Analysis of Seasonal Temperature Variation on Thunderstorm Activity over Barkin Ladi, Palateau State Nigeria

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ABSTRACT-Variation in temperature has been a general concern to scientist due to its direct and indirect effect on meteorological phenomena (thunderstorm). This research work examined the effects of seasonal temperature variation on thunderstorm occurrences over Barkin Ladi area of Plateau State. Thirty five years (1981-2015) of temperature (Max) and thunderstorm (TS) occurrence was extracted from the archive of Nigerian Meteorological Agency Abuja. The data were subjected to statistical analysis using regression and correlation analysis to evaluate the effect of seasonal temperature variation on the occurrence of TS. The analysis revealed that there was a low (weak) relationship between the two variables with R^2 0.0004 this implies that only about 0.003% of TS occurrence was as a result of variation in temperature (max) does not have much effect on TS occurrences over the study period. The trend on temperature revealed a positive with the highest record of 27-30^{0}c (max). For the TS I show a general fluctuation for both monthly and annually. Based on this outcome it was recommended from the study that since temperature variation has less effect on the occurrences of TS over the study period which may be as a result of other factors which were no considered in the study suck as rainfall, orographic effect and topography. Also that care should be taken during especially during the late afternoon and evening for TS occurrences to avoid its effect on human activities.

Key words: - Seasonal, Temperature, Thunderstorm, Occurrence, Variations, Activity, Variables.

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INTRODUCTION

Thunderstorm (TS) are stationary weather system that are highly localized which affect a limited area of about 20-50 km² depending on the cumulus size World Meteorological Organization (WMO). Research on the variation of temperature on TS activity on both diurnal and seasonal occurrences have always been of interest to both the meteorologist and climatologist across the globe. The reason is that, such research provides a basis of scientific information about the environmental control of TS formation, occurrence and characteristics and to its importance as to the process of soil erosion. Over the years TS activity have generated much concern by scientist and scholars across the globe especially by the havoc caused to the environment, Ochei, et al (2015) examine the season, inter-seasonal and spatial variation of TS frequency and its activity over Nigeria and revealed that, the highest rate of activity and frequency are predominant over the central and western parts of the country. It was also observed that over the Sahel region the activity are tend to decrease around places which include Maiduguri and Sokoto. So also the general fluctuation and trend over country have generated a great concern over the years especially how it moves from decade to decade which prompt some scholars such

like Temi and Alex (2004) which revealed that there are positive correlation coefficients (on average) for the entire country. This implies that there is upward increase in TS trend by some selected areas like Sokoto, Enugu and Ibadan while the other place like Nguru, Katsina, Bauchi, Yola, Lagos, Calabar, Wari and Port-Harcourt indicate a decrease with a negative correlation coefficient at 95% significance level.

The frequency of thunderstorm produces, heavy rain gusty winds, and *et al* hail. It may produce a single cumulonimbus cloud and influence only a small area, or it may be associated with clusters of cumulonimbus clouds covering a large area Naeem (2011). Although, according to definition rainfall need not be associated with thunderstorm (in fact, in dry climates, TS often occur without measurable precipitation. However, in this work a possible relation is expected to establish between the two variables. For this reason thunderstorm and related temperature is of much importance and interest in Nigeria especially for the fact that the climate is changing.

Many studies of thunderstorms in the past have been done in the tropics. ; Moid, (2001); Siddiquie and Rashid (2008) and Mir *et al.* (2006) The most notable once are the likes of; Temi and Alexander (2007) who carried a study on the Diurnal Variation of TS activity over Nigeria using a meteorological data; Pinto (2012) carried out a study on the sensitivity of the TS activity in the city of Sao Paulo to temperature changes; Leszek (2004) the influence of air temperature and humidity on the frequency of TS in Suwakili Poland, Omotosho (1984) carried out research on the individual contribution of thunderstorm line squall and Monsoon, to the total rainfall in Nigeria over five years, Ologunorisa et, al (2007), discussed the characteristics of thunderstorm in Zaria, Salau (1986) carried out a study on the temporal and comparative analyses of thunderstorm and related phenomena on the influence of Jos plateau over the occurrence of thunderstorm activity in Jos, Zaria and Kaduna, Aeleke (1998) the importance of TS in terms of their contribution to flooding episode. Pinto (2012) in his work the sensitivity of the thunderstorm activity in the city of São Paulo to temperature changes: predicting the future activity for different scenarios revealed that the relationship between thunderstorm activity and surface temperature for the city of São Paulo shows a clear positive trend that is very probably caused by the growth of the city and the related increase in the urban heat island effects. Alexander (2015) in his work the statistical analysis of seasonal temperature variation and thunderstorm activity over Yola revealed that there was a decrees of thunderstorm over the years also temperature variation does not have effect on thunderstorm activity the study period. Temi and Alexander (2007) in their work on the diurnal variation of thunderstorm activity over Nigeria revealed that thunderstorm is in decrease over the years.

