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Assessment of Inter-Tropical Convergence Zone (ITCZ) Impact on Precipitation in Six Locations in Nigeria

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Abstract: ***The effect of inter-tropical convergence zone movement on the precipitation fall has been investigated in six locations in a tacit form. The investigation shows that the ITC movement affects precipitation fall index though not in isolation. Otherfactors include prevailing trade winds and the air mass they carry. The work also identifies the onset of rain in a location with the initial appearance of ITCZ.***

Keywords: ITCZ, North- East Trade wind, North-easterly, Onset of rain, Precipitation, South-West Trade wind, South-westerly.

1. Introduction

The amount precipitation fall is a serious concern to people all over the globe, in that virtually every human activity revolves around it, such as Agricultural activities [1], Remote sensing [2]. Variation of precipitation has been well investigated in many regions of the world using long term observed data. Some even go to extent of investigating differently night time and day time precipitation such as [3][4], Others went as far as observation and modeling through the use of remote sensing instruments, space borne radio-meters and global positioning system (GPS). These include [5], [6],[7]and [8].

Third world countries like Nigeria are also contributing their quota (based on the available meteorological information) in this direction such as the Distribution of annual precipitable water in Nigeria, [9], Measurement of atmospheric precipitable water vapour at micrometer wave length over tropical stations [10]. To add to the fact finding about precipitation, this work would investigate in tacit form the impact of Inter-tropical convergence zone (ITCZ) movement on the precipitation fall in six Nigeria locations: (i) Uyo, (ii) Ikeja, (iii) Enugu, (iv) Minna, (v) Sokoto and (vi) Yola representing (i) South-South, (ii) South-West, (iii) South-East, (iv) North-Central, (v) North-West and (vi) North-East zone respectively.

2. Method of Analysis

This research is carried out in six locations which are randomly selected to represent six geopolitical zones in the country. The locations and their geographical co-ordinates are given in Table 1 below and are also presented in figure 1.

Table 1: Locations and their co-ordinates

Zone	Location	Latitude (^{o}N)	Longitude (^{o}E)
South - South	Uyo	05.00	07.50
South – East	Enugu	06.47	07.55
South - West	Ikeja	06.58	03.33
North Central	Minna	09.39	06.32
North – West	Sokoto	13.01	05.25
North – East	Yola	09.12	12.29

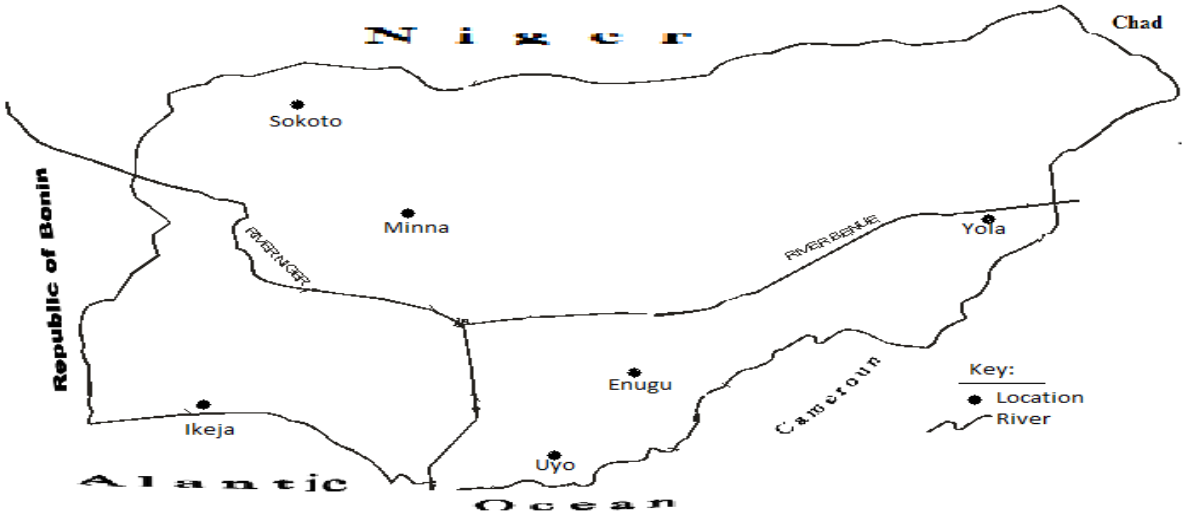


Fig.1: Position of locations on the map

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The data used in this work were collected from Nigeria Meteorological (NiMet) Agency, Abuja. The data were ten years (1989 – 1998) rainfall amount measured in millimeters. The mean values of the precipitation for the ten years in each location were computed and used for the analysis.

