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AIR TEMPERATURE PATTERN FORECASTING AND ANOMALY IN SELECTED LOCATIONS IN NIGERIA.

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Abstract:
Temperature forecast and trend analysis was carried out across various locations in Nigeria to serve as an essential tool to caution on possible threatening weather events such as severe heat waves, storms, drought, floods, etc. which poses great risk to mankind and his environment. Six locations were chosen across Nigeria (4^0N – 14^0N, 2^0E – 15^0E) for this research work. Satellite data of annual temperature is obtained from the European Centre for Medium-Range Weather Forecast (ECMWF) database for 35years (1985-2019) is used for this work. The Mann-Kendall trend test was carried out for the various locations to observe and study the trend. Four Models: Auto Regressive and Integrated Moving Average (ARIMA), Exponential smoothening (ETS), (TBATS) and the linear model, were employed to forecast average temperature for 10 years for all the locations. The model that will produce the best forecast at the 95% confidence level is expected to have the lowest Root Mean Square Error (RMSE) value. For Uyo, Lagos, Abuja, Owerri and Makurdi, the trend analysis carried out on the collected data revealed a positive increasing trend while the trend analysis in Maiduguri showed no significant trend because the P-value of 0.711is greater than the set α-value of 0.05. The linear model produced the best forecast for Maduguri, Uyo, Lagos and Owerri while the TBATS model produced the best forecast for Abuja and Makurdi. Forecast result at 95% confidence level gave point forecast average temperature values of 21.40^0C representing 1.06% increase for Maiduguri, 22.01^0C representing 2.94% increase for Uyo, 22.21^0C representing 1.46% increase for Lagos, 22.49^0C representing 2.46% increase for Owerri, 21.32^0C representing 0.48% increase for Abuja and 24.05^0C representing 4.79% increase for Makurdi. These results agree extensively with the IPCC projections of high likelihood of warming across West Africa. The slight increase in temperature have serious effects in various sectors of the Nigerian economy especially in agriculture, water resources, Aviation and also the health sector and prior knowledge of these changes in climate will help in mitigating the negative effects on man and his environment.

Keywords: Trend, Analysis, Forecast, Temperature, Nigeria, Mann-Kendall, Models.

Introduction:

The variations in temperature in Nigeria plays a vital role in Climate differences in the country making it important to observe, study the trends and forecast it for the sole purpose of anticipating unexpected weather events which will assist us in taking the requisite steps to minimize such impacts on human life and nature.

In this century, global climate change has drawn the attention of researchers and policy makers making it a focus of research due to the fact that the resulting effects of the changes in climate affect the activities of human beings and the natural environment, causing damages all over the world. (Choi, et. al. 2020).

The changes in temperature due to global climate change has affected to a large extent

the hydrological processes and fluid distribution in the region and as the climate changes, the temperatures around the globe will increase significantly in the future and the weather will be uncontrollably to the extreme. (Yang, et al. 2019).

Variations in temperature and precipitation in a long term is significant in determining the present and future alterations observed naturally. Monthly precipitation distortions may be desirable or undesirable in various months of the year as crop growth period can be disrupted by heating from high temperatures. Crop production and water efficiency is expected to be very poor due to lower precipitation during this period resulting in higher demand of water under higher temperatures. (Dissanayake, et. al. 2019).

Land surface temperature variations is observed to increase as a result of rapid land use conversion and modification which may pose greater possibilities of ushering in climate related dangers such as flood, erosion and any other associated environmental hazard. (Ibitoye, et. al. 2019).

These harsh conditions are expected to be doubled in the future also due to increasing level of migration attributed to favorable socio-economic, agricultural, political and physical factors constitute significant threats to water resources, agricultural activities and ecosystem services. (Ogunjobi, et. al.2018).

These variations in temperature is a strong indices which the future of any location depends on and weather forecasting is highly demanded for several applications in agriculture, air traffic services, floods, energy and environment control. (Jaseena & Kovoor, 2020).

The changes in the trends of temperature contribute greatly to the increase in global warming of any location. According to the Intergovernmental Panel on Climate Change (IPCC) the greenhouse gases emitted is the main factor responsible for the increase in temperature thereby making global warming come to stay longer than expected except the release of the greenhouse gases are strongly checked. (IPCC, 2021).

Daramola, et. al. (2017) in his analysis of Temperature over the climatic zones across Nigeria used data from ten Global Circulation Models (GCM) re-grided to a 1° x 1° spatial resolution. His analysis showed the standardized temperature forecast and anomaly over the different climatic zones in Nigeria from 2011-2100. From the summary statistics of the temperature anomaly for the zones, he concluded that positive anomaly exceeds the negative anomaly across all the zones, indicating more warm years than colder years.

Najib, et al. (2017) investigated the temperature trend in Nigeria using a network of ground based Automatic Weather Stations (AWS) installed at different locations in Nigeria. The results reveal a continuous variability that is seasonally dependent in each of the years. It was also seen that the results showed a steady increase in temperature recorded in the locations under study. This temperature increase is connected to the climate change observed in the locations under study as a result of increase in the concentration of greenhouse gases.

Study area:

The location of Nigeria is within the geographical latitudes 4^0N – 14^0N and longitudes 2^0E – 15^0E respectively. The country lies in an area of 923,768 square kilometers which falls into four climatic zones (Semi-arid, Humid, Sub-Humid Humid and Sub-Humid Dry) which varies from the Northern part of the country, through the middle belt and to the Southern part of the country.

Data collection:

For the purpose of this research work, the atmospheric data were satellite remote sensing data obtained from the archives of the European Centre for Medium-Range Weather Forecasts (ECMWF) Website.

