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Variability and Probabilistic Extremes of Some Climatic Elements over Ibadan

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Abstract: Data on different climatic elements, like monthly rainfall monthly mean relative humidity, monthly lowest relative humidity; monthly mean temperature, monthly mean maximum and minimum temperatures with their monthly extremes values and monthly mean prevailing wind speeds over Ibadan for the months of January through to December during the period of 1979 through to 2005 have been considered to study their variability and to determine the probabilistic extreme values of these elements. The probabilistic extremes values have been computed for 3 time scales: In 1 year out of 4 years, in 1 year out of 10 years and in 1 year out of 25 years-representing relative more frequent events, moderately extreme events and extreme events, respectively.

Key words: Rainfall, temperature, humidity, probabilistic extreme, Ibadan

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INTRODUCTION

Urbanization is increasing on the earth and rural areas are decreasing. In a developing country like Nigeria, the rate of growth is faster. People come to cities and dwell. Thus, very large number of houses comes up. As per present days ideas, the stable houses are supposed to be made of concrete. Simultaneously roads come up most of them become tarred. Urbanization has been shown to have impacts on urban climate (Oke, 1979; Landsberg, 1981). The rapid urbanization sometimes may lead to severe problems associated with environmental deterioration ----erosions, unhealthy living conditions, shortage of energy, water and increased exposure of the population to floods, severe storms, heat waves or extreme winds especially in the countries where natural calamities are recurring phenomenon. If climatologically information, principles and experiences were incorporated in the planning of rapidly growing urban areas, most of the above problem could be solved.

Rapidly growing buildings, industries, roads, etc. in urban areas have effects on radiative cooling/heating, precipitation, fog, visibility, wind circulation, etc. The types of materials and designs of buildings/houses, the drainage system, etc depend very much on climatic elements and their extreme values. Therefore, the planners and designers must consider the climatic factors and the extremes values of climatic elements before engineering constructions of buildings and houses, industries, roads, drains, etc. in urban areas.

Cities and urban areas represents the overwhelming bulk of the sources of the particulate and gaseous emissions underline many of the real or perceived global change issues, which at present hold the attention of much of the world community (e.g., depletion of stratospheric ozone, increasing concentrations of trace gases, acidifications of precipitations, arctic haze and decline visibility) (Oke, 1994).

This research attempts to study the variability of different climatic elements and their probabilistic extreme values over a low-latitude city, Ibadan (Adebayo, 1994).

MATERIALS AND METHODS

Daily data of January through to December during the period of 1979 through to 2005 of climatologically elements are obtained from International Institute of Tropical Agriculture, IITA, Ibadan. Monthly values of the variables needed for the study is extracted from the daily data.

The variables are:

- Monthly rainfall for each year of 1979-2005
- Monthly mean relative humidity and monthly lowest relative humidity
- Monthly mean temperature
- Monthly mean maximum and minimum temperature with their extremes
- Monthly mean solar radiation

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The probabilistic estimates of the extreme values of climatic elements like monthly lowest minimum temperature are computes for 3 time sales:

- In 1 year out of 4 years
- In 1 year out of 10 years
- In 1 year out of 25 years, representing relatively more frequent, moderately extreme events, extreme events, respectively.

In probabilities studies, it is necessary to ensure that the data have a normal distribution. The climatic elements used are found to be normally distributed with the help of corns test up to 95% of significance. The probability of occurrence of some climatic element in some expected percentage may therefore, be computed by Z score (Samarendra and Ayesha, 1994). For computations of probabilities, the Z score can be written as:

$$\sigma' = \bar{\sigma} \pm Z\sigma$$

Where:

σ' = The probabilistic estimate of the variable
σ = The mean value of the variable
σ = The standard deviation

The equations of the probabilistic estimates of the variables for the above mentioned time scale are

- In 1 year out of 4 years: $\sigma' = \bar{\sigma} \pm 0.675\sigma$
- In 1 year out of 10 years: $\sigma' = \bar{\sigma} \pm 1.28\sigma$
- In 1 year out of 25 years: $\sigma' = \bar{\sigma} \pm 1.75\sigma$

RESULTS AND DISCUSSION

Variations of monthly mean temperature, monthly mean maximum and minimum temperature, monthly mean solar radiation and monthly prevailing wind speed over Ibadan are shown in Fig. 1. The Fig. 1 shows that the mean solar radiation increases from a minimum value in January to a maximum value in April. It then has a decreasing trend to August and thereafter increases to a secondary maximum in November. The maxima observed in April and November implies that solar radiation reaching the Earth's surface is highest for these months.