3. Result and Discussion

The mean values of precipitation for the six locations are presented in table 2-7 below:

Table 2: Average Monthly Precipitation in Uyo

Month	*Precipitation (mm)*
Jan	3.21
Feb	19.47
Mar	77.97
Apr	76.80
May	187.40
Jun	228.69
Jul	351.70
Aug	71.31
Sep	224.34
Oct	199.87
Nov	19.56
Dec	13.56
$\sum$	1473.88
$\overline{\sum}$	122.82

Table 3: Average Monthly Precipitation in Ikeja

Month	**Precipitation (mm)**
Jan	3.21
Feb	20.01
Mar	79.87
Apr	82.24
May	229.20
Jun	351.70
Jul	320.60
Aug	73.30
Sep	224.46
Oct	198.86
Nov	20.02
Dec	14.46
$\sum$	1617.93
$\overline{\sum}$	134.83

Table 4: Average Monthly Precipitation in Enugu

Month	**Precipitation (mm)**
Jan	4.50
Feb	18.92
Mar	75.87
Apr	169.19
May	221.76
Jun	374.63
Jul	363.55
Aug	85.60
Sep	222.00
Oct	210.07
Nov	31.72
Dec	5.49
$\sum$	1783.31
$\overline{\sum}$	148.61

Table 5: Average Monthly Precipitation in Minna

Month	**Precipitation (mm)**
Jan	0.00
Feb	0.00
Mar	0.24
Apr	16.80
May	71.70
Jun	123.47
Jul	130.49
Aug	137.45
Sep	98.16
Oct	20.70
Nov	0.10
Dec	0.00
$\sum$	599.11
$\overline{\sum}$	49.93

Table 6: Average Monthly Precipitation in Sokoto

Month	**Precipitation (mm)**
Jan	0.00
Feb	0.40
Mar	3.00
Apr	21.40
May	47.50
Jun	87.10
Jul	134.00
Aug	165.90
Sep	69.60
Oct	4.90
Nov	0.00
Dec	0.00
$\sum$	533.80
$\overline{\sum}$	44.48

Table 7: Average Monthly Precipitation in Yola

Month	**Precipitation (mm)**
Jan	0.00
Feb	0.00
Mar	9.30
Apr	34.00
May	46.50
Jun	98.60
Jul	146.00
Aug	164.00
Sep	86.43
Oct	13.00
Nov	0.00
Dec	0.00
$\sum$	589.30
$\overline{\sum}$	49.11

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The effect of ITCZ on precipitation fall in the afore-mentioned location will be discussed under the following headings

3.1 PrecipitationDistribution in the Locations

In comparison, on the average Enugu has the highest value of precipitation (148.61mm) followed by Ikeja (134.83mm) then Uyo (122.82 mm), Minna (49 93mm) Yola 49.19mm) and Sokoto (44.48mm) lags, (tables 2- 7). The reason Enugu has the highest value of precipitation than Ikeja and Uyo despite its geographical location could be attributed to (i) the effect of strong solar heating direction onits surface: the South-West trade wind blows north easterly, this wind carries mT air mass which is warm and moist from the Atlantic Ocean. Near the coast in which Ikeja and Uyo are situated (fig 1), the velocity of the horizontal component of the trade wind becomes very strong (strong enough to carry away mT air). Since the wind blows north easterly, it will pass through Eastern part of the country in which Enugu is located. At Enugu (due to interaction of the trade wind with local air as it travels) the horizontal velocity of the trade wind reduces. Couple with the strong solar heating of its (location's) surface and the presence of ITCZ, vertical updraft becomes eminent, hence at Enugu, precipitation becomes high (higher than Ikeja and Uyo).

Another interesting discovering is that Yola has higher precipitation index than Sokoto, (tables6 and 7). The reasons could be; (i) the relative higher influence of South-west trade wind on Yola as compared to Sokoto: as the trade wind blows north easterly it first reaches Yola with its relatively stronger influence than when it reaches Sokoto which is far North-West; (ii) Yola is near water bodies such as River Benue, (fig 1). Combination of these two facts strengthens the maritime characteristic in Yola than in Sokoto. In the strength of this, the north east trade wind which blows south-westerly wedges below South-West trade wind as both meet in Yola and Sokoto respectively and produce a front: a narrow zone of transition between air masses that are differ in density and temperature. Consequently, frontal uplift yield higher precipitation in Yola whose air mass is of more maritime characteristics than Sokoto with cT air mass as its dominant air mass.

3.2 Precipitation Onset in the Locations

Nigeria is one of the tropical countries in the world, situated between 4^{o}N and 14^{o}N of latitude. Her location in the world map favours two seasons-wet and dry seasons. The alternating wet and dry seasons is primarily due to intermediate position of the country between the inter-tropical convergence zones (ITCZ). For better understanding of the effect of ITCZ in precipitation fall in Nigeria, the rainfall index variation would be viewed with respect to ITC movement. ITC zone is not fixed, it varies from time to time, the variation of ITCZ goes with trade winds-North-East or South-West trade winds. The importance of the movement of ITCZ and its associated winds in the understanding of rainfall in the country cannot be over emphasized. The ITCZ starts to move toward Northern hemisphere by March, during this period, Uyo, Ikeja and Enugu start to experience low pressure system. Because of the low pressure system in the inter-land, the maritime air masses would be forced to move to these locations, thereby increasing buoyancy of the air parcel even to condensation level, hence precipitation formation. Thus by March, the locations begin to experience rainfall (onset of rain). By April - May, another pole-ward shift in ITCZ towards the northern hemisphere is experienced; this brings about a new zone of ITC which is closed to Minna.