ECMWF makes extensive use of satellite observations in atmospheric, oceanic and land surface analyses and also for atmospheric composition both in the Integrated Forecasting System and in MACC (Monitoring Atmospheric Composition and Climate).

The meteorological data which was in degree Celsius were obtained using the geographical coordinates of each of the locations for the period of 35 years (1985 – 2019) covering 6 different locations across Nigeria. The locations are Maiduguri, Abuja, Makurdi, Lagos, Owerri and Uyo representing the North, West, East and South. The data which were originally gridded in NetCDF format were converted to readable format using the Anaconda software. The hourly data were further averaged to daily, monthly and yearly data using the same software to reduce the data, to obtain smoother profiles for easy presentation and analysis as presented in table1.

Table 1: Average Satellite Temperature data computed for the locations under study

YEARS	**Maiduguri (^{0}C)**	**Abuja(^{0}C)**	**Makurdi (^{0}C)**	**Lagos (^{0}C)**	**Owerri (^{0}C)**	**Uyo (^{0}C)**
1985	22.7214	21.3068	23.0260	21.2320	21.3731	22.0174
1986	20.3806	20.9414	22.3553	21.3634	21.5056	21.8666
1987	22.5387	21.0449	22.9359	22.5990	22.5327	22.6166
1988	21.5225	21.1041	23.3580	21.5537	21.6922	22.3310
1989	19.8915	20.5368	22.4678	21.4527	21.6490	21.2007
1990	20.6685	20.2376	22.4497	21.4628	21.7623	16.5076
1991	21.4238	20.5711	22.3741	21.4756	21.5624	21.9660
1992	20.2904	20.39985	22.226	21.3958	21.4837	21.4753
1993	21.0133	20.4457	22.7350	21.6834	21.7559	21.9783
1994	21.3311	20.6030	22.7757	21.5402	21.6787	22.0226
1995	20.3547	20.8386	22.8795	21.9201	22.1143	22.4200
1996	20.8326	20.6285	22.9871	21.7488	21.7329	22.2500
1997	21.1161	21.0670	22.9042	21.7212	21.6810	22.0225
1998	21.0247	20.8041	23.0944	21.8394	21.8325	22.2023
1999	21.4573	20.6363	22.9437	21.1929	21.4192	21.9810
2000	22.0745	20.7536	23.0301	21.4680	21.4673	22.2091
2001	20.7024	20.0089	21.9209	21.5729	21.7262	22.0747
2002	21.3217	20.7369	22.6027	21.9735	22.1129	22.0287
2003	20.9983	21.0574	22.8810	21.7332	21.5752	22.0257
2004	21.7722	20.5059	22.9557	21.5617	21.8403	22.5520
2005	20.9571	21.4099	22.8664	21.9169	22.1225	21.9144
2006	23.3503	21.6432	23.98115	22.3835	22.3654	22.7725
2007	21.4924	20.4521	22.8723	22.1616	22.0365	21.6727
2008	21.2408	20.6473	22.7736	21.8277	21.8866	21.9204
2009	22.9809	21.2178	23.4588	22.1791	22.1257	22.5118

2010	21.8707	20.9629	23.3196	22.2433	22.1548	22.7777
2011	21.6009	20.1852	22.2921	22.1325	22.0881	21.9497
2012	21.2305	20.0244	22.6575	21.7009	21.9967	22.3102
2013	22.6015	21.0389	23.2423	21.7971	22.2009	22.8606
2014	22.0555	20.8011	23.0621	22.2641	22.5234	22.8273
2015	21.3415	20.4797	22.9384	22.2236	22.3465	22.0949
2016	20.8685	20.8327	23.3111	22.1387	22.4392	22.9438
2017	22.5024	21.4037	23.6449	22.0342	22.3026	22.6267
2018	21.0395	20.6408	22.7054	21.9298	22.0644	22.1213
2019	21.6868	21.0249	23.5214	21.8944	22.1787	22.6946

Data analysis:

Mann-Kendall trend analysis was carried out using the R programming language in all the locations to understudy and observe the trend of the parameter so as to compare with the forecasted values.

Four different models were employed to forecast the parameter using the already obtained set of data for each of the locations. The models were Auto regressive integrated moving average (ARIMA), Exponential smoothing (ETS), Trigonometric seasonality, Box-Cox transformation, ARMA errors, Trend and **S**easonal components (TBATS) and the linear regression models. Such a model which will come out as the best in forecasting temperature in that location is expected to have the lowest RMSE value.

The root mean square error is commonly used to evaluate quality predictions because it measures the differences between predicted values and the observed or recorded values.

Root mean square error can be expressed as

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(p_i - o_i)^2}{n}}$$

Where P = predicted values

O = Observed values

n = sample size or number of data points

$P_i - O_i$ = the residual.

In machine learning, it is extremely helpful to have a single number to judge a model's performance, whether it be during training, cross-validation, or monitoring after deployment. Root mean square error is one of the most widely used measures for this. It is a proper scoring rule that is intuitive to understand and compatible with some of the most common statistical assumptions.

The RMSE indicates the absolute fit of the model to the data by telling us how close the observed data points are to the models forecasted values. RMSE is a perfect measure of how precise the model predicts the response and is the most vital criterion for fit if the main purpose of the model is forecasting. The lower values of RMSE portrays a better fit. (Chai et. al. 2014).

Results:

From the Mann-Kendall trend analysis, the parameters obtained include the Z-value, the Mann-Kendall statistic (S), the probability value (p-value) and the tau (τ). These parameters were computed for the period of study which covers all locations in the scope.