The direct relationship between temperature variation and thunderstorm occurrence is above the surface while the indirect relationship is on the ground surface, therefore to identify the impact of temperature variation on the thunderstorm activity or their occurrence does not only depend on looking at their variation or changes in the two variables but require a detailed analysis on their trends, thunderstorm occurrence and the relationship between them. This so far is one of the most difficult aspects in the long-run of analysis of meteorological phenomenon.

TS occurrence is due to many interaction of simultaneous factors one of it is the regional-macro circulation of the atmosphere which is one of the major factor

determining the weather condition directly with temperature values of a flowing air masse Marz and Stryszyska (2001). The aim of this work was to examine the effect of seasonal temperature variation on thunderstorm occurrences using daily maximum temperature over the study area.

Study Area

The study area which is Plateau state, it lies between Latitude $80^0$24`N-$80^0$32` and Longitude $80^0$38`E it has a total land area cover of about 26,899 square kilometers (km2) with a population estimated at about 3,178,712 people (2006 census). It has an altitude which ranges from around 1,200 meters (about 4000 feet) to a peak of 1,829 metres above sea level in the shere Hills range near Jos. The climate is characterized with an average temperature of between 18 and 22^0c. Harmattan winds cause the coldest weather between December and February. The warmest temperature usually occurs in the dry season months of March and April. The mean annual rainfall varies from 1318mm in the southern part to 1446mm on the plateau during the wet season with 8-9 months of rain. The main ecological zone is mostly exposed forest mixed with tall grass this may be attributed to bush fire and other devastating factors that make the plants adapt to the environment; the plants species found in the area have some structure that make them more resistant to survive the dry season and resist bush fires example are baobab tree, shear butter, tsammarine tree, are some of the dominant trees in the area.

