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Trend Analyses Of Rainfall Patterns In Nigeria Using Regression Parameters

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Abstract: Rainfall data collected by the Nigerian Meteorological Agency, Oshodi over a thirty - year period and from twenty three weather measuring stations were used for the study. This covered the period between January 1997 and December 2007. Regression equations were generated for each of the ten parameters in each station. Regression constants **a** and **b** were therefore extracted from these equations. The regression parameters which are reported in the form of tables show that the constant **a,** which is a reflection of the trend of the parameter lies between 0.006 and 0.230 while **b** lies between 35.81 and 228.5. Monthly mean daily total rainfall shows marked latitudinal dependence as can be seen in the positive slopes of the graph of **b** against latitude in Figure 2. Hence, rainfall shows consistent increase during the thirty years of this study. Constant **b** which is an indication of the volume of rainfall shows strong latitudinal dependence. We observe that the parameter decreases with latitude at the rate of 18.87 per degree rise in latitude. The correlation between latitude and parameter **b** is 0.92. The lowest values of Monthly mean values of rainfall as shown by constant **b** are in katsina which is in the far North and the highest values were in Calabar located in the far South. Katsina stands out as the lowest rainfall station while Calabar has been identified as having the highest rainfall in Nigeria.

Key Words: Trend Analyses, Rainfall Patterns, Regression Parameters, Nigeria

1.0 Introduction

Precipitation is any form of water (either liquid or solid) that falls from the atmosphere and reaches the ground, such as rain, snow, or hail. In Nigeria the major form of precipitation is rainfall. Because of its location in the low pressure zone of the earth and its proximity to the Atlantic Ocean in the South, Nigeria experiences heavy rainfall especially in the southern part of the country. This why rainfall in Nigeria is latitude dependent Rain gauges are used to measure rainfall. The standard rain gauge used by the Nigerian Meteorological Services consists of a funnel-shaped collector that is attached to a long measuring tube. Modern day rain gauges are automated with memory systems to measure various aspects of rainfall such as the rate of rainfall; daily, weekly and monthly totals (Newman *et al.*, 2006; Agbor et al 2013; Ewona et al 2008, 2009, 2013, Udoimuk et al 2014). Significant changes in rainfall have occurred both in pattern and seasonality. Incidentally rainfall is an important index in climate change considerations. Climate change is now a common feature even in ordinary village discussions(Ewona et al 2013, 2014; Agbor et al 2013; Ojar et al 2014; Udoimuk et al 2014). The possibility for rapid and irreversible changes in the climate system exists, although there is a large degree of uncertainty about the mechanisms involved and hence also about the likelihood or time-scales of such transitions (Osang et al 2013; Obi et al 2013; Ushie et al 2014). The climate system involves many processes and feedbacks that interact in complex nonlinear ways. This interaction can give rise to thresholds in the climate system that can be crossed if the system is perturbed sufficiently. The frequency of extreme precipitation events is projected to increase almost everywhere. Precipitation extremes are projected to increase more than the mean and the intensity of precipitation events are projected to increase also (Udo,2002; IPCC, 2007; Osang, et al 2013, Ushie et al 2014). Oladipo (1995) reported that decline in the rainfall in Nigeria started in the beginning of the 1960s when a decade of relatively wet years ended. According to him, the persistence of below-mean rainfall in the last two decades before 1995 in Nigeria is an indication of an abrupt change in climate. The agricultural sector is highly sensitive to rainfall pattern especially in southern Nigeria where rain-fed agriculture is mainly practiced (NOAA, 2008; Osang et al 2013; Udoimuk et al 2014). Changes in the rainfall pattern in Nigeria are greatly affecting the agricultural productivity in the region. Farmers in the region begin cultivation at the beginning of the rainy season. They plant their crops as the rain begins to fall in April (Okecha, 2003 and Ewona and Udo, 2008; Osang et al 2013; Udoimuk et al 2014; Obot et al 2010). Anticipated and continuous warming of the climate system increases the need for accurate climate projections. The problem, however, is associated with the large uncertainties in these model projections. Sometimes the problem is that these estimates are based on expert judgment rather than on objective quantitative methods. Further, important climate model parameters are still given as poorly constrained ranges that are partly inconsistent with the observed data (Knutti et al, 2003; Osang et al 2013; Udoimuk et al 2014). The unpredictability of clouds as one of the greatest modulators of climate has brought about great difficulty in the modeling of climate in two ways. One, the presence of clouds increases surface albedo meaning that solar radiation, the major forcing function of climate is drastically attenuated and two, clouds reradiate and absorb energy in the form of infrared radiation. And infrared radiation is one basic factor responsible for surface temperature rise and climate change. Yet clouds can rise and decline within a matter of minutes which further complicates climate forecast (Udo 2002; Udo et al 2008. 2009; Ewona et al 2013; Osang et al 2013; Udoimuk et al 2014). In this paper, the monthly mean rainfall data in the period of 1997-2007 from 23 rainfall monitor stations in Nigeria. This were carefully selected to ensure even distribution across the country except where weather stations were not available. Predictive mining is a task that is performed to make inference on the current time series data in order to make a prediction. A monthly mean rainfall

