

REGIONALIZATION OF THE METEOROLOGICAL FEATURES OF SOUTHEAST REGION OF NIGERIA

Ibeje, A. O.

Department of Civil Engineering, Imo State University, P.M.B. 2000, Owerri, Nigeria

Corresponding email: engineeribeje@yahoo.com

ABSTRACT

Accurate description of the climatic features of any studied area usually constitutes most scientific articles. This study aims at characterizing some of the meteorological variables in southeast region of Nigeria using descriptive statistics and trend analysis techniques. Climatic data lasting 86 years of five meteorological stations located in Owerri, Imo state, Enugu, Enugu state, Umuahia, Abia state, Abakaliki, Ebonyi state and Awka in Anambra state were used for the study. The results revealed that towns in the northern part of the region received more heat than their southern counterparts while the southern part received more moisture. Rainfall is the most variable weather element. It is observed that only cloud cover is positively skewed while only sunshine hours, solar radiation and rainfall have positive coefficient of kurtosis in the entire regional data. The results at 5% significance level, the Mann-Kendall test reveals that while there is no trend in solar radiation except for Umuahia, monotonic trend in evaporation was detected all over southeast, Nigeria, with significantly increasing trend in Enugu at a rate of 4.371 cal/cm²/minute/year. The outcome of this study sufficiently describes the climatic features of the region and thus can be used to confidently describe the region as a study area in scientific reports.

Keywords: Mann-Kendall; statistical analysis; Trend analysis, southeast Nigeria

1 INTRODUCTION

Statistical analysis pervades climate studies. For this reason, different definitions of climate are rooted in statistics. [1] described the study of climate as the study of statistics of weather. [2] defined climate as the statistical reorientation of weather elements over a long period of time. On the other hand, weather describes the state of the atmosphere [3]. Previously, 19th to 20th century climatology was primarily bookkeeping for meteorology [1]. In those eras, climate studies were focused on recording climate variables in an objective and representative manner. Recently, climatology sciences explore statistics in the understanding and quantification of processes that govern climate variability. Statistical reasoning is also a key player in the development and evaluation of dynamic models used to forecast weather and climate on varying time scales. In the area of collection of primary climatic data, a gamut of statistical procedures is employed in data retrieval from remotely-sensed observation (e.g. satellite and radar). Furthermore, to seek physically meaningful interpretations of observed climate variability require statistical techniques. Statistical analysis facilitates proper representation of climatic information using estimators such as mean rainfall, maximum relative humidity etc. Climate statistics may also be captured as daily minimum temperature, variance of hours of sunshine, frequency of rainfall etc. Descriptive statistics of climatic variables are often used to provide firsthand information about the climatic features of a geographical location. In climatic characterization of an area, the common descriptive statistics include: mean, standard deviation, maxima, minima, kurtosis and skewness of climatic variables [1]. Southeast geopolitical region of Nigeria is made up of five states namely: Abia, Anambra, Ebonyi, Enugu and Imo states with their respective administrative capitals as Umuahia, Awka, Abakaliki, Enugu and Owerri respectively. Southeast Nigeria as well as its constituent states has been offered varying descriptive statistics concerning its climatic features. One wonders which of them is accurate. [4, 5] asserted that the average rainfall depth of southeast Nigeria ranges between 1800meters and

2000meters; and that the temperature averaged at 27°C. [4] also stated that the region experiences eight months of rainfall between March and October and four months of dry season between November and February. In another study, [5] in [6] claimed that wet season in the region lasted from April to July and September to October. [7] stated that the highest annual rainfall in southeast was about 1952mm and that rainy season commenced full in March and stopped in November. [8] offered a different climatic description of southeast Nigeria. They claimed that the highest mean annual rainfall of 2380mm occurred in Owerri with the lowest of 1860mm occurring in Enugu. Umuahia was said to have a relative humidity of 60-80%, minimum and maximum temperatures of 23°C and 32°C and average rainfall of 2238mm by [9]. [10] painted a different picture of Abia state. They argued that Abia state had mean annual climate data as: maximum and minimum temperatures of 25°C and 32°C, 2400mm rainfall and 80-90% relative humidity. It can be seen that this contradicts the previous report of Umuahia by [9], which incidentally is the capital city of Abia state. In Imo state, [11] reported that the annual average rainfall, temperature and relative humidity of Owerri were 230mm, 29°C-33°C and 65-75% respectively. Obviously this contradicts the range of mean annual rainfall which [8], [7] reported for the entire southeast Nigeria. To address these inconsistencies in the climate descriptive statistics of southeast region of Nigeria, this study is set to statistically analyze all the climatic variables of southeast Nigeria with the aim of establishing accurate characterization of the climate the region. Thus, the outcome of this study would yield climate statistics that can be cited consistently and confidently in future scientific reports.

