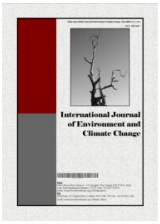

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Validation of Carbon Dioxide and Temperature Distribution in South-South and South-East of Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author GFI designed the draft of the manuscript, performed the analysis and coordination. Author EOE wrote the protocol and supervised the study. Author LOO managed the literature searches and the analyses of the study and author EEA wrote the discussion. All authors read and approved the final manuscript.

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ABSTRACT

The study determined the variations of carbon dioxide and temperature within south-south and south-eastern parts of Nigeria from January 2009 to December 2014. The study specifically focused on the perceived impacts posed by climate change on environment within these regions due to carbon dioxide emissions. The results revealed that rise in temperature within these regions could significantly be dependent on the increase in CO_2 emissions and other greenhouse gases. It was observed that CO_2 emission increases continuously over all the years of study at each station. This could be attributed to high percent occurrences of urban warming experienced in these areas. The results also revealed that various impacts of climate change and weather within these regions could be due to high emission of carbon dioxide caused by fossil fuel, gas flaring etc found within these regions. It was also observed from the results that no gaseous pollutant or greenhouse gas can have 100% influences on climatic parameters like temperature.

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1. INTRODUCTION

Nigerian are experiencing adverse climate conditions with negative impacts on their welfare due to persistent droughts and flooding, off-season rains in a country dependent on a rain-fed agriculture, lakes drying up and a reduction in river flow in the arid and semi-arid regions due to climate change [1]. Knowledge and adequate data on the climatic variations in Nigeria are indispensable for ecological investigation and legitimate planning. Climate change is an undeniable environmental threat of the 21st century which the world is presently encountering and looking for measures to adapt and mitigate its effect. Climate change can be defined as a change which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere over comparable time [2]. Climate change affects life and earth's environment. Around the globe, seasons are shifting, temperatures are increasing and sea levels are rising. Reviews show that the net climate resulting from the change is being driven by atmospheric greenhouse gases [3, 4]. The Germany Advisory Council on climate change has also noted that climate change is a threat already having a substantial impact on humans and natural ecosystem both in developed and developing countries but at varying degrees [5].

Greenhouse gases emissions and sustainability in Lagos Metropolis, Nigeria were studied [6]. He estimated the number of greenhouse gases in the atmosphere in Lagos Metropolis. The result reveals that vehicular movements and air travels have increased by over 50% in the last twenty years. It also stated that greenhouse gases are increasing by the day and recommended that there should be deliberate checks on gas emission from automobiles, plants and machineries and in the aviation industry regularly.

Natural events and human activities are believed to be contributing to an increase in average global temperatures [7]. This is caused fundamentally by an increment in greenhouse gases such as carbon dioxide (CO_2) [1]. These emissions have led to a rise in environmental temperature and changes in related processes [1, 8, 9]. It is global in its causes but its consequences are far more reaching in developing countries particularly Nigeria [10].

The increase in the concentration of greenhouse gases such as CO_2 and methane have been tremendously occurring in the earth atmospheric system over the years. Meanwhile, the concentration of CO_2, has increased significantly in the past few years and this has caused a dilemma on whether changes in CO_2 emissions. This has produced a significant increase in temperature as being globally asserted [11]. According to one of the Nigerian newspapers (Guardian), the average CO_2 emission in Nigeria in the year 2009 was 74.14 million metric tons. They mentioned that this has increased to 80.51 million metric tons in 2012 through the burning of fossil fuel, gas flaring, emissions from combustion engines and other numerous industrial activities [12]. Others include deforestation and clearing of land as well as urbanization and greenhouse gases emission from petroleum products (anthropogenic activities around us) in Nigeria, Anomohanran [13] concluded that the greenhouse gases have been increasing for the past ten years. These gases absorb the radiation in the earth atmospheric system and react with the ozone layer which results in the variation of climatic and temperature in Nigeria. The temperature is the most essential meteorological parameter to determined climate change due to its influence on environmental climatic variation.