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data can be grouped as a time-series set because it consists of sequences of values occurring chronologically in time. The analyses of a large volume of data taken chronologically over a long period of time requires time series analyses to process the data. A time series is generally a sequence of observations, which are ordered in time or space, and such observations, which are made throughout time, are best displayed in the order in which they arose particularly when successive observations may be dependent (McDonnel and Newell, 1962 and Ewona and Udo,2008; Osang et al 2013; Udoimuk et al 2014). To forecast time-series data involves using the past history of the data and extrapolating it to the future. Although the general characteristic of rainfall is non – linear, the monthly mean data can show some linear characteristics. Fallah-Ghalhary, et al, (2009). Considering the significance of rainfall in many decision making processes such as water resource management, agriculture and climate change, the present study aims to find out the trend of rainfall in Nigeria from North to South. Priestley (2005) has observed the increasing frequency at which this branch of Mathematical Statistics is being employed in data analyses. The problems brought about by climate change and global warming in particular have made it mandatory for Scientist and climatologist in particular to take a more critical look at the way climate data vary with time in order to offer acceptable explanation on why and how the earth's climate is changing the way it does. The mathematical analysis of dynamic systems has been a matter of concern for several years until the invention of the digital computer. There was particularly the concern of time series experts whose work required large volume of data. Advances were later made in the field of control theory based on state-space concepts and time domain analysis. This triggered more interest in time series analysis and in particular predictive techniques (Enders, 1967)

2.0 Method

- Monthly mean data that were missing were estimated by interpolation or other means used in Ewona and Udo (2008).
- A year with missing data for more than two consecutive months was excluded in the analysis. This follows the method applied by Dugas and Heuer (1985).
- The monthly mean data were spread out as one continuous string of data from month 1 year 1 to month 12 year n. Where n is the number of years used in the study of the parameter in question to enable trend analysis to be performed on them using SPSS statistical package.
- Regression equations were generated for each of the ten parameters in each station from where regression constants **a** and **b** were extracted.

3.0 Goegraphy of the area

The Nigerian meteorological environment has a network of over forty - five data collecting stations which measure parameters such as: Minimum and maximum temperature, rainfall, relative humidity at 9.00hrs and 15.00hrs GMT, evaporation, cloud cover, wind speed and direction, and solar radiation. There are more stations in the South perhaps because of its higher population density and the climate seems to be more complex. In this study ten parameters taken from twenty-three stations evenly selected across the country except were they are sparsely located are used for the analyses. Figure 1 shows the distribution of stations selected for the study. These include: Yelwa, Sokoto, Kaduna, Katsina and Kano in the North West; Bauchi, Maiduguri and Yola in the North East; Minna, Abuja, Lokoja, Jos, Ibi and Ilorin in the Middle Belt; Lagos, Ibadan, Ondo, Binin and Warri in the South West; and Calabar, Port Harcourt, Enugu and Owerri in the South East. The eastern axis of the middle belt has limited stations, hence no stations were available at the extreme end of the belt as shown in Figure 1.