2 STUDY AREA

Southeast region of Nigeria is located between latitudes 04° 30'N and 07° 30'N and longitudes 06° 45'E and 08°45'E as shown on Figure 1. The area is well drained with notable rivers like Niger, Imo, Nike Lake, Anambra, Idemili, Njaba, Oguta Lake, Nkisi, Ezu, Oji etc. The area is characterized by tropical rainforest nature. The Southeast region occupies a total land mass of 10,952,400 hectares with a population of 16,381,729 people [15]. The five meteorological stations of southeast Nigeria under study are located as follows: Umuahia (lat. 5.5249°N and long. 7.4946°E), Awka (lat. 6.2220°N and long.7.0821°E), Abakaliki (lat. 6.3231°N and long. 8.1120°E) Enugu (lat. 6.4584°N and long. 7.5464°E) and Owerri (lat. 5.4891°N and long.7.0176°E).

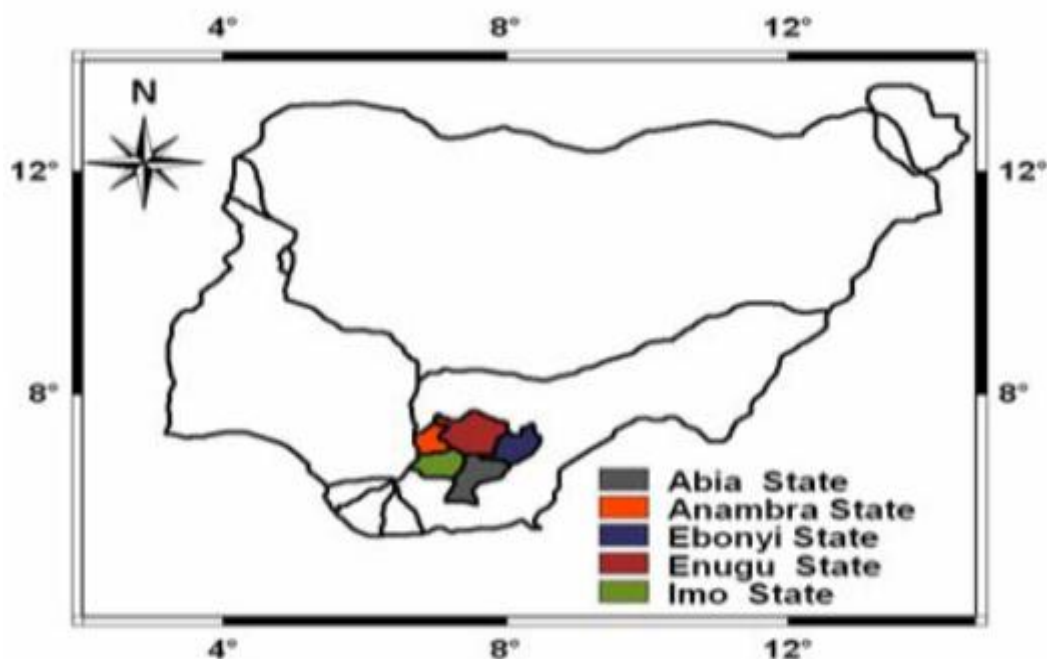


Figure 1. Map of Nigeria showing the location of States in southeast Nigeria

3 MATERIAL AND METHOD

Records of monthly climatic data were rainfall depth, maximum and minimum air temperatures, sunshine hours, evaporation, humidity, wind speed, soil temperature, cloud cover, solar radiation, and atmospheric pressure for the cities of Umuahia in Abia, Awka in Anambra, Abakaliki in Ebonyi, Enugu in Enugu and Owerri in Imo states were obtained from the Nigerian Meteorological Agency. The data spanned variedly between 1922 and 2008 (86 years) for all stations but the length of data varied among the different climatic variables. This was the available data as at the time of this study. The mean daily temperature was computed as the arithmetic average of the maximum and minimum temperature recorded on that day. The mean monthly temperature was computed as the arithmetic average of the mean daily temperatures of all the days in the month. All monthly data were all averaged to obtain time series of annual averages for all the climatic data available. By adopting the approach used by [12], SPSS version 20.0 statistical software was used to estimate the statistical parameters of the climatic variables. These parameters include: mean, maximum, minimum, standard deviation, skewness and Kurtosis. Estimate of the annual mean measured the central tendency of the data, while the annual standard deviation provided the spread of the data [1]. [12] posited that the coefficients of skewness and kurtosis furnished information concerning the symmetries and lengths of the tails of the annual distributions of the climate variables. The presence of a monotonic increasing or decreasing trend was tested with the non-parametric Mann-Kendall test and the regression coefficients: a and b, between the meteorological variables and time. The linear trend relation between the meteorological variables and time was expressed as:

$$Y_t = a + b_t \quad (1)$$

Where: Y_t is the value of the trend for a given time period, a is the value of the trend when the time t is 0, b is the change in Y_t per unit period of time, t is the unit of time. The least square method was used to calibrate the trend line to estimate the constants; a and b. The non-parametric Mann-Kendall test was used to detect trends that are monotonic but not necessarily linear. The Mann-Kendall test does not require the assumption of normality, and only indicates the direction but not the magnitude of significant trends [13]. A very high positive value of the Mann-Kendall test statistic, S is an indicator of an increasing trend, while a very low negative value indicates a decreasing trend. However, it is also necessary to compute the probability, p associated with S and the sample size, n, to statistically quantify the significance of the trend [14]. If the p value were less than the significance level $\alpha = 0.05$, H_0 was rejected implying that no trend was detected. These computations were calculated using MS Excel software.

