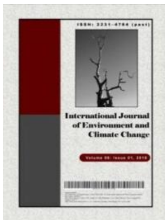

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Determining Temperature Extreme in Warri City, Niger-Delta Region, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author YSO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and author VBO managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

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 of maximum and minimum annual temperature of Warri in Nigeria between (2005 and 2015) to determine trends and identified extreme fluctuation in temperature. Data used for this study were sourced from the Nigerian Meteorological Agency's Zonal Office, Warri. An objective method for determining temperature extreme has been used. Least square linear regression equation has been used 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. 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.

Keywords: Mean temperature; least square; linear regression equation; Warri; fluctuation.

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1. INTRODUCTION

During the second half of the 20th century, the globally averaged air temperature increased by 0.6°C [1]. However, this warming effect 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 [2]. Extreme temperature events can impact many aspects of human life including mortality, comfort, ecology, agriculture, and hydrology [3,4]. Accordingly, the characterisation of climate extremes can provide invaluable information for impact assessment studies, particularly those related to hydrological and environmental modelling. 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 [5,6,7,8,9,10]. These studies have analysed 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 [11]. For instance, [12] noted a global significant decrease in cold temperature extremes throughout the second half of the 20th century. Also, [13] showed that extreme weather and climate events have 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.

Changes in temperature can stimulate other components of the environment capable of arousing human health problem which links 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 [14,15]. It is also expected that the geographical range of vector will be expanded as temperature rises. [16] 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 [16]. Hence, the trends of extreme temperature fluctuation in Warri are needed to be determined and identified so as to avoid any health hazard linked with it.

Fig. 1. Map of Delta state showing location of the study area (Warri)

2. DERIVATION

2.1 Warm Temperature

The ideal method for determining the frequency distribution of temperature would be to obtain actual distributions of hourly temperature for *n* long period. These data were readily available for a large number of stations in Nigeria (Fig. 1) but on a worldwide basis, there are insufficient numbers of stations with complete, long term (at least 10 years) records to permit an accurate analysis. This difficulty was overcome by an earlier study by Paul and Arthur [17] and Paul and Arthur [18] on the frequency of high temperatures. In that report, he determined that high temperatures corresponding to low probabilities were found where the monthly mean temperatures were highest and the mean daily range was greatest. A simple index of these values was expressed by Paul and Arthur [19].

$$I_w = T + (T_x - T_n) \quad (1)$$

Where,

I_w = the warm temperature index
T = the mean,
T_x = the mean daily maximum, and
T_n = the mean daily minimum temperature for the warmest month.

Since good climatic records were readily available for these parameters, it was decided to determine if equation (1) was 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
$T_{5\%}$= 0.733I_W + 5.682
$T_{10\%}$ = 0.762I_W + 2.902.

Note: The numbers on the x-axis in Figs. 2, 3 and 4 represent the month as indicated in Table 1.

2.2 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, was expressed by:

$$I_c = T - (T_X - T_N) \quad (2)$$

Where,

T is the mean
T_X = the mean daily maximum for the coldest month, and
T_N = the mean daily minimum temperature for the coldest month.

The index was correlated with 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 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)	$T_{1\%}$ (°C)	$T_{5\%}$ (°C)	$T_{10\%}$ (°C)
OCT(1)	29.0	26.0	25.3	28.3	29.788	26.422	24.467
NOV(2)	29.8	20.8	26.6	35.6	34.723	31.776	30.029
DEC(3)	29.6	26.8	27.4	30.2	31.072	27.819	26.004
JAN(4)	30.1	25.4	27.7	32.4	32.559	29.431	27.591
FEB(5)	30.8	27.4	30.0	33.4	33.235	30.164	28.353
MAR(6)	30.2	28.0	33.9	36.1	35.061	32.143	30.410

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 $T-(T_X-T_N)$	$T_{1\%}$ (°C)	$T_{5\%}$ (°C)	$T_{10\%}$ (°C)
APR (1)	30.6	27.2	29.2	25.8	20.567	24.917	27.216
MAY (2)	30.4	27.8	28.1	25.5	20.246	24.586	26.887
JUN (3)	28.8	26.8	29.9	27.9	22.812	27.194	29.484
JUL (4)	28.4	26.6	25.8	34.0	29.333	33.806	36.084
AUG (5)	26.6	26.6	26.9	25.7	19.819	24.158	27.103
SEP (6)	23.4	23.4	27.3	22.3	16.826	21.123	23.425