The disadvantages of some climate change in the environment such as flooding include; loss of buildings that leads to loss of lives, distortion of the ecosystem, deposition of sewages etc. However, water stagnation caused by flooding in the environment causes wild spread of diseases to humans, animals and plants. Many global issues that are related to CO_2 emission which may be a threat to the environment include temperature variations (temperature increase and decrease), sea-level rise and changes in precipitation [14]. This paper focused on the distributions of CO_2 emission and pattern of temperature variation as it relates to climate change in the South-South and South-East, Nigeria

2. MATERIALS AND METHODS

2.1 The Study Area

The study areas used in this paper were four (4) stations within the South-South and South-Eastern part of Nigeria (Figure 1). The interval

Table 1. Coordinates of the selected Stations and their Data Points over Nigeria

Points	Y Latitude(^{o}N)	XLongitude(^{o}E)	State
1	4.59	5.84	Bayelsa
2	4.25	7.25	Rivers
3	5.75	5.75	Delta
4	5.75	7.25	Imo
5	5.75	8.75	Cross River

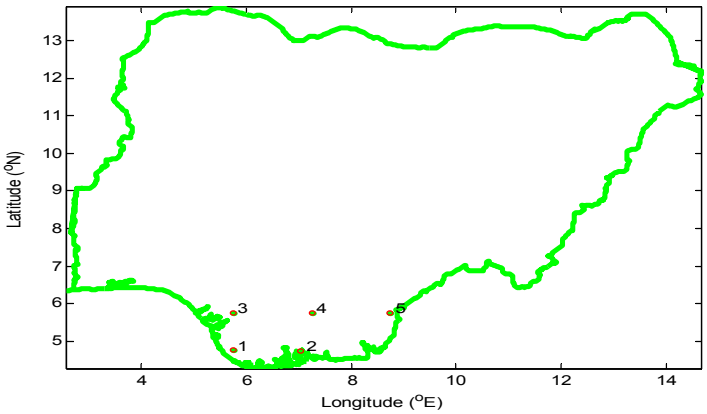

Fig. 1. Map of Nigeria showing data points for the selected stations in South-South and South-East

between one point and another is 1.5 ^o, where 1 ^o represents about 111 km. Table 1 shows the coordinates of the selected points station.

2.2 Sources of Data

Two satellite data sets were employed on this paper. The carbon dioxide and temperature data respectively were obtained from the website www.gmes-atmosphere.eu/data and http://www.esrl.ncep.gov/csfr/data. The data covered a period of six (6) years; from January 2009 to December 2014. This paper considered only the satellite data because the ground-based data of greenhouse gases measurement was unavailable in Nigeria within the period of this study.

2.3 Methods

The CO_2 and temperature data collected for all the period considered were in NetCDF format which was extracted and converted to binary format, sorted and merged to file using MATLAB software program. The CO_2 and temperature data collected were all daily data. The daily data were processed to monthly to determine the monthly variations. It was also converted to annual data.

3. RESULTS AND DISCUSSION

Figures 2 and 4 presents the line graphs of average yearly data of carbon dioxide and temperature distributions from 2009 to 2014 of South-South and South –East (Delta, Rivers, Imo and Bayelsa states) of Nigeria. The average yearly data of column graphs for carbon dioxide and temperature variations between 2009 and 2014 are presented in Figures 3 and 5, respectively.

The above results reveal the variations in temperature and carbon dioxide emission within the South-South and South-Eastern regions of Nigeria. The yearly data of CO_2 depicted in Figures 2 and 3, respectively show that within the years under consideration, there is continuous yearly increase in CO_2 over all the five stations investigated. This could be as a result of burning of fossil fuel, gas flaring, emissions from combustion engines and other numerous industrial activities, deforestation and clearing of

land as well as urbanization. Figures 2 and 3, respectively also revealed that the preceding rise within the five stations is between 375 ppm and 395 ppm. In all the years River State was recording the highest value which may be as a result of gas flaring at offshore exploration sites within this region.

The yearly data of temperature depicted in Figures 4 and 5, respectively show that there was increase in temperature from 25°C to 30°C within the years considered. It was revealed that Delta and Imo states temperature values were higher than that of Baysela state and River State between the year 2009 and 2013. In the year 2014, however, Delta and Bayelsa States recorded higher value than River State and Imo state. Meanwhile, the higher temperature value observed in Delta state over all the years considered may be connected to the present of other greenhouse gases (methane) that have the tendencies of influencing temperature aside carbon dioxide.

From the results, it could be said that no gaseous pollutant or greenhouse gas can have 100% influences on climatic parameters like temperature. This agrees with the work by Tuller [15] who asserts that most effects on climatic variations do not involve a single parameter but are the synergy result of multiple of parameters.

Figure 6 depicts the monthly variation of CO_2 for the year 2009. The plot shows that River State recorded the highest value of about 384 ppm while Imo state has the lowest value of about 378ppm. The monthly variation of temperature for the year 2009 as showed in Figure 7 reveals that the highest and lowest temperature values of about 32°C and 22°C, respectively were observed in Delta.
Figure 8 shows the plot of monthly variation of CO_2 for 2010. The result shows that the highest and lowest values of about 390 ppm and 380 ppm, respectively were recorded in Rivers and Delta. The temperature monthly variation depicted in Figure 9 revealed that Delta has the highest value of about 31°C and River State recorded the lowest value of about 22°C.

