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Impact of Sea Surface Temperature over East Mole and South Atlantic Ocean on Rainfall Pattern over the Coastal Stations of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study examines the impacts of South Atlantic and East mole Sea Surface Temperatures on rainfall in some selected coastal stations in Nigeria. This study seeks to investigate the relationship between SST and rainfall in some of the coastal stations of Nigeria, also to find the correlation between rainfall and SST's of east mole and south Atlantic and to develop statistical model to estimate monthly/seasonal rainfall over the selected station using January, February and December SST of east mole and south Atlantic ocean.
Study Design: Sea surface temperature (SST) and rainfall data were used for this study. The SST for east mole covers 17 years spanning between 1990 and 2007 and rainfall data for 30 years (1979-2007) were collected from the Nigerian Meteorological Agency Oshodi, Lagos (NIMET). South Atlantic SST (0-20ºSouth, 30ºWest-10ºEast) was obtained from the National Weather Service, Climate Prediction Center (NOAA) for 59 years from 1950-2008.
Place and Duration of Study: The stations are Lagos, Benin, Calabar and Portharcourt.
Methodology: Statistical analysis which includes (Mean, standard deviation, trend analysis and correlation analysis) were carried out. SPSS and statistica softwares were used to carry out the analysis. The rainfall and SST were standardized.
Results: The result showed that rainfall in Lagos can be predicted for the early period April-June,

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mid period of June-September and the entire raining season April-October using east mole SST data for dry months of November, December and January. The trends of SST were found to be increasing in South Atlantic Ocean, so also was rainfall in all the coastal stations. Some ENSO years also affected rainfall as it reduces rainfall drastically far below normal in the coast, Nigerian coastal waters were observed to be warmest in April and coldest in August.

Conclusion: The trends of SST and rainfall were found to be increasing within the study period. The correlation of SST and rainfall was 0.64 for (Jun-Sept) and 0.59 for (APR-OCT) in Lagos. The correlation was found to be 0.44 For Portharcourt.

Keywords: ENSO; SST; rainfall; South Atlantic Ocean; NIMET.

1. INTRODUCTION

Sea surface temperature (SST) is the temperature of the sea surface representing the condition in the surface mixed layer underlying the ocean skin. It is a geophysical variable of importance to marine meteorological services, the world climate research programme and also other large and small-scale research programmes. Its distribution on local, regional, hemispheric or global scales are of interest to scientists for the study of variety of processes in the sea, coastal areas and in the atmosphere. These ranges from local air-sea interaction and their relationship to local weather which include rainfall, which is the considered in this study. Processes in the ocean often have thermal expression at the sea surface e.g. Mesoscale eddies and upwelling. The importance of SST cannot be overemphasized in the field of meteorology and water resources, it has diverse uses ranging from forecasting of weather such as development of showers, thunderstorm, fog and rainfall amount [1,2,3]. SST may also determine areas of fish catchment by fishing fleet.

The heat content of the world's oceans is estimated to have increased by 14.2x1022 J during the period of 1961 to 2003 [4]. This is no surprise as there has been a unanimous agreement to curb the rate of global warming, which is also evident on sea surface temperature. Some evidence of global warming in Nigeria has been observed using sea surface temperature (SST) for the period 1989-2006 in East Mole Station, about 2 kilometers from the coast [5].

The surface water off the Nigerian coast is basically warm with temperature generally greater than 24^{o}C. Sea surface temperature show double peaked cycles which match quantitatively the cycle of solar heights. Between October and May, south Atlantic sea surface temperatures range from 23.39ºC-27.55ºC while during the peak of the rainy season of June-September; the range is between 22.29º-25.47ºC.

Edafienene et al. [6] showed that seasonal variation of SST of the Atlantic ocean, 2km off the coast at Lagos(east mole station),peak in April (30ºC) and November (29ºC), and the minimum in August (26ºC), corresponding to the observed monthly and seasonal rainfall distribution in Lagos. The lowest SST in August may be related to the extension of the cold tongue of the St Helena High in the South Atlantic to the Gulf of Guinea, overriding the warm Guinea current.

The few studies of the relationship between SSTs and the atmospheric parameters in the Atlantic have been concerned with the influence of SSTs on rainfall and have produced evidence both direct forcing by SSTs and of complex changes of atmospheric parameters which force both SSTs and rainfall [7,8,9]. A phenomenon called ENSO also referred to as El Nino (an exclusive warming of the upper ocean in the tropical eastern pacific lasting three or more season) influences SST and has a drastic effect on coastal rainfall. An ENSO episode is primarily evidenced through the appearance of SST anomalies and this was evident in the South Atlantic sea surface temperature, it was discovered that this had a profound effect in creating drier than normal conditions with below normal rains, the conditions with below normal rainfall, especially in strong El Nino years like 1983/1984, 1987/1988, 1991/1992, 1992/1993, 1997/1998. The most recent El Niño event began in the spring months of 1997. Instrumentation placed on Buoys in the Pacific Ocean after the 1982-1983 El Niño began recording abnormally high temperatures off the coast of Peru. Over the next couple of months, this strength of these anomalies grew. The anomalies grew so large by October 1997 that this El Niño had already become the strongest in the 50+

years of accurate data gathering. (http://ww2010.atmos.uiuc.edu/%28Gh%29/guides/mtr/eln/rcnt.rxml). Also, La Niña is associated with cooler than normal water temperatures in the Equatorial Pacific Ocean, unlike El Niño which is associated with warmer than normal water.

There are other factors that contribute to coastal rainfall apart from SST. In the coastal area thunderstorm are of greater importance to rainfall [10]. This study seeks to investigate the relationship between SST and rainfall in some of the coastal stations of Nigeria, also to find the correlation between rainfall and SST's of east mole and south Atlantic and to develop statistical model to estimate monthly/seasonal rainfall over the selected station using January, February and December SST of east mole and south Atlantic ocean.

1.1 Climate of Study Areas

Nigeria is a maritime state with a coastline of approximately 853 km and lies between latitude 4º10' to 14º'N and longitude 2 º45' to 8 5'E. The Nigerian coastline stretches from the western border with the Republic of Benin to the eastern border with the Cameroon Republic. SST was taken from eastmole in Victoria Island which is a coastal station in Nigeria and located at longitudes 3º27E and latitude 6º25N with an altitude of 2.5m [11]. Also south Atlantic SST was taken at a location (0-20ºSouth, 30ºWest-10ºEast), Nigeria as a maritime state, is signatory to the Law of the Sea Convention. Her sovereignty extends beyond her internal waters to her territorial sea of 30 nautical miles. In 1978, Nigeria established an Exclusive Economic Zone which is an area beyond and adjacent to the territorial sea extending 200 nautical miles from the baseline. The surface area of the continental shelf is 46,300 km2 while the EEZ covers an area of 210,900 km2 (World Resources 1990), within which Nigeria exercises sovereign rights for the purpose of exploring, exploiting, conserving, and managing the natural resources. Much of Nigeria's population and economic activities are located along the coast with over 20% of the population inhabiting coastal areas. The Nigerian coastal zone and its resources have vast implications for the economy.

