Original Research Article

DETERMINING TEMPERATURE EXTREME IN WARRI CITY, NIGER-DELTA REGION, NIGERIA

ABSTACT

Climate change and global warming which is also known as a change in Earth's overall climate or rising temperature have taken centre stage in international concerns, several fora and treaties have been observed with a view of stemming trend, in rising temperatures. This study evaluated ten years maximum and minimum annual temperature of Warri in Nigeria (2005 to 2015) to determine trends and identified extreme fluctuation in temperature. Data used for this study were sourced from the Nigerian Meteorological Agency's Warri.

An objective method for determining temperature extreme is described herein. Least square linear regression equation have been developed to estimate temperature that would be equalled or surpassed 1%, 5% and 10% of the hours at any given location during the warmest and coldest months of the year. These equations are based on an index calculated from the three readily available parameters; the mean monthly temperature, the mean daily maximum temperature for the month and the mean daily minimum temperature for the month. From the results of data analysis, the warmest month in Warri was March with a mean monthly temperature of 33.9 $°C$ while the coldest month was July with mean monthly of 25.8°C. However, the trends in temperature of Warri conform to global trend and mean annual temperature varied remarkably in positive and negative extreme fluctuations which have influenced human health condition in Warri. Hence, as temperature increases, cases of health condition decrease. Therefore, there is a gradual rising (upward) fluctuation in temperature trends of Warri.

Keywords: Mean temperature, Least square, linear regression equation, Warri, flunctation.

1.0 INTRODUCTION

During the second half of the 20th century, the globally averaged 2m air temperature increased by 0.6°C (Folland et al., 2001). However, this warming was not spatially or temporally uniform. Typically, climate change detection is associated more often with the analysis of changes in extreme events than with changes in the mean (Katz and Brown,1992). Extreme temperature events can impact many aspects of human life including: mortality, comfort, ecology, agriculture, and hydrology (Ciais et al., 2005; Patz et al., 2005). Accordingly, the characterization of climate extremes can provide invaluable information for impact assessment studies, particularly those related to hydrological and environmental modeling. Recently, substantial efforts have been made to estimate not only changes in mean temperature series, but also changes in the frequency, intensity, and duration of extreme events (Easterling et al., 2000; Jones et al., 2001; Frich et al., 2002; Kostopoulou and Jones, 2005; Moberg and Jones, 2006; Moberg et al., 2006; Brown et al., 2008). These studies have analyzed temperature extremes at different spatial scales, ranging from the regional to the global. In general, most of the findings revealed a significant upward (downward) trend in the duration and frequency of hot (cold) extremes. For instance, Alexander et al. (2006) noted a global significant decrease in cold temperature extremes throughout the second half of the 20^{th} century. Also, Parmesan et al., (2000) showed that extreme weather and climate events has severely influenced ecosystems and human society. High temperatures are among the most frequently investigated extreme events; the domains in which they affect society include agriculture, water resources, energy demand and human mortality.

1.1 Literature Review: Extreme Weather and Climate

Many research activities focus on extreme climate phenomena both because of their current impacts and the threat of their possible increases in frequency, duration and severity in a climate perturbed by enhanced concentrations of greenhouse gases in the atmosphere. Impacts of climate change would result from changes in variability and extreme event

occurrence rather than from an increase in mean temperature (Houghton et al., 1996) and even relatively small changes in the means and variations of climate variables can induce considerable changes in the severity of extreme events [12]. Impacts of extreme events are more serious when extreme weather conditions prevail over extended periods. That is why prolonged extreme temperature events (usually referred to as heat waves and cold spells) are frequently investigated. Temperature is an important element of climate and its trend in the Niger Delta should be studied temporally and spatially. Rising temperature or global warming has indeed been a worrisome meteorological problem of global concern and several fora and treaties have been observed to find solutions to this problem. Hansen (2005) noted that global warming is at least in parts a consequence of increasing anthropogenic greenhouse gases. Afangideh et al. (2005) noted that annual averages for rainfall and temperature in Uyo, Akwa-Ibom State in Nigeria are not just fluctuating, being primary characteristics of natural system, but steadily and slowly changing due to human inadvertent incursion into nature by way of socio-economic development initiatives, population growth, agricultural activities as well as growth in science and technology. The projected impact of rising temperature on environmental stability and life on earth can rather be imagined and some of these include:- changes in global climate and consequent disruption of temperature, precipitation, cloud, evapo-transpiration, shift in vegetation belt, rise in sea level, melting of polar ice-cap etc. all these are believed to have implications on fresh water resources, agriculture and food supply, natural ecosystem and human health among others. Warri in the Niger Delta of Nigeria is a part of the global environment and given increase industrial activities, population growth, transportation activities and all other activities that will accelerate the build-up of Carbon dioxide (CO_2) and other Greenhouse gases (GHGs), it is necessary to study temperature trends of Warri and the health