4 RESULTS AND DISCUSSION

4.1 Descriptive Statistics of the Meteorological Variables

Table 1 shows the descriptive statistics of climatic data in Enugu, Owerri, Umuahia, Abakaliki and Awka. Table 1 show that the highest mean annual evaporation was 4.3969mm in Umuahia and the lowest mean annual evaporation was 3.2485mm in Awka. The annual evaporation in Umuahia was the most variable with a standard deviation of 0.2028. The maximum annual evaporation was 5.2 in Umuahia and the minimum annual evaporation was 3.0 in Awka. It was only in Umuahia that the annual evaporation was positively skewed. Kurtosis was negative only in Owerri. Table 1 also shows the results of descriptive statistics for sunshine in southeast Nigeria. The highest mean annual sunshine was 5.4718hours in Enugu and the lowest mean annual sunshine hours 4.3829 hours in Owerri. This is because Enugu is closer to northern Nigeria which is characterized with high sunshine hours [6]. The annual sunshine in Awka was the most variable with a standard deviation of 0.5357. The maximum annual sunshine was 6.6 hours in Enugu and the minimum was 3.2 hours in Awka. It was only in Owerri, Enugu and Umuahia that the annual sunshine was positively skewed. Kurtosis was negative only in Owerri, Umuahia and Abakaliki.

Table 1. Descriptive Statistics of Evaporation and Sunshine hours

State Capitals	Descriptive Statistics of Evaporation (mm)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	3.3766	0.0622	3.15	3.52	-0.44	1.03
Owerri	4.2732	0.0729	4.1	4.4	-0.03	-0.34
Umuahia	4.3969	0.2028	4.1	5.2	2.01	3.71
Abakaliki	3.834	0.0691	3.6	4	-0.37	0.59
Awka	3.2485	0.0694	3	3.4	-0.42	0.93
State Capitals	Descriptive Statistics of Sunshine Hours					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	5.4718	0.3127	5.11	6.63	1.71	4.35
Owerri	4.3829	0.3907	3.7	5.1	0.06	-0.51
Umuahia	4.4629	0.3835	3.8	5.2	0.04	-0.42
Abakaliki	5.5424	0.3691	4.9	6.6	0	-1.2
Awka	4.9625	0.5357	3.2	5.7	-1.51	3.16

Table 2 shows that the highest mean annual solar radiation was 45.5 cal/cm²/minute in Enugu and the lowest was 12.453 in Umuahia. The highest mean annual solar radiation recorded in Enugu is consistent with highest hours of sunshine which is also observed in Enugu from Table 1. The annual solar radiation in Enugu was the most variable with a standard deviation of 70.7. The maximum annual solar radiation was 20.3 cal/cm²/minute in Awka and the minimum annual solar radiation was 7.9 cal/cm²/minute in Enugu. It was only in Owerri, Abakaliki and Awka that the annual solar radiation was positively skewed. Kurtosis was not negative any of the cities in southeast. Table 2 shows that the highest mean annual rainfall was 183.73 in Owerri and the lowest mean annual rainfall was 144.59mm in Awka. Owerri is closer to south-south Nigeria, which is a coastal region characterized with high rainfalls [6]. The annual rainfall in Owerri was the most variable with a standard deviation of 53.50. The maximum annual rainfall was 293.9mm in Awka and the minimum annual rainfall was 4.0mm in Awka. It was only in Abakaliki, Enugu and Umuahia that the annual rainfall was positively skewed. Kurtosis was not negative in any of the cities in southeast.

Table 2. Descriptive Statistics of Solar Radiation and Rainfall

State Capitals	Descriptive Statistics of Solar Radiation (Cal/Cm ² /Minute)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	45.5	70.7	7.9			
Owerri	13.516	2.271	11.1	18.3	1.5	0.58
Umuahia	12.453	0.502	11.1	13.4	-0.82	0.93
Abakaliki	12.654	0.395	11.9	13.8	1.28	2.58
Awka	18.278	0.661	17.1	20.3	0.73	0.58
State Capitals	Descriptive Statistics of Rainfall (Mm)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	156.21	22.25	75.8	207.1	1.7	1
Owerri	183.73	53.5	5.2	245.9	-2.6	6.39
Umuahia	180.7	13.98	134.5	216.9	0.06	0.39
Abakaliki	172.46	13.08	131.8	209.3	1.09	3
Awka	144.59	50.84	4	293.9	-1.55	3.84

