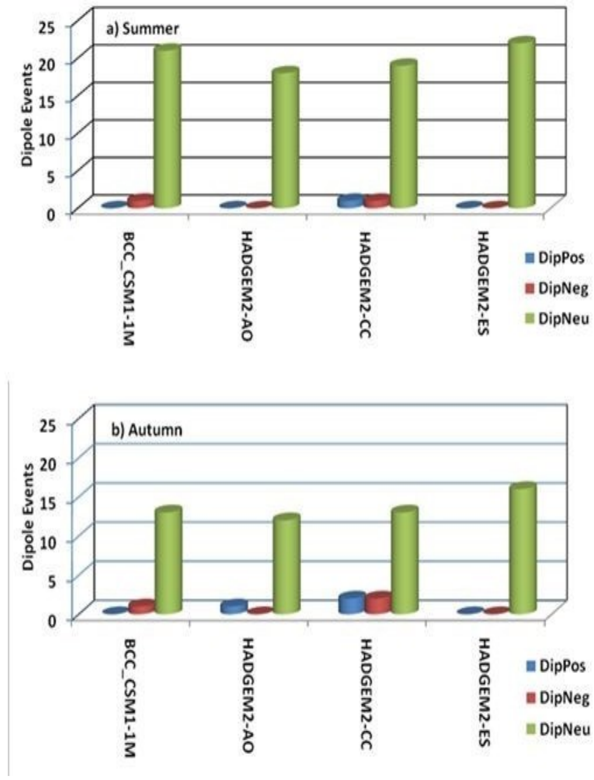

Figure 6 – As Figure 5 to the equatorial to selected CMIP5 models by EOFs analysis. a) Summer and b) Autumn.

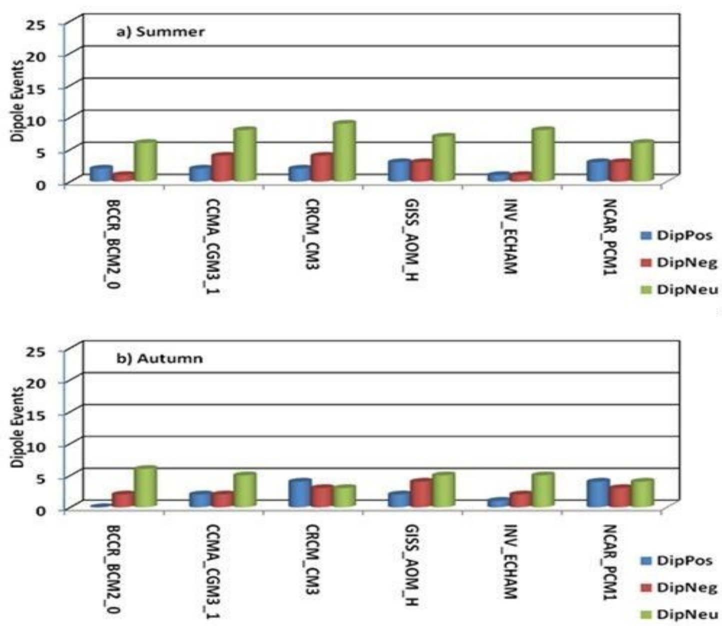

Figure 7 – As Figure 5 to the meridional gradient to selected CMIP3 models by EOF analysis. a) Summer and b) Autumn.

