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# ASSESSMENT OF AEROSOLS FORCINGIN CLIMATE MODELS OVER KANO, NORTH-WEST OF NIGERIA

**Shuaibu Uba**
Physics Department, Yusuf Maitama Sule University, Kano
*Corresponding Authore-mail**:** (+2348023890393), suba@yumsuk.edu.ng, shuba356@gmail.com

**ABSTRACT**
The presence of atmospheric aerosols often observable as dust, smoke, and haze sourced from both natural and anthropogenic processes, contribute to an increase in earth's radiative balance which occur directly through scattering and absorbing solar radiation, consequently affecting cloud properties which influence the climatic condition of a given geographical location. Satellites based data was extracted from the historical radiative forcing and historical mean temperature recorded in Climate Time Series Browser System (CTSBS) and AR5 which are considered as either positive or negative perturbations to the earth radiation balance which gave rise to direct and indirect effects on solar intensity and produce climate projections. The major radiative forcing influential sensitive factor in weather and climate effects over Kano were due to high emissions aerosols from both natural and anthropogenic sources. Whereas the highest monthly mean temperatures over Kano recorded from March to June annually of 34.6 $^0$C with the lowest mean temperature recorded from November to February (21.4 $^0$C) annually signify the temperature variations. In good agreement with the regional mean annual high temperature record of 36.3 $^0$C and coldest month (January) 22.5 $^0$C signify the temperature variations. The RF is positive for all the periods and was increasing from 0.3 to a value greater than 0.86 Wm$^{-2}$ as such; average annual temperature in Kano has generally increasing. Hence, warming effects in Kano increasing annualy

**Key words:** Kano, climate Radiative forcing, atmospheric aerosols, solar radiation.

## INTRODUCTION

The prevalent cases of aerosol emission into our environment emanating from such incidences as harmattan dust, fuel combustion, bush burning, solid west, Sea Salt, incinerations automobile exhaust, etc. has constituted a huge annual atmospheric particle loading to the country (Akeredolus 2012). Light Absorbing Aerosols (LAA), (such as soot and dust) influence the energy budgets of the atmosphere in different ways, they also associated with atmospheric heating by absorption of solar radiation and interactions with clouds, LAA deposited on the atmosphere can reduce cloud reflectance which is likely to accelerate the cloud aging process (Qian *et al.*, 2014). Knowledge of the natural and anthropogenic processes that affect this energy balance is critical for understanding how Earth's climate has changed in the past and will change in the future. Regional variations in radiative forcing may have important regional and global climatic implications that are not resolved by the concept of global mean radiative forcing. Tropospheric aerosols have particularly heterogeneous forcings. Regional aerosols forcings can lead to global climate responses, while global aerosols forcings can be associated with regional climate responses. There have been only limited studies of regional radiative forcing and response.

The main factors that affect climate change are categorized into forcing and feedback. Climate forcing is an imbalance in energy imposed on the climate system either externally or by human activities. These include changes in solar energy output, volcanic emissions, land cultivations or modification, anthropogenic emissions of greenhouse gases, aerosols. Climate feedback is an internal climate process that amplifies or dampens the climate response to an initial forcing, such as the increase in atmospheric water vapor that is triggered by an initial warming due to rising carbon dioxide (CO2) concentrations, which then acts to amplify the warming through the greenhouse properties of water vapor (Akeredolus, 2012). The paper is aimed to assess the impacts of aerosol radiative forcing in climate models over Kano, North-West of Nigeria.

## ATMOSPHERE OF THE EARTH

The characterization of the state of the Earth atmosphere was reported by (Matveey 1991), (Timofeyev and Vasi'lev 2008). The atmosphere is mainly controlled by some of the structural parameters include temperature, pressure, and air density. These quantities are linked by the relationships.

