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SEASONAL VARIATIONS IN THE EARLY AND MID-YEAR RAINSTORM CHARACTERISTICS IN IBADAN, NIGERIA

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Abstract

A rainstorm is a relatively short period of uninterrupted and intense rainfall. However, spatial and temporal variations are known to occur in rainstorms through the year. These temporal variations are largely due to seasonal changes in weather characteristics. Previous studies have largely characterised variations in rainstorm based on limited data from rainfall stations that are not evenly distributed over the city of Ibadan, hence their inability to analyse the seasonal variations of rainstorm characteristics at the metropolitan level. This study analysed the seasonal variations in rainstorms duration, rainfall amount, intensity, speed and areal coverage of rainstorms in the early and mid-year rainstorm events in Ibadan, Nigeria. A 3x3 km grid was superimposed on the map of Ibadan metropolis and one raingauge was installed in each of the 50 resultant grids. Rainstorms data were recorded daily from the 50 rainfall stations during the early and mid-year rainstorm events of 2013 and 2014. Descriptive statistics and Student's t-test were used to analyse the data, at $p \leqslant 0.05$. Out of the 48 rainstorms studied, 66.7% showed data for early rainstorms. There was significant difference in the mean duration of rainstorm between the early and mid-year rainy seasons (t=3.68). Results from this analysis could potentially be used to provide a baseline for future investigations of dynamics of rainstorms in urban areas.

Keywords: Seasonal variations, Rainstorm characteristics, Early and mid-year rainstorms, Ibadan

Introduction

A rainstorm is a relatively short period of uninterrupted and intense rainfall. Rainstorms usually last for less than 2 hours (Ayoade and Akintola, 1983). Rainstorms serve as an integral part of tropical rainfall, accounting for over 90 percent of the rainfall received (Ayoade and Akintola, 1983). Rainstorms provide rainfall for a variety of natural and anthropogenic uses from groundwater and stream recharge to water for domestic uses. Since rainfall is the easiest source of water availability in the tropics, the importance of rainstorms cannot be underscored in rainfall distribution and occurrence alone (Ayoade, 2004).

In the tropics, the distribution characteristics and variability of rainfall and rainstorms in particular is extremely vital (Ayoade, 1970; Ayoade and Akintola, 1983; Ayoade, 2004; Ologunorisa, 2006; Adediran, 2017). Rainstorms serve as a primary feature in the climate over areas in the tropical sub-region of the world and are extremely vital for three reasons (Ayoade, 2004). Firstly, rainstorms are very important because they account for up to 97% of the total rainfall experienced in the tropics. Additional studies indicate that in some inland areas, rainstorms supply up to ninety five percent (95%) of the total annual rainfall received. Secondly, they produce rainfalls of moderate to high intensity which in turn generates significant amounts of runoff and sediment especially in areas where vegetal cover is either absent, or less than sufficient. Thirdly and finally, rainstorms occur variably over space and time. This therefore contributes to the high variability of rainfall that is characteristic of tropical areas.

The existing literature suggests that rainstorm characteristics are very important, although they can pose problems if not seriously considered (Ayoade,

2012). A proper understanding of past and recent rainstorm characteristics aids in proper planning and physical development (Adefolalu, 2001; Akintola et al., 2009; Mario, et al., 2016; Hongyan et al., 2016). A lack of understanding of rainstorms, in terms of rainstorm behaviour and characteristics, could lead to several problems. Problems of flooding, damage to infrastructure and amenities, water issues and agricultural difficulties could arise if a proper understanding of rainstorms is not achieved before man undertakes any endeavour. For example, rainstorms studies are extremely vital, especially in developing countries (Ayoade, 2012; Keggenhoff et al., 2014; Zhihe et al., 2015; Ivana et al., 2016; Adediran, 2017). The significant increase in rainfall and evaporation rates over the last half century have theoretically become a threat to the population, given the increased frequency in extreme rainstorm events (Kundzewicz et al., 2007). These heavy increments are as a direct result of global warming in some areas of the Earth. The threat by the increasing rates of precipitation and evaporation pose a greater risk to the developing countries of the world (of which Nigeria is a primary example) as a result of lack of resources, technology and scientific knowhow in the mitigation and control of extreme climatic events (Oyebande, 1982; Adefolalu, 2001).