The Mann-Kendall parameters for all the locations in Nigeria are presented below in table 3.

Table 2: Mann-Kendall trend test parameters for locations in Nigeria.

NIGERIA					
	Z-value	**Sens's slope**	**p-value**	**tau(τ)**	**Trend**
Maiduguri	0.3692	0.0026	0.7120	0.0453	No Trend
Uyo	3.0107	0.0201	0.0026	0.3580	Increasing Trend
Lagos	3.8344	0.0211	0.0001	0.4554	Increasing Trend
Owerri	4.2320	0.0233	2.3E-05	0.5025	Increasing Trend
Abuja	4.3518	0.0363	0.00003	0.4292	Increasing Trend
Makurdi	2.1586	0.0180	0.0309	0.2571	Increasing Trend

Table 3: Summary Forecast Error Metrics for Computer simulated Models locations in Nigeria.

LOCATION	**MODEL**	**FORECAST ERROR METRICS (RMSE)**
MAIDUGURI	ARIMA	0.7488
	ETS	0.7897
	LINEAR	0.7504
	TBATS	0.7897
UYO	ARIMA	1.0311
	ETS	1.0294
	LINEAR	0.9547
	TBATS	1.0295
LAGOS	ARIMA	0.3699
	ETS	0.2823
	LINEAR	0.2822
	TBATS	0.3111
OWERRI	ARIMA	0.3227
	ETS	0.2486
	LINEAR	0.2482
	TBATS	0.2747
ABUJA	ARIMA	0.3812
	ETS	0.3812
	LINEAR	0.3808
	TBATS	0.3798
MARKURDI	ARIMA	0.4205
	ETS	0.3871

	LINEAR	0.3870
	TBATS	0.3848

MAIDUGURI

Fig 1: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Maiduguri using different models.

From fig 1, Seasonal average temperature was observed to vary over the years in Maiduguri with the highest value at 23.35^{0}C in 2006 and the lowest value at 19.89^{0}C in 1989.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 21.889^{0}C as and as low as 20.526^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast can go as high 21.937^{0}C as and as low as 20.937^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast can go as high 22.553^{0}C as and as low as 20.243^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast can go as high 21.866^{0}C as and as low as 20.994^{0}C.

From Table 4, the model that made the best forecast was the linear model since it recorded the lowest Root Mean Square Error value of 0.75 for the location with a forecast range of 20.243 – 22.553. The average observed value was 21.062 and the forecast value is 21.398 with a percentage increase of 1.06%.

UYO

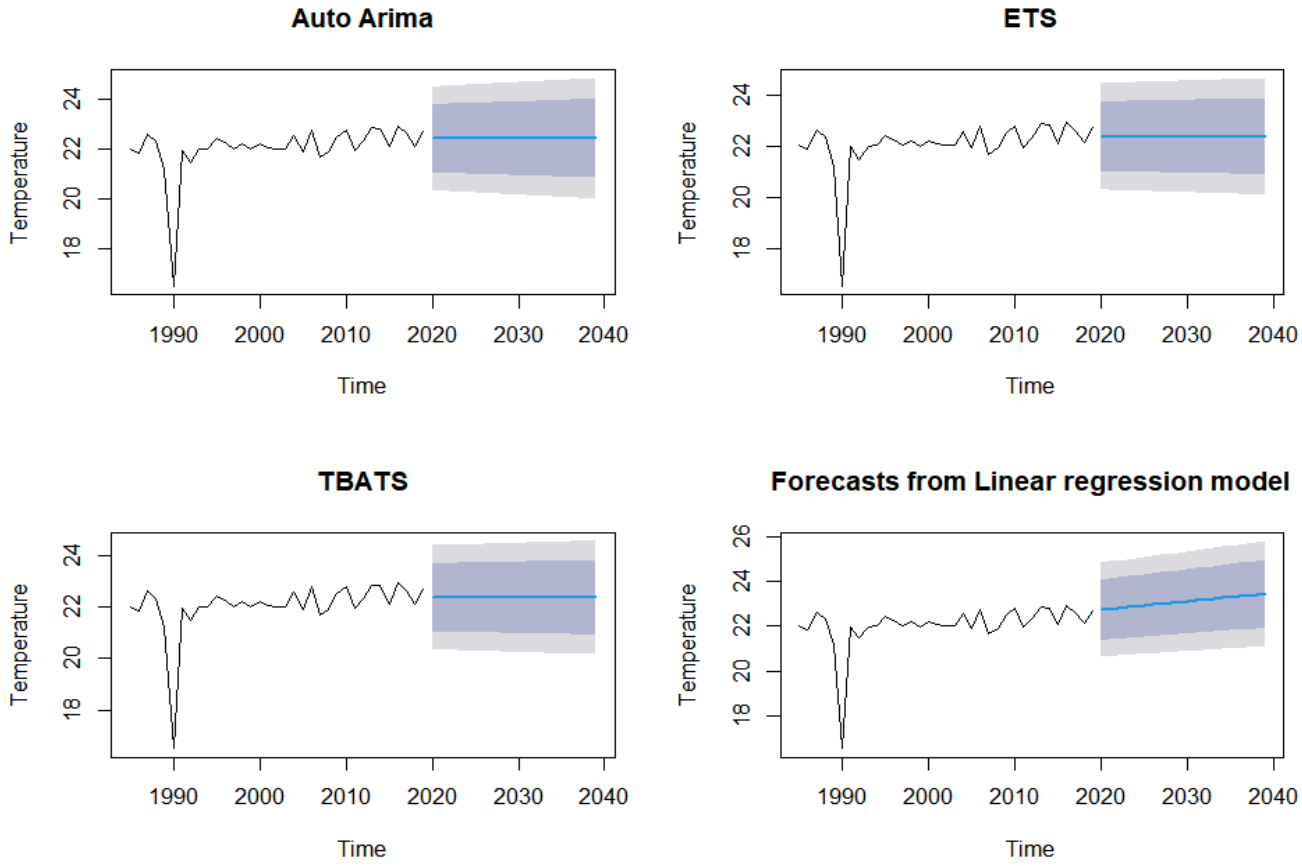

Fig 2: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Uyo using different models.