implications with a view to sensitizing relevant authorities in Nigeria and the international community to rise up to the challenges of the realities of current temperature trend.

In this context, few studies have analysed changes in daily temperature extremes in the study domain.

Fig 1: Map of Delta State Showing location of the Study Area (Warri)

1.2 Epidemiology of Rising Temperature

Changes in temperature can stimulate other components of the environment capable of arousing human health problem which link weather parameter such as solar radiation, temperature wind etc to human health; that exposure to high air temperature accompanied by intense radiation may result in heat stroke; and other health problems. It is also expected that the geographical range of vector will be expanded as temperature rises. Susan et al (2008) stated that mosquitoes, tick, rodents and other vectors are expanding their geographic range altering long established patterns of diseases as a result of global warming. Temperature affects pathogenic replication, maturation and period of infectivity, hence indirectly, human health. West Nile encephalitis, lung cancer, heart diseases, asthma and allergies and other health problem are linked to global warming (Susan et al., 2008). Rising temperature, could

lead to worsen air pollution which brings about disease and death, global warming has dramatically affected the quality and safety of the air we breathe. It should be noted that there are also some indirect health problems associated with some environmental impact of rising temperature such as flooding which can cause upsurge of rodent -borne illness (Leptospirosis, Tulare mina plague, viral hemonhagic diseases and cholera) and the impact of flooding on human health continues long after the water, with mental health problems (Post-traumatic stress disorder and depression).

From the foregoing, climate change as in rising trends of temperature globally or global warming is creating serious problem with food and water supplies, increasing mental health concern and exacerbating air pollution which elevate chronic diseases risk among others.

2.0 METHODOLOGY

2.1 Derivation of Temperature Frequency Relationships

2.1.1 Warm Temperature

The ideal method for determining frequency distribution of temperature would be to obtain actual distributions of hourly temperature for *n* long period. These data are readily available for a large number of stations in Nigeria but on a world-wide basis, there is an insufficient number of stations with complete, long term (at least 10 years) records to permit an accurate analysis. This difficulty was overcome in an earlier study by Tattelman on the frequency of high temperatures. In that report he determined that high temperatures corresponding to low probabilities are found where the monthly mean temperatures are highest and the mean daily range is greatest. A simple index of these values is expressed by:

$I_w = T + (T_x + T_n)$ ..... (1)

Where I_w is the warm temperature index

T is the mean,

T_x is the mean daily maximum, and

$T_n$is the mean daily minimum temperature for the warmest month.

Since good climatic records are readily available for these parameters, it was decided to determine if equation (1) is applicable on a more general basis than just the very hot locations for which it was originally used. The index was correlated with each of the observed 1%, 5% and 10% warm temperatures during the warmest month.

The following regression lines for the 1%, 5% and 10% temperatures were found by the method of least squares:

$T_{1\%} = 0.676\, I_W + 10.657$

$T_{S\%} = 0.733 I_W + 5.682$

$T_{1O\%} = 0.762 I_W + 2.902.$

Table 1: The Mean Daily Maximum and Minimum Warm Temperature

Month	The mean Daily maximum T_X	The mean Daily minimum T_N	Monthly mean T	Temperature Index I_W $T+(T_X- T_N)$	$T_{1\%}$ (^{0}C)	$T_{5\%}$ (^{0}C)	$T_{10\%}$ (^{0}C)
OCT	29.0	26.0	25.3	28.3	29.788	26.422	24.467
NOV	29.8	20.8	26.6	35.6	34.723	31.776	30.029
DEC	29.6	26.8	27.4	30.2	31.072	27.819	26.004
JAN	30.1	25.4	27.7	32.4	32.559	29.431	27.591
FEB	30.8	27.4	30.0	33.4	33.235	30.164	28.353
MAR	30.2	28.0	33.9	36.1	35.061	32.143	30.410