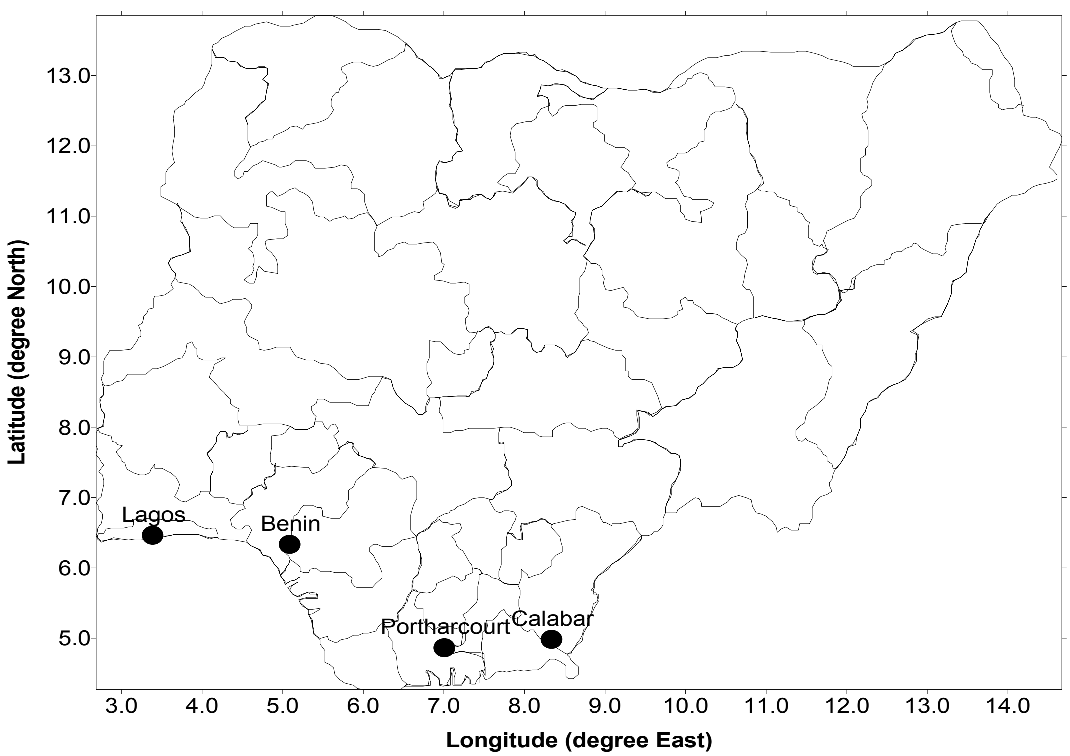

Fig. 1. Map of Nigeria showing the coastal stations

2. DATA

The data used for this study are sea surface temperature (SST) and rainfall. The SST for east mole for 17 years spanning between 1990 and 2007 were collected from the Nigerian Meteorological Agency Oshodi, Lagos (NIMET).

South Atlantic SST (0-20ºSouth, 30ºWest-10ºEast) was obtained from the National Weather Service, Climate Prediction Center (NOAA) for 59 years from 1950-2008. So also was rainfall data for Portharcourt, Victoria Island Lagos, Calabar and Benin for 30 years (1979-2007) were collected from NIMET.

2.1 Methodology

Statistical analysis which includes (Mean, standard deviation, trend analysis and correlation analysis) were carried out. SPSS and statistica softwares were used to carry out the analysis. The rainfall and SST were standardized as in 2.2 below.

2.2 Standardized Anomalies (Z)

2.2.1 Rainfall

$$Z_{ijk} = \frac{Z_{ijk} = X_{ijk} - X_{jk}}{S_{jk}} \quad (1)$$

Where Z_{ijk} = Standardized Anomaly
X_{ijk} = Annual rainfall value given by $X_m = \frac{\Sigma R_m}{N_m}$
R_m = Monthly Rainfall Value
X_{ik} = Mean annual rainfall given by $X = \frac{\Sigma X_m}{N}$

S_{ik} = Standardized deviation $\sigma = \frac{\Sigma (X_m - X)^2}{N}$

N = Number of years.

2.3 Sea Surface Temperature

$$Z_{ijk} = \frac{X_{ijk} - X_{jk}}{S_{jk}} \quad (2)$$

Where Z_{ijk} = Standardized Anomaly
X_{ijk} = Annual SST value given by

$$X_m = \ = \frac{\Sigma R_m}{N_m}$$

N_m= No of month

R_m = Monthly SST Value
X_{ik} = Mean annual SST given by $X = \frac{\Sigma X_m}{N}$
N = Number of years.

S_{ik} = Standardized deviation $\sigma = \frac{\Sigma (X_m - X)^2}{N}$

The correlation was found between SST and rainfall for the months (April, may and June) (June, July, august and September), and (April-September).

The mean SST of December -January, and November - December was used because any meaningful impact of SST on rainfall would occur in this dry months considering onset of rainfall starts from March and sometimes February in the coastal areas.

3. RESULTS AND DISCUSSION

3.1 Monthly Variation of SST and Rainfall

Fig. 2 shows the monthly variation of sea surface temperature of South Atlantic Ocean and East mole, while Fig. 3 shows the mean monthly variation of rainfall in one of the coastal stations. April has the highest value of both SST's and the lowest was observed in August (Fig. 2), the lowest SST value in august coincides with a period of low rainfall in the coastal stations considered in this study. This break in rainfall in the coastal areas is called 'little dry season' which is as a result of subsidence.

3.2 Trend Analysis of SST and Rainfall

The trend of South Atlantic SST for the 50 years in Fig. 5 was found to be increasing. East mole SST trend was decreasing (Fig. 4). Rainfall trend was increasing in all the coastal stations Fig. 6 (Benin), Fig. 7 (Lagos), Fig. 8 (Portharcourt) and Fig. 9 (Calabar).

It is obvious to note that SST affect coastal rainfall patterns [12]. For instance, El NINO warming off Peru causes above-normal rainfall in coastal Peru. It is intuitive that warmer waters are associated with wetter conditions, but the details of how sensitive precipitation is to SST, and how far inland the effect can be felt, depend on coastal topography as well as on prevailing wind, tropospheric stability, and rain-producing weather patterns. Generally, rainfall totals are very sensitive to the offshore SST in areas where most of the rain occurs when onshore winds prevail. For instance, in New South Wales (Australia) places closer to the coast appear to be affected more by coastal SST than places slightly further inland [12]. Further inland in New South Wales, especially west of the Dividing Range, most rain results from offshore moving weather systems (towards the east), hence east coast SST anomalies have virtually no effect on rainfall anomalies there [12].

The association between coastal SST and rainfall may not be a cause-and-effect relation. Some feature of winds or ocean currents may govern both. For instance, a change in wind speed/direction from strong/along-shore (southerly) to weak/onshore in coastal Peru may be responsible for both a SST and a rainfall increase. Some ingenious logic indicates that the rainfall in coastal New South Wales is enhanced by two factors independently - the nearby SST and the wind direction [12].