Unlike most developed countries, the inability to predict, avoid and control the effects of these extreme climatic events due to the abject lack of adaptation and control methods leave these third world countries susceptible to great loss of life, infrastructure and socio-economic resources (Gbuyiro, 2002). The destructive effects of rainstorms are becoming increasingly frequent in developing countries (Audu et al., 2013). Damage to infrastructure and socio-economic amenities is coupled by the upheaval of trees and the destruction of plant life. Felled trees block roads and other transport routes thus hindering the effectiveness and fluency of transportation. Livestock and human property is also frequently damaged as a result of heavy, intense rainstorms and these rainstorms have even resulted in loss of human life (Audu et al., 2013).

In general, due to the need for a better understanding of tropical climate, studies have been carried out in order to observe the variations in climatic conditions. The diurnal, monthly, and annual variations in rainfall characteristics is evidence of the seasonal variation in the nature of rainfall experienced in this region through the year (Ayoade, 1970; Jackson, 1977; Walsh and Lawler, 1981; Oyebande, 1982; Oguntoyinbo and Akintola, 1983; Gbuyiro, 2002; Ayoade, 2004; Ologunorisa, 2006; Audu et al., 2013; Keggenhoff et al., 2014; Zhihe et al., 2015; Ivana et al., 2016; Adediran, 2017; 2019). However, an empirical study should depict these dissimilarities in the early and mid-year rainstorm characteristics, and possibly proffer reasons for these variations. Based on the foregoing discussion, this study therefore, analysed the characteristics of rainstorms with a view to determine the seasonal variations in the early and mid-year rainstorm characteristics in Ibadan.

The study therefore aimed to analyse the characteristics of rainstorms with a view to determine the seasonal variations in the early and mid-year rainstorm characteristics in Ibadan. The specific objectives are to:

i. analyse the temporal patterns of the frequency, duration, rainfall amount, intensity, speed and areal coverage of rainstorms in the early and mid-year rainstorm events in Ibadan; and

ii. examine the difference in the durations, rainfall amounts, speeds and areal coverage of rainstorms in the early and mid-year rainstorm events in Ibadan.

Materials and Methods

The study area

Ibadan is located approximately on latitude 7° 22 N and longitude 3° 58 E. Nevertheless, the expanse of land normally referred to as the metropolitan area lies between latitudes 7° 15 and 7° 30 North and longitudes 3° 50 and 3° 00 East covering about 450 km^2 (Figure 1).

The area is in the vegetational transitional zone between the forest and savanna. The area experiences two seasons, the dry and the wet. The onset of the wet season is estimated at 15 March within a two week variation period and 15 November as the tentative end of the wet season with the same level of variation (Oguntoyinbo and Akintola, 1983; Ayoade, 2012). The area also experiences the double maxima rainfall regime with the characteristic break in August known as the "little dry season" (Ayoade and Akintola, 1986; Ayoade, 2012; Adediran, 2017and Sikorsta and Seibert, 2018).

