Diurnal and Interannual Variability of Rainfall in Nigeria Climatic Zones as Seen from In-situ and Satellite Measurements

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Abstract
Rainfall has been considered as a key indicator of changes in the climate and important factor of flood. Its measurements are important for climate change assessment on the water cycle and water balance of the world while her intensities monitoring are necessary for flood predictions. This study investigated the variation of Rainfall Intensity and Rainfall depth in Nigeria climatic zones and to predict the reoccurrence of such type of rainfall for planning purposes. The climatic zones of Nigeria were grouped into four; Coastal, Rain forest, Savannah and Sahel. The Rainfall data used in this study were collected in five minutes average for rainfall intensity for years 2007 to 2015 from Centre for Atmospheric Research (CAR-NASRDA) using Automatic Weather Stations and Tropical Rain Measuring Mission (TRMM) of NASA while monthly rainfall depth of 1980 to 2010 from Nigeria Meteorological Agency (NiMet). The Intensity was converted from mm/5mins to mm/h followed by diurnal values over the months and annual rainfall amounts were derived from the monthly rainfall depth for variability and probability analysis. Statistical analyses were performed using SPSS package to further ascertain the deviations from normal rainfall pattern. The Result shows that short and violent rain (> 50mm/h) are more frequent in the Savannah and Sahel zones compared to Rain forest and Coastal zones where prolonged and light rain (< 2.5mm/h) persist. The Coastal zone experience the highest precipitation of 2823.50 mm while the least precipitation of 925.70 mm occurred in the Sahel during the period considered with some fluctuations within the zones. The decadal wetter trend zone is the Sahel with an increment in rainy of more than 200mm and other zones rainfall increase by nothing less than 50mm of rain since 1980s. The occurrence of yearly rainfall like these could be predicted using the probability curve generated from the annual rainfall values.
Keywords: rainfall, climatic zones, intensity, depth, probability

1. Introduction

Rainfall is the primary source of water and major component of the water cycle for most human activities in the world. The total rainfall received and its intensity in a given period at a location is highly variable from year to another. The variability depends on the type of climate and the length of the period considered (Bibi, *et al.* 2014; Ajibla, *et al.*, 2016). The climate of a location can be understood easily in terms of annual or seasonal averages of temperature and precipitation. Detecting the trend and periodicity of observed rainfall data is a meaningful method in the study of climatic and hydrological changes (Olusola *et al.* 2015). Long-term time analysis are important because it allows the study of climatic changes using real observation or the reconstruction of longer series using different mathematical tools (Li *et al.* 2012). The global climate has been reported to change rapidly with the global mean temperature increasing by 0.7^{o}C within the last century and erratic increase or decrease in rainfall. However, the rates of change are significantly different among regions (IPCC, 2013).

Rain is of three basic types and the most common type in the tropic such as Nigeria is convectional rainfall which depends on some meteorological variables influenced mostly by West Africa monsoon (WAM) and nature of land surface (Bibi *et al*., 2014). It is important to understand the climatic variability of rainfall locally in term of space, duration, intensity, and depth with the effects on both human and ecosystem. Rainfall intensities are generally characterized into four ranges. Light and moderate of intensity less than 5mm/h and 10mm/h respectively, heavy of 10m/h to 50mm/h, and extreme rainfall, greater than 50mm/h (Ajibola *et al*., 2016). It is of various frequencies and durations which can serves as an input in hydrologic design and rainfall-runoff models. Precipitation frequency analysis can be used to estimate rainfall depth at a location for a specified exceedance probability and duration (Ramanchandra Rao and Shih-Chieh, 2006).

In Several studies have proved that heavy and extreme rainfall are the major cause of flood worldwide (Folland *et al.* 1986). Other studies have identified the characteristics of extreme rainfall that are associated with flood frequency to include duration, intensity, frequency, seasonality, variability, trend and fluctuation (Ologunorisa, 2001), others include less predictable events such as Tsunami and Storm surges. The study of diurnal and seasonal variability of rainfall in sub-Sahel (Ilorin) has been carried out by Pinker, *et al.* (2006). They concluded that satellite estimates agreed with ground observation in terms of inter-annual variability but satellite overestimates the ground observed rainfall. The changes in Rainfall characteristics in northern Nigeria has been analysed by Terhule and Woo (1998) using rainfall depth, intensity and rain days. Their study suggests annual rainfall reduction from 1965 onward which is due to low occurrence of high intensity rainfall. All

Temporal and spatial trends were investigated on Nigeria's rainfall and temperature data by Akinsanola *et al.* (2014) and their results show evidence of warming in some locations in the Country with alternating decreasing and increasing trends in precipitation and air temperature.

This study is aimed at analysing the short term rain intensity and the long term rainfall depth in Nigeria climatic zones to be able to understand dominant intensity and predict the re-occurrence of the rainfall depth for water management and planning in the country.

2. Data and Methods

2.1 Study Area

Nigeria lies between 4^{o} and 14^{o} N latitude and longitude 4^{o} to 14^{0} E. It is bounded in the north by Sahel and Sahara desert and by the Atlantic Ocean in the south. The Nigerian climate is characterized mainly by movement of Inter-tropical Discontinuity (ITD) Zone. The major climatic zones are Coastal, Rainforest, Savannah and Sahel. The major rivers are River Niger and River Benue while the two major lakes are Kainji (artificial) and Chad (natural) Lakes.