From fig 2, Seasonal average Temperature was observed to vary over the years in Uyo with the highest value at 22.69^{0}C in 2019 and the lowest value of 16.51^{0}C in 1990.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 23.049^{0}C as and as low as 19.625^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 23.114^{0}C as and as low as 20.837^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast could go as high 24.697^{0}C as and as low as 19.330^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 22.999^{0}C as and as low as 22.971^{0}C.

From table 4, the model that made the best forecast was the linear model since it recorded the lowest Root Mean Square Error value of 0.95 for the location with a forecast range of 19.330 – 24.697. The average observed value was 19.60 and the forecast value is 22.01 with a percentage increase of 2.9%.

LAGOS

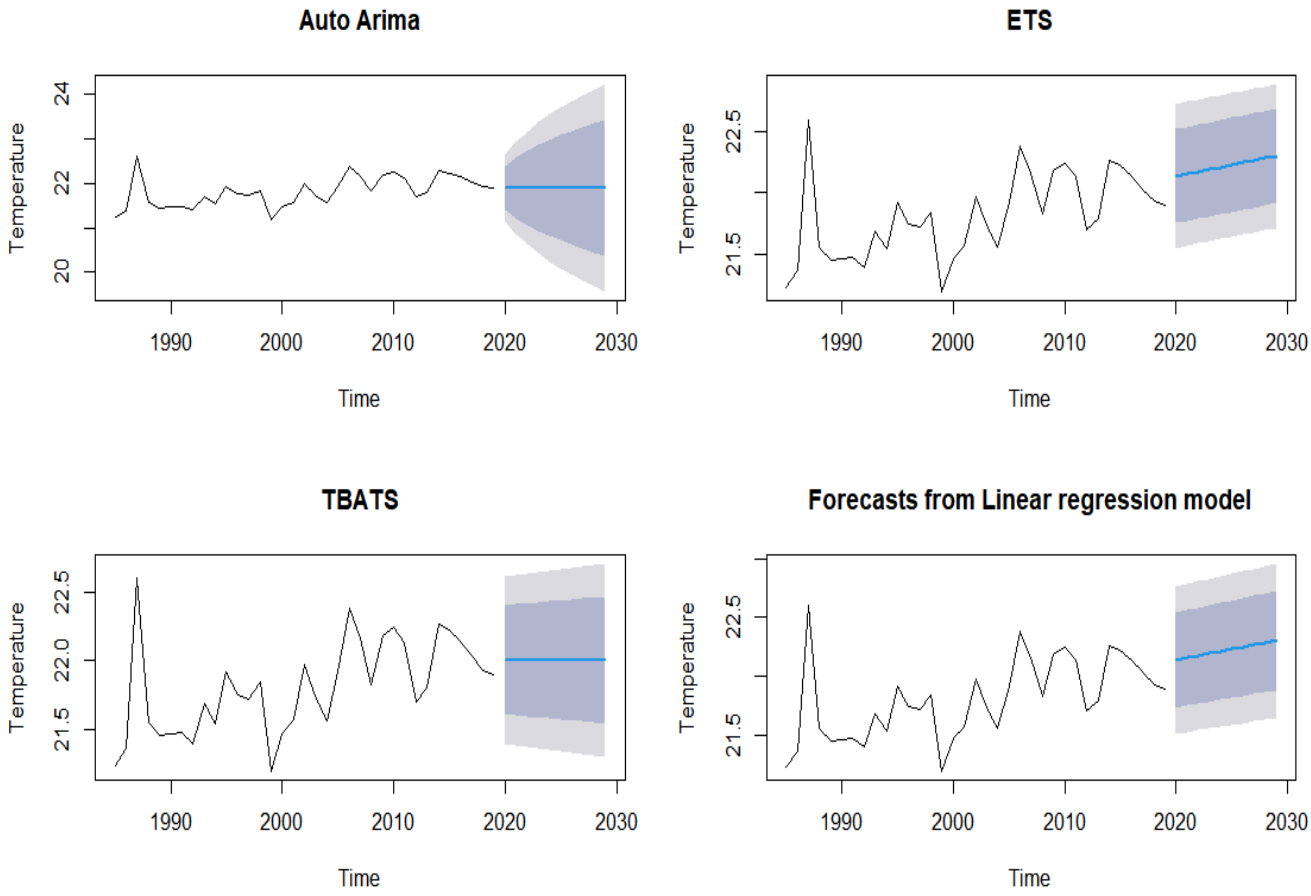

Fig 3: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Lagos using different models.

From fig 3, Seasonal average Temperature was observed to vary over the years in Lagos with the highest value at 22.59^{0}C in 1987 and the lowest value of 21.19^{0}C in 1999.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 22.093^{0}C as and as low as 20.581^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 22.487^{0}C as and as low as 21.024^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast could go as high 22.808^{0}C as and as low as 21.441^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 22.190^{0}C as and as low as 21.300^{0}C.