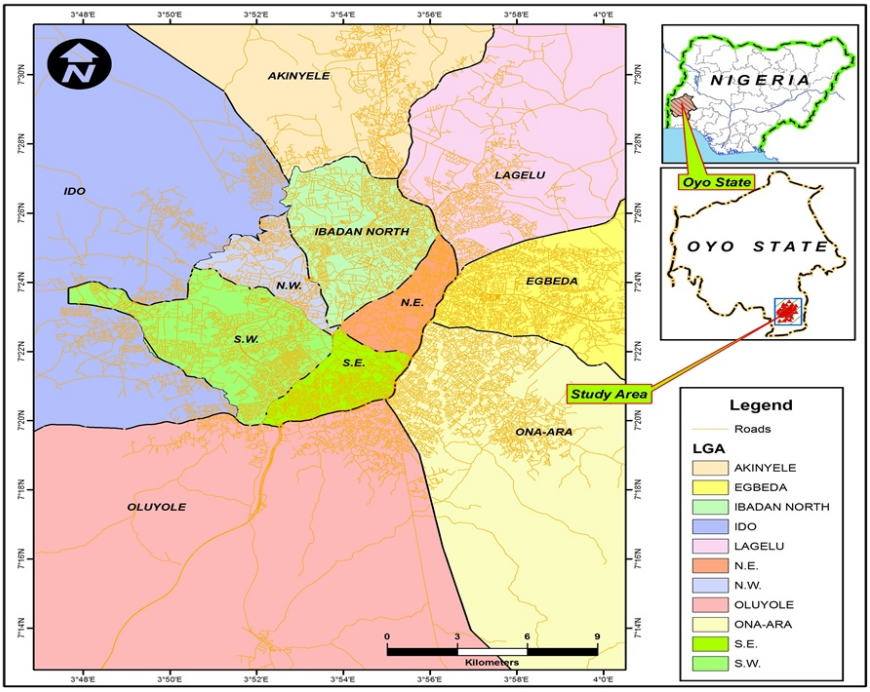

Figure 1: The study area (Shuttle Radar Topographical Mapping (SRTM), 2013)

The mean annual rainfall over the study area is about 1500 mm. According to Ayoade and Akintola (1986), four seasons of rainfall events exist in Ibadan and they include, dry (November to February), early (March to April), rainy (May to August) and late (September to October) rainy seasons. More than 30% of annual rainfall is received during early rainy season. The study area experiences the double maxima rainfall regime characterized by two peaks, one in June and the other in September/October with a period of relatively lower rainfall in between.

Data base and analysis

Archival meteorological (higher resolution precipitation) data from 50 rainfall stations in Ibadan (Fig. 2) (Adediran, 2017), documenting daily rainstorms for the months of March and April, and July and August were obtained for this study. These months were selected because March and April coincide with the beginning of the earliest rains in the year, while July and August coincide with the middle of the year (Ayoade and Akintola, 1983). From each daily chart, a series of data was derived, and these include: Day; Month; Time of start and cessation of rainstorm; Duration (minutes); Rainfall amount (millimeters); Intensity (mmh^{-1}) etc. Similarly, a 3x3 km grid was superimposed on the map of Ibadan metropolis and one self-recording raingauge was installed in each of the 50 resultant grids. Data on rainstorms such as frequency of occurrence, duration, rainfall amount, intensity were recorded hourly from the 50 weather stations. Duration equals to the difference between the times of onset and times of cessation of rainstorm Singh (2002a). Rainfall amount (mm) equals to the volume of rain water obtained from the rain gauges after the rainstorms. Intensity of rainfall is the rainfall amount divided by storm duration (Ayoade, 2004). Storm speed (ms^{-1}) was calculated from the perpendicular distance between the rain-gauge stations and the difference between their time values (Niemczynowicz, 1984; 1984b; Diskin, 1987). The areal coverage (km^2) of rainstorms was measured using square method (Ayoade, 2004). The rainstorms data for the period of the study were screened, aggregated, examined and analysed. This was done to analyse the temporal variation in the early and mid-year rainstorm characteristics in Ibadan.

The study involved the measurement of the duration, rainfall amount, intensity, speed, areal coverage of rainstorms. The statistical methods employed for this study were both descriptive and inferential statistical tools such as tables, bar charts, mean, standard deviation and paired samples t-test statistics, respectively. The descriptive statistical method was used to summarize the observed speed data collected. The paired-samples t-test procedure compares the means of two variables for a single group.