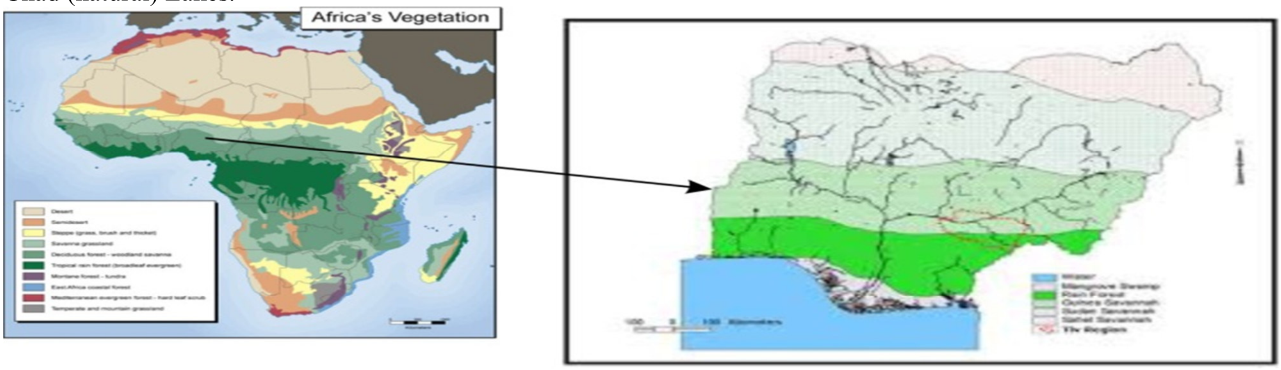

Figure 1. Study Area

2.2 Instrumentation

2.2.1 TRODAN Equipment

Tropospheric Data Acquisition Network (TRODAN) is a network of fully configured automated weather station powered by solar panel over Nigeria. It consists of Campbell Scientific data logger, 12V battery and charge controller with many Atmospheric Parameter Sensors such as rain rate, relative humidity, temperature, etc. The equipment records average data at 5 minute intervals.

2.2.2 TRMM

Tropical Rains Measuring Mission (TRMM) was a joint space mission between NASA and the Japan Aerospace Exploration Agency designed to monitor and study tropical rainfall for weather and climate research. It measures rain rate (mm/h) in the troposphere on global scale. It is operated on 0.5^{o}x0.5^{o} resolution and provided important precipitation information using several space-borne instruments (NASA, 2015). The detail of TRMM can be found on NASA/TRMM website *https://trmm.gsfc.nasa.gov/.*

2.3 Data Sources

The data used for this study is of three categories namely TRODAN and TRMM rain rate (2007-2015) for the short term and NiMet monthly rainfall depth (1980-2010) for the long term studies for all the climatic zones.

2.4 Data Analysis

The weather stations were grouped into four each to represents a climatic zone. The rain rate five minute data was used to compute hourly intensity in mm/h for the stations in each zone. The diurnal and monthly averages were computed afterward in order to investigate seasonality in the variation of intensity across the zones. Both rainy days and non-rainy days in the month were analysed together. TRMM data was retrieved through NASA's Giovanni Data and Information Services Centre (http://disc.sci.gsfc.nasa.gov/giovanni) for the purpose of comparison with the TRODAN data and to be able to analyse micro-climatic zone not covered by TRODAN equipment. The annual rainfall amount was computed from the monthly values for the long term variation and computation of probability of exceedance with the return period of the rainfall depth adapted from Reining *et al.* (1989) using the probability equation for the tropical region given in equation 1.

$$P = \frac{(r-3/8)}{(n+1/4)}100 \quad (1)$$

where P is probability in %, r is the rank of the observation, and n is total number of observations used (n = 10 to 100 years). The Return Period is the reciprocal value of the probability when expressed as a fraction as shown in equation 2:

$$T_x = \frac{100}{P_x} \quad (2)$$

These parameters are generally employed in water resource management and agricultural planning. The measure of central tendency and dispersion were conducted on both TRODAN and NiMets data to give information on the normal amount of rainfall one can expect in the area which can be used to obtain an estimate of the departure of the annual rainfall from the normal. The distribution patterns of the observations were investigated with statistical tools (Kurtosis and Skewness) using SPSS 15.0.

3. Results and Discussion

3.1 Rain intensity

3.1.1 TRODAN Rain intensity

Rainfall intensity is group into four types, i.e light rainfall (R < 5 mm/h); moderate (5 < R < 10 mm/h), heavy (10 < R < 50 mm/h), and extreme (R > 50 mm/h). The intensity data used for this study were considered for four climatic zones in Nigeria namely; Sahel, Savannah, Rain forest and Coastal zones.

I. Sahel Zone: The data range; (2013 – 2015).

Figure 2 shows the monthly average of hourly rainfall intensity for the Sahelian region. The rain started with slight shower in April and gradually increases in intensity until it reaches the peak in July. Rain in August occurred throughout the hours of the day making the month the wettest of the year. The rainiest hours across the seasons in the Sahel are 22:00 and 23:00. It was further observed from Figure 2 that more intense rain clustered around the two ends of the hours of the day. First, from 0:00 to 03:00 and from 15:00 to 23:00 h, low intensity rains scattered around the mid-day for about eight hours. The rainy days were 251out of the 900 days period considered which is equivalent to 27.9% of the total period, while the non-rainy days were 72.1%. This makes the zone the driest of the four zones. The non-rainy hours of the diurnal average was 47.2% with 5.9% of rain in excess of 0.5mm/h. The highly intense rain commonly occurred in the latter hours of the day between15:00 and 20:00 hours. The heavy rain is scattered around almost every hour of the rainy months with the peak value greater than 40mm/h occurring in July. This satisfies the probability of occurrence of 1 in 10 chances in a year. For the period of data considered, there were no occurrence of extreme rainfall in the zone but that doesn't mean such cannot occur in the region since its chances of occurrence is 1 in 100 chance in the year. The mean value of monthly rain intensity is 0.11mm/h with standard deviation of 0.2. The data distribution test shows that they are not normally distributed with positive value of skewness and kurtosis.