From table 4, the model that made the best forecast was the linear model since it recorded the lowest Root Mean Square Error value of 0.282 for the location with a forecast range of 21.645 – 22.985. The average observed value was 21.89 and the forecast value is 22.21 with a percentage increase of 1.9%.

OWERRI

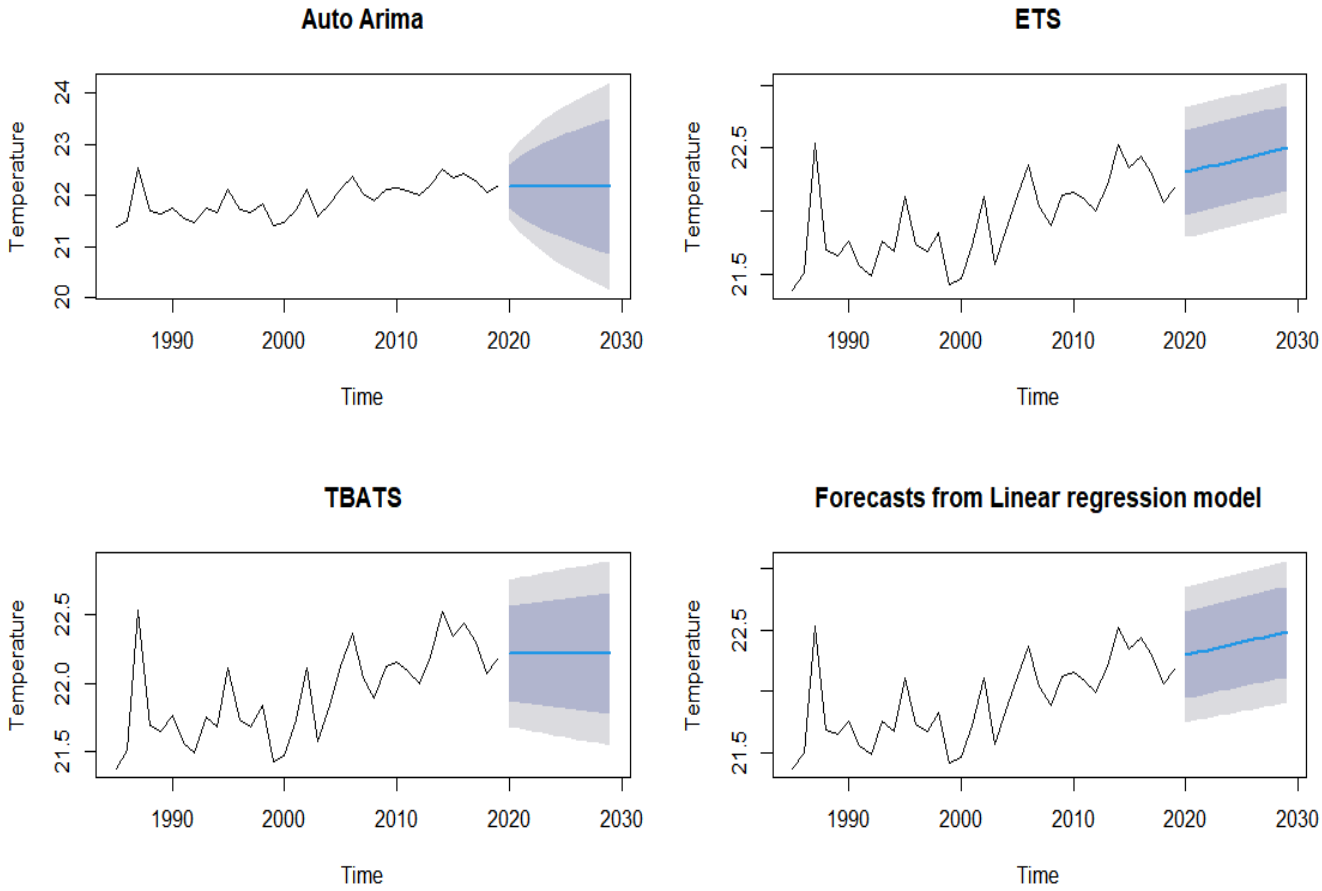

Fig 4: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Owerri using different models.

From fig 4, Seasonal average Temperature was observed to vary over the years in Owerri with the highest value at 22.52^{0}C in 2014 and the lowest value of 21.37^{0}C in 1985.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 24.208^{0}C as and as low as 20.149^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 23.019^{0}C as and as low as 21.984^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast could go as high 23.064^{0}C as and as low as 21.909^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 22.894^{0}C as and as low as 21.543^{0}C.

From table 4, the model that made the best forecast was the linear model since it recorded the lowest Root Mean Square Error value of 0.248 for the location with a forecast range of 21.909 – 23.064. The average observed value was 21.95 and the forecast value is 22.49 with a percentage increase of 2.5%.