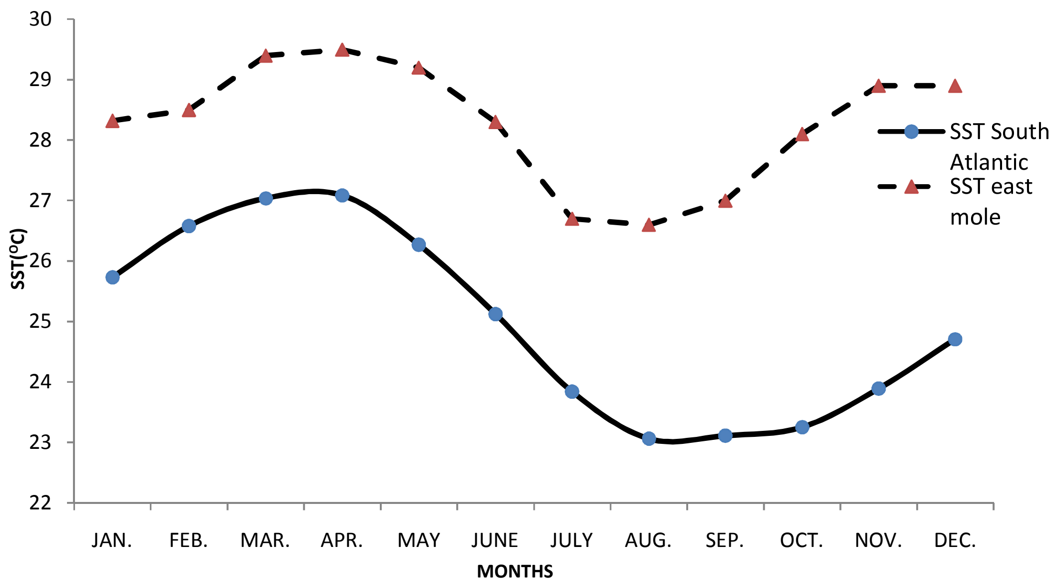

Fig. 2. Monthly SST variation over South Atlantic and Eastmole

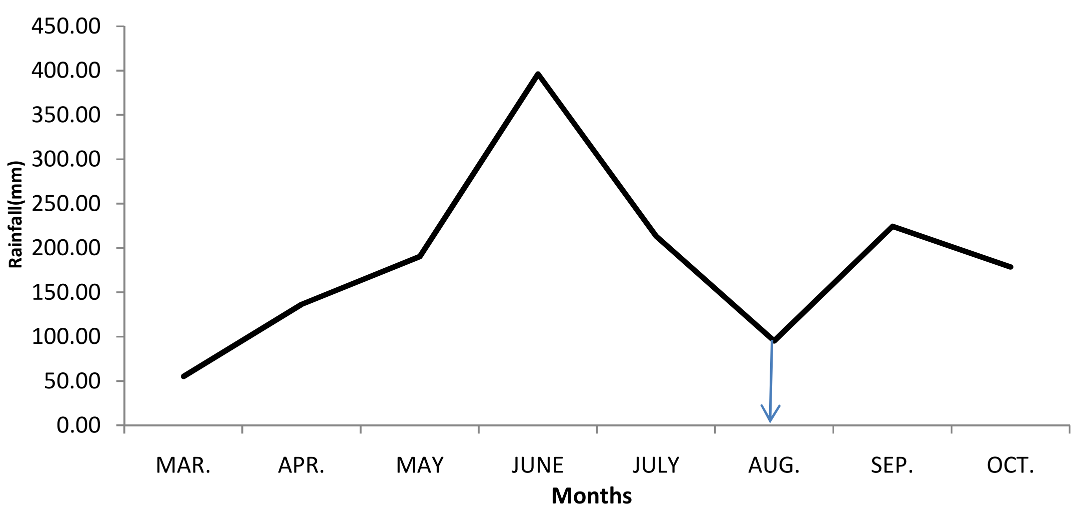

Fig. 3. Mean monthly rainfall variation from (1986-2007) in Lagos

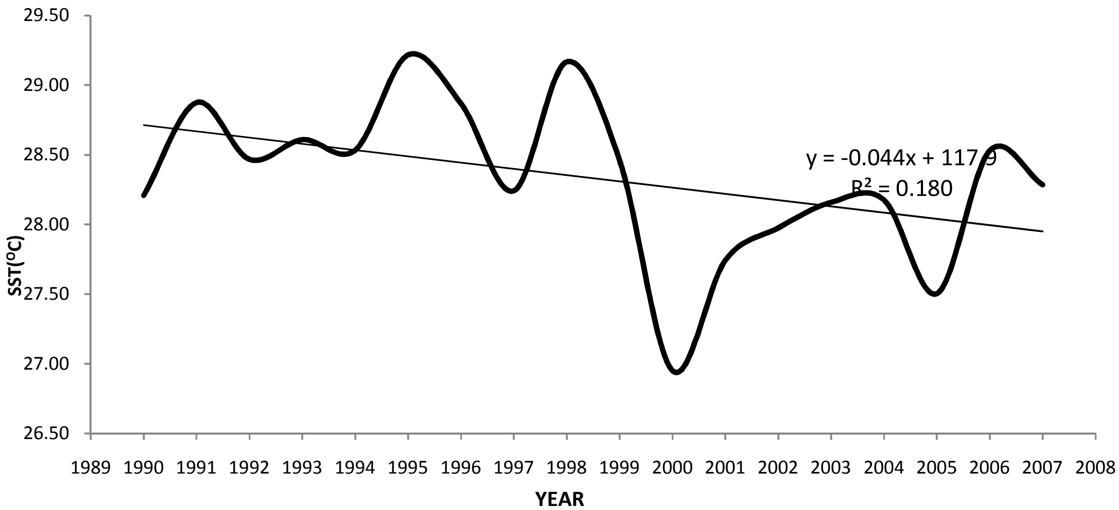

Fig. 4. SST Trend over east mole (1990-2007)