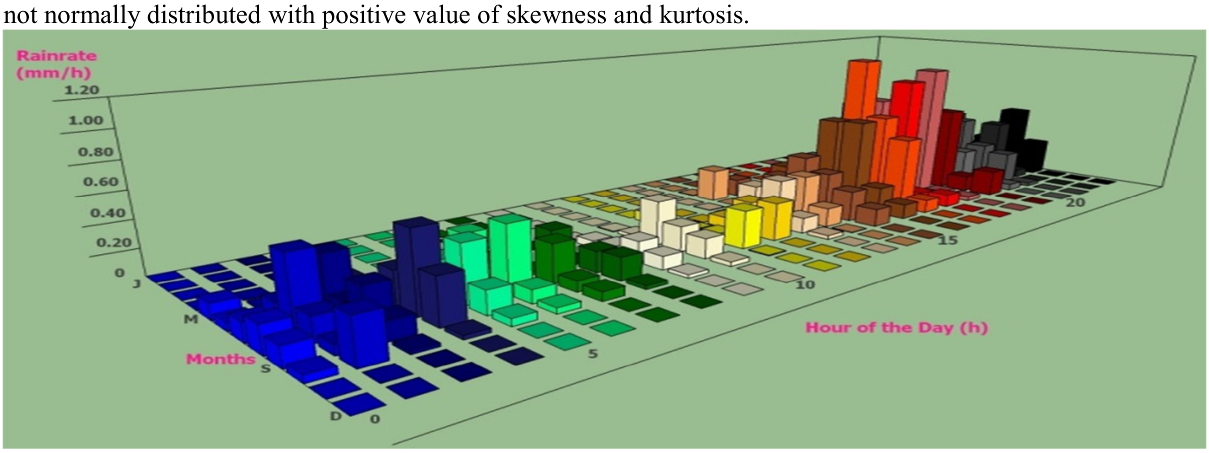

Figure First 2. Seasonal and Diurnal rainfall Intensity for Sahel (2013 – 2015)

II. Savannah Zone: The data range; (2011 to 2013).

From figure 3, the monthly average of hourly rainfall intensity for the Savannah zone shows that rain started early in January though with sparse rain in most of the hours of the month between January and March. The rain gradually increases in occurrence from month of April until it reaches the peak in September. The highest intensity was recorded in January which is one of the least expected rainfall months and this is as a result of extreme rain that was experienced. Rain in August in this zone is quite minimal but there is possibility of the rain extending up to December. 16:00 h is the rainiest hour across the season and Clustered high intensity rains were observed around 15:00h with low intensity rains scattered around the mid-day and early hours of the day. 333 days of rainy were observed during the period of 1096 days considered which is equivalent to 29.5% with non-rainy period equivalents to 70.5%. Most of the rainfall in this zone is moderate spreading across the rainy period and pouring consistently for long hours. For the period of data considered, a case of extreme rainfall in the zone occurred in January with the value of 64.5mm/h at 12:00h in 2011. In diurnal average, the rain intensity in excess of 0.5mm/h was 0.7% of the total with the mean value of 0.06 and standard deviation of 0.09. The rain intensity in the zone is not normally distributed and the non-rainy period has the percentage of 29.5%. This

Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.8, No.2, 2018

agrees well with comparing with the work of Pinker *et al*. (2006) in Sub-Sahel station, in terms of rainfall magnitude across the hours.

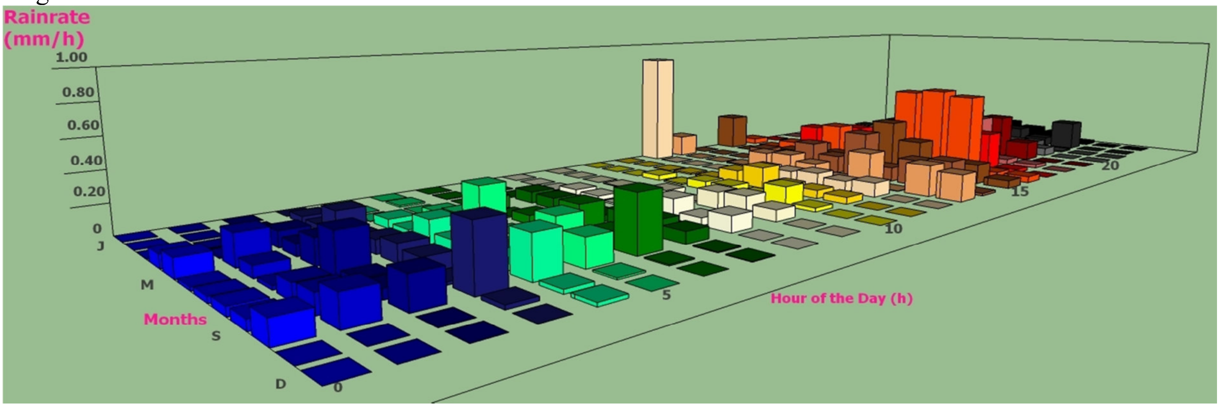

Figure 3. Seasonal and Diurnal rainfall Intensity for Savannah (2011 – 2015)

III. Rainforest Zone: The data range; (2008 – 2010).

The monthly average plot in Figure 4 shows that rain started early in January with low intensity and gently built up to peak in July. Every quarter of the day experienced continuously dense rainfall in most of the months from April to October. The highest intensity was recorded in July which is one of the rainy period peaks. The data show that light and moderate rain prevailed in the zone and this may be as a result of the monsoon wind blowing from the south in addition to the convective cloud system. August break in this zone is not pronounced when the season prepares for the second peak of rainy season. Clustered high intensity rain was observed all through the rainy season and across all hours with 16:00 h experienced rain throughout the seasons over the considered period. 443 days of rain were experienced out of 1096 days equivalent to 40.4% of the total period, while the non-rainy period was 59.6%. Most of the rainfall in this zone is moderate spreading across the rainy period and pouring consistently for a number of days (4 days). No extreme case was recorded for the period considered. In diurnal average, the rain intensity in excess of 0.5mm/h was 9.4% of the total rainfall intensity with a mean value of 0.18 and standard deviation of 0.21. The rain intensity in the zone does not follow a normal distribution just as others and the non-rainy period was 23.3%.