The primary and secondary maxima are at February and December, respectively for the mean maximum temperature. The trend is such that the mean maximum temperature increases to a maximum value in February and decreases to August before, it begins to increase again. These observed primary and Secondary maxima can be attributed to the location of the sun over the tropical

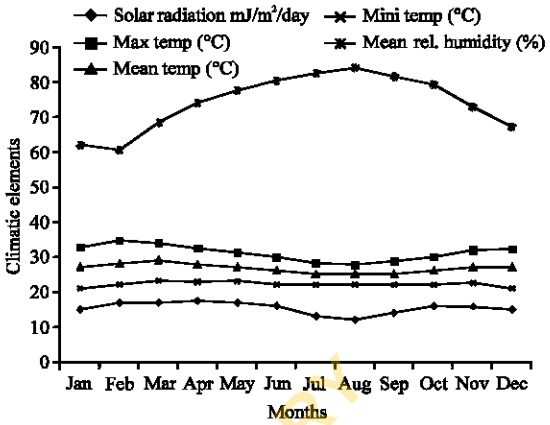

Fig. 1: Variation of monthly means of climatic elements over Ibadan

region and the decreasing trend from February to August is due to the northward migration of ITD (this follows the apparent northward shift of the Sun). The moisture flux and the associated cloud formation are parts of the local effects. The increasing trend after the month of August is due to Southward shift of ITD couple with the associated dissipation of the cloud cover.

The trend for the mean temperature is similar to that of maximum temperature with the maxima values in March and November, respectively. The maxima for the mean minimum temperature are the same with that of mean temperature; however, from March to November, the trend is almost constant.

From the graph, it could be observed that the primary peak of the mean maximum temperature does not correspond to that of the mean minimum temperature. This is due to relatively low moisture content in February (Fig. 1) as compared with month of March, where the mean minimum temperature is maximum. The solar radiation reaching the Earth's surface at the day-time is therefore, highest in February, while at the night time, the radiative cooling is higher for the same reason. Consequently, in the day-time, the mean maximum temperature is higher in February and the mean minimum temperature, which is associated with the night time, is lower when compared with March values.

The trend of the wind speed is such that it has a single peak in April and decreases although to December. This is due to incursion of Southwesterly winds from the Atlantic Ocean into the coastal areas and the convective activities due to intense insolation at that time.

Variations of mean rainfall and relative humidity over Ibadan are shown in Fig. 2. It is obvious from the Fig. 2 that the mean rainfall over Ibadan increases slowly from

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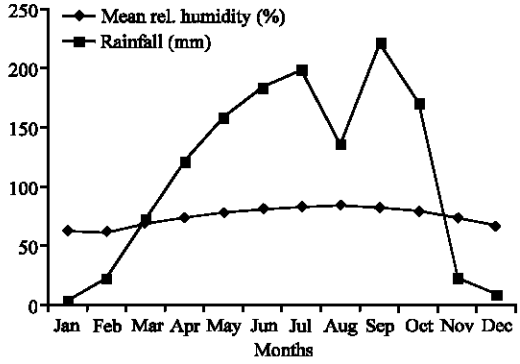

Fig. 2: Monthly variation of rainfall and rel. humidity

January and attains the maximum value of 198.01 mm in July and the second maximum value of 220.7 mm in September and then it decreases sharply to minimum value in December. The maximum values of rainfall in July and September are due to Monsoon rains with its characteristics of long periods of precipitation with little or no thunder (Omotosho, 1985). The first peak attained follows the incursion of moist, unstable, maritime southeasterly winds into the area sas a result of the northward migration of the ITD. ITD attained its northern most position in August and consequently there is a break in the Monsoon rains i.e. (little dry season). The second peak is attained when ITD is shifting southwards at a faster rate compared with its northward migration. Hence, the sharp decline to December.

The mean relative humidity, as shown in Fig. 2 is constant for the months of January and February. The trend is such that it increases gradual from February to August before it decreases again to December.

