THUNDERSTORM FREQUENCY OVER NIGERIA

By

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The research attempted a comparative analysis of thunderstorm frequencies over Nigeria using some geographical parameters. Secondary data on thunderstorm frequencies and locational characteristics of 20 meteorological stations in Nigeria were obtained from the headquarters of the Meteorological Services Department Oshodi, Lagos for a period of 30years (1970-1999). All geographical co-ordinates were first converted to degree before analysis. Multiple correlation and regression analysis was employed to test the relationship between thunderstorm frequencies and locational characteristics of altitude, latitude and longitude for the whole country. The same technique was used to test for regional effect on a north-south basis. Finally, stepwise regression model was used to assess individual contribution of the independent variables. The results show that locational characteristics have a joint positive relationship with thunderstorm, significant at 1% confidence level. The coefficient of determination (r^2) shows that 51% of variation in thunderstorm frequencies over the country is attributed to locational characteristics. The result of the stepwise regression analysis selected two variables significant at 10% confidence level, these are latitude and longitude. Together they accounted for 47% variation in thunderstorm frequency over Nigeria. The research concludes that latitude exhibit the greatest influence on thunderstorm frequency in Nigeria.

Keywords: *Thunderstorm, frequency, altitude, latitude, longitude, Nigeria.*

1. INTRODUCTION

Thunderstorm is an intensive convectional shower which is associated with lightening and thunder. It is an elementary unit of the larger tropical disturbances. Thunderstorms are always purely localized affairs, as they rarely reach diameter of more than 10 km. their duration is limited to 1-2 hours only and, where thunderstorm activities prevails over longer periods, it is merely a repetition of the short process. It is generally estimated that a thunderstorm will develop when the instability reaches levels around 8000 meters.

Thunderstorm phenomena the world over has been studied from various perspectives. Nocturnal thunderstorm occurrence and its related phenomena was studied by Wallace (1975), Gary and Jacobson (1977). The relationships between thunderstorm occurrence and level of industrial activities over selected cities had been studied by Gassman *et al* (1983). Schaefer *et al* (1985) and Barnes and Newton (1985) studied the effect of local conditions on thunderstorm frequencies. The origin and forecasting of thunderstorm using satellite imageries, mean daily air temperature and air vapour pressure has also been done (Walkner, 1992 and Kolendowicz, 2004).

In Nigeria, literatures abound on studies of various aspect of thunderstorm. Its contribution to precipitation in various locations has been documented in the literature (Obasi, 1975; Nnodu,1983; Omotosho,1985; Balogun, 1984; Adeleke,1988 and Binbol, 2005). The seasonal distribution as well as the climatological characteristics of thunderstorms had been documented by Mulero (1973) and Oladipo and Mornu (1985). Ologunorisa (1999) analyzed the diurnal and seasonal variation of thunderstorm in Ondo, southwestern Nigeria. Ologunorisa and Chinago (2004) studied the annual thunderstorm trend, fluctuations and diurnal variations over Nigeria. Wide as these studies are, none attempted a thunderstorm frequency

correlation with geographical parameters neither was a regional frequency comparison made. The need to fill this gap in the knowledge of thunderstorm studied in Nigeria forms the main thrust of this paper.

II. . MATERIALS AND METHOD

THE STUDY AREA

Nigeria, located in the western part of the African continent has a Grid reference of 4^0 1' to 13^0 9' N and 2^0 2' and 14^0 30' E (Fig 1). It has a land area of 924,000Km^2 with an increasing altitude as one moves inland from the sea. Its climate is characterized by two distinct seasons, wet and dry. The duration of both wet and dry seasons varies from south to the north. The dry season is a period characterized by the predominance of the north easterly trade winds, it is generally dry and cool. During the dry season, temperatures dropped considerably and precipitation is absent in most part of the country. This period span about 3 months in the south to as much as 8 months in the extreme north. The wet season is characterized by precipitation occurrence all over Nigeria, while the north has a single maximum, the south enjoys a double maxima regime. The climate is generally dominated by two air masses, the Tropical maritime (mT), a warm moist southwesterly air mass originates over the ocean and the Tr continental (cT), a cool dry wind that orig over the Sahara desert. The boundary wher two air masses meet is termed Inter Tr Discontinuity (ITD). It is the seasonal mov of this boundary zone that determine prevailing climate over Nigeria. The v stratification also varies from evergreen lux forest in the south to Sahel conditions extreme north.