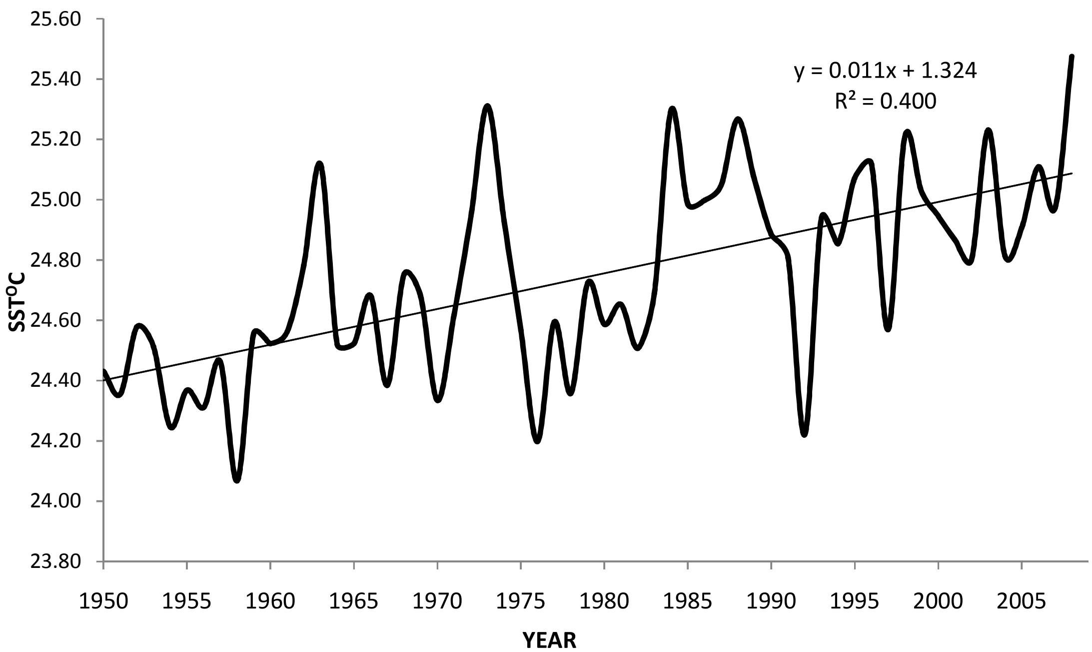

Fig. 5. SST trend Over South Atlantic Ocean (1950-2008)

3.3 Standardized Anomalies of SST and Rainfall

We standardized to note abnormal and normal years for both SST and rainfall. For Rainfall in the stations east mole SST it is assumed that greater than 1 or less than 1(>1 or <-1), means there is an abnormal, but for SST of south Atlantic Ocean, any value greater or less than 0.5(>0.5 or <-0.5) would be deemed abnormal. Sea Surface Temperature anomalies are a commonly used index of the frequency and magnitude of El Niño and La Niña events. The variations in Sea Surface Temperature in that area of the equatorial Pacific are about 4.5 times greater than those of the South atlantic Ocean (Tisdale 2011).

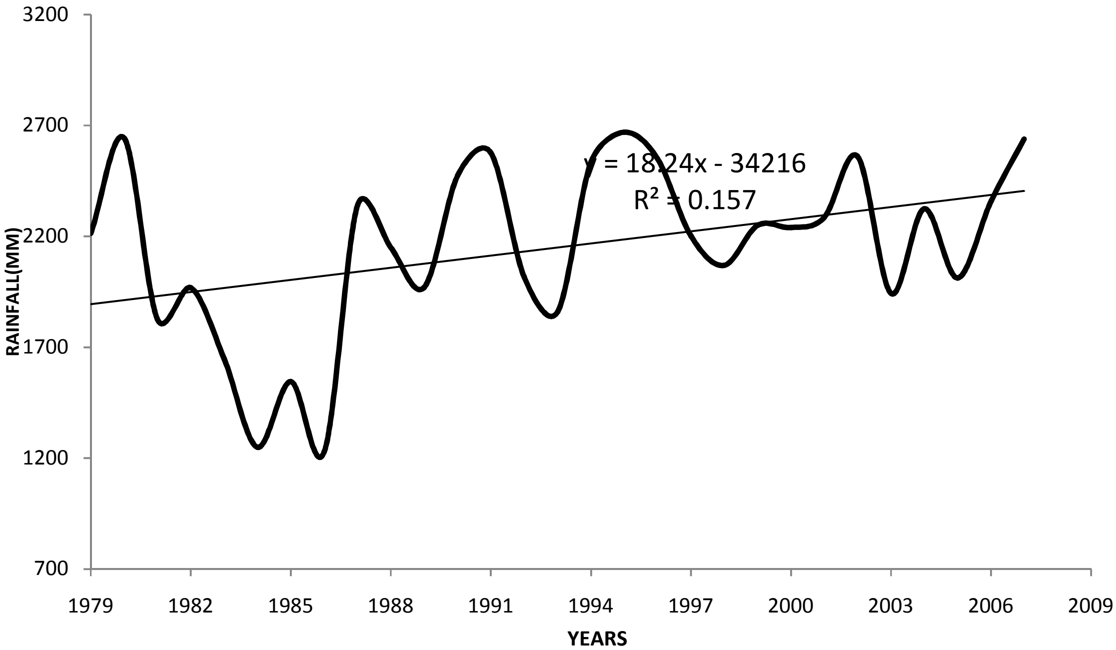

Fig. 6. Trend of rainfall IN BENIN From 1979-2007

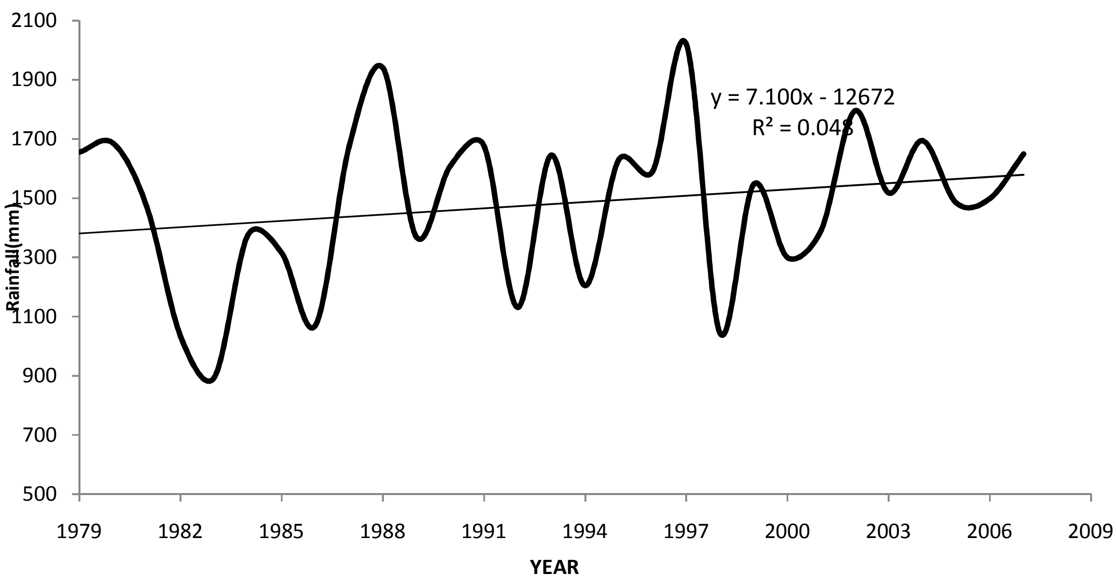

Fig. 7. Trend of rainfall amount in LAGOS from 1979-2000

The SST for east mole Fig. 10 clearly showed 2000 an abnormal years of decreased SST, and from literature 2000 was a strong Lanina years.

In Fig. 11, the years below 0.5 were considered as years with below normal SST in the South Atlantic Ocean, years such as 1958, 1976, and 1992 were years we had below normal SST. The abnormal high SST years were recorded in 1973, 1984, 1988, 1998, 2003 and 2008.