The highest value observed in the month of August is due to prevalent moisture laden, maritime and southwesterly winds over most of the West Africa at that time. This follows the migration of ITD as stated above.

However, the peak of the mean relative humidity does not correspond with peak of the mean Rainfall. In fact, though, there is more moisture in the air in the month of August than July and September; the rainfall in those months is higher compared with August.

Probabilistic estimates of climatic elements: The probabilistic estimates of the extreme values of climatic elements like monthly rainfall, monthly mean maximum relative humidity, highest maximum temperature and lowest minimum temperature have been computed 1979-2005. The lowest relative humidity is the lowest value recorded on a certain day in each month.

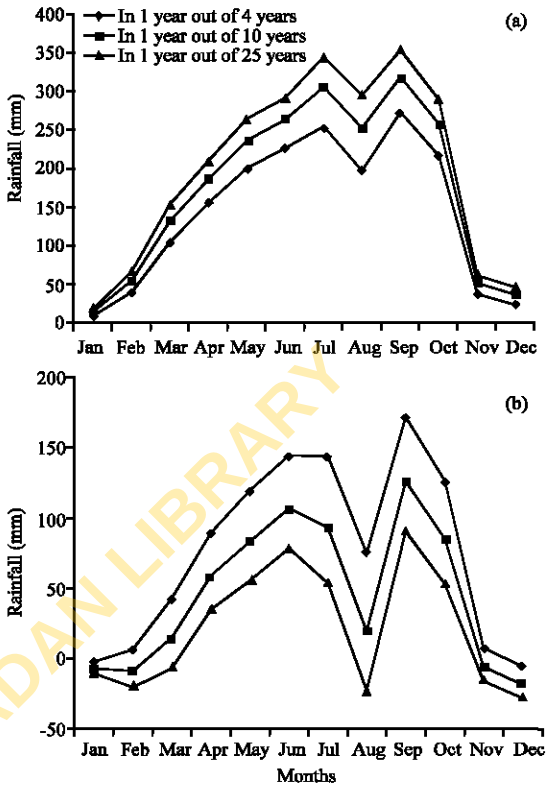

Fig. 3: a): Variation of probabilistic high values of monthly rainfall over Ibadan, b): Variation of probabilistic low values of monthly rainfall over Ibadan

The highest maximum and lowest minimum temperatures are the highest and lowest temperatures on a certain day in each month. These will be treated as the monthly highest maximum and monthly lowest minimum temperatures. The probabilistic estimates of the extreme values of maximum wind speeds during March-May have also being considered.

Probabilistic monthly rainfall: The variation of the Probabilistic high and low values of monthly rainfall over Ibadan are shown in Fig. 3a and b. The variation in most cases is similar to the variation on monthly Mean Rainfall (Fig. 2). The Fig. 3a shows that the probabilistic high rainfall extremes are maximum in July and September with the values 253.9, 304, 342.9, 271.4, 316 and 352 mm, respectively for 1 year out of 4 years, 1 year out of 10 years, 1 year out of 25 years also, respectively. The probabilistic low rainfall extremes in July and September are 142.1, 105.7, 77.1, 169.9, 124.5 and 89.1 mm, respectively for 1year out of 4 years, 1 year out of 10 years, 1 year out of 25 year, respectively. The negative

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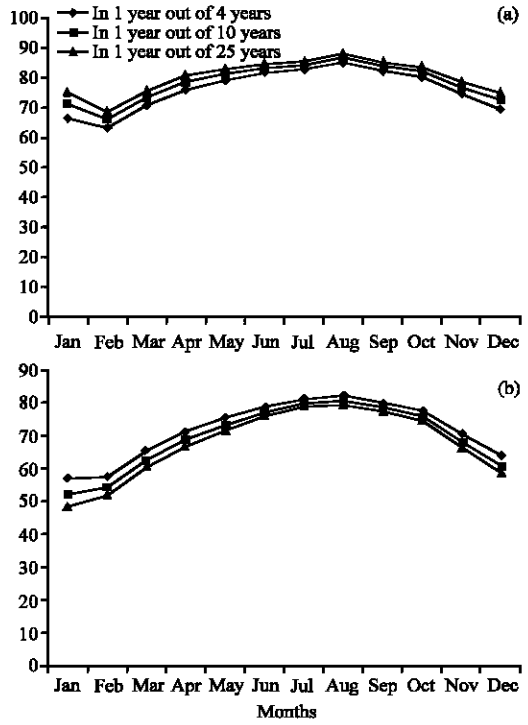