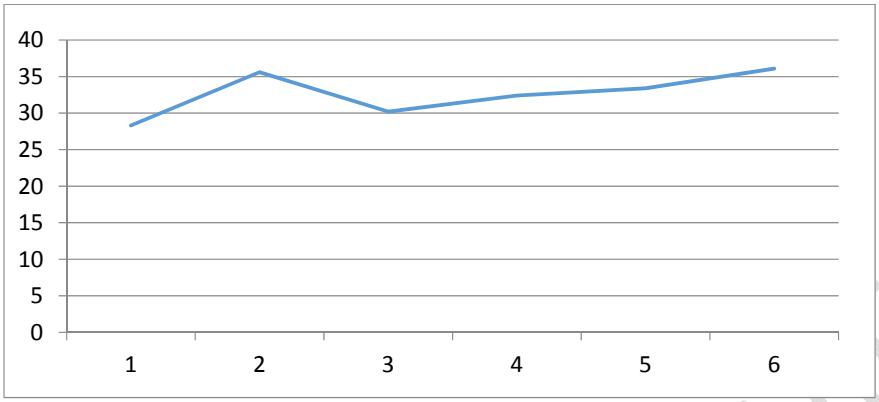

Fig 2: 1% Warm Temperature($°C$)

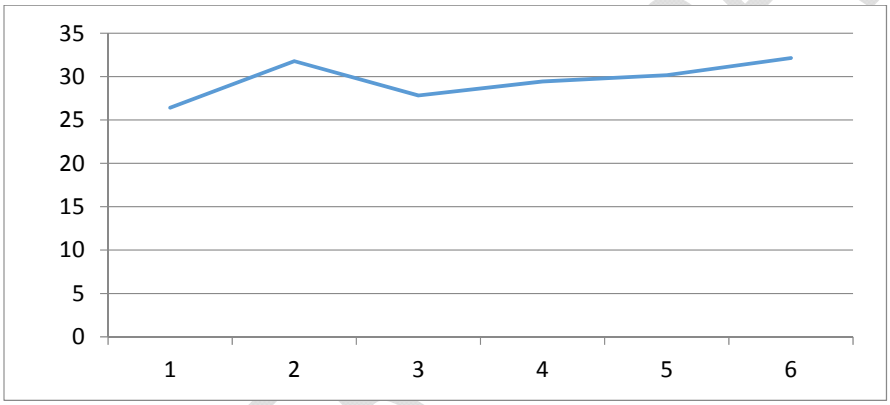

Fig 3: 5% Warm Temperature($°C$)

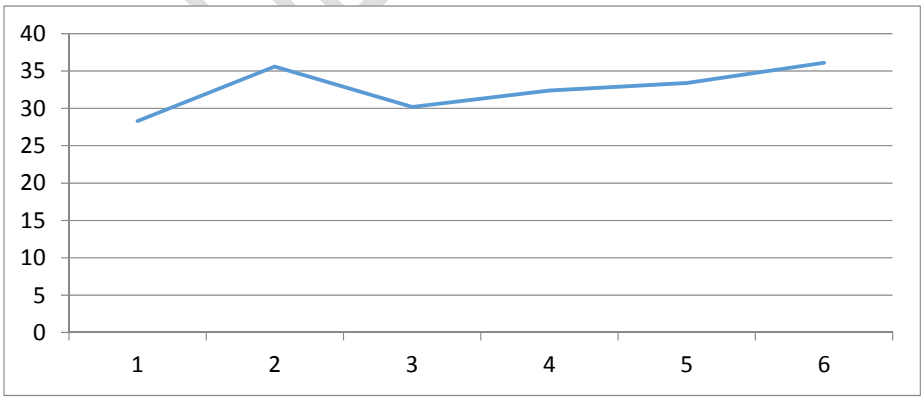

Fig 4: 10% Warm Temperature ($°C$)

2.1.2 Cold Temperatures

Since Equation (1) proved successful for describing warm temperature extremes, the same principle was used to estimate cold temperature extremes. A cold temperature index, Ic, is expressed by:

$I_c = T\text{-}(T_X\text{-}T_N)$……(2)

Where T is the mean

T_X is the mean daily maximum for the coldest month, and

T_N is the mean daily minimum temperature for the coldest month.