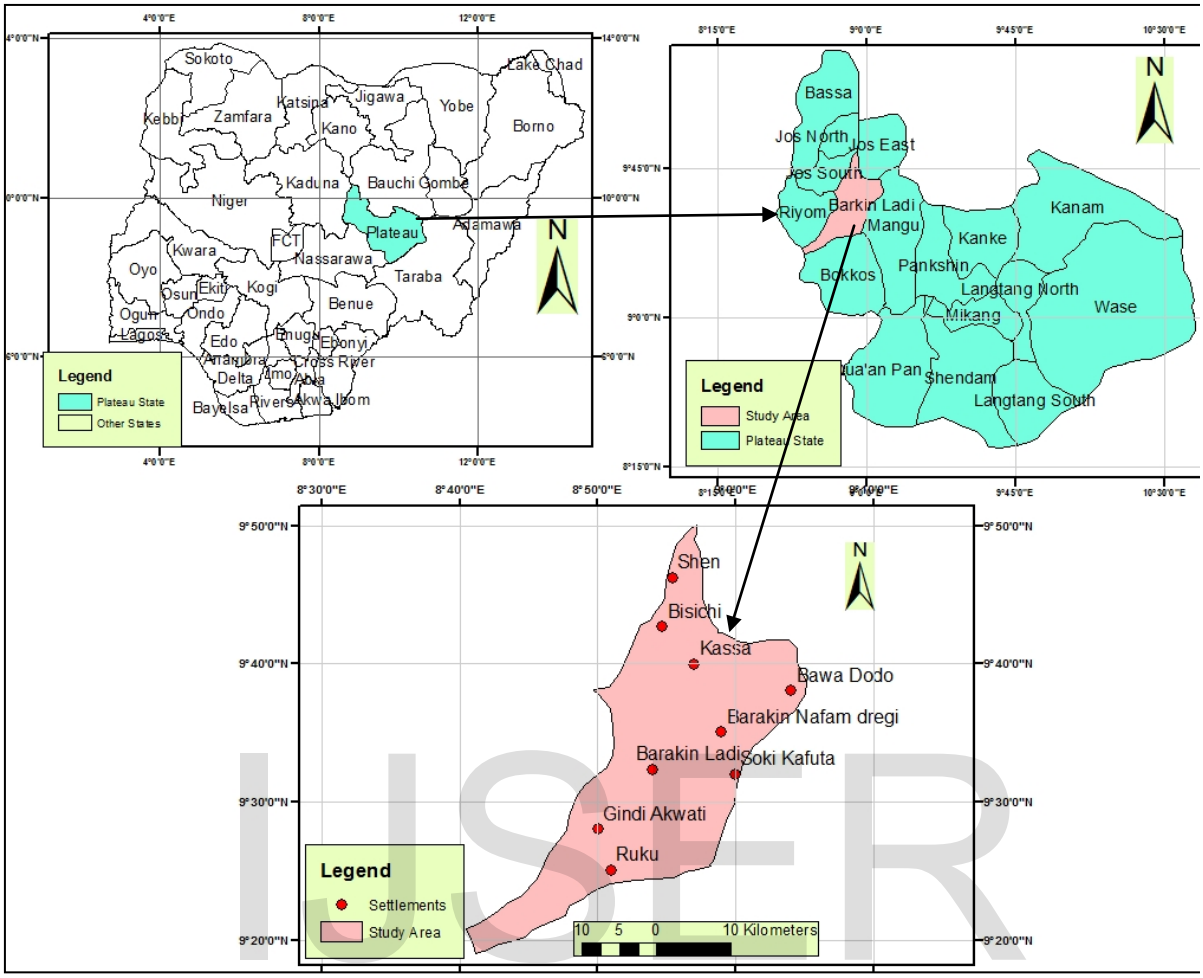

Figure 1 Map of Study Area
Sources:- Plateau State Ministry of Lands Survey and Town Planning

Materials and Methods

The data employ in this study were daily maximum temperature and thunderstorm occurrences which were extracted from the archive of Nigerian Meteorological Agency for a period 35 years (1981-2015).

Descriptive and inferential statistics were used for the analysis. The descriptive statistics used include mean, standard deviation, percentages. The inferential statistics used include linear regression and Pearson moment correlation.

Linear regression was used in the trend analysis of temperature and thunderstorm and their relationship which is expressed as:-

$$y=a+bxi$$

Where

I= integer; a= is constant b= is also constant and shows how responsive y is to a unit increase in x, y= is the regression line and x= is the independent variables

Pearson moment correlation was used to determine the linear relationship between the two variables which is expressed as:-

$$r = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{n(\Sigma x^2) - (\Sigma x)^2}\ \sqrt{n(\Sigma y^2) - (\Sigma y)^2}}$$

Where

n = number of data
Σx = sum of all x
Σy = sum of all y

Σx^2 = the square of each x score and the squares added
Σxy = the sum of the product of each x score and its corresponding y scores
$(\Sigma x)^2$ = the square of the total x scores

RESULTS AND DISCUSSION

Trend Analysis of Temperature Variation

Analysis on seasonal temperature variation as potential influence on thunderstorm occurrence was carried out using linear regression analysis and person moment correlation. Figure 2 shows the result on trend analysis of temperature variation over the study period the study revealed that there was a positive or straight line scope over the months with the months of January to April having the highest temperature record of between 27-30^{0}c (Max) which latter shows a little decreases from the months of May to September with a temperature of about 21-20^{0}c (Max) this implies that temperature over the study period is in a steady state.