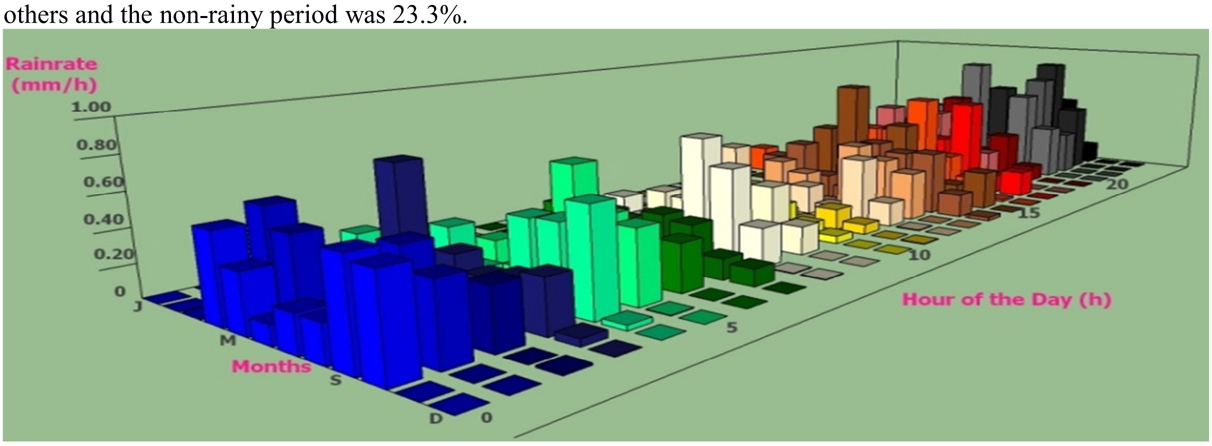

Figure 4. Seasonal and Diurnal rainfall Intensity for Rainforest (2008 – 2010)

IV. Coastal Zone**:** The data range; (2007 – 2009).

Coastal diurnal plot shown in Figure 5 indicate that it rain throughout the year with low intensities at the early and later part of the year. The highest intensity was recorded in the zone which cut across every hour of the day and peak at 05:00h in July. Light dominated rains were experienced during the period considered with this can be attributed to the proximity of the zone to the Ocean. Both high and low intensity rain clustered all through the rainy season and across all the hours with 02:00, 03:00, 05:00 and 06:00 hours experiencing rain throughout the seasons. 265 days of rain were experienced out of 694 days making 38.2% of the total period while the non-rainy period was 61.9%. Extreme case of rainfall up to 81.6mm/h was recorded in 2008 in just one hour. This has the ability to cause more than just a flash flood. The rain intensity in excess of 0.5mm/h was 7.3% with mean value of 0.17 and highest standard deviation of 0.32. The rain intensity in the zone was not normally distributed and the non-rainy period was 12.8%.

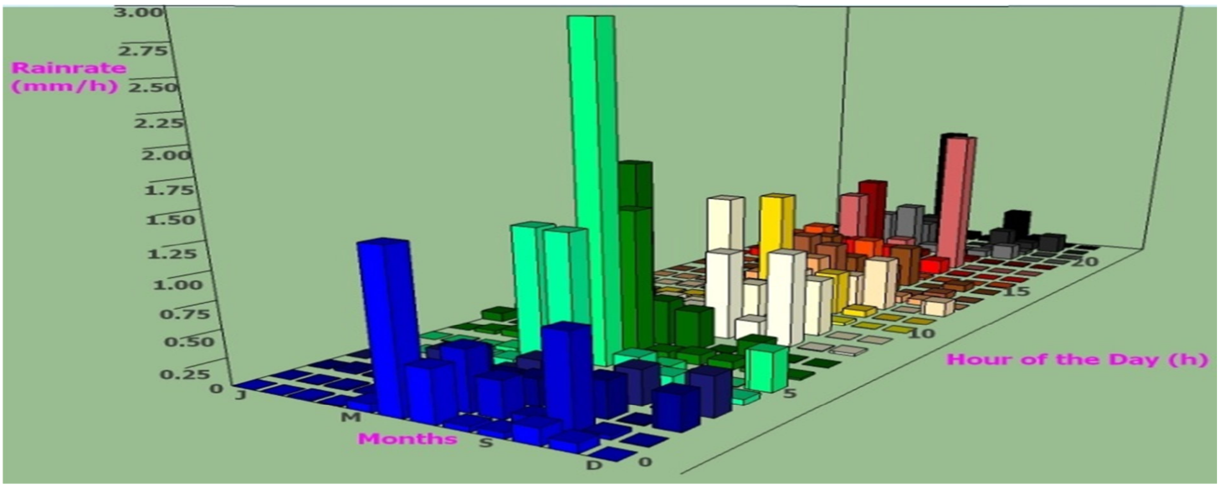

Figure 5. Seasonal and Diurnal rainfall Intensity for Coastal zone (2007 – 2009)

3.1.2 Comparison of TRODAN and TRMM

Comparing the ground based rain intensity (TRODAN) with the space based rain intensity measurements (TRMM), an agreement in term of spatial distribution was observed between them over the climatic zones in Nigeria with the maximum at the coast and minimum at the Sahel. The mountainous region received the highest rain intensity during the period examined and this may be due to its terrain, vegetation cover and micro-climate of the region as shown in Figure 6. Also for the period under review it is observed that TRMM under - estimates the rain intensity across all the zones and with maximum uncertainty in the coastal zone. This may be as a result of heavy clouds obstructing the reflected signals of the TRMM satellite or due to some assumptions made in the retrieval algorithm.