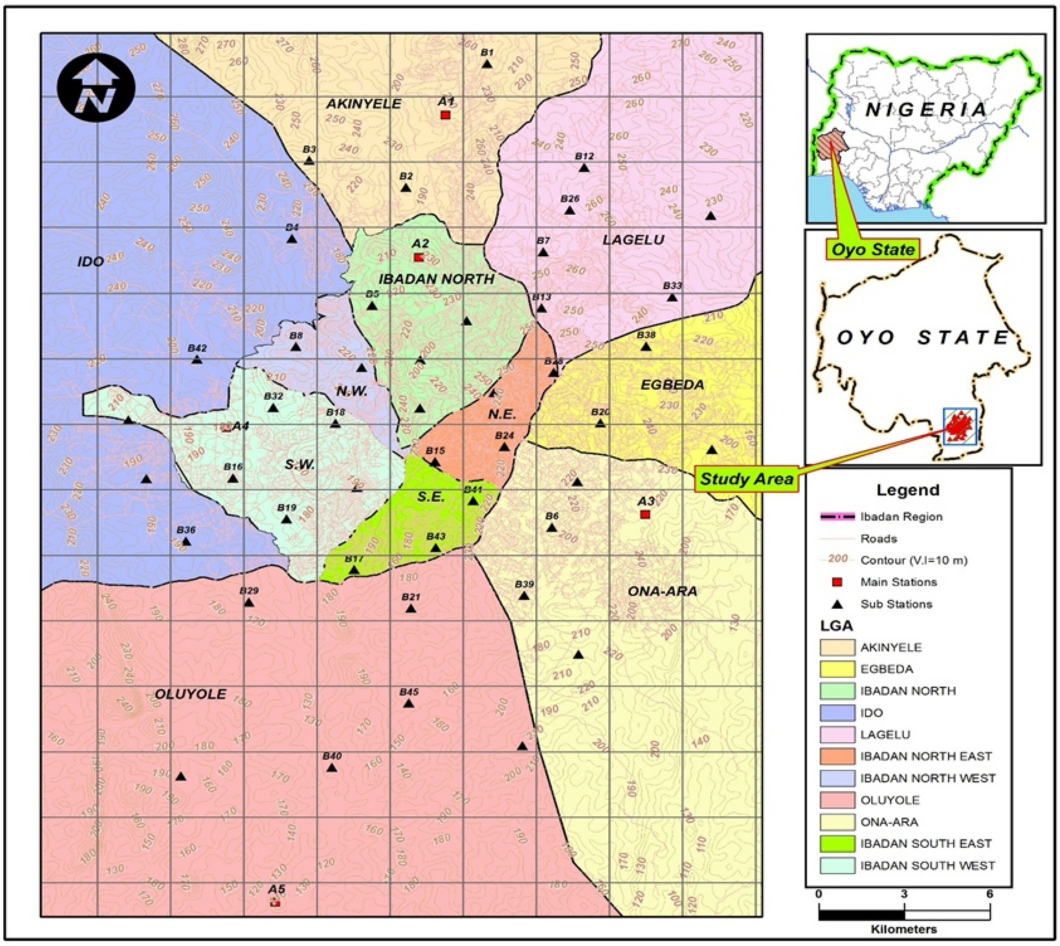

Figure 2: Location of raingauge stations in Ibadan

The paired samples t-test statistics was used to test if there is significant difference in the duration/rainfall amount/intensity/speed/areal coverage of rainstorms between the early and mid-year rainstorm events. It was also used to draw inferences within a known degree of accuracy regarding the weather data under analysis and the distribution of each of the rainstorm characteristics. The interpretation of the result of the descriptive statistics was done based on percentages as well as absolute values. Data collected were analysed using paired samples t-test statistics at $p \leq 0.05$.

$$t = \frac{|\bar{a} - \bar{b}|}{\sqrt{\frac{\sigma a^2}{n_a} + \frac{\sigma b^2}{n_b}}} \quad \text{.......} \; 3.1$$

Where, *(a)* is mean of the duration/rainfall amount/intensity/speed/areal coverage of rainstorms in the early rainy rainstorm events, *(b)* is mean of the duration/rainfall amount/intensity/speed/areal coverage of rainstorms in the mid-year rainstorm events, *(σ)* is standard deviation and *(n)* is number of observations. The aim of doing this is to depict the differences in the duration/rainfall amount/intensity/speed/areal coverage of rainstorms in the early and mid-year rainstorm events in Ibadan.

Results

Temporal variation in the patterns of the selected rainstorm characteristics

The total frequencies of rainstorms in the early and mid-year rainstorm events in Ibadan were recorded as 32 and 16, respectively. In the two data sets, it was found that there was a variation in the frequency of rainstorms in the early and mid-year rainstorm events. The rainstorm events in the early and mid-years showed an average duration of 127 and 135 minutes, respectively. The maximum durations of rainstorm events were 315 and 285 minutes, while 25 and 27 minutes were recorded as the minimum. The

standard deviation values were 66 and 69. In the two data sets, it was found that there was a variation in the durations of rainstorms in the early and mid-year rainstorm events.