Hirst and Linacre [12] proved El Niño events are conducive to an eastward shift of the mid-latitude upper troughs, thus being detrimental to summer rainfall over South Africa. In the coastal stations in this study, El Niño years were years of low rainfall, this was confirmed in Portharcourt because El Niño years such as 1983, 1991, and 1998 experienced low rainfall. Below is a table summarizing the rainfall pattern (Fig. 12 – Fig. 15) of all the stations used and the evidence of below and above normal SST, also considering El Niño years using South Atlantic SST.

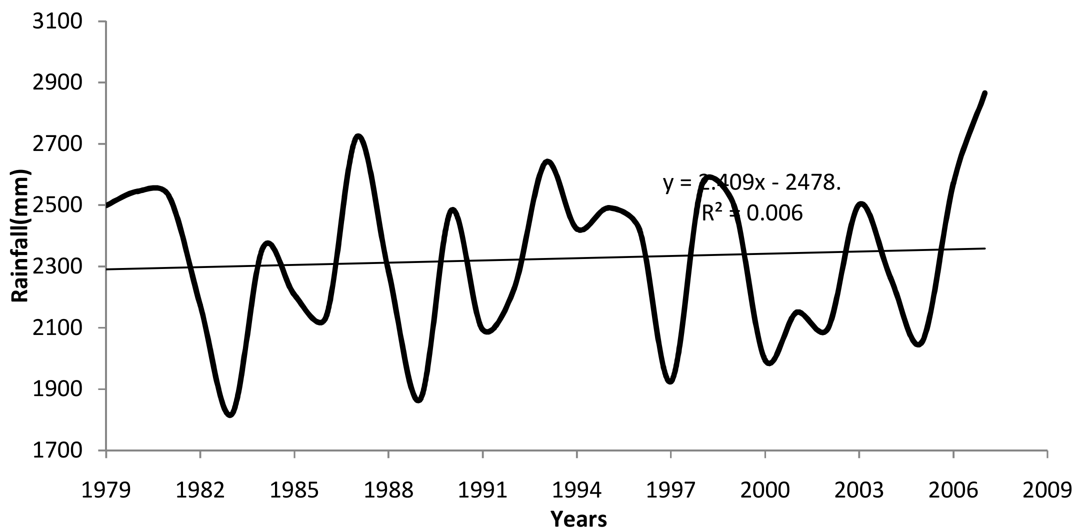

Fig. 8. Trend of rainfall in Portharcourt from 1979-2007

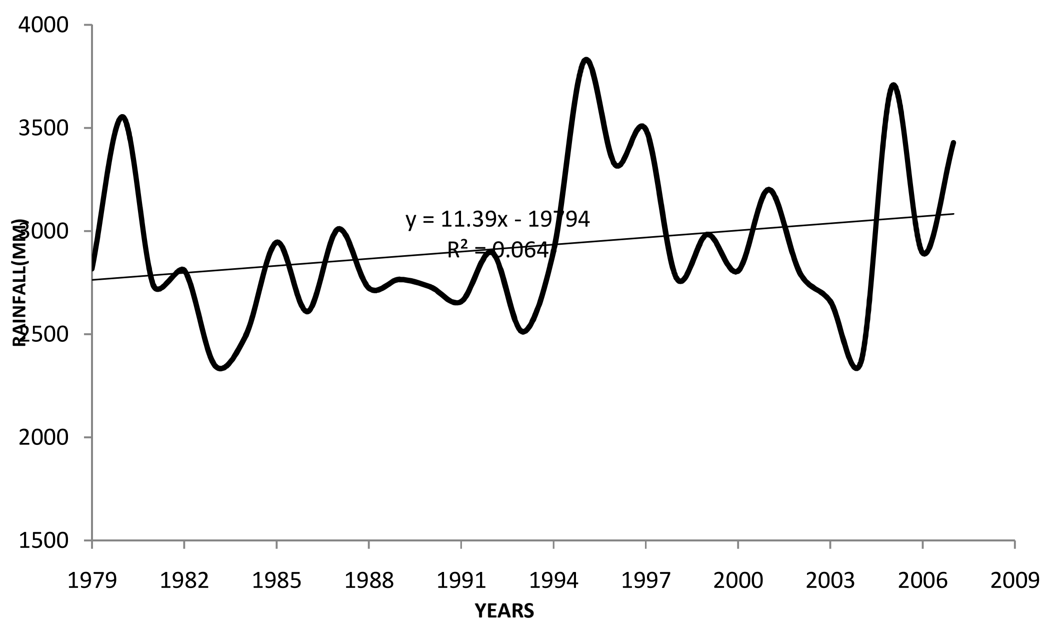

Fig. 9. Trend of rainfall in CALABAR from 1979-2007

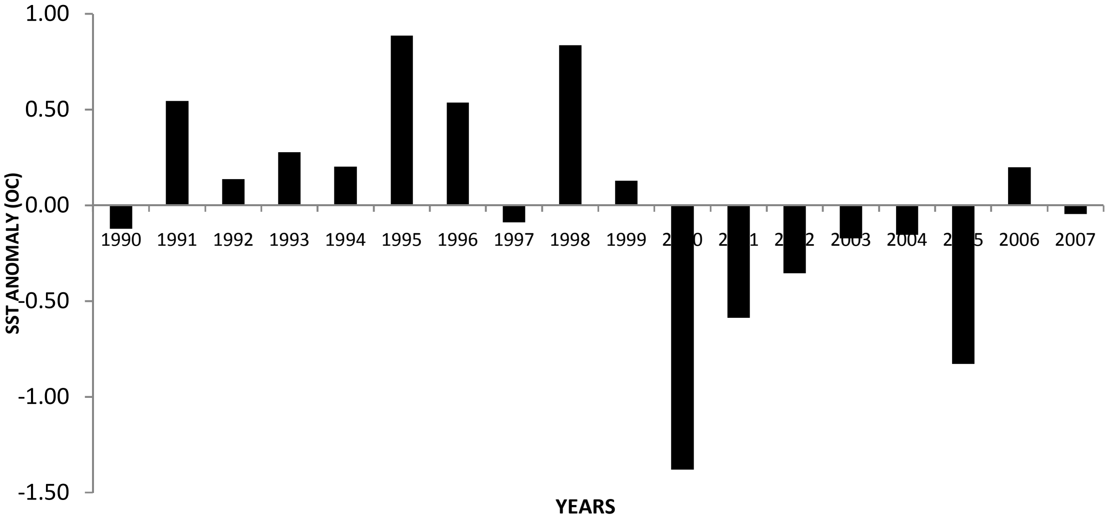

Fig. 10. Eastmole SST anomaly From 1990 TO 2007

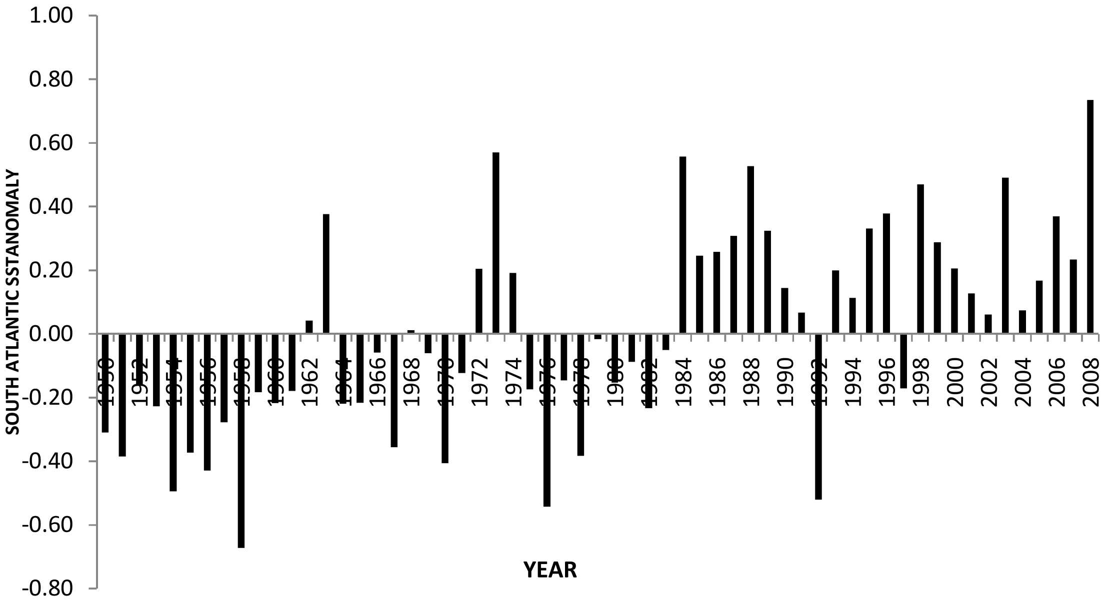

Fig. 11. South Atlantic SST Anomally 1950-2008

There were years that had particularly below normal rainfall without an El Niño event, e.g Portharcourt in 2000, 2005, and Benin in 1985 (Table 1), SST of East mole was found to contradict the claim of El Niño (increased SST) and decreased rainfall, establishing the fact that other factors like thunderstorm, squall lines and Southwest monsoon can lead to below and above normal rainfall in the coastal stations.

3.4 Regression Analysis

Mean SST of December and January, November and December were used. The correlation was found between SST and rainfall of months (April, may and June) (June, July, august and September), and (April- September). The Tables (2-5) below shows the summary of the regressions results of rainfall and SST over the stations. The co-efficient of determination values of 0.30 and above as seen in the table below (Italics) was used in this project as being significant [13,14] a value of 0.197 was also considered in portharcourt. The significant regression graphs were used for validation purpose.