The index was correlated with the 1%, 5% and 10% cold temperatures during the coldest month.

The following regression lines for the 1%, 5% and 10% temperatures were found by the method of least squares:

$T_{1\%} = 1.069Ic - 7.013$

$T_{5\%} = 1.084\ Ic - 3.050$

$T_{10\%} = 1.082Ic - 0.704$

Table 2: The Mean Daily Maximum and Minimum Cold Temperature

	The mean Daily maximum T_X	The mean Daily maximum T_N	Monthly mean T	Temperature Index I_C $T\text{-}(T_X\text{-}T_N)$	$T_{1\%}$ $(°\boldsymbol{C})$	$T_{5\%}$ $(°\boldsymbol{C})$
APR.	3.06	2.72	2.92	2.58	20.567	24.917
MAY.	3.04	2.78	2.81	2.55	20.246	24.586
JUN.	2.88	2.68	2.99	2.79	22.812	27.194
JUL.	2.84	2.66	2.58	3.40	29.333	33.806
AUG.	2.66	2.66	2.69	2.57	19.819	24.158

SEP.	2.34	2.34	2.73	2.23	16.826	21.123

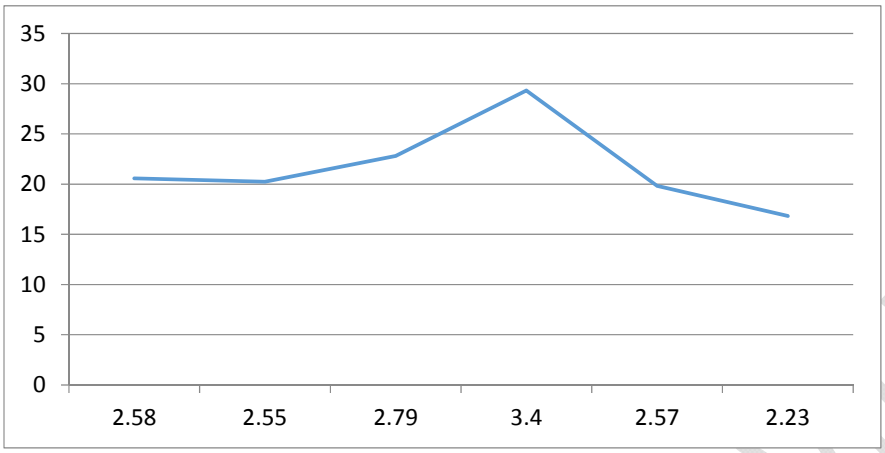

Fig. 5: 1% Cold Temperature $(°C)$

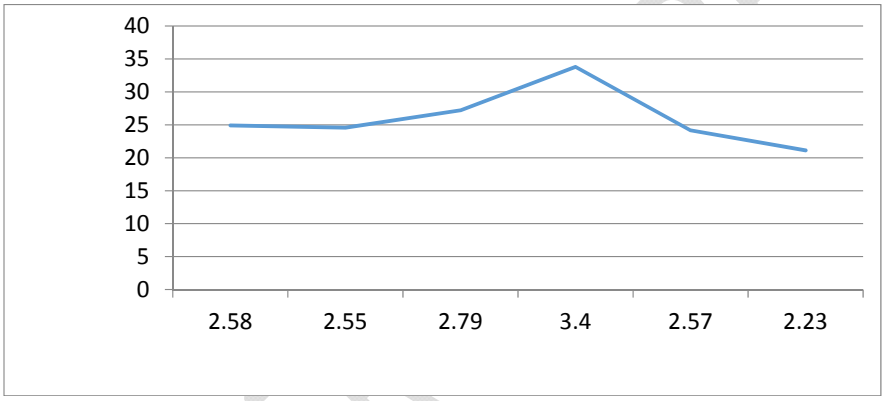

Fig. 6: 5%Cold Temperature $(°C)$

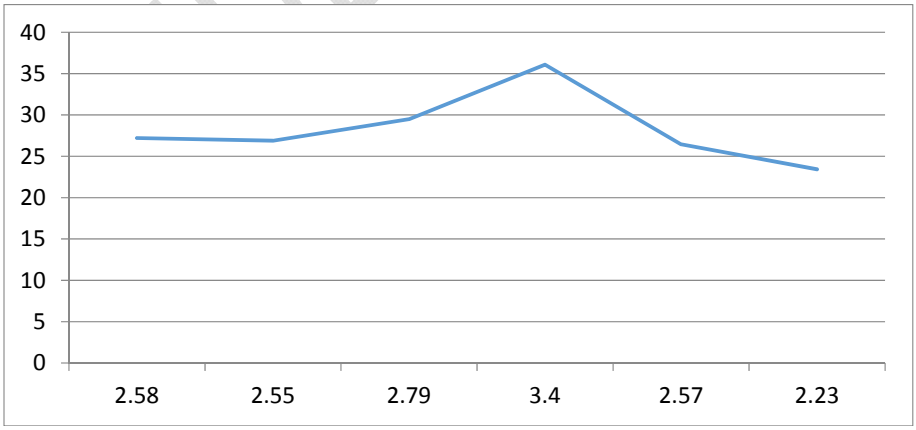

Fig 7: 10% Cold Temperature $(°C)$

3.0 DISCUSSION OF RESULTS.

The warmest month, between the year (2005-2015) in warri, Nigeria is MARCH with an average monthly temperature (mean) of 33.9°C. For warm temperature, the estimated temperature is at extreme at 35.0°C while the observed temperature is at 31.8°$\boldsymbol{C}$.

The coldest month in warri, Nigeria was JULY, with monthly mean temperatures averaging 25.8°C from the year (2005-2015). Warri thus experienced extreme coldness at estimated temperature ranging from 16.0°C to 24.0°C and observed temperature of 26.6°$\boldsymbol{C}$ within the months of April, May, June, July, August, and September within the year 2005-2015.

Warri is a typical Niger Delta area and part of the global environment. Warri has the potential for sustained anthropogenic greenhouse gases blamed for global temperature rise. From the results of data analysis, it is apparent that; trends in temperature of Warri conform with global trend and mean annual temperature has varied remarkably in Positive and negative extreme fluctuations which have influenced human health condition in Warri The relationship between temperature and health condition in Warri is inverse, hence as temperature increases cases of health condition decrease. There is a gradual rising (upward) fluctuation in temperature trends of Warri.