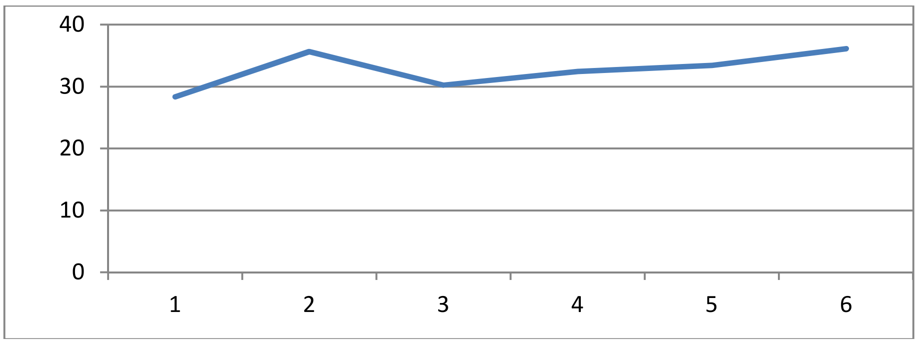

Fig. 2. 1% Warm temperature(°C)

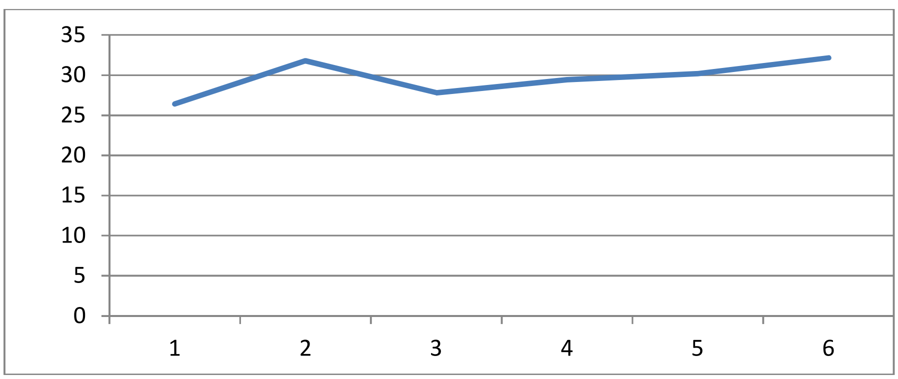

Fig. 3. 5% Warm temperature(°C)

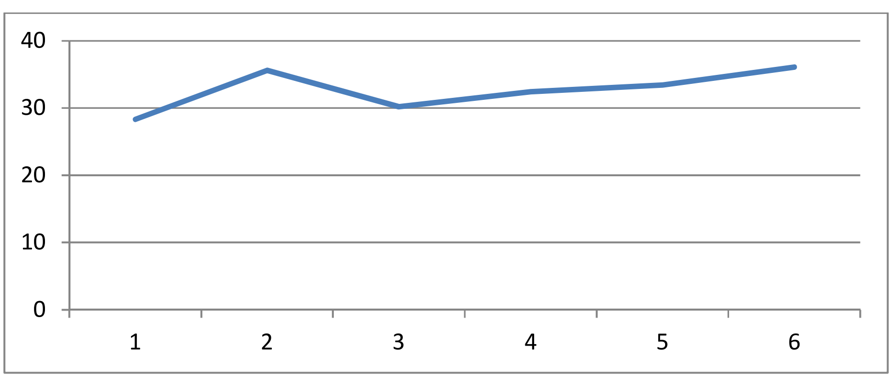

Fig. 4. 10% Warm temperature (°C)

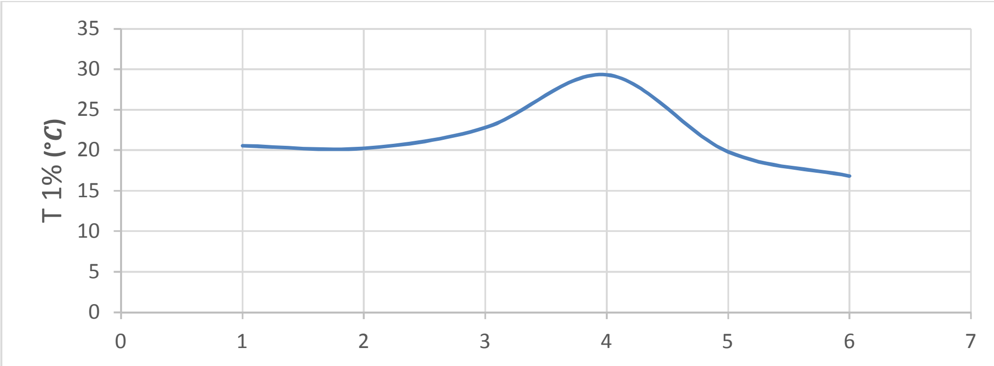

Fig. 5. 1% Cold temperature (°C)