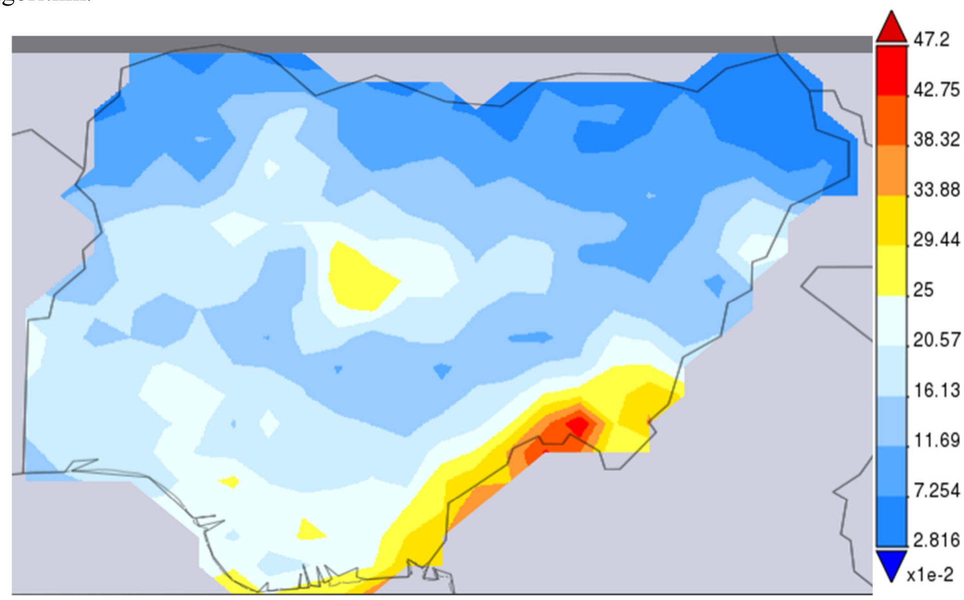

Figure 6. Average TRMM Rain Intensity (mm/h) for 2008-2010

3.2 Rainfall Depth

3.2.1 Monthly Rainfall Depth

From Figure 7, (a) Sahel climatic zone received its maximum rainfall in the month of August (183.8mm) which contributed 31.79% of the total annual rainfall. This was followed by months of July and September with no rainfall in the months of January and February. It was observed that the standard deviation of the month of August is less than that of July with lower rainfall. This indicates more random variation in the depth of rainfall in July compared to the month of August. (b) Savannah, September received the highest rainfall amount of 217.2mm contributing 18.09% of annual rainfall depth followed by month of June (183.5mm) and the least in the month of January with 0.57%. It was observed that the standard deviation values of January, February, November and December were higher than the averages of the months and this may be as a result of deviation from normal distribution. (c) Rainforest zone, it was observed that the maximum rainfall occurred in September with the amount of 280.6mm equivalent to 16.03% of annual rainfall depth. This was followed by the month of

July of 274.6mm and the least rainfall depth in this zone was in the month of December with 0.21%. Furthermore, it was observed that the standard deviation values of August was the highest, followed by that of October then September while December had the least standard deviation. Finally, (d) Coastal zone, July recorded the highest rainfall depth amounting to 371.3mm contributing 15.93% of annual rainfall and was closely followed by month of September (348.2mm) while the month of December had the least rainfall depth of 1.16%. It was observed that the standard deviation values of January, February, March and December were together higher than the standard deviation of the month of July and this may account for the deviation from normal distribution. The maximum amount of rainfall in the months of June, July, August and September across the zones may be due to location of inter-tropical convergence zone (ITCZ) or Inter-tropical Discontinuity area (ITD) in case of near-surface convergence zone which was determined by the convergence of moist air (monsoon wind) in the troposphere and highest amount of solar radiation concurrently hitting the ITCZ region causing deep convection (Haywood *et al.*, 2008; Kim *et al.*, 2009; Olusola and Israel, 2015). Skewness and Kurtosis values reveal that the monthly rainfall depths of all the zones are not normally distributed. The percentage of frequency distribution across the zones reveals that the coastal zone has the least of no rainfall period over the years considered.

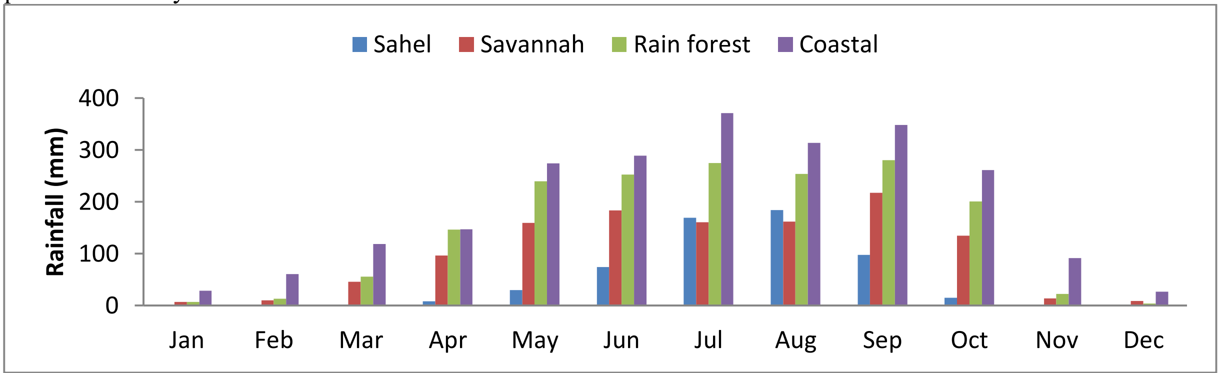

Figure 7. Average Monthly Rainfall Depth across the Zones

3.2.2 Annual Rainfall depth

Precipitation over Nigeria is highly variable and irregular due to her location in the tropics (Ikhile, 2007). Some years are in dry period while others are in wet period. It could be observed from figure 8 and Table 1 for the years under review that year 2007 experienced the highest annual rainfall of 925.7mm with the mean of 575.7mm for Sahel. The minimum amount of 263.5mm was experienced in the year 1983 and the Standard deviation of 158.1mm was estimated accounting for 17.1% of maximum rainfall. The annual rainfall in Sahel zone is approximately symmetrical compared to other zones except coastal zone due to its closeness of the values of skewness to zero.