DATA COLLECTION

The major sources of data for this study secondary data. This was obtained fro headquarters of Nigerian meteorological se department Oshodi, Lagos. It has a station nı 100/3 and serve as a collecting and col station for all synoptic stations scatter arou country. Data were collected for a period years (1970-1999). The stations were se based on data availability and consisten records. Geographical coordinates and da altitude of each station were also obtained the same source. Station selection was dc reflect equal representation of the nort southern regions of the country each wi

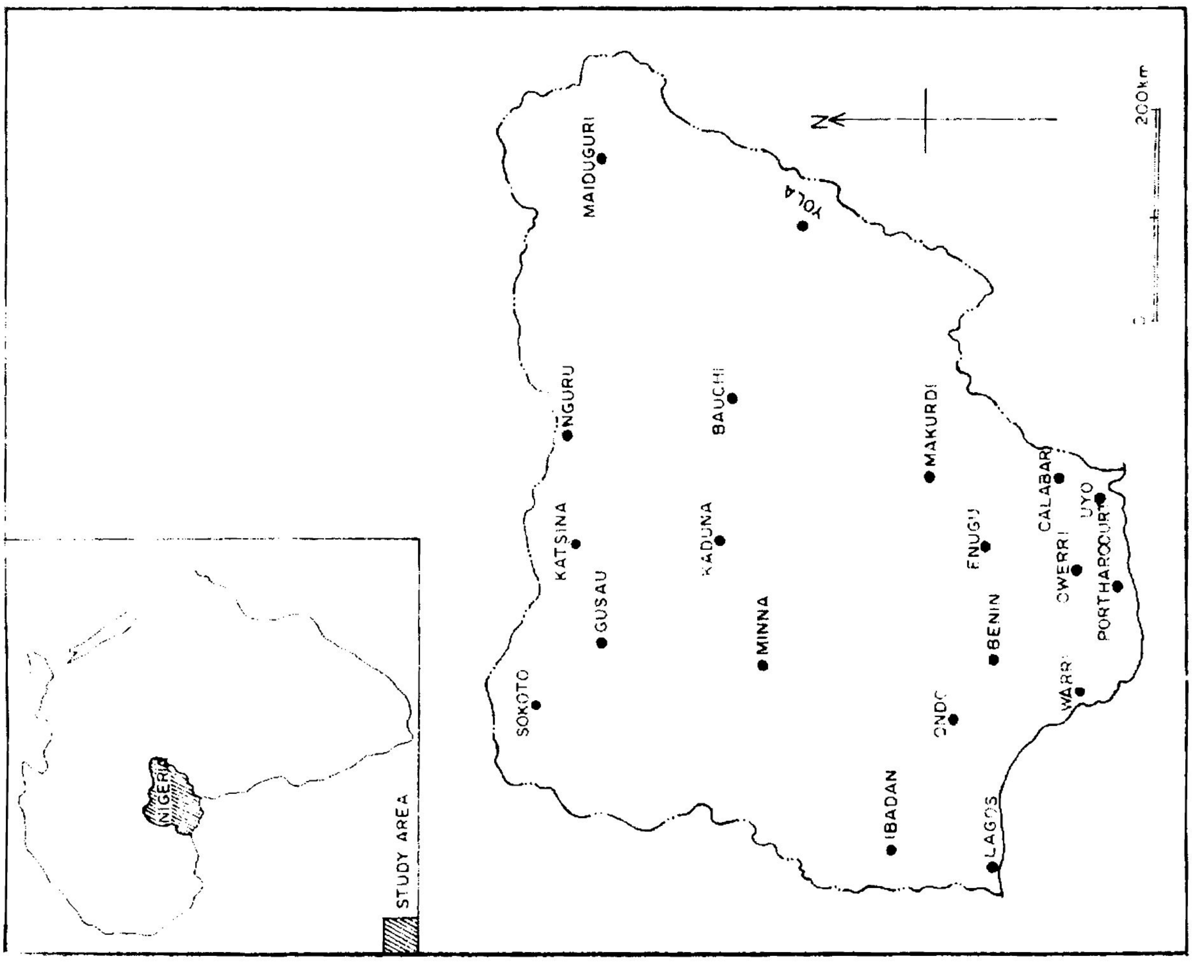

Table 1, Thunderstorm frequency and locational characteristics of selected synoptic stations.

S/no	Station	Latitude	Longitude	Altitude	Thunderstorm frequency
1	Bauchi	10^0 17	09^0 46	609.30	5,493
2	Benin	06^0 19	05^0 36	77.72	7,039
3	Calabar	04^0 58	08^0 1	61.87	6,961
4	Enugu	06^0 8	07^0 33	141.73	6,114
5	Gusau	12^0 10	06^0 42	643.60	5,235
6	Ibadan	07^0 26	03^0 54	227.08	5,628
7	Kaduna	10^0 36	07^0 27	644.69	6,573
8	Katsina	$13^0$01	07^0 41	517.25	3,900
9	Lagos	06^0 27	03^0 24	14.33	1,850
10	Maiduguri	11^0 15	13^0 05	535.57	3,321
11	Makurdi	07^0 44	08^0 32	112.75	3,360
12	Minna	$09^0$37	06^0 12	258.47	7,067
13	Nguru	12^0 53	$10^0$28	342.90	2,100
14	Ondo	$07^0$6	$04^0$50	286.51	7,751
15	Owerri	05^0 29	07^0 02	100.58	4,848
16	PortHarcourt	04^0 43	$07^0$05	19.51	9,234
17	Sokoto	13 ^{0}0	05^0 15	350.52	3,391
18	Uyo	05^0 2	$07^0$6	38.10	6,526
19	Warri	05^0 31	$05^0$33	6.10	7,700
20	Yola	09^0 14	$12^0$28	185.98	4,578

Source: Nigerian Meteorological Services Department, Oshodi.

DATA ANALYSIS

Thunderstorms constitute the dependent variable in the study, while latitude, longitude and altitude were used as independent variables. Multiple correlation and regression, analysis were used to establish relationship between thunderstorm and the variables for the whole country. ANOVA was used to test the joint significance of the predictor variables, while t test was employed for individual significance test. Finally step wise multiple regression model was used to asses individual contributions of the independent variables. Replication of the same method was done independently for the northern and southern region of the county in order to establish which part of the country is mostly affected by the variables under examination. Ordinary least square method was also employed to establish a lead model for thunderstorm prediction base on the variables under consideration. All coordinates were recorded in degree values as presented in table 1.

III. RESULTS AND DISCUSSION

3.1 Relationships between thunderstorm, latitude, longitude and altitude

The result of multiple correlation and regression of thunderstorm frequency with longitude, latitude and altitude is presented in table 2.