The placement of inter-tropical convergence zone (ITCZ) close to this location (Minna) modifies the climatic condition of the location by creating low pressure system there, thus triggers buoyancy of the parcel in the location to favour formation of precipitation (onset of rain). Around the months of late May - July, inter-tropical convergence zone again makes pole-ward advancement toward Northern hemisphereand create a new zone around Sokoto and Yola. Withthe placement of ITC in its new locations, the locations (Sokoto and Yola) expierence low pressure system. Hence, by May - July Sokoto and Yola experience onset of rain, (tables6 and 7).

From September - February, ITCZ begins to migrate to the Southern hemisphere; the reversal of ITCZ movements brings about change in wind direction. From South-West to North-East trade wind. The North-East trade wind carries continental tropical (cT) air masses which are dry and hot. The air masses as they blow produce an abrupt and important change in whether which results in seasonal change: from wet monsoon to dry season, [11].

Though solar radiation input is high during dry season, the high ground temperature only brings a steep temperature lapse rate and unstable condition. But despite the instability, cT air masses often remain cloud free because of their inherent dryness hence; Sokoto and Yola begin to experience the onset of dry season by September - October. By November – January Uyo, Ikeja, Enugu and Minna begin to experience the onset of dry season as the ITC makes pole-ward advancement to the Southern hemisphere with cT temperature regime with its moderating factor hence,the onset of dry season during this period.

By late November Uyo, Ikeja, Enugu begin to experience the onset of dry season (though not as dry as that of Minna, Sokoto and Yola) because the characteristic of cT masses becomes moderate as they migrate away from their source region due to interaction with local wind (in this case sea breeze) which carries mT air masses to inland. Consequently, Uyo, Ikeja and Enugu do not experience total dry season as compared to Minna, Sokoto and Yola.

3.3 Precipitation Peak

Uyo, Ikeja and Enugu have two-times rain fall peaks namely: (i) the months of June and July mark the first peak; this is influenced by the northward movement of ITC and its associated South-West trade wind which carries mT air to the inter-land, (ii) the second phase of the rainfall peak (September and early October) seems to be related with the thinning away of cT air mass due to long distance and the development of strong southern sea breeze at the coastal area of the Atlantic Ocean. The penetration of this sea

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breeze suppresses completely the cT air mass characteristic thus, promoting instability around the region of low pressure system through convergence of moist and warm air around the area hence, by September – October Uyo, Ikeja and Enugu have another rainfall peak, (tables 2 – 4).

By August ITC makes again advancement Northward, during this time ITC impact is greatly felt in the Northern zones – Minna, Sokoto and Yola than in the Southern zone - Uyo, Ikeja and Enugu. The presence of ITCZ in the Northern zones creates low pressure system in Minna, Sokoto and Yolaand relatively high pressure system in Uyo, Ikeja and Enugu. High pressure system in Uyo, Ikeja and Enuguresults in strong horizontal wind velocity from Uyo, Ikeja and Enugu to Minna, Sokoto and Yola. With its mT air mass characteristic, the prevailing wind transports warm and moist air toMinna, Sokoto and Yola hence around the locations (Minna, Sokoto and Yola) there exist good relationship between convective instability which can be represented as precipitation; hence by August Minna, Sokoto and Yolaexpeerience rainfall peak while Uyo, Ikeja and Enugu are exposed to August break.

Minna has its rainfall peak from July – August (table 5), this is so because Minna is an intermediate location between Uyo, Ikeja, Enuguin the Southern zone and Sokoto, Yola in the Northern zone, (fig 1). In this situation Minna shares at one instant what happens to Uyo, Ikeja, Enugu and at another instant it enjoys the influence of SokotoYola, hence Minna has long period of rainfall peak (longer than Sokoto and Yola and one time rainfall peak less than Uyo, Ikeja and Enugu, (tables 2 – 7).

4. Conclusion

Uyo, Ikeja and Enugu do not have absolute dry season as it is experienced by Minna, Sokoto and Yola the research also reveals two times rainfall peak at Uyo, Ikeja and Enugu. First, the months of June – July, this is influence by the first phase of ITC movement. Second, September – October, this is influence by the reversal direction of ITC toward the southern hemisphere. Minna is an intermediate location between Uyo, Ikeja, Enugu and Sokoto, Yola. In this case Minnaat one instant enjoys what influences Uyo, Ikeja and Enugu and at another instant shares in the influence of Sokoto and Yola. This causes Minna to (though having one peak of rain), experiences a longer period of rainfall peak (July – August) than Sokoto and Yola whose peak last for just one month (August).

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