Trends in extreme temperature indices over Lagos, Nigeria

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Abstract. There is the need to understand the trend and impact of extreme temperature on coastal cities because they are generally susceptible to extreme precipitation events. This study explores the trend in extreme temperature for Lagos State, Nigeria. The indices for daily minimum and maximum temperature data was calculated for the period 1991–2015 using the RClimDex software. The result showed that both minimum value of daily minimum temperature (TNN) and cool days (TX10p) showed negative trends among the indices considered. Significant trends were observed in warm nights (TN90p), warm days (TX90p) and mean of maximum temperature (Tmax-mean). Warm nights were found to be increasing while cold nights are either unchanged or decreasing. This study reveals that there are evidences of increase in warming of Lagos State.

KEY WORDS: Trends; extreme temperature; climatic change indices

1. Introduction

The change in intensity of climate has great impact on human life and ecosystem. The world is presently experiencing different disaster of climate change such as flash flood, drought, tornadoes, wild fire, etc., which interrupts the normal flow of the ecosystem. One of the major effects of climate change is extreme temperature which results to extreme heat and cold. The effect of extreme temperature is substantial and has serious implications on human society, plants and animals, natural resources and the ecosystem. Some of these effects are fainting, heatstroke, dehydration, destructive frosts and freezes, ice storms, death etc. Numerous studies have been carried out on the trend in extreme temperature over the globe and its impact on different areas of human lives [1-6]. [7] predicted that extreme temperature would be more profound and frequent than what was experienced in the previous years. More than 70% of the land area of the world indicates both a remarkable decrease in the annual occurrence of cold nights and increase in the annual occurrence of warm nights [8]. [9] confirmed a notable increase in the frequency of hot extremes and cold extremes.
over various regions in Nigeria. A remarkable increase in temperature has also been projected over all the ecological zones for the 21st century [10] which may have a damaging effect on food security and agriculture.

Climate extremes in Lagos is expected to impact on housing [11], air pollution [12], physical environment [13], road infrastructure [14], sea level rise [15], and diseases [16]. Lagos has been ranked among port cities with exposure to climate extremes [17]. Climate change is set to affect the livelihood of people living in low-income communities with Lagos State [18]. Having a good insight in the events of the previous extremes is very paramount in order to avoid or prevent some devastating occurrence in the future.

This study aims to investigate the temporal variation of ten temperature extreme indices and their trends. Furthermore, the statistical variations in the indices were considered. The results from this study will provide information on historical patterns of variation of temperature-based extremes and a basis for development of future models and strategic plans.

2. Methods

Maximum temperature and minimum temperature data for Lagos State were obtained from the archives of the Nigerian Meteorological Agency (NIMET) for the period 1991 to 2015. In this study, 10 temperature indices that illustrate both cold and warm extremes was selected from a total of 27 core climate change indices which was endorsed by the Expert Team on Climate Change Detection Monitoring and Indices (ETCCDI) [19]. The indices were calculated using RClimDex (1.0) [20]. The data quality control procedure in RClimDex was conducted before carrying out the calculations. Outliers in daily maximum and minimum temperatures were also determined and checked manually.

Lagos (6.5244°N, 3.3792°E) is a coastal city in Southwest Nigeria. As a former capital city of Nigeria, it is a cosmopolitan city with increasing population over the years. The city has two distinct climatic seasons, typical of tropical locations. From March to October, Lagos experiences the wet season with rainfall of about 24 mm [11]. The month of November through February is the dry season in Lagos State.

3. Results and Discussion

Box plots of the ten indices were considered to examine their statistical properties (Figure 1). The percentile based temperature indices of cool nights (TN10p), warm nights (TN90p), cool days (Tx10p), and warm days (TX90p) have large interquartile range which suggests large variations in values. No outliers were detected for diurnal temperature range (DTR) and mean of maximum temperature (Tmax-mean). However, other indices showed significant outliers with the largest observed in TN90p. The temporal variations and trend of the indices are presented in Figure 2. Summary statistics of the trends are shown in Table 1. The mean values of the indices are in the range of 7.26 – 36.51. The highest standard deviation of 7.78 days was found in TN90p index. Only two of the indices which are minimum value of daily minimum temperature (TNn) and minimum value of daily maximum temperature (TXn) were found to be negatively skewed. Negative trends were observed in both TNn and TX10p while the other indices showed positive trends. The negative trends in both TNn and TX10p decreases at a rate of 0.05°C per year. Trends in TN90p, TX90p and Tmax-mean were found to be significant at 95% confidence interval. The significant trends in both TN90p and TX90p were found to be increasing at a rate of 0.5°C/year. There was no observable trend in TN10p. The smallest standard errors in the linear fit were found in both DTR and Tmax-mean while the largest standard errors were observed in TN90p. Increasing maximum value of daily maximum temperature (TXx) and reducing TXn values indicates an increasing temperature range. This implies that Lagos residents will be exposed to a wider range of temperature. The implication of high increasing trends in TN90p and TX90p is an increase in extreme temperatures...
in the State. Increasing warm temperatures will affect human and animal comforts, as well as, accelerate the spread of diseases.

Fig. 1: Box plot showing the statistics of the temperature extreme indices

Fig 2: Temporal variation and trend in temperature climate extremes.
Table 1: Statistics and trend analysis of temperature extremes in Lagos, Nigeria. Significant slopes (indicated by * were considered at 95% confidence interval).

| Indices     | Mean Min | STD Max | Skew Trend | Stdevr |
|-------------|----------|---------|------------|--------|
| DT          | 7.53     | 7.08    | 0.32       | 8.2    | 0.46  |
| TN10p       | 8.62     | 0.27    | 4.89       | 20.74  | 0.66  |
| TN90p       | 7.26     | 0       | 7.78       | 34.08  | 1.88  |
| TNn         | 18.08    | 1       | 2.34       | 22.2   | -1.29 |
| TNx         | 27.8     | 2       | 6          | 1.09   | 31.2  |
| TX10p       | 8.39     | 3.53    | 2.96       | 16.31  | 0.74  |
| TX90p       | 8.52     | 1.01    | 6.15       | 23.63  | 0.9   |
| TXn         | 24.92    | 2.27    | 0.89       | 27.7   | -0.44 |
| TXx         | 36.51    | 3       | 5.04       | 38.9   | 0.43  |
| Tmax-mean   | 31.43    | 30.89   | 0.31       | 32.03  | 0.27  |

4. Conclusion

This study has investigated the temporal variation and trends in temperature extremes in Lagos, Nigeria using ten indices. Results obtained showed positive trends across all indices except TNn and TX10p. The temperature extremes indices considered were not found to be significant except TN90p, TX90p and Tmax-mean. We conclude that there are evidences of warming in Lagos State.

Mitigating the impact of the warming climate in Lagos, Nigeria is essential. To this end, we propose that trees with large covers be planted in strategic places within the State to protect citizens from the Sun. Increasing temperatures come with attendant health related issues. Safe public drinking water fountains should be provided in various parts of the State to prevent dehydration and succour during heat wave events.

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