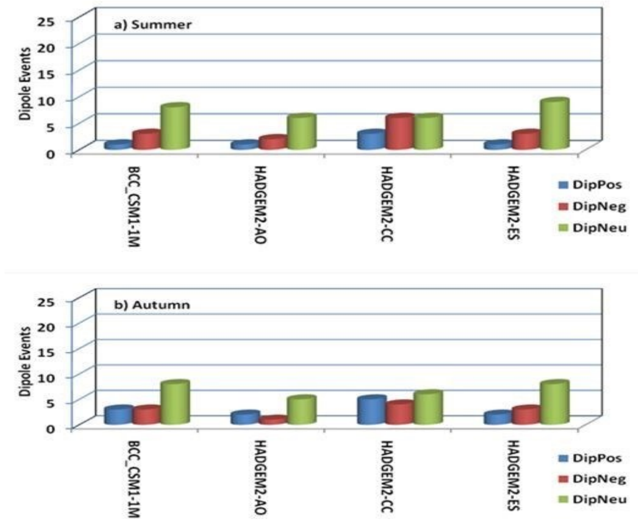

Figure 8 – As Figure 5 to the meridional gradient of SST to selected CMIP5 models by EOFs analysis. a) Summer and b) Autumn.

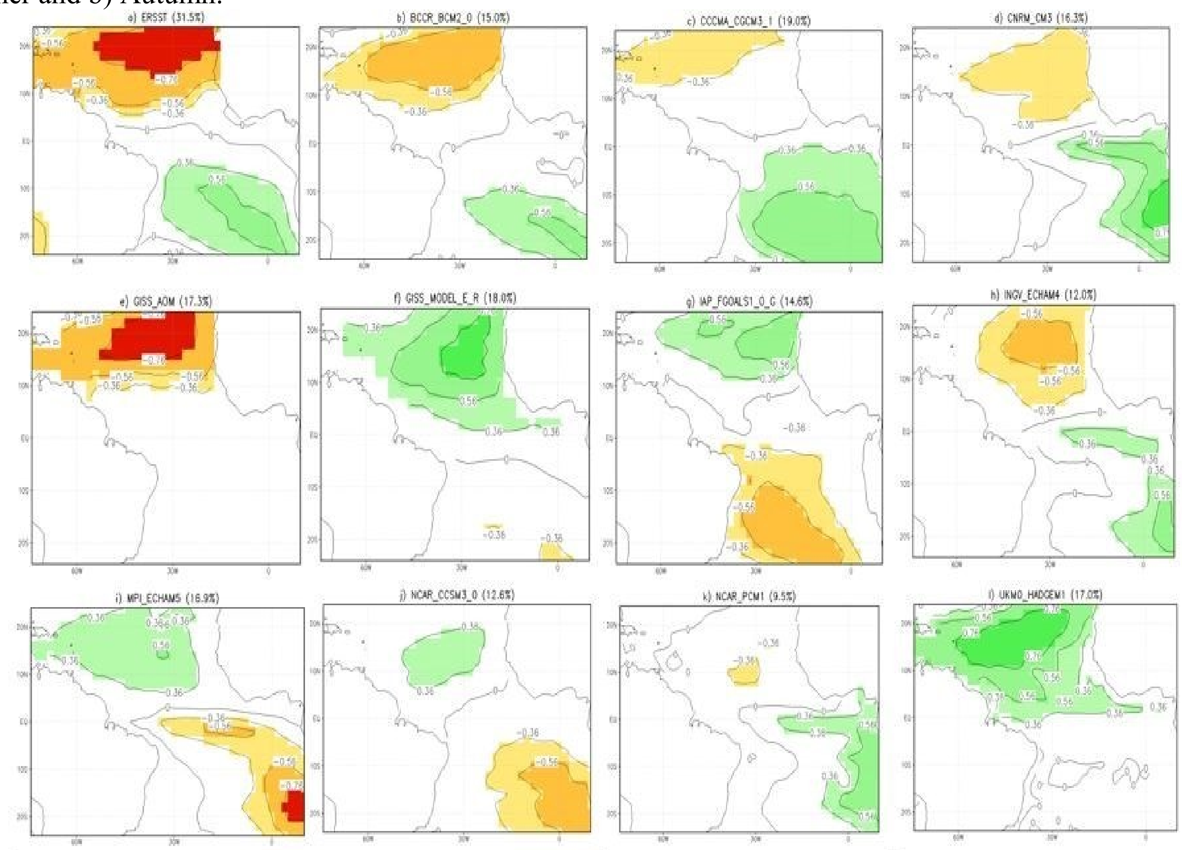

Figure 9 – Correlation between IPNEB and observed SST anomalies in the Tropical Atlantic (ERSST) and from CMIP3 models. a) ERSST, b) BCCR_BCM2_0, c) CCMA_CGCM3-1, d) CNRM_CM3, e) GISS_AOM, f) GISS_Model_E_R, g) IAP_FGOALS1_O_G, h) INV_ECHAM4, i) MPI_ECHAM5, j) NCAR_CCM3_0, l) NCAR_PCM1 e k) UKMO_HADGEM1. Correlations above than absolute value of 0.36 are statistically significant for a level of 5% following t-Student test. Values between parentheses in each figure means the explanation of the variance in the basin.