Table 2. Multiple correlation and regression of thunderstorm frequency with longitude, latitude and altitude

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Model	r	r^2	r^2 adjusted	Std error of the estimate	sig
1	.714	.510	.418	1524.46	.008

The results in table 2 shows that all requested variables entered (longitude, latitude and altitude) have a joint positive relationship with thunderstorm frequency over the country. That is, longitude, latitude and altitude will individually and jointly affect or predict thunderstorm frequency over Nigeria. The co-efficient of determination in the relationship shows that the predictors entered account for 51% variation in thunderstorm frequency over the country. The use

of ANOVA shows that they predictors were jointly significant at the 1% confidence level.
The use of t-test on the regression co-efficient to highlight the nature and extent of relationship of each independent variable is presented in table 3

Table 3. T-test coefficient results

Model	Unstandardized coefficients		Standardized coefficient	t	Sig.
	B	Std Error	Beta		
1 (Constant)	11445.589	1530.758		7.477	.000
ALTD	5.977	2.848	.666	2.099	10%
LAT	-681.759	217.635	-1.006	-3.133	1%
LONG	-262.891	149.738	-.318	-1.756	10%

The table shows that only altitude has a positive effect on thunderstorm frequencies which is significant at 10% confidence level. This implies that with every 1 meter increase in altitude there is a 90% chances that thunderstorm frequencies will increased by 6 (Six) incidences. This finding further gives credence to the works of Ologunorisa and Chinago (2004) who identified isolated highlands especially in the northern part of the country as breeding grounds for the generation of thunderstorms. Latitude, though significant at 1% confidence level, exhibited a negative relationship. That is, with one degree (1^0) increase in latitude, thunderstorm frequency will decrease by about 681.76 incidences. This finding also agrees with the earlier works of Balogun (1981), Nnodu (1983), Omotosho (1985) and Binbol (2005) who found out that while the southern part of the country, up to Latitude 8^0 N enjoys a double maxima rainfall regime. The northern part enjoys a single maximum. This means that the longer an area enjoy rainfall regime the more likely the thunderstorm frequency it will record. Longitude, though significant at 10% confidence level also exhibited a negative relationship with thunderstorms.

Stepwise regression was introduced at this stage to filter out individual contributions. The results are presented in table 4.

Table 4. Stepwise regression of geographical parameters on thunderstorm frequency

Variable Entered	Partial (R)	Model (R)	F	Sig. level
X1 Latitude	28.3	28.3	7.104	0.016
X2 Longitude	18.7	47.0	4.130	0.057
X3 Altitude	05.9	52.9	1.139	0.300

From the results in Table 4, it will be noted that only two variables entered the model at significant level. These are latitude and longitude, they both account for 47% variation in the frequency of thunderstorms over Nigeria. Latitude alone has the greatest single contribution of 28.3%. The probable explanation for this being that, since thunderstorm are associated with intensive convectional showers, it will be most frequent around the equator. The reason being that it is a zone of great heat and high temperature; therefore it is mostly covered by clouds. A general analysis of the global distribution of thunderstorm shows a general decrease in thunderstorm frequency towards the pole from the equatorial latitude.

3.2 REGIONAL ANALYSIS

In order to ascertain which region benefit most from the effect of these geographical parameters, the twenty stations were sorted according to regions (north and south) with equal number of stations. Multiple regression and student t-test were used to compare regional effect of measured parameters on thunderstorm frequency. The result of the analysis carried out is presented in Table 5 and Table 6. Results in Table 5 shows that all the parameters under study have a positive effect on thunderstorm frequency in both the north and south regions of Nigeria, but non was significant. This means that although latitude, longitude and altitude have some bearings on thunderstorm frequencies over locations in Nigeria; they are not the ultimate deciders of thunderstorm occurrences over the country.

Table 5. Multiple regression results for north and south region

Region	Variables	r	r^2	t	Sig. level
North	Latitude	.329	.108	2.466	.039
	Longitude	.373	.139	3.699	.006
	Altitude	.288	.083	2.810	.023
South	Latitude	.239	.057	2.312	.050
	Longitude	.157	.025	2.312	.028
	Altitude	.080	.006	6.290	.000

Table 6. Student t-test result for northern and southern stations

t-cal	t-tab	df	n	sig
2.31	2.10	18	20	0.05

The student t-test was particularly introduced to test a null hypothesis of no significant relationship between northern and southern stations thunderstorm frequency. The result shows that the critical value 2.10 is less than the calculated value of 2.31. Therefore we accept the fact that there is a significant difference acceptable at the 5% confidence level between thunderstorm frequency in the northern and southern of the country. The slight difference maybe explained mainly by the latitudinal factor which alone accounted for 28.3% variation in thunderstorm frequency over Nigeria.