N=November
D=December
J=January
R^2=Co-efficient of determination

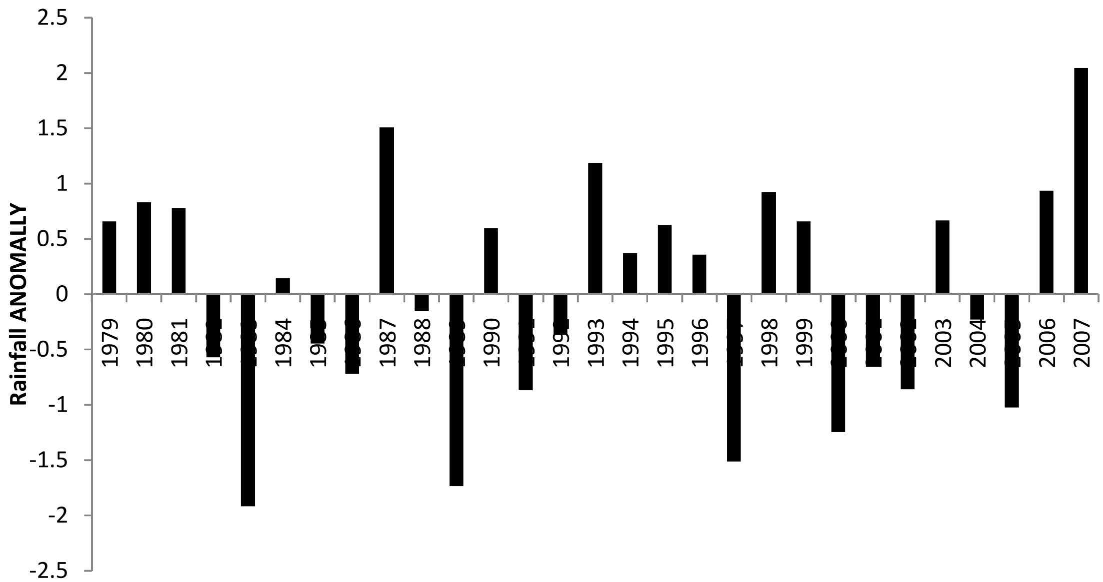

Fig. 12. Portharcourt standardize rainfall Anomally

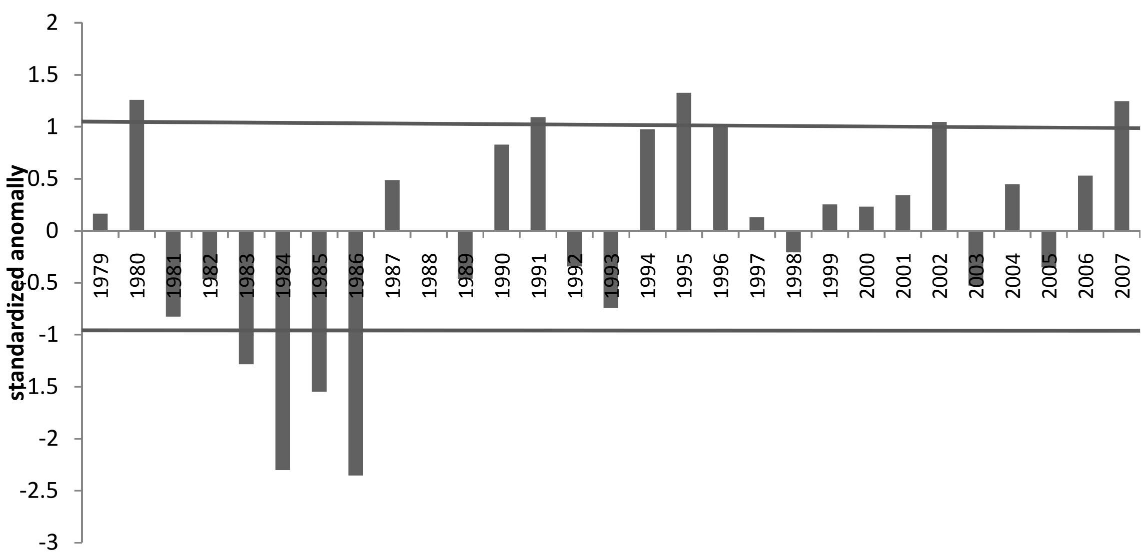

Fig. 13. Benin standardize rainfall anomaly

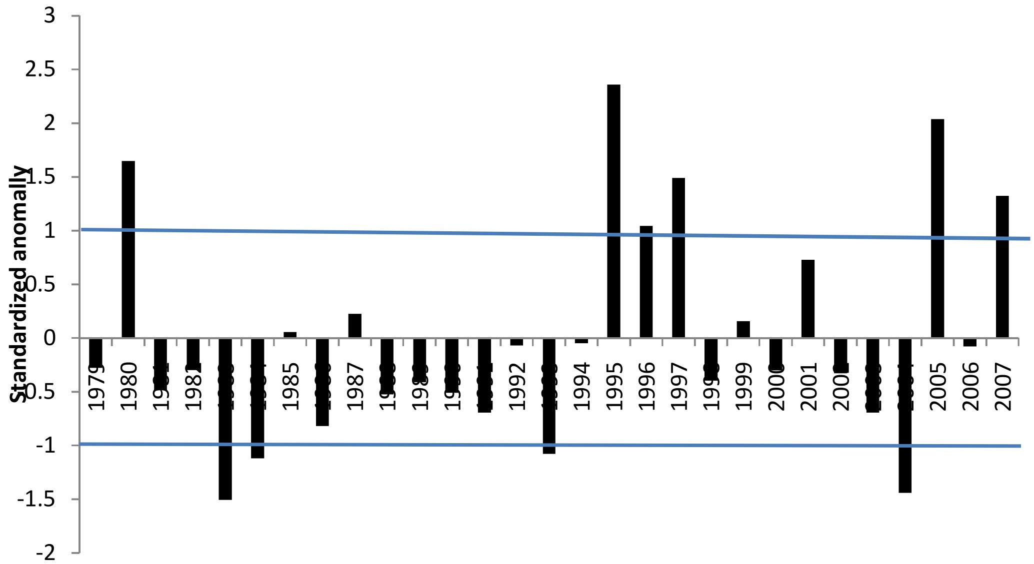

Fig. 14. Calabar standardize rainfall anomaly

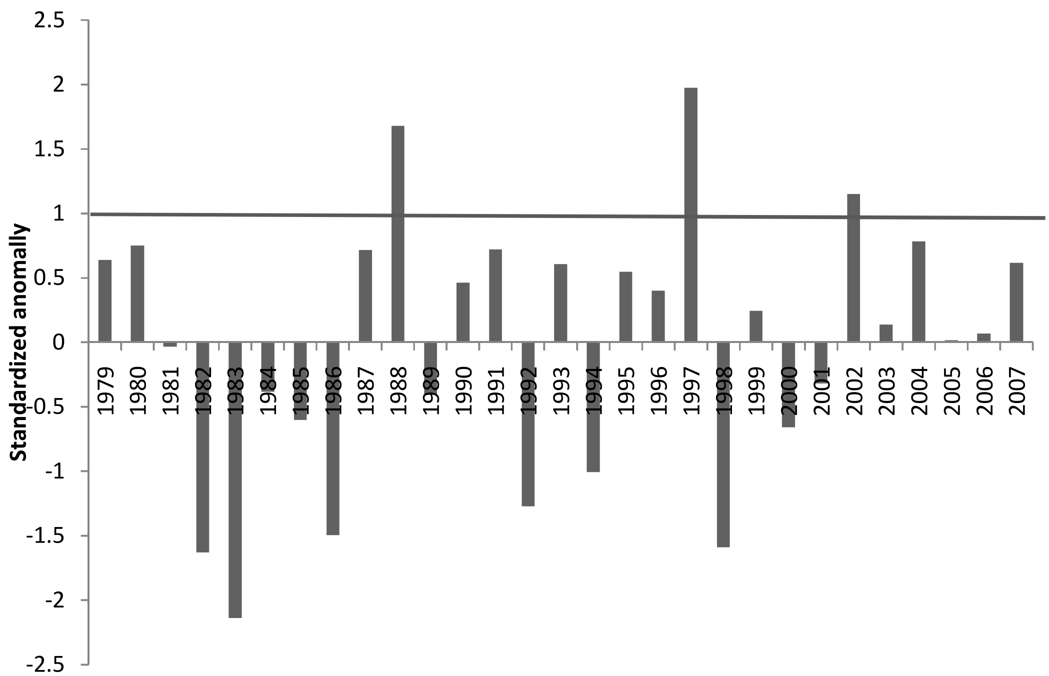

Fig. 15. Lagos standardize rainfall anomaly

Table 1. Above and below normal Rainfall years and the corresponding rainfall years of El Niño

Stations	Years with below normal rainfall	Years with above normal rainfall	Below normal rainfall years showing El Niño
Portharcourt	1983,1989,1997,2000, 2005	1987,1993,2006,2007	1983,1997
Lagos	1982,1983,1986,1992, 1994,1998,	1988,1997,2002	1983,1998
Benin	1983,1984,**1985**,1986,	1980,1987,1994,1995,1996, 2002,2007	1983,1986
Calabar	1983,1984,1993,2004	1980,1995,1995,1996,1997, 2005,2007	1983,1986,1993

3.4.1 East mole

Table 2. R^2 using SST (N+D/2)

Stations	A+M+J	J+JL+A+S	APR-OCT
V-I LAGOS	0.124	0.400	**0.355**
PORTHARCOURT	0.004	0.093	0.042
CALABAR	0.034	0.034	0.064
BENIN	0.000	0.000	0.002