In Table 3, the highest mean annual atmospheric pressure was 12.318 bars in Awka and the lowest mean annual atmospheric pressure was 10.810 bars in Owerri. The annual atmospheric pressure in Owerri was the most variable with a standard deviation of 0.630. The maximum annual atmospheric pressure was 195.6 bars in Awka and the minimum annual atmospheric pressure was 9.3 bars in Owerri. It was only in Abakaliki and Umuahia that the annual atmospheric pressure was positively skewed. Kurtosis was not negative any of the cities in southeast. The highest mean annual air temperature was 28.063°C in Enugu and the lowest mean annual air temperature was 26.396°C in Abakaliki (Table 3). This is because Enugu is closer to northern Nigeria which is a semi-arid region with a characteristic high mean annual temperature [6]. This is derived from the northeast wind that brings about dry season in Nigeria [11]. This result is consistent with observations made in sunshine hours, solar radiation and soil temperature, in which Enugu had the highest values. The annual air temperature in Owerri was the most variable with a standard deviation of 2.057. The maximum annual air temperature was 31 °C in Awka and the minimum annual air temperature was 20.9 °C in Awka.

Table 3. Descriptive Statistics of Atmospheric Pressure and Air Temperature

State Capitals	Descriptive Statistics For Atmospheric Pressure (Bars)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	11.207	0.376	10.85	19.56	-0.72	0.93
Owerri	10.81	0.63	9.3	11.5	-1.59	3.48
Umuahia	11.036	0.243	10.8	11.5	1.35	0.71
Abakaliki	11.33	0.427	10.8	12.1	0.04	0.45
Awka	12.318	0.504	11.1	13.1	-0.7	0.01
State Capitals	Descriptive Statistics For Air Temperature (°c)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	28.063	2.057	26.35	11.6	0.43	*
Owerri	26.792	0.686	25.7	28.55	0.78	-0.38
Umuahia	26.524	0.297	25.75	27.25	-0.08	-0.03
Abakaliki	26.396	0.273	25.65	26.95	0.23	-0.64
Awka	27.073	1.059	20.9	31	-1.4	12.32

It was only in Abakaliki and Enugu that the annual air temperature was positively skewed. Kurtosis was negative in all of the cities in southeast except Awka. Table 4 shows the results of descriptive statistics for wind speed. The highest mean annual wind speed was 5.480km/hr in Enugu and the lowest mean annual wind speed was 2.652km/hr in Umuahia. The annual wind speed in Owerri was the most variable with a standard deviation of 1.374. It was only in Owerri and Enugu that the annual wind speed was positively skewed. Kurtosis was negative in all of the cities in southeast except Owerri. From Table 4, it was observed that the highest mean annual relative humidity was 79.025% in Umuahia and the lowest mean annual relative humidity was 70.289% in Awka. The annual relative humidity in Awka was the most variable with a standard deviation of 4.339. The maximum annual relative humidity was 82.6% in Owerri and the minimum annual relative humidity was 58.4% in Awka.

Table 4. Descriptive Statistics of Wind Speed and Relative Humidity

State Capitals	Descriptive Statistics of Wind Speed (Km/Hr)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	5.48	1.299	2.75	32.3	1.3	-0.19
Owerri	3.995	1.374	2.6	7.6	1.49	1.03
Umuahia	2.652	0.297	2.575	27.25	-0.08	-0.03
Abakaliki	3.652	0.145	3.4	4.1	-0.15	-0.22
Awka	3.725	0.755	2	5.2	-0.05	-0.01

State Capitals	Descriptive Statistics of Relative Humidity (%)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	72.352	3.074	64	78	-0.51	-0.09
Owerri	78.824	1.922	74.3	82.6	-0.11	-0.45
Umuahia	79.025	1.819	74	82	-0.69	0.63
Abakaliki	73.525	2.331	68	78	0.53	1.36
Awka	70.289	4.339	58.4	79.1	-0.47	1.17

It was only in Abakilii that the annual relative humidity was positively skewed. Kurtosis was negative in all of the cities in southeast except Awka, Abakilii and Umuahia. Table 5 shows that the highest mean annual soil temperature was 27.09^oC in Enugu and the lowest mean annual soil temperature was 25.08^oC in Owerri. The annual soil temperature in Enugu was the most variable with a standard deviation of 0.443. The maximum annual soil temperature was 76.9^oC in Enugu and the minimum annual soil temperature was 24.5^oC in Owerri. This is because Enugu is closer to northern Nigeria which is a semi-arid region with a characteristic high surface temperature [16].