Figure 10 depicts the monthly variation of CO_2 for 2011. The result shows that Bayelsa has the highest value of about 392ppm and Imo recorded the lowest value of about 382ppm. The variation of temperature presented in Figure 11 revealed that the highest and lowest value of about 29°C and 18°C, respectively was recorded in Imo and River State.

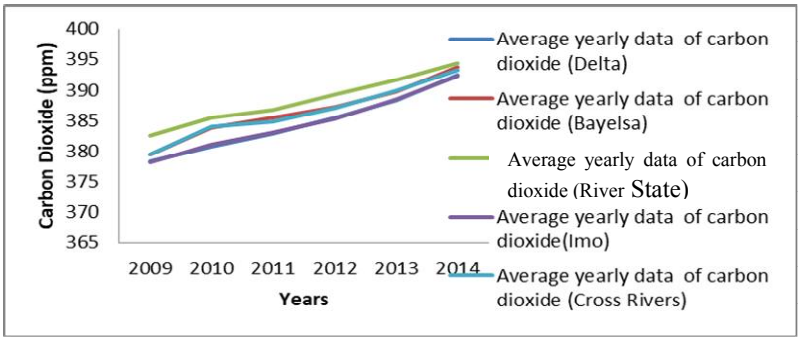

Fig. 2. Graph of average yearly data of carbon dioxide (2009 - 2014)

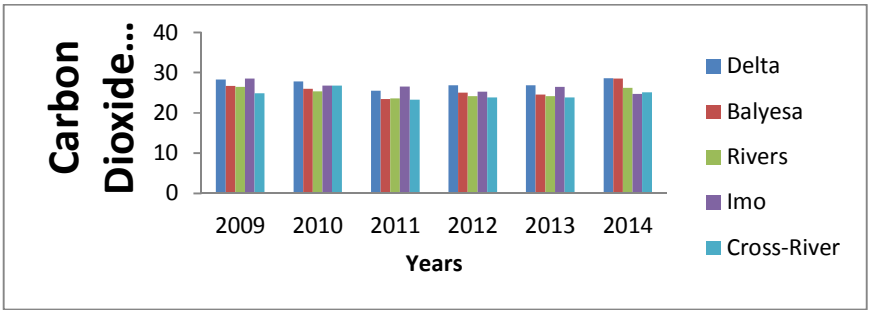

Fig. 3. Column of Average Yearly Data of carbon dioxide (2009 - 2014)

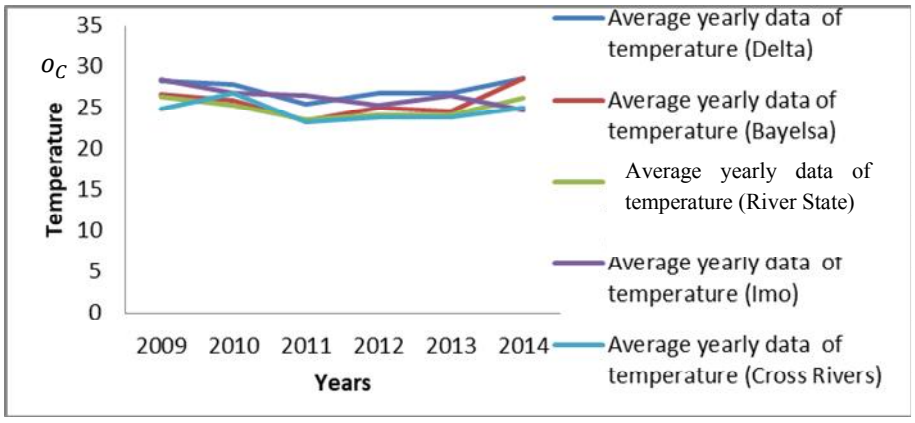

Fig. 4. Average yearly data of temperature (2009 - 2014)

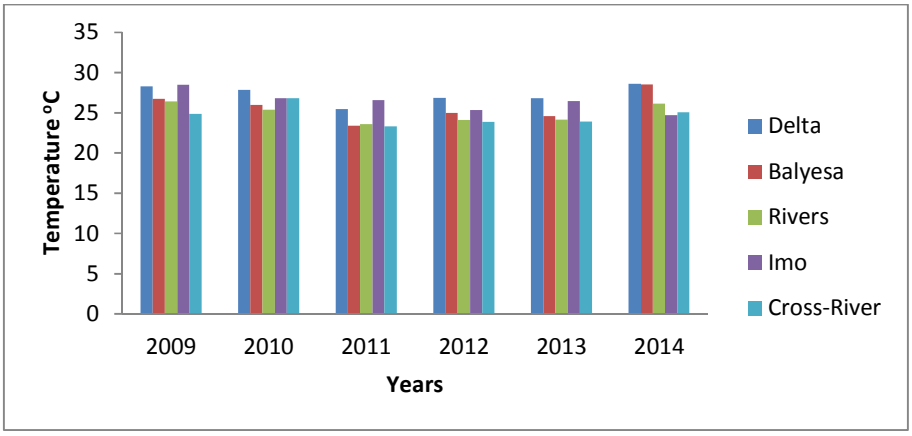

Fig. 5. Column of Average Yearly Data of Temperature (2009-2014)