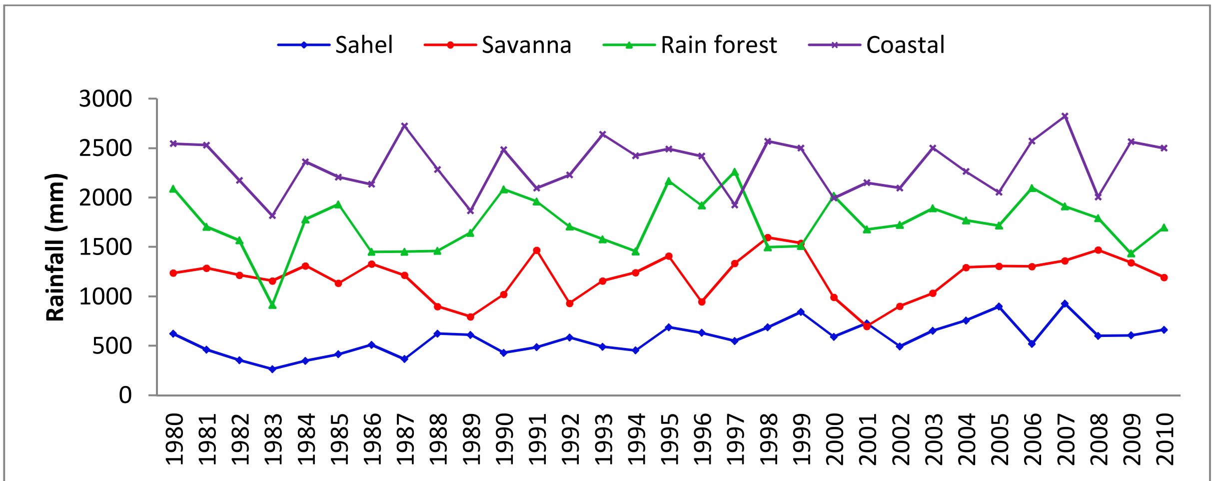

Figure 8. Annual Rainfall Depth across the zones

Furthermore, the annual variability in this zone is the least compared to the others considering the highest value of the ratio of maximum to minimum rainfall depth. The highest annual rainfall depth of 1595.5mm in the Savannah zone was experienced in the year 1998 with the least (697.1mm) in 2001. The mean value of 1197.2mm accounted for 13.7% of the period and standard deviation value is 219.2mm. The annual rainfall in this zone is more varied and less symmetrical compared to the Sahel using the value of the ratio of maximum and minimum values and skewness calculated. Rainfall depth received in the rain forest zone was the highest in all the zones in the year 1997 and it is of the value 2262.4mm. Minimum rain received during the year in review was 913.1mm in 1983 with the mean value of 1737.3mm and standard deviation of 280.8mm. The distribution of annual rainfall in the zone has the highest symmetrical value in the negative direction and the kurtosis value showing distribution platykurtic (< 3). Coastal zone experienced the maximum rainfall of 2823.5mm in the year 2007, minimum 1816.4mm in 1983 and mean value of 2328.5mm with standard deviation of 263.2mm. The variation of annual amount in the zone is highest in comparison to other zones due to the least value of the ratio of maximum to minimum values as shown in Table 1. It was observed that 1983 was the driest year for the Sahel, Rain forest and Coastal zones while year 2001 was the driest for the Savannah zone. The wettest period for all the zones occurred in different years except for Sahel and Coastal that occurred in the same year. This may be as a result of other local factors contributing to the formation of rain such as boundary layer forcing and moisture build-up (Akinsanola and Ogunjobi, 2014). The decadal analysis reveals the trend of the depth is on increase across the zones by at least 50mm of rain and wetter trend is strongest in Sahel zone where rain has increase for more than 200mm especially around Maiduguri axis.

Table 1. Statistical summary of Hourly Rainfall Intensity and Annual Rainfall Depth for the four zones

	Sahel	**Savannah**	**Rainforest**	**Coastal**	**Sahel**	**Savannah**	**Rainforest**	**Coastal**
Min	.000	.000	.000	.000	263.500	697.100	913.100	1816.400
Max	1.191	.694	.904	2.927	925.700	1595.500	2262.400	2823.500
Mean	.113	.062	.181	.166	575.732	1197.226	1737.342	2320.490
Std. Dev.	.201	.093	.209	.322	158.092	219.165	280.826	263.236
Skewness	2.496	2.941	1.183	4.093	.302	-.424	-.486	-.174
Kurtosis	6.997	12.135	.714	23.399	.001	-.304	1.080	-.883
Max/Min					3.5	2.2	2.4	1.5

3.3 Probability Analysis

The probability of re-occurrence of a certain given rainfall depth or more than that is what is referred to as probability of exceedance (Raes, 2013). This was derived from the annual rainfall depth using Reining (1989) method as shown in equation 1 while the return period for each rainfall depth re-occurrence was computed using equation 2 as shown in Table 2. Probability curve for predicting any re-occurrence depth for the entire zone were plotted as shown in figure 9 (a-d). This will always assist in efficient management of water resources. From figure 9 (a-d), the R^2 value of the fitting curve for an entire zone was above 0.9 which shows the high accuracy of predicting either of the two parameters. The re-occurrence interval or return period (T) in years is the year an individual probability or rainfall depth is expected to return. From Table 2, the probability of maximum rainfall depth is 2% while that of minimum depth is 99.6% across the zones. Hence the return period for the maximum is 50 years while that of minimum is less than 1.004 years.