4.0 CONCLUSION

The temperatures on which this study is based were observed within standard meteorological instrument shelters. As a result, they approximate temperatures of the free air about 5 or 6 ft above the ground. The high temperatures described herein normally will be encountered during periods of strong sunshine and fairly light winds. Similarly, low temperatures

generally will be encountered during nights with clear skies and little or no wind. The ground can attain temperatures from 15°C to 30°C higher and 50°C to l0°C lower than that of the free air, depending upon radiation, conduction, wind, and turbulence. Since the design philosophy for temperature extremes, as adopted for this report, is based on the probability of being exceeded during the warmest (coldest) month of the year, the number of hours this temperature is encountered during all other months will be smaller than in the warmest (coldest) month. Also, the annual risk will be roughly one tenth of that shown for the warmest (coldest) month. It should be noted that the warmest (coldest) month is not necessarily the same for each station. This fact, however, does not alter the desired concept of percentage of time (risk) of inoperability for design. Hence, as temperature increases, cases of health condition decrease. Therefore, there is a gradual rising (upward) fluctuation in temperature trends of Warri.

4.1 RECOMMENDATIONS

The current trend of rising temperature can be checked through effective legislations and enforcement of policies and laws aimed at reducing greenhouse gas emission by the government, population control and environmental education programme, international co-operation in endorsing and domestication of international treaties and laws on environmental protection. Mitigation measure such as provision of sustainable, efficient and affordable health care delivery system be put in place to meet the health need of the people since they cannot run from the environment. Deliberate plan be made to monitor trends in temperature and other climatic parameters and their implications on health, agriculture, wildlife and the economy.

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