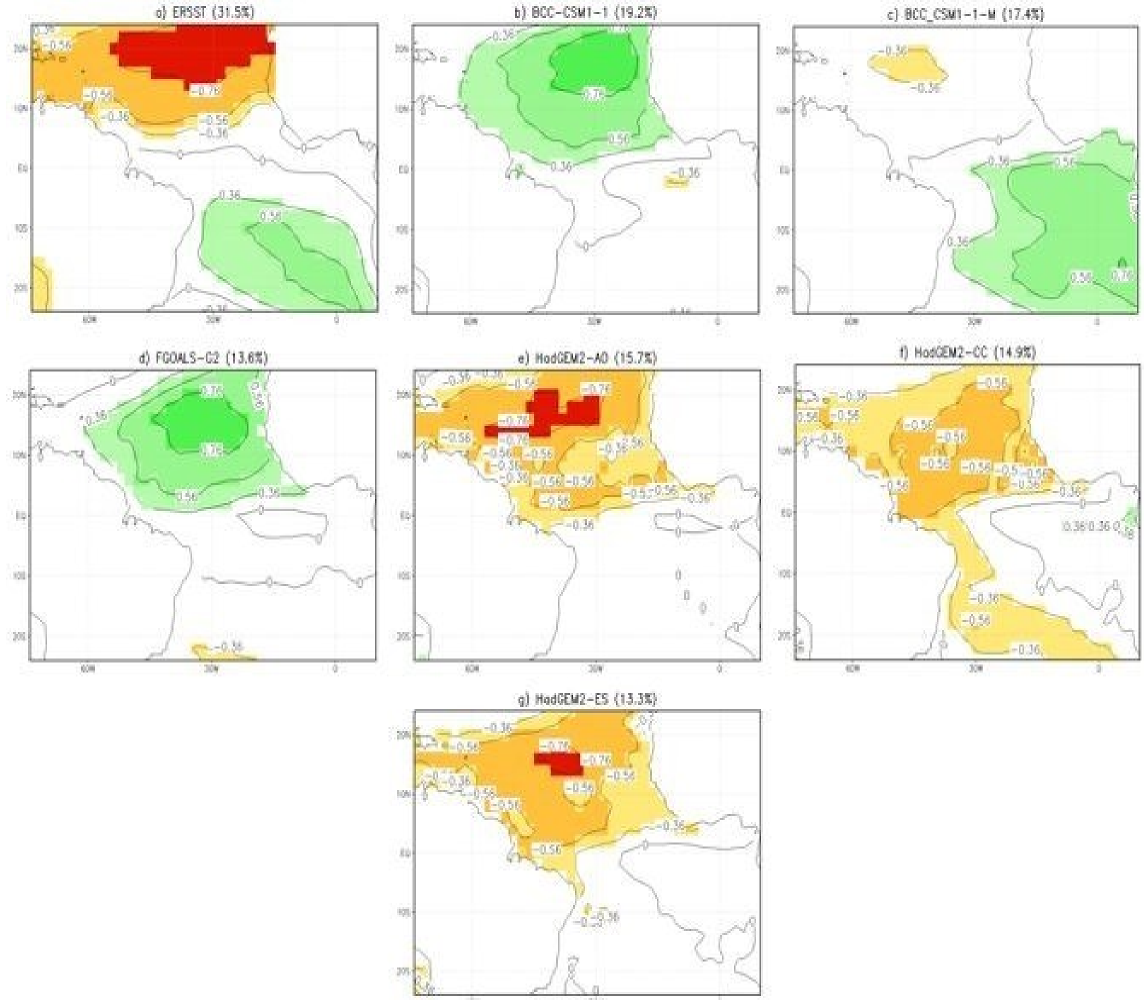

Figure 10 – As figure 9 but to CMIP5 models. a) ERSST, b) BCC-CSM1-1, c) BCC_CSM1-1-M, d) FGOAL5-G2, e) HADGEM2-AO, and f) HADGEM2-C e g) HADGEM2-ES.

Summary and Remarks

According to the results of the study, the main conclusions could be drawn. Major part coupled models of CMIP3 and CMIP5 have performed poor in simulating the equatorial and meridional modes of SST anomalies in the Tropical Atlantic. The correlations of the first EOF mode of its auto-value of the SST anomalies showed that the most consistent model for equatorial mode was GIS_MODEL_ER, which had a coefficient of correlation of 0.91 and explained a variance of 36.1% to mode. For the meridional mode, the following CMIP3 models had good correlations: BCCR_BCM2_0 (0.94), CCCMA_CGCM3_1 (0.93), CNRM_CM3 (0.83), GISS_AOM (0.86) and INGV_ECHAM4 (0.88). For CMIP5 models and equatorial mode, most of the models present a negative correlation, and the absolute magnitudes of the correlation exceed those of the CMIP3 models. The models had a positive coefficient correlation for HadGEM2-ES (0.78). The explained variance of the FGOALS-gs had a value more similar to observations (35.7). For the meridional mode in CMIP5, the following models had correlations with positive and high values: Bcc-CSM1-1-m (0.93), HadGEM2-AO (0.86), HadGEM2-CC (0.64) and HadGEM2-ES (0.86).

In relation the correlation of the first auto-value EOFS of the equatorial and meridional modes and SST anomalies in Atlantic Basin, the majority of the CMIP3 models did not capture the negative (positive) correlation signal over the Tropical North (South) Atlantic, which is highlighted by the observations. We highlight the models that capture this signal from the correlations of the observations mentioned