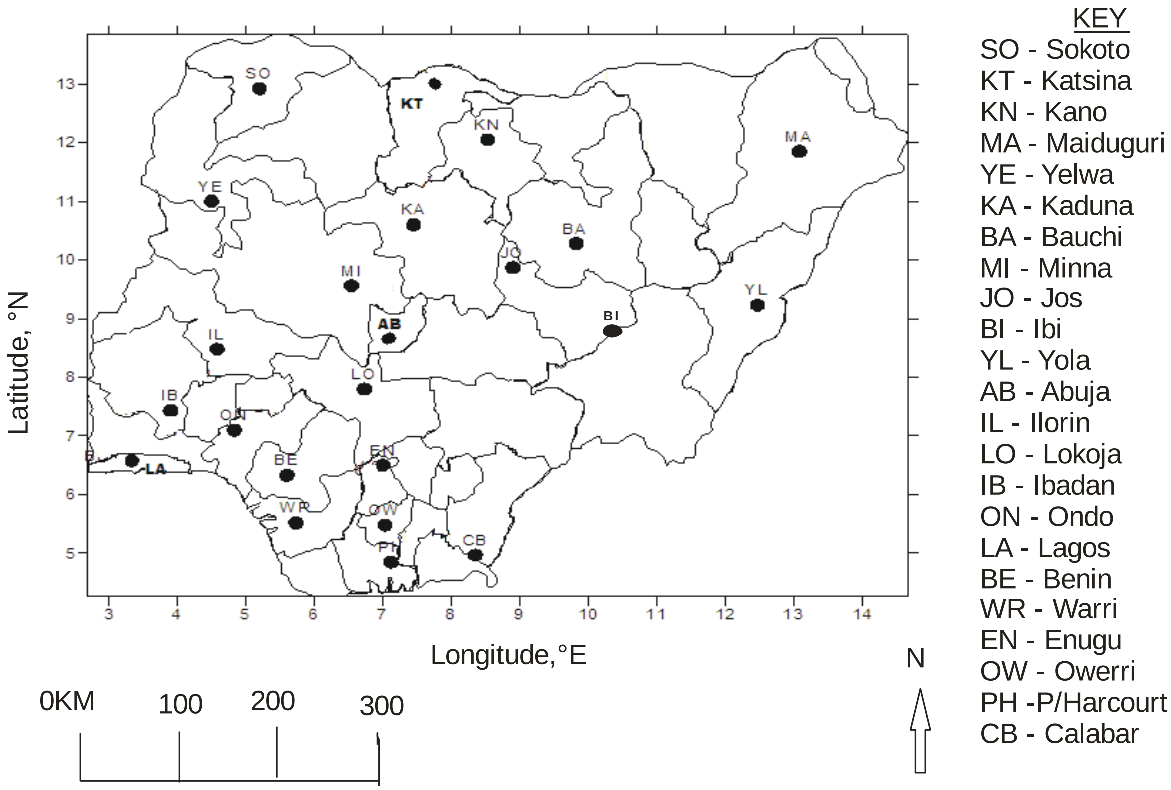

FIG.1 Map of Nigeria showing selected meteorological locations for the study.