Table 5. Descriptive Statistics of Soil Temperature and Cloud Cover

State Capitals	Descriptive Statistics Of Soil Temperature (^o c)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	27.09	0.443	26.4	76.9	-1.26	0.96
Owerri	25.075	0.346	24.45	25.85	0.5	-0.13
Umuahia	25.2	0.344	24.6	26	0.53	0.04
Abakaliki	25.822	0.401	25.1	26.7	-0.32	0.32
Awka	26.456	0.389	25.863	27.442	0.61	0.04

State Capitals	Descriptive Statistics Of Cloud Cover (%)					
	Mean	St. Deviation	Minimum	Maximum	Skewness	Kurtosis
Enugu	41.68	2.604	38.1	28.2	0.55	-0.2
Owerri	44.6	4.76	39.5	52	0.76	-1.19
Umuahia	43.05	4.12	38.3	50.4	0.94	-0.27
Abakaliki	39.45	1.708	37.7	42.6	0.33	-0.42
Awka	40.37	2.86	36.6	47	1.34	2.78

It was only in Owerri and Umuahia that the annual soil temperature was positively skewed. Kurtosis was negative only in Owerri. Table 5 also shows the results of descriptive statistics for cloud cover. It can be observed that the highest mean annual cloud cover was 44.6% in Owerri and the lowest mean annual cloud cover was 39.45% in Abakaliki. The annual cloud cover in Owerri was the most variable with a standard deviation of 4.76. The maximum annual cloud cover was 52.0% in Owerri and the minimum annual cloud cover was 36.6% in Awka. Owerri is closer to south-south Nigeria, which is a coastal region characterized with clouds and subsequent rainfalls [6]. This is consistent with the previous observations made in which Owerri had the highest mean annual rainfall because rainfall is derived from heavy clouds. The annual cloud cover was positively skewed in all the cities in the southeast. Kurtosis was negative in all of the cities in southeast except Awka.

4.2 Results of Trend Analysis

On running the Mann-Kendall test on the evaporation data, the results in Table 6 were obtained. Table 6 indicates that the null hypothesis is rejected in all the capital cities in southeast Nigeria. This means that there is trend in evaporation in these capital cities. The S statistic is strongest in Enugu implying that it has the most significant trend in southeastern region of Nigeria. Increase in evaporation during the second half of the 20th century is a significant indication of increased terrestrial annual evaporation in water-limited regions [17, 18, 19, 20].

Table 6. Result of Mann-Kendall Test for Evaporation (mm)

State Capital	Mann-Kendall Test For Evaporation (Mm)							
	Mann-Kendall Statistic (S)	Kendall Tau	P-Value (2-Tailed Test)	Alpha	Test Interpretation	Trend Rate (Slope)	Trend Equation	Trend
Enugu	1148	0.252	0.00034213	0.05	Reject H0	0.000750	$3.3398 + 0.000750t$	increasing
Owerri	1093	0.296	0.00019383	0.05	Reject H0	0.00099	$4.2246 + 0.00099t$	Increasing
Umuahia	846	0.218	0.0046504	0.05	Reject H0	0.001531	$4.3219 + 0.001531t$	Increasing
Abakiliki	831	0.232	0.0039904	0.05	Reject H0	0.000655	$3.8019 + 0.000655t$	Increasing
Awka	833	0.233	0.0039539	0.05	Reject H0	0.000714	$3.2135 + 0.000714t$	Increasing

Table 7 indicates that there is no trend in solar radiation in all the capital cities in southeast except Umuahia. The S statistic is strongest in Awka which means it has the most significant trend in all of southeast. Although increased solar radiation has been reported since the 1980s [21], there is no significant relation between evaporation and solar radiation [22]. Increased rainfall since the 1950s [23] probably made more soil moisture available for evaporation, which resulted in increased evaporation.

Table 7. Result of Mann-Kendall Test for Solar Radiation

State Capital	Mann-Kendall Test For Solar Radiation (Cal/Cm ² /Minute)							
	Mann-Kendall Statistic	Kendall Tau	P-Value (2-Tailed Test)	Alpha	Test Interpretation	Trend Rate (Slope)	Trend Equation	Trend
Enugu	48	0.0722	0.539	0.05	Accept H0	4.371	$-37.5+4.371t$	increasing
Owerri	-90	-0.139	0.242	0.05	Accept H0	-0.1317	$16.018 - 0.117t$	decreasing
Umuahia	110	0.263	0.0499	0.05	Reject H0	0.0135	$12.244 + 0.0135t$	increasing
Abakiliki	-83	-0.268	0.0676	0.05	Accept H0	-0.0134	$12.835 - 0.0134t$	decreasing
Awka	260	0.324	0.0777	0.05	Accept H0	0.02873	$17.675 +0.02873t$	increasing