The rainstorm events in the early and mid-years showed an average rainfall amounts of 14.7 and 16.8 mm, respectively. The maximum amounts of rainstorm events were put at 45.2 and 34.8 mm, while 0.6 and 0.8 mm were recorded as the minimum. The standard deviation values were 11 and 8. The intensities of rainstorm events showed an average of 0.1 and 0.2 mmh^{-1}. The maximum intensities of rainstorms were recorded as 0.3 mmh^{-1} in the early and mid-year rainstorm events. Similarly, the minimum intensities were put at 0.2 mmh^{-1} in the early and mid-year rainstorm events, respectively. The standard deviations were .09 and .08. In the two data sets, it was found that there was a variation in the amounts of rainstorms in the early and mid-year rainstorm events.

The speeds of rainstorm events showed an average of 13.0 and 9.7 ms^{-1}. The maximum and minimum speeds of rainstorms were recorded as 79.4 ms^{-1}, and 0.4 and 0.2 ms^{-1} in the early and mid-year rainstorm events, respectively. The standard deviations were 21 and 19. The rainstorm events in the early and mid-years showed an average areal coverage of rainstorms of 39.4 and 27.1 km^2. The maximum areal coverage of rainstorm events were put at 85.4 and 55.7 km^2, while 46 and 53 km^2 were recorded as the minimum. The standard deviation values were 25 and 17. In the two data sets, it was found that there was a variation in the amounts of rainstorms in the early and mid-year rainstorm events.

Comparative analysis of the selected rainstorm characteristics

Duration of rainstorms between the early and the mid-year rainstorm events

The comparison of duration of rainstorms between the early and mid-year rainstorm events is presented under this section. The results of the analysis of the differences between the mean of duration of rainstorms between the early and the mid-year rainstorm events (Table 1) revealed that there was significant difference in the duration of rainstorms in the early and mid-year rainstorm events, with calculated T-value of 3.68, which was greater than the T-critical value of 2.06 at 0.05 confidence level. This result means that the duration of rainstorms between the early and the mid-year rainstorm events varied significantly.

Rainfall amount between the early and the mid-year rainstorm events

The comparison of rainfall amount between the early and mid-year rainstorm events is presented under this section. The results of the analysis of the differences between the mean of rainfall amount between the early and the mid-year rainstorm events (Table 1) revealed that there was no significant difference in the rainfall amount in the early and mid-year rainstorm events, with calculated T-value of 0.20, which was less than the T-critical value of 2.06 at 0.05 confidence level. This result means that the rainfall amount between the early and the mid-year rainstorm events did not vary significantly.

Intensity of rainstorms between the early and the mid-year rainstorm events

The comparison of intensity of rainfall between the early and mid-year rainstorm events is presented under this section. The results of the analysis of the differences between the mean of rainfall intensity between the early and the mid-year rainstorm events (Table 1) showed that there was no significant difference in the rainfall intensity in the early and mid-year rainstorm events, with calculated T-value of 1.40, which was less than the T-critical value of 2.06 at 0.05 confidence level. This result means that the rainfall intensity between the early and mid-year rainstorm events did not vary significantly.

Speed of rainstorms between the early and the mid-year rainstorm events

The comparison of speed of rainstorms between the early and mid-year rainstorm events is presented under this section. The results of the analysis of the differences between the mean of speed of rainstorms between the early and the mid-year rainstorm events (Table 1) showed that there was no significant difference in the speed of rainstorms in the early and the mid-year rainstorm events, with calculated T-value of 0.50, which was less than the T-critical value of 2.06 at 0.05 confidence level. This result implies that the speed of rainstorms between the early and the mid-year rainstorm events did not vary significantly.

Table 1: Summary of the analysis of t-test for two-independent-sample comparison of the selected rainstorms characteristics

Characteristics of rainstorms in the early and mid-year rainstorm events	T-cal	T-critical	Level of significance
Duration	3.68	2.06	Significant at 0.05 level
Rainfall amount	0.20	2.06	Not significant at 0.05 level
Intensity	1.40	2.06	Not significant at 0.05 level
Speed	0.50	2.06	Not significant at 0.05 level
Areal coverage	1.90	2.06	Not significant at 0.05 level

Areal coverage of rainstorms between the early and the mid-year rainstorms events

The comparison of areal coverage of rainstorms between the early and mid-year rainstorm events is presented under this section. The results of the analysis of the differences between the mean of areal coverage of rainstorms between the early and the mid-year rainstorm events (Table 1) revealed that there was no significant difference in the areal coverage of rainstorms in the early and the mid-year rainstorm events, with calculated T-value of 1.90, which was less than the T-critical value of 2.06 at 0.05 confidence level. This result implies that the areal coverage of rainstorms between the early and the mid-year rainstorm events did not vary significantly.