ABUJA

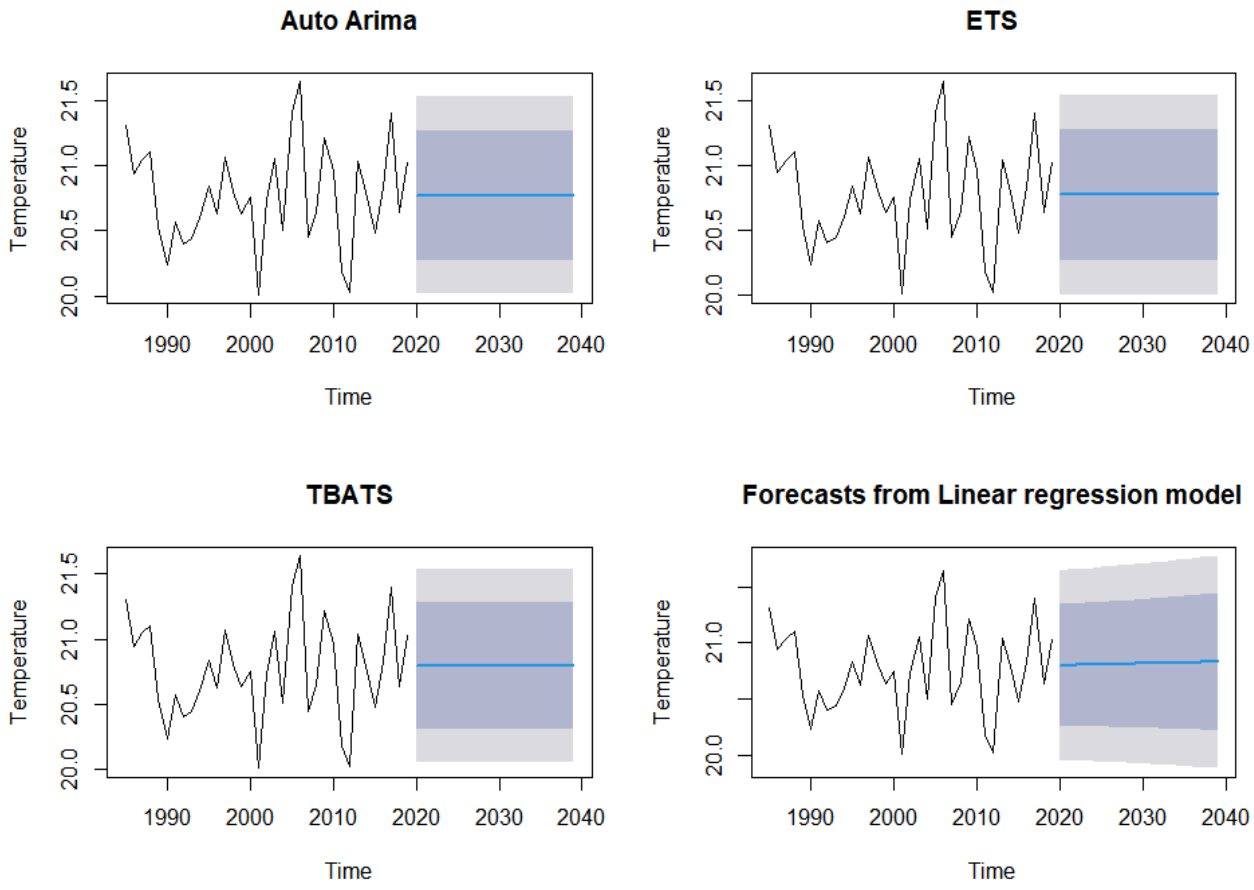

Fig 5: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Abuja using different models.

From fig 5, Seasonal average Temperature was observed to vary over the years in Abuja with the highest value at 21.4^{0}C in 2005 and the lowest value of 20.00^{0}C in 2001.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 21.256^{0}C as and as low as 20.341^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 21.253^{0}C as and as low as 20.344^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast could go as high 23.464^{0}C as and as low as 20.217^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 21.322^{0}C as and as low as 20.287^{0}C.

From table 4, the model that made the best forecast was the TBATS model since it recorded the lowest Root Mean Square Error value of 0.379 for the location with a forecast range of 20.217 – 21.322. The average observed value was 20.70 and the forecast value is 20.80 with a percentage increase of 0.5%.