4.0 Trend analyses

Tables 1 show basic variations in the regression parameters for rainfall in all 23 stations used for the study. Results show that the regression constant **a** is clearly positive for monthly mean daily total rainfall in all the stations**.** The regression parameters which are reported in the form of tables show that the constant **a,** which is a reflection of the trend of the parameter lies between 0.006 and 0.230 while **b** lies between 35.81 and 228.5. Monthly mean daily total rainfall shows marked latitudinal dependence as can be seen in the negative slope of the graph of **b** against latitude in Figure 2. Hence, rainfall shows consistent increase during the thirty years of this study. Constant **b** which is an indication of the volume of rainfall shows strong latitudinal dependence. We observe that the parameter decreases at the rate of about 18.87 per degree rise in latitude. Constant **a** however shows no latitude dependence but may depend on environmental factors such as relief and vegetation. The lowest values of Monthly mean daily total rainfall as shown by constant **b** are in katsina which is in the far North and the highest values occur in Calabar located in the South. Katsina therefore stands out as the lowest rainfall station with Calabar as the highest rainfall bearing city in Nigeria.

Table 1: Regression parameters for monthly mean daily total rainfall

STATION	LATITUDE	RAINFALL	
		a	b
KATSINA	13.38	0.035	38.04
MAIDUGURI	13.17	0.069	35.81
SOKOTO	13.07	0.051	43.43
YOLA	12.45	0.024	71.13
KANO	12.00	0.230	41.00
YELWA	10.97	0.062	72.13
KADUNA	10.52	0.026	107.70
BAUCHI	10.30	0.034	78.16
JOS	9.92	0.014	100.40
IBI		0.034	92.65
MINNA	9.96	0.053	91.65
ABUJA	9.18	0.064	106.30
ILLORIN	8.50	0.006	97.40
LOKOJA	7.72	0.054	92.55
IBADAN	7.37	0.016	112.60
ONDO	7.10	0.022	142.70
LAGOS	6.50	0.029	143.60
ENUGU	6.45	0.055	136.00
BENIN	6.32	0.110	159.90
WARRI	5.68	0.021	226.00
OWERRI	5.50	0.009	197.90
CALABAR	4.95	0.088	228.50
P/ H	4.68	0.028	188.30

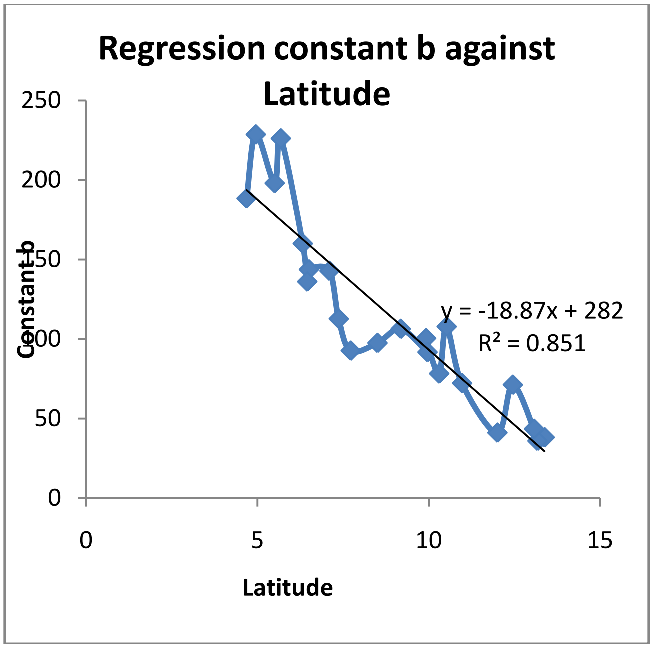

FIG2: Graph of regression constant b against Latitude

The negative slope of 18.87 of the trend line in figure 2 shows that that monthly mean daily total rainfall falls at the rate of 18.87mm per degree rise in latitude. Apart from environmental effects such as relief features and pollution latitudinal dependence play a key role in the determination of at the amount of rainfall in Nigeria. Hence latitudinal factors are essential in the prediction of rainfall in Nigeria. We observe that the correlation between latitude and regression parameter **b** is about 0.92 and this is a significant relationship.

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