Discussion

The seasonal variation in the characteristics and occurrence of rainstorms has imposed its influence on the weather patterns and climatic expectations of this region. All human activities that are rainfall-dependent are thus based on this principle (Kamara, 1986). For this reason, most human activities are planned with due consideration of weather conditions. Sporting championships, for example, and football matches are usually scheduled for those times at which there would be minimal or no rainfall. Most agricultural activities are largely dependent on the prevalence and availability of rainfall. With an understanding of the growth cycle of different crops, farmers and other agriculturists are able to plan their planting and harvesting periods. The growth of some crops may be adversely affected by high intensity or very frequent rainfall. The water needs of these crops cannot, however, be ignored and they are thus planted in the early period of the rainy season. Most crops receive their growth boosts in the July/August period, as water availability is not usually a problem. This is sufficiently balanced by the short dry season period in August, which is usually characterized by lower rainfall (Ayoade and Akintola, 1983; kamara, 1986).

Generally, planting season thus coincides with the early rainy season, while harvest comes after the second maximum peak of rainfall in this region. This is a good example of the influence of an understanding of rainfall patterns on agricultural regimes. Such an understanding, of the influence and relationship between man and his environment would further aid in the healthy sustenance of both man and his environment.

In modern times, variations in climatic characteristics have been prevalent, especially in the tropics. These have further blurred the predefined time boundaries for the seasons. This has been observed, for example, in the occasional occurrence of devastating floods in the month of August, when dry conditions are expected to prevail. Some deviations from expected weather projections have also been observed. These have been attributed, in some quarters, to the now popular subject of climate change. Yet, studies have also shown that seasonal and temporal variations in climatic conditions have been occurring for millennia (Ayoade and Akintola, 1983; kamara, 1986; Adediran, 2017).

References

Adediran, A. (2019). Comparative Analysis of the Characteristics of Rainstorms over Ibadan, Nigeria. *Osun Geographical Review*, Department of Geography, Osun State University, Osogbo, Nigeria, 2:135-143

Adediran, A. (2019). Seasonal Variation in the Patterns of the Lifetime and Speed of Rainstorms over Ibadan, Nigeria. *Journal of Geography, Meteorology and Environment*, 2(2):38-48. https://www.jgmeonline.com/our-publications/

Adediran, A. (2017). *Seasonal Dynamics and Patterns of Rainstorms over Ibadan, Nigeria.* Unpublished PhD Thesis, University of Ibadan, Ibadan, xxv-337 pp

Adefolalu, D.O. (2001). Climatic Change and Natural Disasters during the 1999 Rainy Season, FUT – NUC/UBR Res. Pub. 88 pp.

Akintola, F.O. and Ologunorisa, E.T. (1999). Areal Analysis of Rainstorm Coverage in Ibadan', *Journal of Geographical Teachers Association* 1: 65-73.

Audu, E.B.; Rizama, D.S.; Obateru, O.C. and Binbol, N.L. (2013). An Assessment of Socio–economic Impacts of Rainstorm as a Meteorological Hazard in Lokoja Local Government Area of Kogi State, Nigeria. *Journal of Science, Technology, Mathematics and Education (JOSTMED),* 9 (3):32-46

Ayoade, J.O. (2012). Meteorological Hazards and their Impact on the Nigerian Urban Environment. M.F.A. Ivbijaro and F. Akintola, (Eds.) *Sustainable Environmental Management in Nigeria.* Ibadan: BookBuilders Publication. 157-178.

Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics*. London; John Wiley Publishers.

Ayoade, J.O. and Akintola, F.O. (1986). Some Characteristics of Rainstorms in Lagos, Nigeria. *Malaysian Journal of Tropical Geography,* 14:17-21.

Ayoade, J.O. and Akintola, F.O. (1982). A Note on some Characteristics of Rainstorms in Ibadan. *Weather,* 37(2): 56-58.