Table 3. R^2 using SST (D+J/2)

Stations	A+M+J	J+JL+A+S	APR-OCT
V-I LAGOS	0.005	0.005	0.000
PORTHARCOURT	0.014	0.002	0.197
CALABAR	0.060	0.067	0.027
BENIN	0.053	0.036	0.037

3.4.2 South Atlantic

Table 4. R^2 using SST (N+D/2)

Stations	A+M+J	J+JL+A+S	APR-OCT
V-I LAGOS	0.038	0.043	0.014
PORTHARCOURT	0.012	0.088	0.008
CALABAR	0.005	0.065	0.069
BENIN	0.097	0.094	0.108

Table 5. R^2 using SST (D+J/2)

Stations	A+M+J	J+JL+A+S	APR-OCT
V-I LAGOS	0.016	0.021	0.004
PORTHARCOUR⁻	0.005	0.021	0.010
CALABAR	0.000	0.037	0.043
BENIN	0.000	0.007	0.015

In Victoria Island Lagos the correlation was 0.64 when the rainfall months of July-September was plotted using the average east mole SST (Nov and Dec) of the previous year.

This was the highest correlation value recorded, and within these four months (July-Sept) period we have the little dry season, when the lowest SST value coincides with the a drop in the coastal rainfall values. For the entire rainy season in Victoria Island Lagos (Apr-Oct), there was a correlation of 0.59 when the entire rainy season was plotted against average East mole SST of Nov-Dec of the previous year.