Fig. 4: a): Variation of the probabilistic high value of mean relative humidity, b): Variation of the probabilistic low value of mean relative humidity

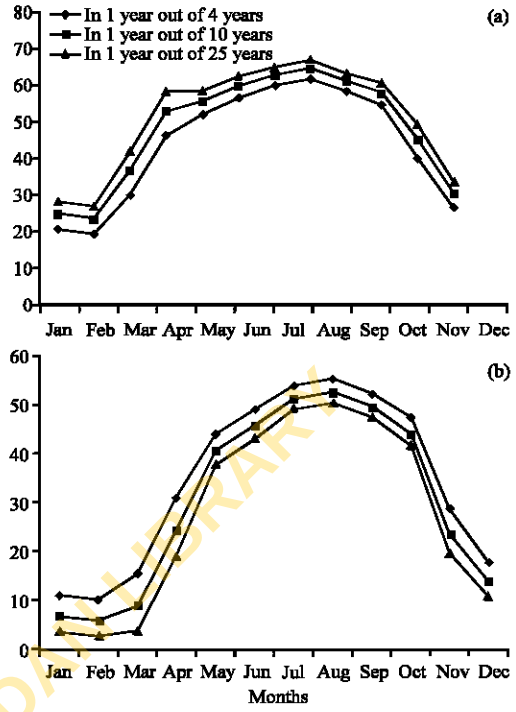

Fig. 5: a): Variation of probabilistic high values of monthly lowest relative humidity, b): Variation of probabilistic low values of monthly lowest relative humidity

values of probabilistic low rainfall observed around December and January could be explained as partly due to high insolation and partly due to prevalent of northesterly dry wind (locally called harmattan) at that time.

Probabilistic monthly mean relative humidity: The variation of the probabilistic high and low values of monthly mean relative humidity are shown in Fig 4a and b, respectively. The Fig 4a shows that high value of the monthly mean relative humidity is minimum in February. This could be ascribed to persistence of dry, hot, northeasterly winds, increased solar radiation (causing dryness also) and less condensation of evapotranspiration. The trend after February increases gradually to a peak value in August and there after decreases. The probabilistc high values of monthly mean relative humidity 87.6, 87.6 and 88.9% in 1 year out of 4 years, 10 and 25 years, respectively. The probabilistic high values obtained for January is due to higher variability (~5%) compared with any other month. The low value of monthly mean relative humidity is minimum in January and maximum in August. The values in January and August, respectively are 56.8, 52, 48.2 and 82.1%, 80.4, 79.1% in 1 year out of 4, 10 and 10 years also, respectively.

Probabilistic monthly lowest relative humidity: The variations of the probabilistic high and low values of monthly lowest relative humidity are shown in Fig. 5a and b, respectively. Figure 5a representing the variations of the humidity shows that the high value is a minimum in February having the values of 19.4, 23.5, 23.5 and 26.8% in 1 year out of 4, 10, 25 years, respectively. The lowest relative humidity then increases sharply as the season progresses and attains higher values in April during the southwest monsoon season with maximum value in August. The values of lowest relative humidity in August are 61.7, 64.6 and 66.8% in 1 year out 4, 10 and 25 years, respectively. With the retreat of southwest monsoon winds from Nigeria (it follows the retreat of I.T.D from its northern most position in the tropics), the probabilistic high values of lowest relative humidity start decreasing.

The probabilistic low values (Fig. 5b) of lowest relative humidity are also minimum in February having 10, 5.8 and 2.5% in 1 years out of 4, 10 and 25 years, respectively. The trend increases sharply to higher values in August having 55.3, 52.4 and 50.2% in 1 years out of 4, 10 and 25 years, respectively before it decreases sharply to January again.