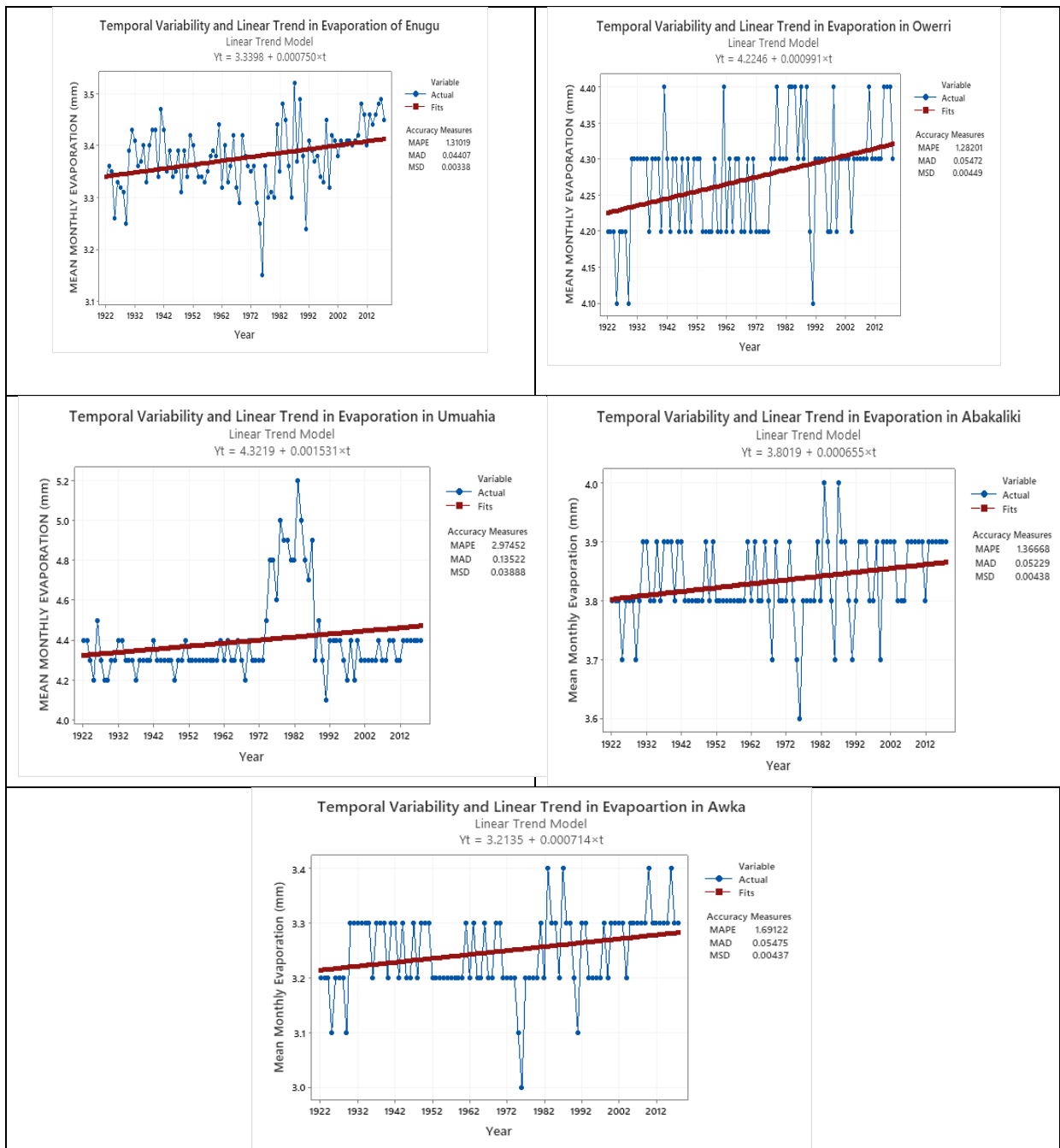


Figure 2. Linear trend line of Evaporation data for each of the Southeast cities

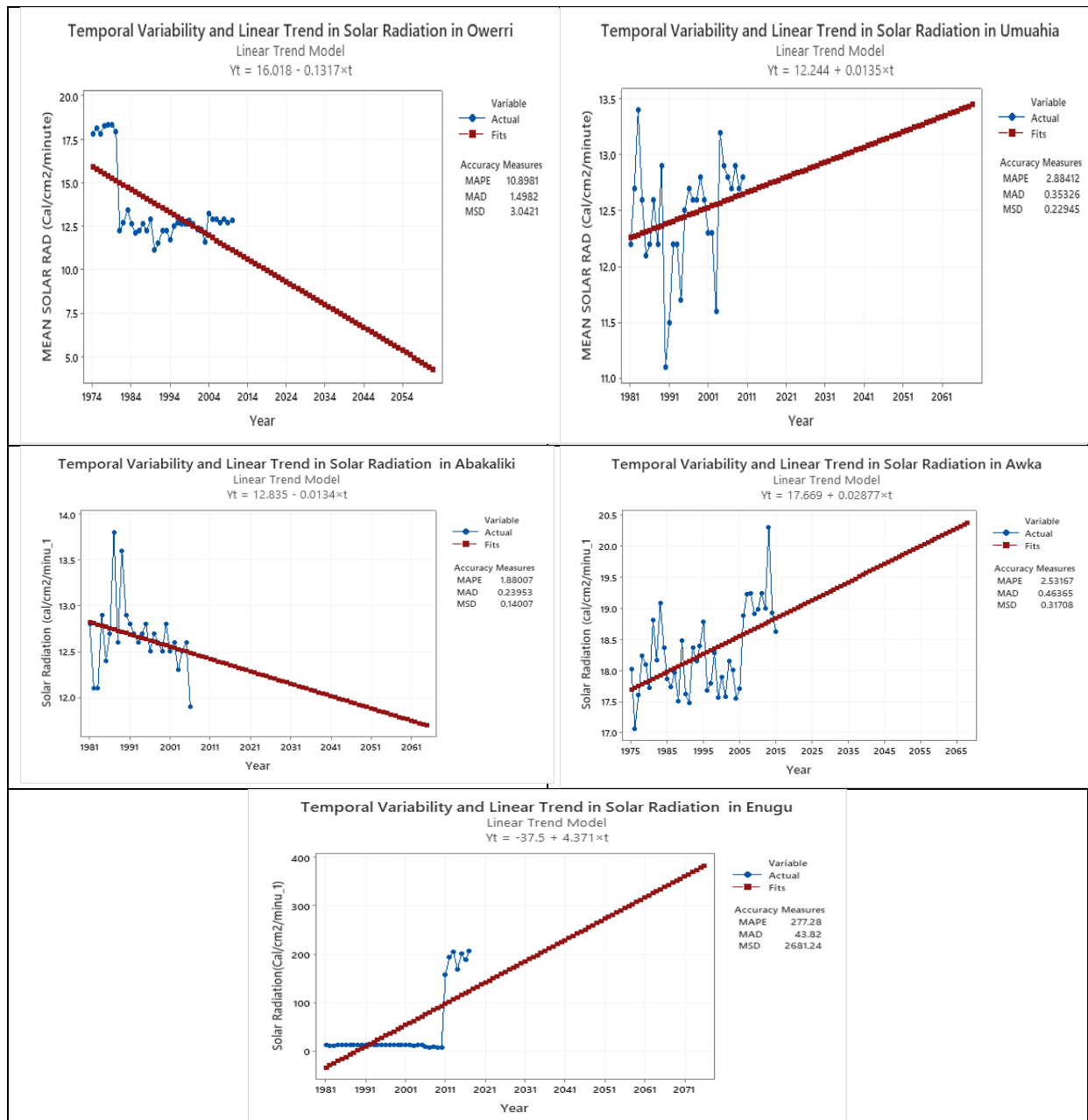


Figure 3. Linear trend line of Solar Radiation data for each of the Southeast cities

From Figure 3, it is observed that the trend of solar radiation is increasing for all the study areas except Abakaliki and Owerri. For the study period, the highest trend rate of solar radiation occurred in Enugu (4.371 cal/cm²/minute/year).

4 CONCLUSIONS

This study examines the evidence of climate change using the trend analysis technique for the five states of southeastern Nigeria. For this purpose, temporal trends in annual evaporation and solar radiation were detected using non-parametric Mann-Kendall test at 5% significance level. Also, descriptive statistics of all the climatic data in selected catchment areas of southeastern region of Nigeria were estimated in order to establish the accurate characterization of the climate the region. Statistical parameters such as mean, maximum, minimum, standard deviation, skewness and Kurtosis were estimated from annual meteorological variables such as rainfall depth, maximum and minimum air temperatures, sunshine hours, evaporation, humidity, wind speed, soil temperature, cloud cover, solar radiation, and atmospheric pressure for the cities of Umuahia in Abia, Awka in Anambra, Abakaliki in Ebonyi, Enugu in Enugu and Owerri in Imo states, all located in southeast Nigeria. The

highest mean annual atmospheric pressure of was observed in Awka. Enugu recorded the highest mean annual soil temperature, air temperature and solar radiation in southeast Nigeria. The highest mean rainfall and cloud cover occurred in Owerri. The highest evaporation, wind speed and relative humidity were observed in Umuahia. From the values of standard deviation, rainfall was evaluated as the most variable weather element in the region. For the time period, 1926 to 2018, the Mann-Kendall test was conducted at 5% significance level indicates that there is no trend in solar radiation in all the capital cities in southeast, Nigeria. Also during this period, linear trend line showed that there is increasing trend in air and soil temperatures in all the capital cities in southeast. These findings provide valuable information for assessing the influence of climate change in the southeast region of Nigeria. As this study dwelt on annual values of climatic variables, further studies are recommended to estimate the monthly descriptive statistics of the meteorological data of the region.