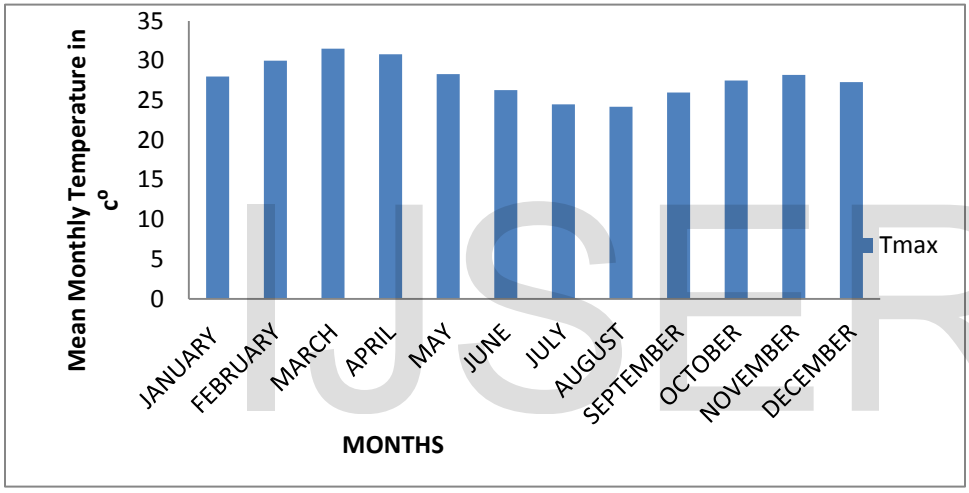

Figure 2:- Mean Monthly Trend of Temperature Variations in the Study Area
Author's Field Analysis, 2017

Figure 3 is the Annual Temperature Variations over the study period it revealed that annual temperature over the study period was in a negative or downward movement over the years. This implies that temperature variation over the years is averagely on the increase with 1987 been the year with highest variation in temperature with a recorded of 28.5^{0}c (Max) followed by 1995 with 28.4^{0}c and 2005 having 27.3^{0}c while the least mean annual Max was recorded in 1992 with 26.9^{0}c followed by 1982 with 27.1^{0}c and 1985 having 27.3^{0}c, generally there was a fluctuation between the first and second decade in temperature as depicted by figure 3. This is an indication that temperature variation over the study period generally varies greatly with time.

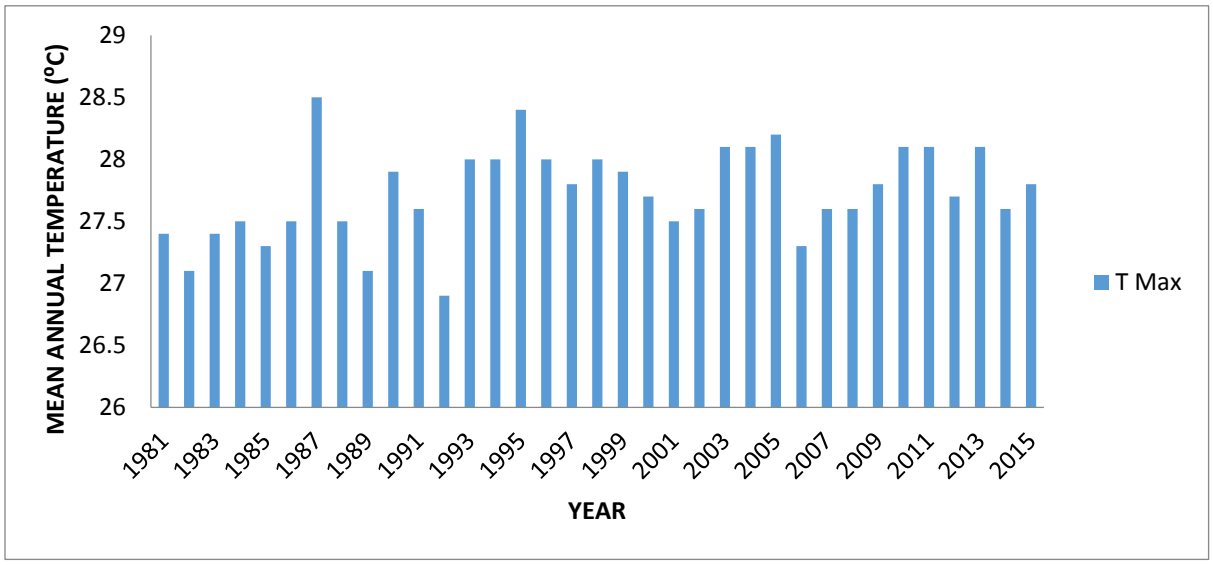

Figure 3:- Mean Annual Trend of Temperature Variation over the study period
Author Field Survey, 2017