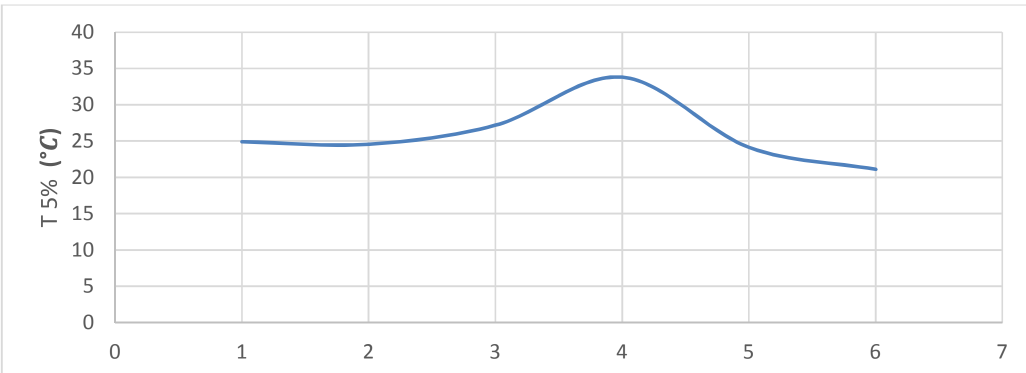

Fig. 6. 5%Cold temperature (°C)

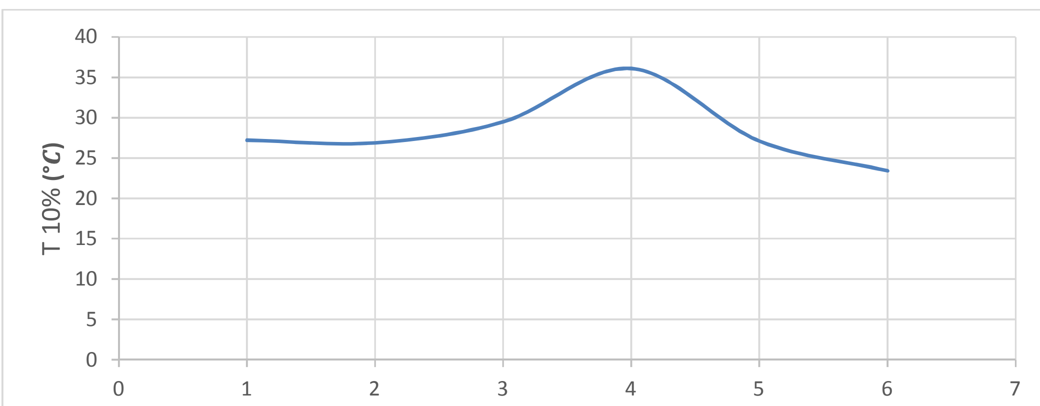

Fig. 7. 10% Cold temperature (°C)

Note: The numbers on the x-axis in Figs. 2, 3 and 4 represent the month as indicated in Table 2.

3. DISCUSSION

The warmest month, between the year (2005-2015) in Warri, Nigeria is March with an average monthly temperature (mean) of 33.9°C (Table 1). For warm temperature, the estimated temperature was at extreme at 35.0°C while the observed temperature was observed at 31.8°C. (Figs. 2, 3 & 4)

The coldest month in Warri, Nigeria was July, with monthly mean temperatures averaging 25.8 °C from the year (2005-2015) (Table 2). Warri thus experienced extreme coldness of an estimated temperature ranging from 16.0 °C to 24.0°C and observed the temperature of 26.6**°C** within the months of April, May, June, July, August, and September within the year 2005-2015. (Figs. 5, 6 & 7).

Warri, a typical Niger Delta area and part of the global environment had been the potential for sustained anthropogenic greenhouse gases blamed for global temperature rise. From the results of data analysis, it was apparent that; trends in temperature of Warri conform with the global trend and mean annual temperature has varied remarkably in Positive and negative extreme fluctuations which 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. CONCLUSION

This method represented a unique tool for estimating warm and cold temperature extremes. Least squares linear regression equation had been used to calculate temperatures that would equalled or exceeded 1, 5 and 10% of the hours at Warri during the warmest month of the year while Analogous regression has been used to calculate temperatures equalled or less than 1, 5 and 10% of the hours at Warri during the coldest month of the year. The high temperatures described herein normally would be encountered during periods of strong sunshine and fairly light winds. Similarly, low temperatures generally would be encountered during nights with clear skies and little or no wind. The ground could 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 the current report, based on the probability of being exceeded during the warmest (coldest) month of the year, the number of hours this temperature was encountered during all other months would be smaller than in the warmest (coldest) month. Also, the annual risk would be be roughly one-tenth of that shown for the warmest (coldest) month. It should be noted that the warmest (coldest) month was not necessarily the same for each station. This fact, however, did not alter the desired concept of percentage of time (risk) of inoperability for design. Hence, as temperature increased, cases of health condition decreased. Therefore, there was a gradual rising (upward) fluctuation in temperature trends of Warri.

5. RECOMMENDATION

From the mitigation measure, a sustainable, efficient and affordable health care delivery system should be put in place to meet the health need of the people since they cannot run from the environment. Also, a deliberate plan should be made to monitor trends in temperature and other climatic parameters, so as to avoid any implications on health, agriculture, wildlife and the economy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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