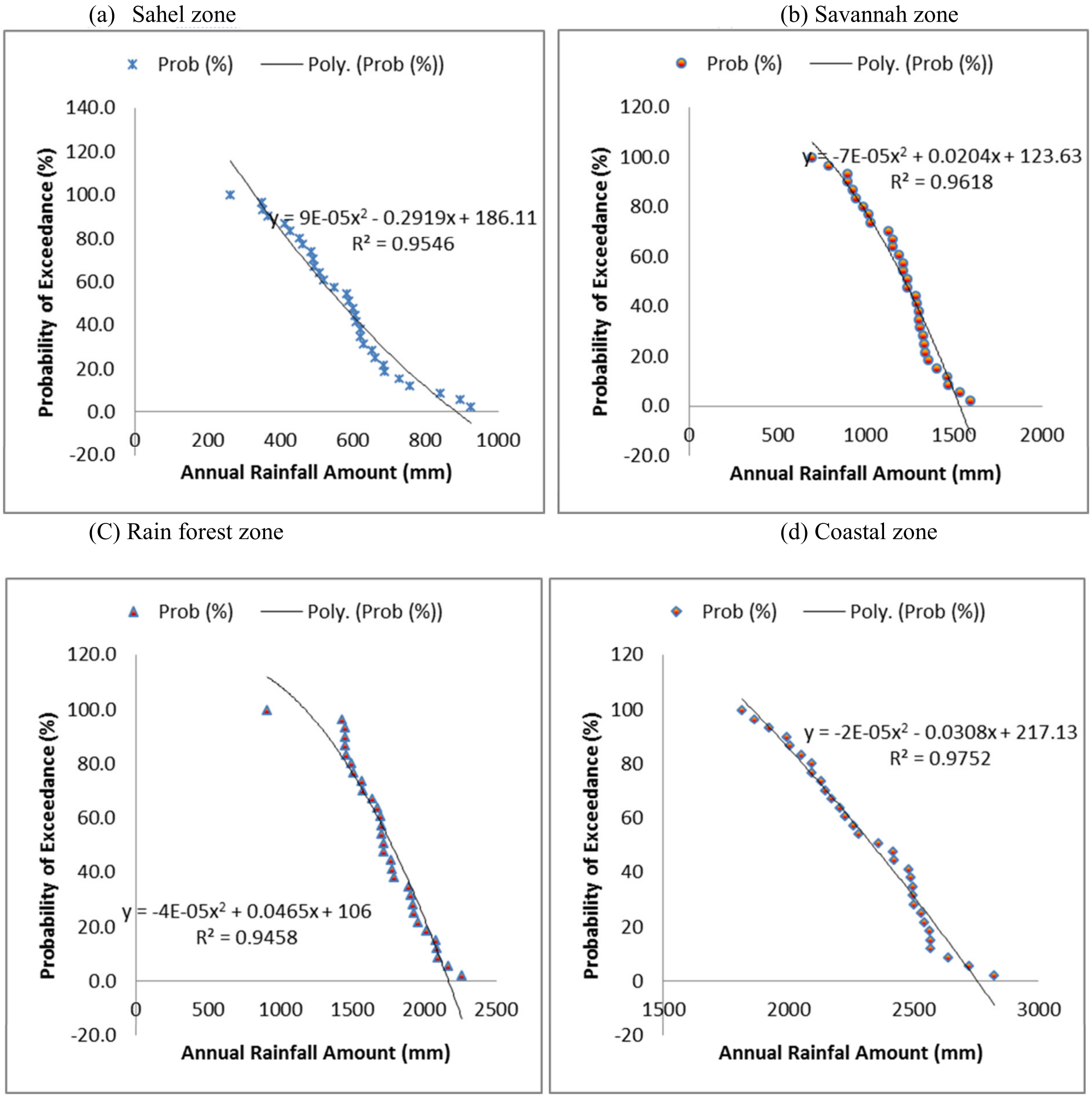

Figure 9(a-d). Probability of Exceedance for all zones

Table 2. Probability and Return period for Rainfall Depth across the zones

Sahel				Sava nnah				Rain forest				Coastal			
YEAR	Annual amt. (mm)	Prob. (%)	T (yr.)	YEAR	Annual amt. (mm)	Prob. (%)	T (yr.)	YEAR	Annual amt. (mm)	Prob. (%)	T (yr.)	YEAR	Annual amt. (mm)	Prob. (%)	T (yr.)
2007	925.7	2.0	49.2	1998	1595.5	2.0	49.2	1997	2262.4	2.0	49.2	2007	2823.5	2.0	49.2
2005	897.1	5.3	18.9	1999	1539.3	5.3	18.9	1995	2167.9	5.3	18.9	1987	2723.9	5.3	18.9
1999	842.6	8.5	11.7	2008	1470.5	8.5	11.7	2006	2096.3	8.5	11.7	1993	2639.4	8.5	11.7
2004	756.8	11.8	8.5	1991	1468.4	11.8	8.5	1980	2090.8	11.8	8.5	2006	2572.0	11.8	8.5
2001	727.7	15.0	6.6	1995	1409.2	15.0	6.6	1990	2083.4	15.0	6.6	1998	2569.1	15.0	6.6
1995	688.9	18.3	5.5	2007	1361.4	18.3	5.5	2000	2017.8	18.3	5.5	2009	2564.0	18.3	5.5
1998	686.2	21.5	4.6	2009	1342.7	21.5	4.6	1991	1961.2	21.5	4.6	1980	2544.9	21.5	4.6
2010	662.3	24.8	4.0	1997	1334.4	24.8	4.0	1985	1930.9	24.8	4.0	1981	2530.7	24.8	4.0
2003	653.3	28.0	3.6	1986	1328.4	28.0	3.6	1996	1919.4	28.0	3.6	2003	2501.6	28.0	3.6
1996	630.7	31.3	3.2	1984	1310.5	31.3	3.2	2007	1910.9	31.3	3.2	1999	2499.6	31.3	3.2
1988	622.8	34.6	2.9	2005	1305.9	34.6	2.9	2003	1890.9	34.6	2.9	2010	2499.1	34.6	2.9
1980	621.3	37.8	2.6	2006	1303.8	37.8	2.6	2008	1793.0	37.8	2.6	1995	2490.9	37.8	2.6
1989	610.3	41.1	2.4	2004	1294.0	41.1	2.4	1984	1779.4	41.1	2.4	1990	2482.7	41.1	2.4
2009	605.9	44.3	2.3	1981	1286.9	44.3	2.3	2004	1770.1	44.3	2.3	1994	2422.8	44.3	2.3
2008	600.9	47.6	2.1	1994	1242.0	47.6	2.1	2002	1722.2	47.6	2.1	1996	2419.5	47.6	2.1
2000	590.9	50.8	2.0	1980	1237.1	50.8	2.0	2005	1716.5	50.8	2.0	1984	2362.5	50.8	2.0
1992	584.6	54.1	1.8	1982	1215.1	54.1	1.8	1992	1706.5	54.1	1.8	1988	2283.8	54.1	1.8
1997	549.7	57.3	1.7	1987	1213.7	57.3	1.7	1981	1704.2	57.3	1.7	2004	2263.3	57.3	1.7
2006	519.5	60.6	1.7	2010	1193.1	60.6	1.7	2010	1696.8	60.6	1.7	1992	2227.4	60.6	1.7
1986	509.5	63.8	1.6	1993	1157.9	63.8	1.6	2001	1677.2	63.8	1.6	1985	2206.8	63.8	1.6
2002	494.1	67.1	1.5	1983	1157.2	67.1	1.5	1989	1643.7	67.1	1.5	1982	2173.7	67.1	1.5
1993	491.0	70.3	1.4	1985	1133.3	70.3	1.4	1993	1577.8	70.3	1.4	2001	2150.0	70.3	1.4
1991	486.1	73.6	1.4	2003	1033.5	73.6	1.4	1982	1566.6	73.6	1.4	1986	2133.6	73.6	1.4
1981	461.4	76.8	1.3	1990	1020.1	76.8	1.3	1999	1508.2	76.8	1.3	2002	2097.0	76.8	1.3
1994	453.1	80.1	1.2	2000	990.3	80.1	1.2	1998	1497.0	80.1	1.2	1991	2094.4	80.1	1.2
1990	429.0	83.3	1.2	1996	945.3	83.3	1.2	1988	1461.0	83.3	1.2	2005	2053.0	83.3	1.2