REFERENCES

1. Zwiers, F.W. and Storch, H.V. (2017). On the role of statistics in climate research. *International Journal of Climatology*, vol. 24, pp. 665-680.
2. Murdock, T.B., Miller, A.D. and Goetzinger, A. (2007) Effects of classroom context on university students' judgments about cheating: mediating and moderating processes. *Social Psychology of Education*, vol. 10, pp.141-169.
3. Swietlicki, E., Zhou, J. and Berg, O.H. (1999). A closure study of sub-micrometer aerosol particle hygroscopic behavior. *Journal of Atmospheric Resources*, vol. 50, pp. 205-240.
4. Anyadike, R.N.C. (2002). Climate and Vegetation. In G.E.K. Ofomata (Eds.). A Survey of Igbo Nation. Onitsha: *Africana Publishers Ltd*, pp. 73-82.
5. Okonkwo, E. and Eyisi, A.P. (2014). Traditional Methods of Preserving Dead Human Bodies in Southeastern Nigeria. *Research on Humanities and Social Sciences*, vol.4, no.5, pp. 113-121.
6. Balogun, I., Adegun, O. and Adeaga, O. (2012). An Assessment of Rainfall Erosivity in Parts of Eastern Nigeria: A Case Study of Owerri and Enugu. *Geography ss.*,vol. 7, pp. 259-265.
7. Igbokwea, J.I., Akinyedeb, J.O.B., Alagac, D.T., Onoa, M.N., Nnodud, V.C. and Anikee, L.O. (2008). Mapping And Monitoring Of The Impact Of Gully Erosion In Southeastern Nigeria With Satellite Remote Sensing And Geographic Information System. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, (Part B8)*. Beijing, vol. 37, pp. 865-875.
8. Okonkwo, G.I. and Mbajiorgu, C.C. (2010). Rainfall Intensity-Duration-Frequency Analyses for South Eastern Nigeria. *Agricultural Engineering International: the CIGR Ejournal.*, vol. 12, no. 1, pp. 22-30.
9. Nzezbule, E. and Ogbonna, P. (2008). Quantity and Quality of Litterfall In Pure Pine and Pine/Gmelina Mixed Plantations in Umuahia, Abia State. *Global Journal of Agricultural Sciences*, vol. 7, no. 1, pp. 93-96.
10. Akpootu, D.O., Iliyasu, M.I., Mustapha, W., Aruna, S. and Yusuf, S.O. (2017). The Influence of Meteorological Parameters on Atmospheric Visibility over Ikeja, Nigeria. *Archives of Current Research International*, vol. 9, no.3, pp. 1-12.
11. Ileoje, N.P. (1981). A new geography of Nigeria. *William Clowes (Beccles) Limited*, Beccles, London, pp. 85-120.
12. Adepitan, J.O., Falayi, E.O. and Ogunsanwo, F.O. (2017). Confirmation of Climate Change in Southwestern Nigeria through Analysis of Rainfall and Temperature Variations over the Region Covenant. *Journal of Physical & Life Sciences (CJPL)*. vol. 5, no.1, pp. 43-78.
13. McBean, E. and Motiee, H. (2008). Assessment of Impact of Climate Change on Water Resources: a long term analysis of the Great Lakes of North Am. *Hydrol. Earth Syst. Sci.*, vol. 12, pp. 239-255.

14. Khambhammettu, P. (2005). Mann-Kendall Analysis. *Annual Groundwater Monitoring Report of Hydro Geologic Inc*, pp. 1-6.
15. National Population Commission (NPC) (2006). The 2006 Nigeria Demographic and Health Survey: Findings and Implications for Action, South East Zone. Abuja: *Government Printer*, pp. 87-90.
16. Hassan, Z. and Ajibola, T.B. (2015). Ajibola Statistical Analysis of Some Meteorological Variables Data for Sokoto and its Vicinity. *World Scientific News*. vol. 24, pp. 8-17.
17. Brutsaert, W. and Parlange, M. (1998). Hydrologic Cycle Explains the Evaporation Paradox. *Nature*, vol. 396, no. 30, pp. 56-60.
18. Roderick, M.L. and Farquhar, G.D. (2002). The Cause of Decreased Pan Evaporation over the Past 50 Years. *Science*, vol. 298, pp. 1410-1411.
19. Golubev, V.S., Lawrimore, J.H. and Groisman, P.Y. (2001). Evaporation Changes over the contiguous United States and the former USSR: A reassessment. *Geophysical Research papers*, vol. 28, no. 13. pp. 2665-2668.
20. Brutsaert, H. (2006). Gender-role identity and perceived peer group acceptance among early adolescents in Belgian mixed and single-sex schools. *Gender and Education*, vol. 18, no. 6, pp. 635-649.
21. Wild, D., Grove, A., Martin, M., Eremenco, S., McElroy, S., Verjee-Lorenz, A. and Erikson P. (2005). Principles of Good Practice for the Translation and Cultural Adaptation Process for Patient-Reported Outcomes (PRO) Measures: Report of the ISPOR Task Force for Translation and Cultural Adaptation. *Value in Health*, vol. 8, no. 2, pp. 94-104.
22. Teuling, A.J., Hirschi, M., Ohmura, A., Wild, M., Reichstein, M., Ciais, Ammann, P.C., Montagnani, L., Richardson, A.D., Wohlfahrt, G. and Seneviratne, S.I. (2009). A regional perspective on trends in continental evaporation. *Geophysical Research Papers*, vol. 36, no. 2, pp. 1-5.
23. Groisman, P.Y., Knight, R.W., Easterling, D.R., T. R., Hegerl, G.C. and Razuvaev, V.N. (2005). Trends in Intense Precipitation in the Climate Record. *Journal of climate*, vol. 18, no. 9, pp.1326-1350.