IV. CONCLUSION

The relationship between thunderstorm frequency and some geographical parameter have been examined for Nigeria. It was observed that altitude and latitude will both individually and jointly affect and predict thunderstorm frequency for the country since the general tendency observed from analysis shows that thunderstorms tend to decrease with increasing latitude. Regional comparison also shows a slight variation in thunderstorm frequency between the north and south at the 5% level of significance. The research concludes that though altitude, latitude and longitude contribute slightly in the variations in thunderstorm frequency over Nigeria, they are not the sole determinants of thunderstorm occurrences. The regression residue of 47.1% could be attributed to some meaningful factors that can explain the variations noted. In this regards, the research therefore recommends further investigations into the relationship between high surface air temperature and thunderstorm frequency over Nigeria.

References

Adelekan, I.O. (1998) "Spatio- temporal variations in thunderstorm rainfall over Nigeria." ***International journal of climatology*** 18, 1273-1284

Balogun, E.E. (1984) "Seasonal and spatial variations in thunderstorm activities over Nigeria." ***Weather*** 36; 192-196

Barnes, S.N. and Newton, C.W. (1985) "thunderstorm in the synoptic setting" in Kessler (ed) ***Thunderstorm morphology and dynamics***. university press, Oklahoma

Binbol, N.L. (2005) "Seasonal variation in linesquall and thunderstorm activities over Yola." ***Nasara scientifique*** 1, 59-65

Gasman, F., Haschke, D. and Rudin, F. (1983) "Moeglickelten antropogner veraederungen der Gewittertae tigkeit" EIR-Bericht N 500, Weirenlinger November

Gray, W. M. and Jacobson, R.W. (1977) "Diurnal variation of deep cumulus convection" ***Mon Wea. Rev*** 105 1171- 1188

Kolendowicz, L. (2004) "The influence of air temperature and humidity on the frequency of thunderstorms in Suwalki, Poland" ***Jour. Met.*** UK 29 (286) 45-51

Mulero, M.A. (1973) "On seasonal distribution of thunderstorm days in Nigeria" ***Quarterly Meteoroid Mag*** 3, 73-78

Nnodu, I.D. (1983) "Frequency and seasonal variation of linesquall over Nigeria". Unpublish M.sc dissertatation, university of Ibadan.

Oladipo, E.O. and Mornu, M. (1985) "Characteristics of thunderstorm in Zaria, Nigeria". ***Weather*** 40 316-321

Ologunorisa, T.E. (1999) "Diurnal and seasonal variations of thunderstorm activity in Ondo, southwestern Nigeria". ***Geo. Research***, 2, 47-51

Ologunorisa, E.T. and Chinago, A. (2004) "Annual thunderstorm trends and fluctuations in Nigeria". ***Jour. Met.*** UK 29,(286) 39-44

Omotosho, J.B. (1985) "The separate contributions of linesqualls, thunderstorms and moosoon to the total rainfall in Nigeria". ***Journal of climatology*** 5, 543-555

Schaefer, J.T.R. and Chapel, C.F. (1985) "Thunderstorms and their mesoscale" in Kessler, E. (ed) ***Thunderstorm morphology and dynamics***. University of Oklahoma press. 113-132

Walkner, A. (1992) "Grossraunige Austanschprozesse der atmosphere als ursache von starkgwe witten" ***Phisiche geographic***, 35 Zurich

Wallace, J.M. (1975) "Diurnal variations in precipitation and thunderstorm frequency over the conterminous United states". ***Mon. Wea. Rev*** 103, 406-419

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