1985	414.1	86.6	1.2	1992	931.6	86.6	1.2	1994	1455.9	86.6	1.2	2008	2006.2	86.6	1.2
1987	366.2	89.8	1.1	2002	902.3	89.8	1.1	1987	1451.6	89.8	1.1	2000	1994.3	89.8	1.1
1982	354.0	93.1	1.1	1988	898.9	93.1	1.1	1986	1450.6	93.1	1.1	1997	1924.2	93.1	1.1
1984	348.5	96.3	1.0	1989	794.6	96.3	1.0	2009	1434.3	96.3	1.0	1989	1864.9	96.3	1.0
1983	263.5	99.6	1.0	2001	697.1	99.6	1.0	1983	913.1	99.6	1.0	1983	1816.4	99.6	1.0

4. Conclusion

Rainfall is considered to be the primary source of water and it is important for human activities and existence in the world. The rainfall intensity received for the period of 2007 – 2013 using TRODAN and TRMM data for the four climatic zones in Nigeria was analysed from zone to zone while the rainfall depth was considered using NiMet data for the period of 1980 – 2010 over the same location which represents the country. The statistical analysis was conducted on diurnal and monthly rainfall intensity as well as monthly and annual rainfall depths. Probabilities of exceedance and return periods were adopted for prediction purposes for the annual rainfall depth estimated. Rainfall intensity in mm/h ranges from dominant light in the Coast to dominant heavy in the Sahel with occurrence of extreme rainfall in any zone in the country. The annual rainfall depth across the zones shows from medium to high variability and oscillatory trend with no regular pattern. The frequency analysis shows the percentages of both rainy and non-rainy months under the years in review. This study equally shows that the coastal zone of Nigeria is prone to more and persistent rainfall when compared to the other zones of Rain forest, Savannah and Sahel. The maximum hourly rainfall intensity for the period considered was 2.9mm/h experienced at the coastal zone and the maximum annual rainfall depth was 2823.500mm. Probability of exceedance curve was generated for prediction of re-occurrence of any kind of rain depth recorded. This prediction gives a low probability with long years of returning for high rain depths and low rain depths with higher probability and short years of return of re-occurrence. Both intensity and depth did not give normal distribution and no trend was found in them.

Acknowledgement

The authors wish to acknowledge the TRMM mission scientists, associated NASA personnel, CAR-NASRDA, and NiMet for the production of the data used in this research effort. Also, we are grateful for the support received from University of Ilorin during the cause of this study.

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