Figures 6, 8, 10, 12, 14 and 16 are the monthly distributions of average monthly data of carbon dioxide emissions for Delta, Rivers, Imo and Cross-Rivers States. The monthly average variations of temperature are presented in Figures 7, 9, 11, 13, 15 and 17, respectively.

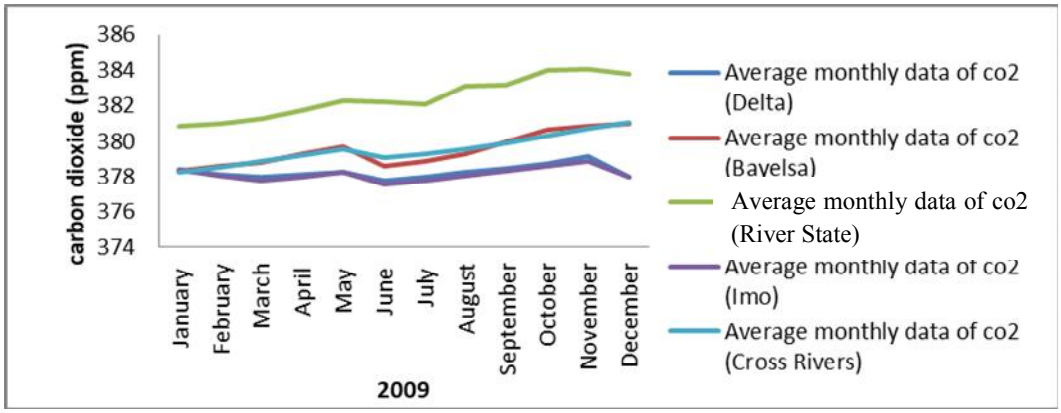

Fig. 6. Average monthly data of carbon dioxide

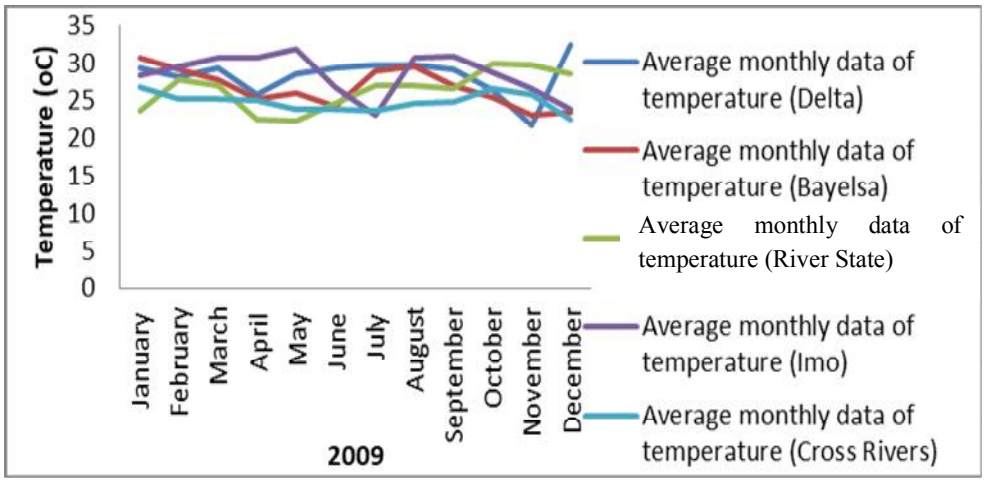

Fig. 7. Average monthly data of temperature

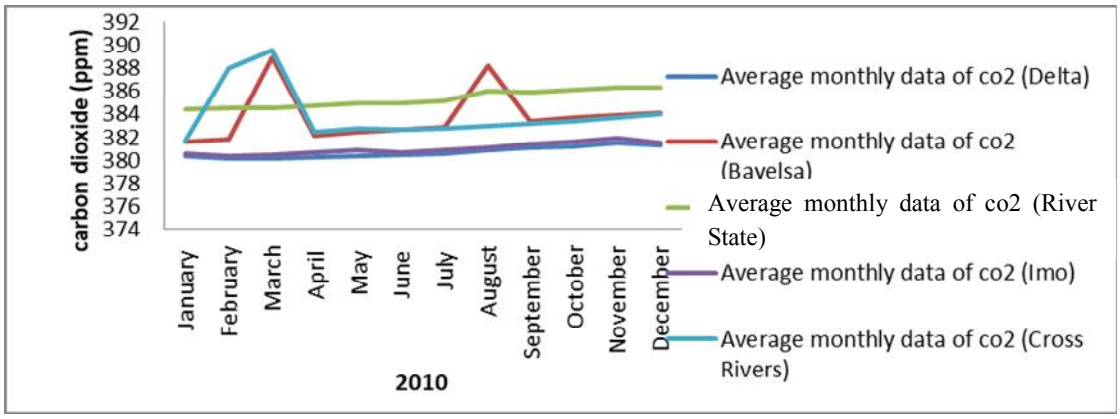

Fig. 8. Average monthly data of carbon dioxide 2010