MARKUDI

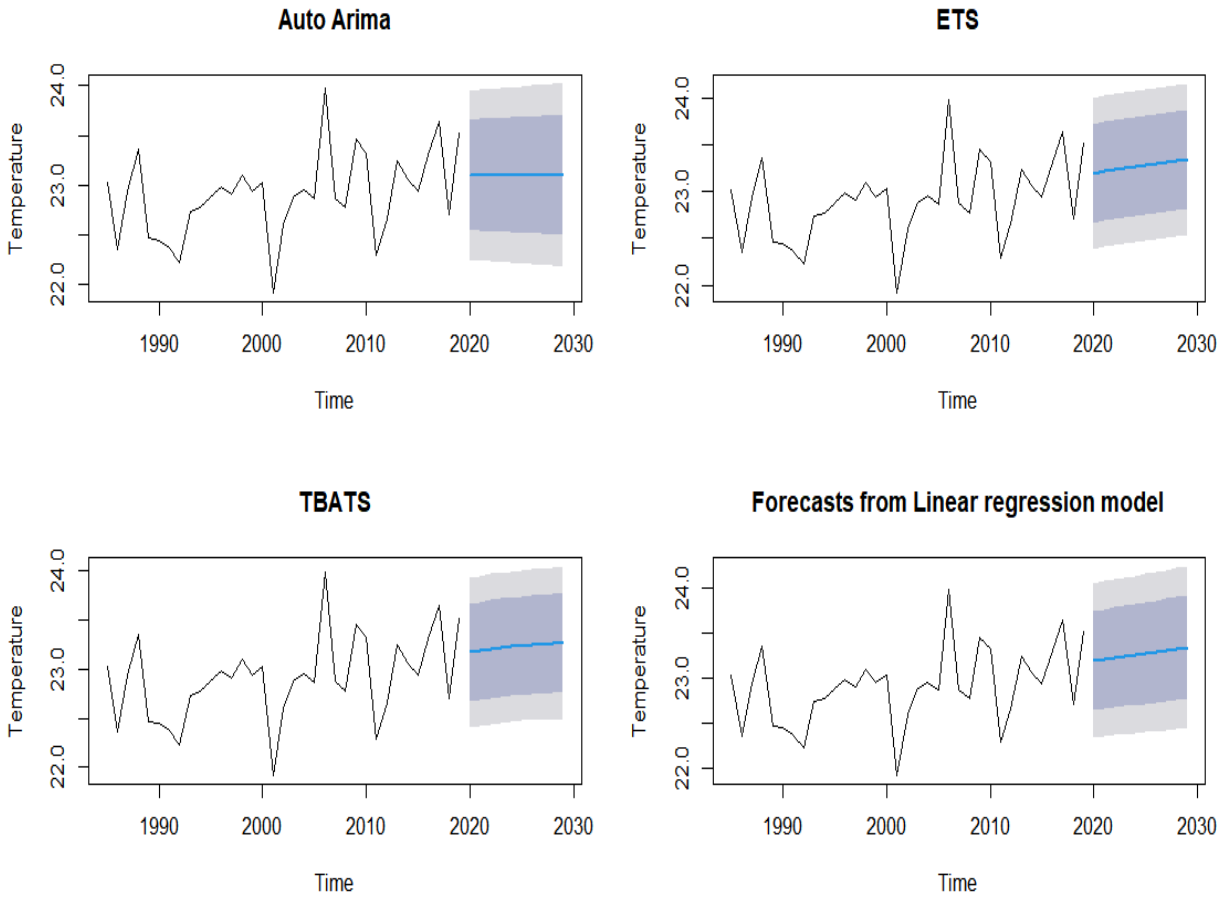

Fig 6: Graphs showing temperature variations between 1985 and 2019 and forecast between 2020 and 2030 for Makurdi using different models.

From fig 6, Seasonal average Temperature was observed to vary over the years in Makurdi with the highest value at 23.98^{0}C in 2006 and the lowest value of 21.92^{0}C in 2001.

For the Arima Model, temperature was forecasted at the 95% confidence level and the forecast can go as high 24.02^{0}C as and as low as 22.19^{0}C.

For the ETS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 24.24^{0}C as and as low as 22.43^{0}C.

For the Linear regression model, temperature was forecasted at the 95% confidence level and the forecast could go as high 24.05^{0}C as and as low as 22.48^{0}C.

For the TBATS model, temperature was forecasted at the 95% confidence level and the forecast could go as high 24.05^0C as and as low as 22.87^0C.

From table 4, the model that made the best forecast was the TBATS model since it recorded the lowest Root Mean Square Error value of 0.385 for the location with a forecast range of 22.87 – 24.05. The average observed value was 22.95 and the forecast value is 23.46 with a percentage increase of 2.2%.

Discussions:

Temperature variations from 1985-2019 and 10 year forecast for Maiduguri is as shown in fig 1. Table 3 shows the Mann-Kendall trend analysis parameters for Maiduguri and the results obtained exhibits no significant trend, making it difficult to assess the recent changes in temperature patterns in this location over the years considered. This is because the p-value of 0.711 is greater than the set alpha value of 0.05. The positive z-value of 0.369237 recorded as well as the positive tau value of 0.045 becomes insignificant since there is no trend. The linear model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.75 for the location with a forecast range of 20.243 – 22.553. The average observed value was 21.06^0C and the forecast value is 21.398^0C with a percentage increase of 1.60%.

Temperature variations from 1985-2019 and 10 year forecast for Uyo is as shown in fig 2. The Mann-Kendall trend analysis parameters in Table 3 shows that the p-value of 0.002 is less than the set alpha value of 0.05, hence we conclude that there is a trend. The Positive z-value of 3.01 as well as the positive tau value of 0.357 recorded in these locations shows that the trend is an increasing trend. The small value of Sen's slope shows that the increase is a small increase. The linear model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.95 for the location with a forecast range of 19.330 – 24.697. The average observed value was 19.60^0C and the forecast value is 22.01^0C with a percentage increase of 2.94%.

Temperature variations from 1985-2019 and 10 year forecast for Lagos is as shown in fig. 3. The Mann-Kendall trend analysis parameters in Table 3 shows that the p-value of 0.00012 is less than the set alpha value of 0.05, hence we conclude that there is a trend. The Positive z-value of 3.83 as well as the positive tau value of 0.455 recorded in these locations shows that the trend is an increasing trend. The small value of Sen's slope shows that the increase is a small increase. The Linear model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.282 for the location with a forecast range of 21.645 – 22.985. The average observed value was 21.89^0C and the forecast value is 22.21^0C with a percentage increase of 1.46%.

Temperature variations from 1985-2019 and 10 year forecast for Owerri as shown in fig 4. The Mann-Kendall trend analysis parameters in Table 3 shows that the p-value of 0.0000231 is less than the set alpha value of 0.05, hence we conclude that there is a trend. The Positive z-value of 4.23 as well as the positive tau value of 0.50 recorded in these locations shows that the trend is an increasing trend. The small value of Sen's slope shows that the increase is a small increase. The Linear model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.248 for the location with a forecast range of 21.909 – 23.064. The average observed value was 21.95^0C and the forecast value is 22.49^0C with a percentage increase of 2.46%.

Temperature variations from 1985-2019 and 10 year forecast for Abuja is as shown in fig.