Ayoade, J.O. (1970). The Seasonal Incidence of Rainfall. *Weather* 25: 414-418

Diskin, M.H. (1987). On the determination of the speed of moving rainfall patterns, *J. Hydrol. Sci.*, 32: 1-14.

Gbuyiro, S.O.; Lamin, M.T. and Ojo, O. (2002). Observed characteristics of rainfall over Nigeria during ENSO years. *Journal of Nigeria Meteorological Society,* 3(1): 1-17.

Hongyan, L.I.; Shanshan, B.; Xiaojun, W. and Hang, L.V. (2016). Storm flood characteristics and identification of periodicity for flood-causing rainstorms in the second Songhua river basin. *J. Water Clim. Chang*. 8: 529-538.

Ivana T.; Matija, Z. and Jaka, O. (2016). Annual and seasonal variability of precipitation and temperatures in Slovenia from 1961 to 2011. *Atmospheric Research*, 168: 220-233.

Kamara, S.I. (1986). The origins and types of rainfall in West Africa. *Weather*, 41: 48-56

Keggenhoff, I.; Elizbarashvili, M. and Amiri-Farahani, A. (2014). Trends in daily temperature and precipitation extremes over Georgia, 1971-2010. *Weather and Climate Extremes*, 4: 75-85.

Kundzewicz, Z.W. (2012). Changes in flood risk in Europe. I.A.H.S. Special *Publication* Mario, P.; Luca, P. and Carmela, V. (2016). Sinkhole occurrence in consequence of heavy rainstorms in Apulia (south-eastern Italy). *Geophysical Research Abstracts* 18: 4758.

Niemczynowicz, J. (1984a). Investigation of the influence of rainfall movement on runoff hydrograph: Part I. Simulation of conceptual catchment. *Nordic Hydrology*, 15: 57-70.

Niemczynowicz, J. (1984b). Investigation of the influence of rainfall movement on runoff hydrograph: Part II. Simulation of real catchments in the City of Lund. *Nordic Hydrology*, 15: 71-84.

Niemczynowicz, J. and Dahlblom, P. (1984). Dynamic properties of rainfall in Lund. Nordic Hydrol. 15(1): 9-24.

Oguntoyinbo, J.S. and Akintola, F.O. (1983). Rainstorm characteristics affecting water availability for agriculture. *Hydrology of Humid Tropical Regions*, Publ. No. 140.International Association for Hydrological Sciences (IAHS), UK: 63-72 pp.

Olaniran, O.J. (2002). Rainfall Anomalies in Nigeria. The Fifty-Fifth Inaugural Lecture, University of Ilorin, pp. 9-13.

Ologunorisa, T.E. (2006). The changing rainfall pattern and its implication for flood frequency in Makurdi, Northern Nigeria. *J. Applied Sci. Environ. Mgt.* 10(3): 97-102.

Oyebande, B.L. (1982). Sediment transport and river basin management in Nigeria. *Tropical Agricultural Hydrology.* Lai, R. and Russell, E.W. Eds. Wiley, Chichester: Wiley. 201-225.

Singh, V.P. (2002a). Effect of the duration and direction of storm movement on infiltrating planar flow with full areal coverage. *Hydrological Processes*, 16: 1479-1511.

Singh, V.P. (2002b). Effect of the duration and direction of storm movement on planar flow with full and partial areal coverage. *Hydrological Processes*, 16: 3437-3466.

Shuttle Radar Topographical Mapping. (2013). Topographical map of Ibadan region; wall map, prepared for Ibadan urban flooding management project (IUFMP), Department of Geography, University of Ibadan, Ibadan, Nigeria.

Sikorsta, A. E. and Seibert, J. (2018). Appropriate temporal resolution of precipitation data for discharge modelling in pre-alpine catchments.

Hydrological Sciences Journal, 63:(1-4): 1-16.

Sumner, G.N. (1988). Precipitation: Process and Analysis. John Wiley Press, Chichester, 455pp.

Walsh, R.P.D. and Lawler, D.M. (1981). Rainfall seasonality: description, spatial patterns and change through time. *Weather* 36 (7): 201-209.

Zhihe, C.; Lei, Y.; Xiaohong, C.; Shuai, W. and Zhihua, Z. (2015). The characteristics of urban rainstorm pattern in the humid area of Southern China: A case study of Guangzhou City. *International Journal of Climatology,* 35(14): 4370–4386.