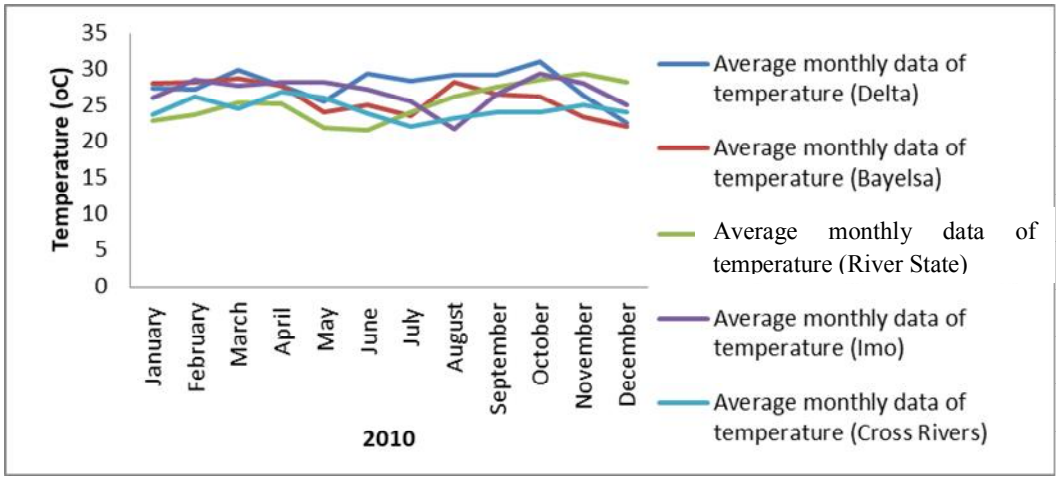

Fig. 9. Average monthly data of temperature

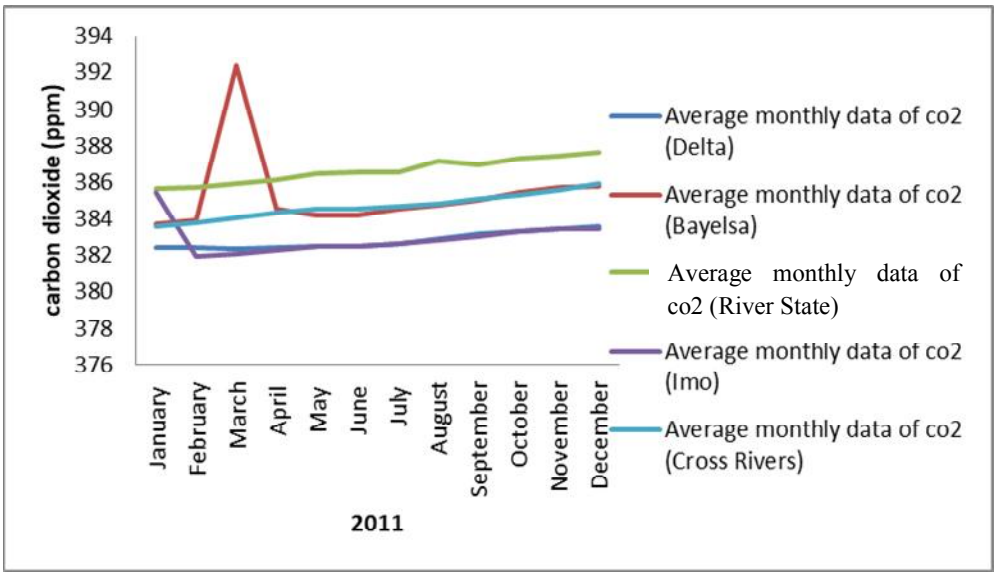

Fig. 10. Average monthly data of carbon dioxide

Figures 14 and 15, respectively presented the monthly variation of CO_2 and temperature for the year 2013. Figure 14 show that River State and Imo recorded the highest and lowest values of CO_2 of about 392ppm and 388ppm, respectively. Figure 15 revealed that Delta and Cross Rivers recorded the highest and lowest temperature values of about 29°C and 21°C, respectively.