Trend in Thunderstorm Activity

Table 1 and figure 4 shows the result on trend analysis of TS. The result revealed that there was a negative relationship between the two variables (TS and Temperature). This means that, TS occurrence is in decrease over the study period with time. The negative correlation (-0.016) implies that the relationship between the two variables is very weak and also a clear indication of a linear tendency on the general decrease of TS activity over the study period. This decrease could also be as a result of reduction in moisture content in the atmosphere resulting in rainfall reduction over the study area. While the R^2 value in figure 4 which is 0.0004 implies that, the relationship between the two variables (TS and Temperature) is very low which coincide with the result in table 1. Figure 4 is a regression plot of thunderstorm activity against temperature variation over the study period which revealed that; the R^2 value is an indication of low relationship between the two variables which is 0.0004. Table 1 show the regression model summary for the study period with the coefficient of determination R (r^2) as 0.004 which is a significant of a weak correlation between the two variables over the study period. This means that only 0.003% of thunderstorm occurrence is as a result of seasonal variation of temperature while the remaining 99.96% is as a result of other factors that aid thunderstorm occurrence. The result also revealed that variation in seasonal temperature has no significant effect on thunderstorm occurrence over the study period.

Table 1. Annual Trend of TS

Regression Coefficient	Regression Equation	t-critical	t-calculated
-0.016	Y= 0.0699+8.8637x	±2.05	0.742

This is 0.0699 is constant 'a', 8.8637 is also constant which represent 'b' and shows how responsive y is to a unit increase in x.

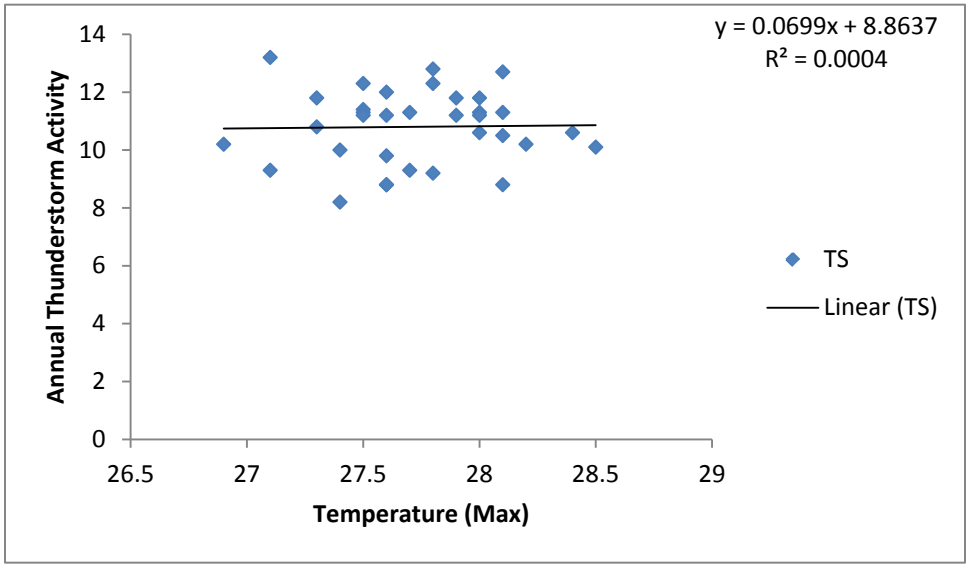

Figure 4 Regression plot of Thunderstorm and Maximum Temperature over the Study Period
Author's analysis, 2017

Table 2 Summary of Analysis of Variance

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.015	1	.015	.009	.926[b]
1Residual	55.329	33	1.677		
Total	55.344	34			

a. Dependent Variable: thunderstorm
b. Predictors: (Constant), temperature

Author's Field Analysis, 2017

Table 2 which is the analysis of variance (ANOVA) shows that, there is no statistically significant effect of variation in seasonal temperature on TS occurrence since the test statistics which (calculated) F=0.096 is less than the critical value which is F= 2.98 from the table. So any relationship that may occur it may be by chance or as a result of other factors which were not considered in this study.