above, BCCR-BCM2_0, CRC_CM3, GISS_AOM_H and INV_ECHAM, which principally the capture of negative correlations over the Tropical North Atlantic, which is an important driver of ITCZ position and, consequently, of rainfall on northern NEB (Nobre and Shukla 1996). Although some models show high correlations in magnitudes of values (greater than 0.8 in absolute values) for both CMIP3 and CMIP5, for the observed and simulated auto values for the two stations under study, it was clear that the thermal configuration in the basin to two modes were not simulated in most of the coupled models. No can be said with these analyzes that the physical improvements of the CMIP5 models get reflect greats assessment in simulation of thermals features in the Tropical Atlantic compared to the CMIP3 models (Wang et al., 2015). This characteristic has already been evident in previous studies (Richter et al., 2008, 2014).

To the simulation of the meridional and equatorial dipole in categories by the CMIP3-5 models compared the observations, the models also performed poorly in matching the number of events in each category between 1971-2000 in the two summer and autumn seasons of south Hemisphere. The dipole Neutro was the event that the models had more coincidences in the interennual variability compare as observations.

For future studies, we intend to investigate other physical variables of the models that, such as wind anomalies, evaporation and latent and sensitive heat fluxes, and perform comparisons with the observations to identify the possible differences in the simulations, since these variables have significant influences on the thermal patterns of the equatorial and meridional modes of SST anomalies in the Tropical Atlantic.

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