The monthly variations of CO_2 and temperature for the year 2014 are presented in Figures 16 and 17 respectively. The results showed that while River State and Bayelsa recorded the highest values of about 395ppm and 32°C of CO_2 and temperature, respectively, Imo recorded the lowest CO_2 and temperature values of about 392ppm and 18°C, respectively.

It is interesting to observe from the result that CO_2 increases yearly at all the stations considered. This could be linked to contribution to rise in temperature and climate change in the region and Nigeria.

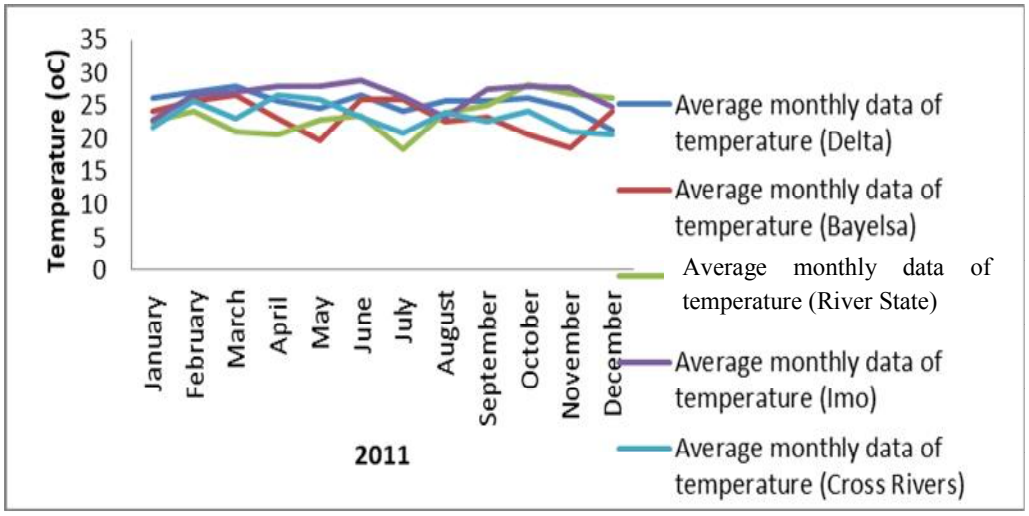

Fig 11. Average monthly data of temperature

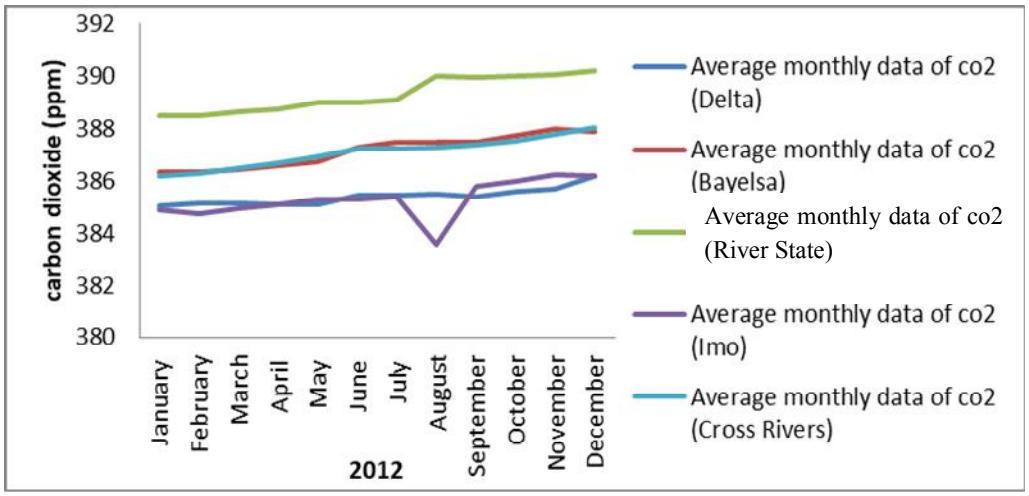

Fig.12. Average monthly data of carbon dioxide

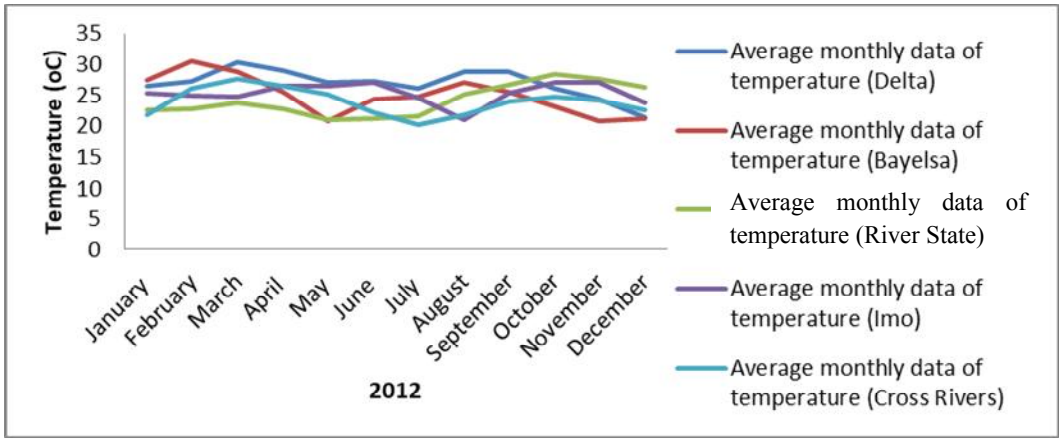

Fig. 13 Average monthly data of temperature

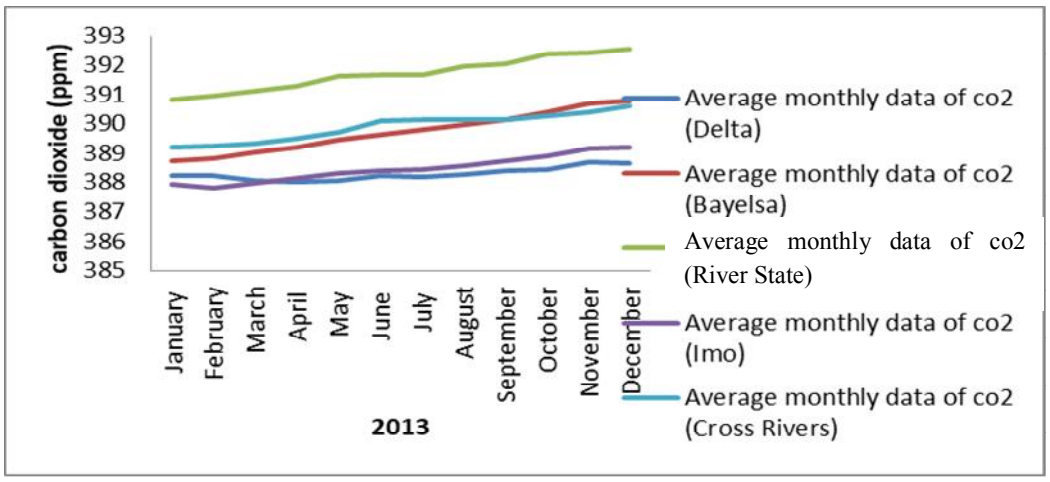

Fig. 14. Average monthly data of carbon dioxide

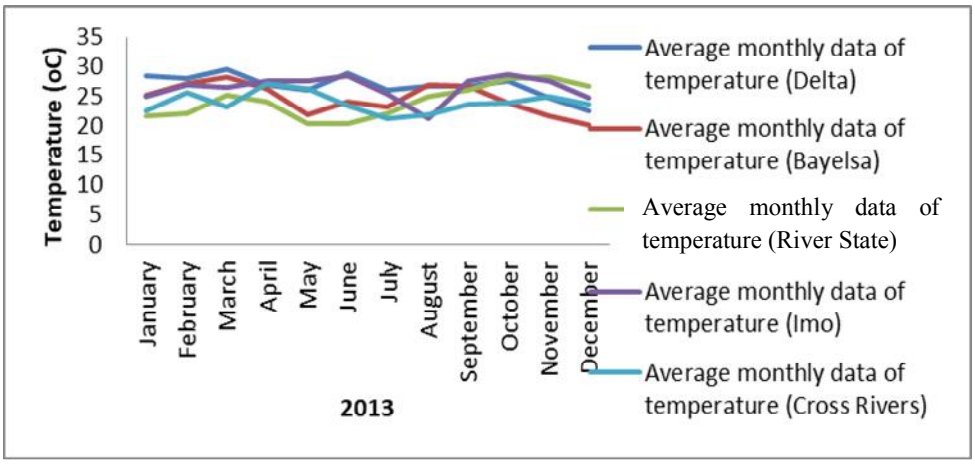

