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abA Shift in Atlantic Ocean Warm Events: A preliminary Study

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Abstract

This work is a preliminary attempt to understand a shift in the occurrence of extreme cold and warm events, and their characteristics, in Equatorial Atlantic Ocean. Sea surface temperature data from merchant ship observations between 1964 through 2000 is used. Through the least squares method a sea surface temperature rise of 0.0221°C/yr reaching an overall value of 0.7956°C for the whole period is observed. Further more, by classifying extreme warm and cold events as those when the sea surface temperature is above or below 1°C, it is found that there is a predominance of extreme cold events prior do 1980 and extreme warm events after that. Compositing the extreme events, according to the criteria above, show that there is a phase locking with the annual cycle with the extreme event always starting in boreal summer (on August, typically)

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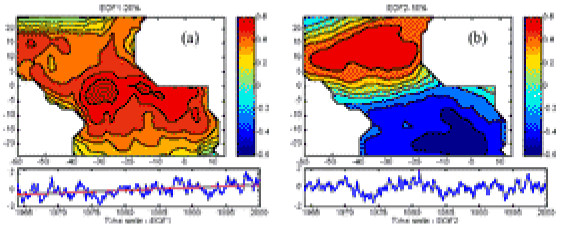

Fig.1 - (a) First and (b) second EOF loadings computed for Servain's 1964-1999 SST anomalies (°C). (click Image to Enlarge)

1. Introduction

Tropical Atlantic Ocean variability has been the target of several studies in the last decades. Differently from Pacific Ocean variability which presents an interannual signal (3-5 years) dominated by El-Niño/Southern-Oscillation (ENSO) phenomena (Wyrtki, 1975; Leetmaa et al., 1983), the Atlantic variability shows the greatest peak in the seasonal scale (Merle et al., 1980). In lower frequencies, the Atlantic Ocean presents two main modes of variability : an equatorial mode similar to Pacific ENSO, and a decadal mode associated with an inter-hemispheric sea surface temperature (SST) gradient symmetric about Inter-tropical Convergence Zone (ITCZ). Decadal and multidecadal scales of variability in the Tropical Atlantic were already shown to exist in the Tropical Atlantic by Mehta and Delwoth (1995). The Equatorial mode, which is the subject of this study, is predominantly associated with ocean dynamics. Changes in the trade wind system in the western Equatorial Atlantic basin causes the thermocline to adjust, which in turn impacts on the equatorial upwelling pattern. Kelvin waves are triggered and cross the Atlantic basin in few weeks. These waves are reflected as Rossby waves or trapped at the African coast propagating polewards generating a higher latitude east-west response.
The events associated with the equatorial mode have important local social-economic consequences. For example, tuna fishing in open ocean and distribution of several pelagic species along the African shore are considerably affected. Adjacent coastal areas also feel

the ocean temperature variation as changes in the regional distribution and intensity of precipitation (Servain et al., 1998).
In the present work the equatorial mode was obtained through an empirical orthogonal function analysis (EOF) as the dominant mode of variability in the Tropical Atlantic, showing periods of warming or cooling along the equatorial band. Based on it, we will build upon the study of Carton and Huang (1994), who have identified and characterized warm events in the region but using a shorter record.

2. Data
The SST data used here is based on monthly means since January 1964 to December 1999 on a 2°x2° grid. The study area extends from 30°N to 20°S and from to 60oW to African coast. Merchant ships measurements that integrate the Volunteer Observing System (VOS), data obtained from the National Climatic Data Center (NCDC) and data from the National Meteorological Center (NMC) compose this product (Servain and Lukas, 1990).

3. Results
Figure 1 presents the two main EOF modes and the associated time series of SST anomalies
(with respect to the annual cycle) for the Tropical Atlantic. The EOF modes were obtained using conventional techniques (Matlab). EOF1 (figure 1a) explains 26% of total SST variability and is associated with a generalized warming trend of the whole basin. EOF2 (figure 1b), which explains 16% of SST variability, corresponds to the interhemispheric gradient of SST anomalies.
In order to evaluate the occurrence of warm and cold events in a fashion consistent with the criteria used by Zebiak (1993) and Carton e Huang (1994), the SST anomalies time series for the equatorial area between 6oS to 2oN and 20°W to 10°E is examined (Figure 2). This region, allows an easier identification of extremes events due to its great variability about the Equator.

The selection criterion for extreme years used was the occurrence of SST anomalies with absolute value greater than 1°C, lasting for more than a month.

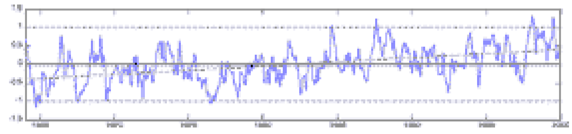

Fig.2 - Time series of SST anomalies for 2°N-6°S and 20°W-10°E (Click Image to Enlarge)

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Using this definition 1964, 1965, 1967, and 1976 were defined as cold years and 1984, 1987, 1997, 1998, and 1999 were defined as warm years. Thus, before 1980 four cold episodes occurred in the studied period, while after this date 5 warm episodes occurred. This fact must be associated with the positive trend observed in figure 2, where through the least squares method a temperature rise of 0.0221°C/yr reaching an overall value of 0.7956°C for the whole period is observed.
It is clear that SST anomalies are predominantly negative before 1984 and become basically positive after this date. The warm episodes for the Atlantic, according to the adopted selection criteria present a frequency of occurrence close to that of the ENSO phenomena in the Pacific Ocean, however, the greatest correlation between the SST anomalies time series of figure 2 and the Southern Oscillation Index is not greater than 0.3.

4. Discussion
The SST anomalies series presents a visible trend associated with the equatorial variability. This way the cooling events observed earlier in the period were more intense and frequent while after 80's the warming events have become more intense and frequent. Trends like the one showed here can also be observed in others data sets as DASILVA (Da Silva et al., 1994) and GOSTA (Bottomley et al., 1990). Some authors associate the positive SST trend to natural variability, anthropogenic effects or even a combination of both factors (Cane et al., 1997). Other authors consider these trends a result of changes in measurement techniques and also by the increased number of observations available (Folland and Parker, 1995). We don't discard the biases induced by observational techniques but the trend appears as a robust climatic signal in several data sets and variables even after the main known biases are corrected.
Another interesting point observed and to be further explored is that an extreme event always starts in boreal summer (on August, typically). This seasonal character is linked to the tropical wind regime acting on ocean circulation.