5. The Mann-Kendall trend analysis parameters in Table 3 shows that the p-value of 0.000032 is less than the set alpha value of 0.05, hence we conclude that there is a trend. The Positive z-value of 4.35 as well as the positive tau value of 0.429 recorded in these locations shows that the trend is an increasing trend. The small value of Sen's slope shows that the increase is a small increase. The TBATS model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.379 for the location with a forecast range of 20.217 – 21.322. The average observed value was 20.70 and the forecast value is 20.80 with a percentage increase of 0.48%.

Temperature variations from 1985-2019 and the 10year forecast for Makurdi is as shown in fig 6. The Mann-Kendall trend analysis parameters in Table 3 shows that the p-value of 0.030 is less than the set alpha value of 0.05, hence we conclude that there is a trend. The Positive z-value of 2.15 as well as the positive tau value of 0.257 recorded in these locations shows that the trend is an increasing trend. The small value of Sen's slope shows that the increase is a small increase. The TBATS model produced the best forecast since it recorded the lowest Root Mean Square Error value of 0.385 for the location with a forecast range of 20.287 – 24.05. The average observed value was 22.95 and the forecast value is 24.05 with a percentage increase of 4.79%.

Conclusion:

Variations of air temperature has been observed in certain locations in Nigeria from 1985-2019 using satellite data from the European Centre for Medium-Range weather forecast (ECMWF) website and a 10-year forecast have been carried out using four different models (ARIMA, TBATS, ETS and the Linear model). The results reveal a continuous increase in temperature across the various locations considered for this research.

The Mann-Kendall trend test employed to study trends of temperature in the various locations under study revealed that Maiduguri exhibits no significant trend while the trend analysis results for Uyo, Lagos, Owerri, Abuja and Makurdi reveals that the trends are positively increasing and as such is connected to the global climate change.

Temperature forecast results shows that the linear model having recorded the least RMSE was very effective in forecasting average temperature for Maiduguri, Uyo, Lagos and Owerri with forecast point value at 21.38^0C representing 1.6% increase, 22.01^0C representing 2.9% increase, 22.21^0C representing 1.9% increase and 22.49^0C representing 2.5% increase respectively using the 95% confidence interval. The TBATS model having recorded the least RMSE have been discovered to be the best model to forecast temperature in Abuja and Makurdi with forecast point value of 21.32^0C representing 0.5% increase and 24.05^0C representing 2.22% respectively using the 95% confidence interval.

These slight increases in average temperature forecasted in all locations are indications that T_{min} and T_{max} have increased symmetrically in the locations which agrees with the Intergovernmental Panel on Climate Change projections that there will be "high likelihood of warming" ranging West Africa. The implication of this is extensive over many sectors of the economy such as the health sector, the aviation, agriculture, water resources etc. and taking proactive measures by individuals, Government, companies will help in mitigating the effects of the changes in Climate.

References:

Choi, D., Gao, Z. & Jiang, W., (2020) *Attention to Global Warming. Review of Financial Studies*, Forthcoming.http://dx.doi.org/10.2139/ssrn.3180045

Chai, T., &Draxler, R. R. (2014*). Root mean square error (RMSE) or mean absolute error (MAE)?–Arguments against avoiding RMSE in the literature.* Geoscientific Model Development, 7(3), 1247-1250. doi:10.5194/gmd-7-1247-2014.

Daramola, M. T., Eresanya, E. O. &Erhabo, S. C. (2017). Analysis of Rainfall and Temperature over Climatic Zones in Nigeria, *Journal of Geography, Environment and Earth Science International 11*(2): 1-14.

Dissanayake, D., Morimoto, T., Murayama, Y., Ranagalage, M., &Handayani, H., (2019). Impact of Urban Surface Characteristics and Socio-Economic Variables on the Spatial Variation of Land Surface Temperature in Lagos City, Nigeria. *Sustainability,11*(1), 25; https://doi.org/10.3390/su11010025.

Ibitoye M. O., Aderibigbe O. G., Adegboyega S. &Adebola A. (2017). Spatio-temporal analysis of land surface temperature variations in the rapidly developing Akure and its environs, southwestern Nigeria using Landsatdata. *Ethiopian Journal of Environmental Studies and Management 10*(3):389, DOI:10.4314/ejesm.v10i3.9.

IPCC Climate Change 2021*: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Aug. 9, 2021.

Jaseena, K. U. & Kovoor, B. C. (2020). Deterministic weather forecasting models based on intelligent predictors: A survey: *Journal of King Saud University - Computer and Information Science*, ISSN 1319-1578, https://doi.org/10.1016/j.jksuci.2020.09.009

Najib Y., Daniel O., Ibrahim A. M. & Oluwaseye S. A. (2017). A Study of the Surface Air Temperature Variations in Nigeria. *The Open Atmospheric Science Journal 11*(1):54-19. DOI: 10.2174/1874282301711010054.

Ogunjobi, K. O., Adamu, Y., Akinsanola, A. A., & Orimoloye, I. R. (2018). Spatio-temporal analysis of land use dynamics and its potential indications on land surface temperature in Sokoto Metropolis, Nigeria. *R. Soc. open sci.5*:180661https://doi.org/10.1098/rsos.180661.

Lau KM, Weng H. Interannual, Decadal–Interdecadal, and Global Warming Signals in Sea Surface Temperature during 1955–97 Am MeteorolSoc 1999.

Yang, K., Yu, Z., Luo, Y.,Zhou, X., & Shang C. (2019), Spatial-Temporal Variation of Lake Surface Water Temperature and Its Driving Factors in Yunnan-Guizhou Plateau. *Water Resources Research Journal 55(6)*: https://doi.org/10.1029/2019WR025316

IPCC Climate Change 2014: Impacts, Adaptation and Vulnerability PART A Global and Sectoral Aspects, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 2014