Fig. 15. Average monthly data of temperature

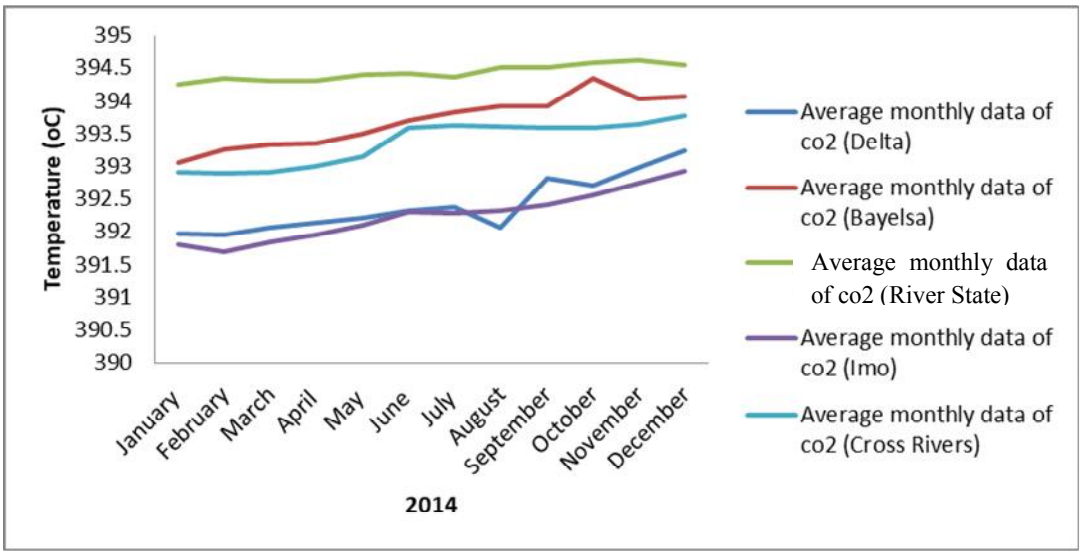

Fig. 16. Average monthly data of carbon dioxide

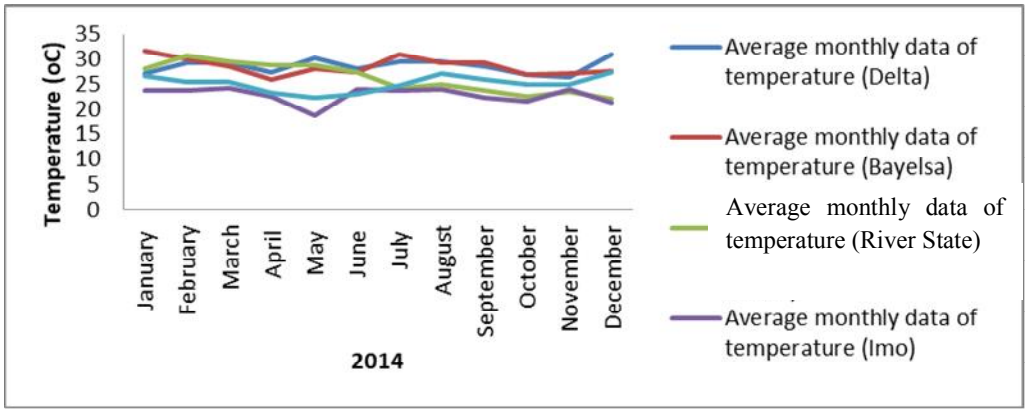

Fig. 17. Average monthly data of temperature

4. CONCLUSION

The study showed the variations of temperature and carbon dioxide emissions from 2009-2014 within South-South and South- East, Nigeria. The results revealed that rise in temperature over all the stations investigated could significantly be dependent on increase in CO_2 emissions in these areas. It was observed that CO_2 emissions increase continuously within the years of study at each station. This could account for high percent occurrences of urban warming experienced in South-East and South-South, Nigeria. It was also observed that various impacts of climate change and weather within these regions could be attributed to high emission of carbon dioxide caused by numerous industries found in these regions. Among others, these includes; burning of fossil fuel, gas flaring, emissions from combustion engines, deforestation and clearing of land as well as urbanization resulting to environment hazards like flooding and many other industrial activities.

Finally, it was revealed from the results that no gaseous pollutant or greenhouse gas can have 100% influences on climatic parameters like temperature.

Arising from the discussions, the study therefore recommends the adoption of green city green roof approach; extinguish gas flaring in oil producing cities, carbon sequestration/carbon capture, massive afforestation, and the implementation of environmental impact assessment. All these activities if implemented will lead to an increase of carbon sinks, an increase of the air buoyancy and fresh air, and reduces the surface temperature of the region.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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