In Portharcourt there was a correlation of 0.40 when the entire raining season of (Apr-Oct) was plotted against the average of December of the previous year and January of the following year.

3.5 Model Validation

From the regression analysis the significant models were noted (italics), and the model is developed to validate our actual rainfall to see exactly how sea surface temperature can be used to predict coastal rainfall in the study areas. The important models are given below.

N=November, D=December, J=January, JJAS=July-September

1. Rainfall (J+JL+A+S) and East mole SST (N+D/2) IN V-I Lagos

   $RR_{JJAS} = -277.8 * EM_{(N+D/2)} + 8882$

2. Rainfall (APR-OCT) and East mole SST (N+D/2) IN V-I Lagos

   $RR_{APR\text{-}OCT} = -320.3 * EM_{(N+D/2)} + 10625$

3. Rainfall (APR-OCT) and East mole SST D+J/2 IN Portharcourt

   $RR_{APR\text{-}OCT} = 187.0 * EM_{(D+J/2)} - 3290.$

Table 6. Validation

Station (Rainfall)	Year	Actual (mm)	Estimated (mm)	Difference (±)	% of difference
Lagos	2005	1596.6	1438	158.6	**9.9%**
(J+JL+A+S)	2006	894.7	764.7	130	15%
	2007	1022.7	853.6	169.1	17%
Lagos	2005	2313.5	2041	272.5	12%
(Apr-Oct)	2006	1277.9	1265.8	12	**1%**
	2007	1320.5	1368.3	47.8	**4%**
Portharcourt	2005	1712.1	2058.2	346.1	20%
(Apr-Oct)	2006	2328.6	1906.7	421.9	18%
	2007	2447.8	2090	358	15%

Actual = Recorded Rainfall data, Estimated=Rainfall Value gotten from model

The Table 6 above show the summary of the validation, when comparing the actual value (rainfall data's) with the estimated value gotten from the model, the difference and the percentage of correctness was also estimated.

From the above validation table it was discovered after using the model, East mole SST can actually be used to predict rainfall in Lagos since the difference is between the range of ± 20mm and percentage of difference between 1-5% which is still acceptable for prediction. For 2006 in Lagos the value was 1% when validating the length of the raining season (Apr-Oct) and 9% for the period (July-September), but for Portharcourt the difference was high as 421 mm when validating for 2006, therefore cannot be used for prediction. The appreciable value for prediction would be nothing more than 5% of difference.

4. CONCLUSION

Much has been said about the major factors that contribute to rainfall especially in the coast, they include thunderstorm, squall lines, ITD and the Southwest monsoon flow, but sea surface temperature also play a significant role in determining the rainfall of the coastal Nigeria. The trends of SST and rainfall were found to be increasing within the study period. The correlation of SST and rainfall was 0.64 for (Jun-Sept) and 0.59 for (APR-OCT) in Lagos. The correlation was found to be 0.44 For Portharcourt. Validating the models revealed that using recorded sea surface temperature of November and December of a particular year can be used to predict rainfall between June-September and the entire April- October of the following year in Lagos with a difference of ± 20 mm and percentage difference of 1%, 4% and 9.9%. Also East mole SST of December of a particular year and January of the following year can be used to predict the amount of rainfall between April-October of that same year.

This is in agreement with earlier studies [15] in his study indicated some evidences of teleconnection between the ocean sea surface temperature and rainfall). The prediction of rainfall pattern can be made using SST [16,17] and that factors that affect SST such as ENSO which contributes to rainfall pattern [18].

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COMPETING INTERESTS

Authors declare that there are no competing interests.

REFERENCES

1. Lamb PJ. Large tropical Atlantic surface circulation pattern associated with sub-Saharan weather anomalies. Tellus. 1978;30:240-251.
2. Eltahir AB, Gong C. Dynamics of wet and dry years in West Africa. J. Climate. 1996;9:1030-1042.

3. Fontaine B Janicot S. Sea surface temperature fields associated with West African rainfall anomaly types. J. Clim. 1996;9:2935-2940.
4. Nolan I, Nardello G. Westbrook, Lyons K. Analysis of an Irish Coastal sea temperature time series: interannual variability and sensitivity to global influence (1958-2007); 2007. Poster S1.1-4792.
5. Archibong O. Ediang, Edaefinene LE, Ediang AA. The teleconnection between sea surface temperature analysis from *in situ* data at East Mole, Lagos and global warming Poster S1.1-4948. 19 May, 2007. 09:15 (S1.1-4947) Plenary.
6. Edafienene LE, Salahu Y, Afiesimama EA. Sea Surface Temperature Analysis from Situ data at East mole, Lagos proceeding of the 12th Department symposium. Department of Meteorological Services. Lagos, Nigeria; 1997.
7. Lamb PJ. Large tropical Atlantic surface circulation pattern associated with sub-Saharan weather anomalies. Tellus. 1978;30:240-251.
8. Hirst AC, Hasternrah SL. Atmosphere – Ocean mechanism of climate anomalies I Angola tropical Atlantic sector. J Physical Oceanography. 1983;13:1146-1157.
9. Lough JM. Tropical Atlantic sea surface temperature and rainfall Variation in sub-sub Saharan Africa. Mon. Wea. Rev. 1986;114:561-570 .
10. Omotosho JB. The separate contributions squall line, thunderstorm and monsoon to rainfall in Nigeria. Int. J. Climatol. 1985;5:543-552.
11. Ibe AC. Coastline erosion in Nigeria. The Nigerian Institute for Oceanography and Marine Research and A.C. Ibe. Ibadan. University Press, Ibadan, Nigeria (ISBN 978-2345-041); 1988.
12. Hirst A, Linacre ET. Associations between coastal sea-surface temperatures, onshore winds and rainfalls in the Sydney area. Search. 1978;9:325-7.
13. Camberlin P, Janicot S, Poccard I. Seasonality and atmospheric dynamics of the teleconnection between African rainfall and tropical SST. Atlantic vs ENSO. International Journal of Climatology. 2001;21:973-1005.
14. Gbuyiro SO, Olaleye JO. The Teleconnection between Nigerian rainfall and southern oscillation. Proceeding of the 12th Department Symposium. Department of Meteorological Services Lagos, Nigeria; 1997.
15. Ogallo LJ. Rainfall variability in Africa, Mon. Weather. Rev. 1979;107:1133-1139.
16. Afiesimama EA. Variability of Sea Surface Temperature and its Influence on the Rainfall over West Africa. Proceeding of the International Conference on school and polar meteorology and oceanography education. 1997;(22-29): 312.
17. Lamin MT. Statistical seasonal forecast model for the Gambia based on Sea surface temperature, stream function, outgoing long wave radiation, 850 and 925 HPA zonal winds. Journal of the Nigerian meteorological society (NMS). Volume 6 No1.115 Department of water resources Banjul, The Gambia; 2006.
18. Hirst AC, Hasternrah SL. Atmosphere – Ocean mechanism of climate anomalies I Angola tropical Atlantic sector. J Physical Oceanography. 1983;13:1146-1157.

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