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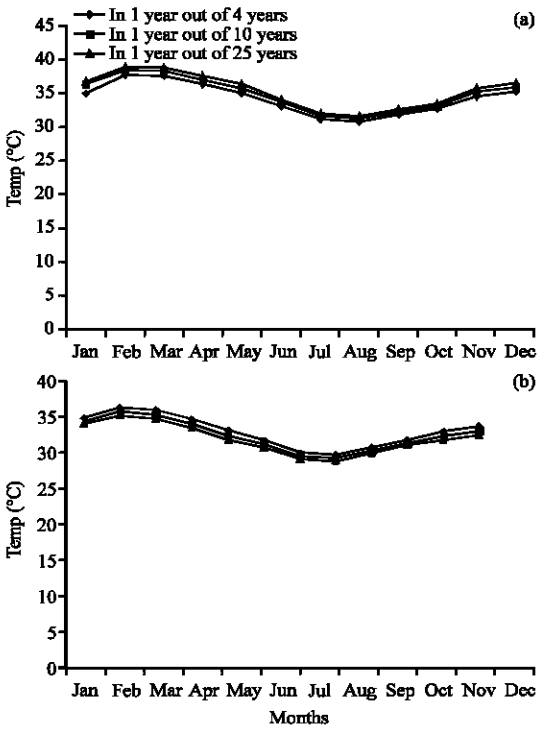

Fig. 6: a): Variation of Probabilistic high value of monthly highest maximum temperature over Ibadan, b): Variation of the probabilistic low values of monthly highest maximum temperature over Ibadan

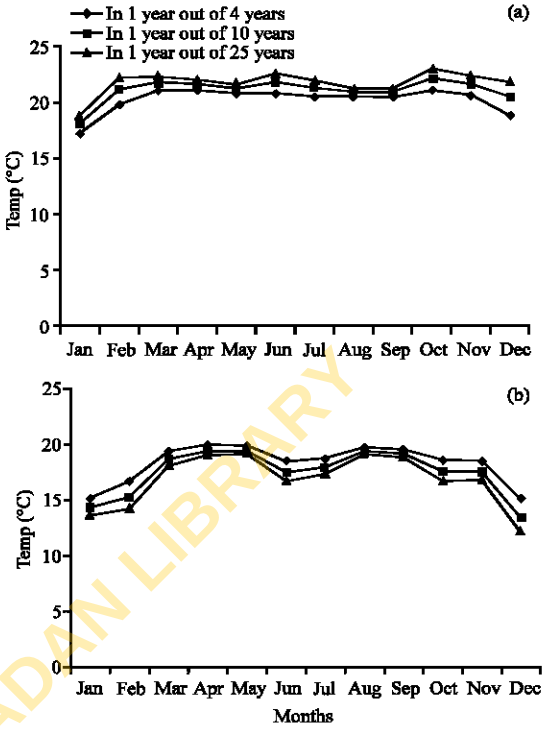

Fig. 7: a): Variation of the probabilistic high values of monthly lowest minimum temperature over Ibdan, b): Variation of the probabilistic low values of monthly lowest minimum temperature over

Probabilistic highest maximum temperature: The variations of the probabilistic high and low values of monthly highest maximum temperature are shown in Fig. 6a and b. The variations are similar to that of the mean maximum temperature. Figure 6a and b show that the probabilistic highest maximum temperature has primary and secondary peaks in February and December, respectively. The probabilistic high values of highest maximum temperature in February are 38.3, 38.8, 38.8°C and in December are 35.8, 35.1 and 36.4°C in 1 year out 4, 10 and 25 years, respectively.

The probabilistic low values of highest maximum temperature in February are 36.2, 35.7 and 35.2°C and in December are 33.6, 32.4 and 32.4°C in 1 year out of 4, 10 and 25 years, respectively.

Probabilistic lowest minimum temperature: The variations of the probabilistic high and low values of monthly lowest minimum temperature are shown Fig. 7a and b. The trend for probabilistic high values is similar to that of the mean minimum temperature shown in Fig. 1. The minimum values are in January and December for probabilistic high and low values, respectively. The probabilistic high values of lowest minimum temperature over Ibadan in January are 17.2, 18.1 and 18.7°C in 1 year out of 4, 10 and 25 years, respectively (Fig. 7a). The probabilistic low values of lowest minimum temperature in December are 15, 13.4 and 12.0°C in 1 year out of 4, 10 and 25 years, respectively (Fig. 7b). These are possible values on a clear sky night due to radiative cooling of the surface.

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