Table 3 Regression Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.016[a]	0.003	-0.027	1.29314

a. Predictors: (Constant), Temperature.

Table 3 which also the standardized beta coefficient for the independent variables (Temperature) revealed that temperature contribute to TS occurrence just with 0.003% this can be concluded that seasonal temperature variation played just little role in TS occurrence over the study period. This is in line with other authors like Alexander (2015) and pinto (2012) that any relationship that may arise may be as a result of other factors like growing in city resulting from urban heat island and possibly topography or orographic factors.

RECOMMENDATIONS

(a) It is also recommended that farmers should observe the emergence of TS, since it is an indication of rainfall; the time lag between the first TS peak and the last should be utilized especially by those in the north for harvesting of rainfall. Understanding of TS occurrences will help in harvesting rainfall effectively, since TS precedes rainfall occurrence.

(b) Government and Non-governmental organizations should be involved in the study of TS, either as a source of energy or to avoid its destructive consequences.

(c) Finally there is the need to carry out study on prediction and warning of thunderstorm on both micro and macro scale to avoid the risk by children and workers to stay indoors during the onset of TS and end of TS especially during the late afternoon and early evening.

CONCLUSION

This study on the analysis of seasonal temperature variation on TS for a period of 35 years revealed that, the trend on temperature shows a positive or straight line scope over the month with the highest temperature record of 27-30^{0}c (max) but annually it shows a negative or downslope low relationship which temperature doesn't have much effect on thunderstorm occurrences over the study period. A weaker negative correlation was observed between the two variables of (-0.016) and R^2=0.0004, the regression output also revealed that variation in temperature does not have any much impact on TS occurrence over the study period with (r2=0.003) on TS occurrence. It also revealed that the decrease in TS over the study period as well as the occurrence is as a result of other factors which were not considered in this study.

Reference

Adeleken, I.O. (1998). Spatio-Temporal variation in thunderstorm and rainfall over Nigeria. International Journal of climatology 18, 1273-1283.

Alexander, .C.B. (2015). Statistical Analysis of Seasonal Temperature Variation and Thunderstorm activity over Yola Nigeria. American Journal of Education Research, 2015, (3), N0. 7,873-880: http;//pubs.sciepub.com/education/3/7/10© Science and Education Publishing DOI: 10.12691/education-3-7-10

Alexander, .C.B. and Aloni .C. (2015). The Effect of Thunderstorm activity over Port Harcourt. Nigeria Journal of Meteorology 18, 1273-1283

Leszek .K. (2004). The influence of air Temperature and Humidity on the frequency of Thunderstorm in Suwalki, Poland. International Journal of Meteorology vol. 29 No. 256

Marsz., .A. and Styszynska., .A. (2001). A North Oscillation and the Air Temperature over Poland. WSM Gdyni, wydzial Nawigacyny.Gdynia.

Naeem., .S. Muhammad., .S.Q.(2011). Thunderstorm and Rainfall Frequencies over Pakistan. Institute of Meteorology and Geophysics, Pakistan Meteorological Department Met Complex, Block No. 5, Gulistan-e-Jouhar. Space Science Elixir Space Sci. 37 (2011) 3981-3985

Omotosho, .J.B. (1984). The Separate Contribution of Line Squalls, Thunderstorm and monsoons to rainfall in Nigeria. 3. Climatology 5, 543-555.

Ologunorisa, E.T. and Alexander, B.C. (2007). The Diurnal Variation of Thunderstorm Activity over Nigeria. International Journal of Meteorology UK. 32, 315, 19-29.

Pinto, .O.J. (2012). The Sensitivity of the Thunderstorm Activity in the City of São Paulo to Temperature Changes: Predicting the Future Activity for Different Scenarios. Atmospheric Electricity Group (ELAT), National Institute of Space Research Sciences Journal Campos, São Paulo, 12227-010 Brazil.

Salau, O.A. (1986). Temporal and Comparative Analysis of Thunderstorms and Some Related Phenomena in Zaria, Jos and Kaduna, Nigeria. International journal 3 of Theory and Applied Climatology, 37, 220-232.

Siddiqui., .Z. .A., and Rashid.,.A. (2008): Thunderstorm frequency over Pakistan (1961-1990); Pakistan Journal of Meteorology, 5 (9), 39-62.