$$\mathrm{pv} = \frac{m}{\mu} RT \qquad (1)$$

Where p, T and m are pressure; temperature; and mass, μ, V and R is, Vis the; $R$ are respectively the molecular mass of air, volume of air and the universal gas constant. Dividing both side of equation (1) by volume V, we obtain the first relationship of the link of the structural parameters

$$\mathrm{P} = \frac{\mathrm{p}}{\mu} RT \qquad (2)$$

Where $\rho$ is the density of air then the hydrostatics equation can be written as

$$dp = -\rho \mathrm{g} \mathrm{dz} \qquad (3)$$

Where $g$ is the free fall acceleration; zis altitude. Using the hydrostatics equation (3), the density of air is determined by the relationship:

$$\mathrm{p} = -\frac{1}{\mathrm{g}} \frac{dp}{dz} \qquad (4)$$

For an ideal gas, the equation of state may be written as:

$$\mathrm{p} = \mathrm{n}k_{B}\mathrm{T} \qquad (5)$$

## DESCRIPTION OF ATMOSPHERIC AEROSOLS

Aerosols are tiny fine particles inform of solid and liquid. Suspended in air. of greatly differing composition, shape, dimensions and properties. (Khrgian *et al.*, 1986),(Timofeyev and Vasi'lev 2008). The aerosol particles play significant roles in the transfer of solar and thermal radiation, affecting the radiation regime of the atmosphere–Earth's surface system, and consequently, the weather and climate on the Earth. Also in the absorption and scattering of solar radiations. The contribution to these processes is very large, and the optics and energetic of the atmosphere cannot be examined without considering the optical properties of atmospheric aerosols. Aerosols also play a significant role in the processes of cloud and fog formation, etc., where they act as nuclei of condensation– nuclei for the condensation of saturated water vapors. Without aerosols this process will be difficult and, therefore, the presence of clouds and precipitation on the Earth are directly linked with the presence of aerosols in the atmosphere. (Timofeyev *et al.*, 2008). Atmospheric particles have both biogenic (natural) and anthropogenic (man-made) sources. These resulted in changes in the radiation budget of the planet, to which it responds by either cooling or warming. (Timofeyev and Vasi'lev 2008).

## RADIATIVE FORCING OF AEROSOLS

Radiative Forcing is the difference between (sunlight) absorbed by the Earth and energy radiated back to space. While the influences that cause changes to the Earth's Climate system altering Earth's radiative equilibrium, forcing temperatures to rise or fall, is called Climate Forcing (Shindell 2018). Aerosols affect Earth's energy budget by scattering and absorbing radiation (the "direct effect") and by modifying amounts of microphysical and radiative properties of clouds (the "indirect effects"). Aerosols influence cloud properties through their role as cloud condensation nuclei (CCN) and/or ice nuclei. Increases in aerosol particle concentrations may increase the ambient concentration of CCN and ice nuclei, affecting cloud properties.

Remote sensing estimates of aerosol indirect forcing are still very uncertain. Even on small spatial scales, remote sensing of aerosol effects on cloud albedo do not match *in situ* observations, (Tomey *et al.*, 2007).

## DATA COLLECTION

Estimates of the impacts from anthropogenic climate change due to atmospheric aerosols rely on projections from climate models to investigate the sensitivity and uncertainties of aerosols forcing and impacts on the climate, we used four different observational variables to collect the data. These are: Historical Radiative Forcing., Historical Natural-only Radiative Forcing, Aerosols (direct) and Aerosols (indirect) effects. Data extracted from the Climate Time Series browser system (CTSBS) is used. The CTSBS is the set of 7169 weather stations with their monthly mean temperature records. The locations of the net stations also provide the basis for extracting time-series temperatures from the gridded climate models.

Kano is in North-west region of Northern Nigeria and is located between longitude $8^{0}31.003^{1}$E and latitude $12^{0}0.007^{1}$N, covering an Area of about 499 square Kilometers (193 square miles). It is the second largest city of Nigeria, it's also the second largest industrial center after Lagos State in Nigeria and the largest in Northern Nigeria, "According to 2006 census figure from Nigeria, Kano state had a population totaling 9,401,288. And is the most populous State in the country (Abdulhanid 2013). Kano experiences four distinct seasons, *Rani* (warm and dry), *Damina* (wet and warm), *Kaka* (cool and dry) and *Bazara* (hot and dry), closely associated with the movement of the Inter Tropical Discontinuity (ITD) zone. The mean annual temperature in the area ranges from 26°C to 32°C and relative humidity of 17% -90% (Abdulhamid 2013).

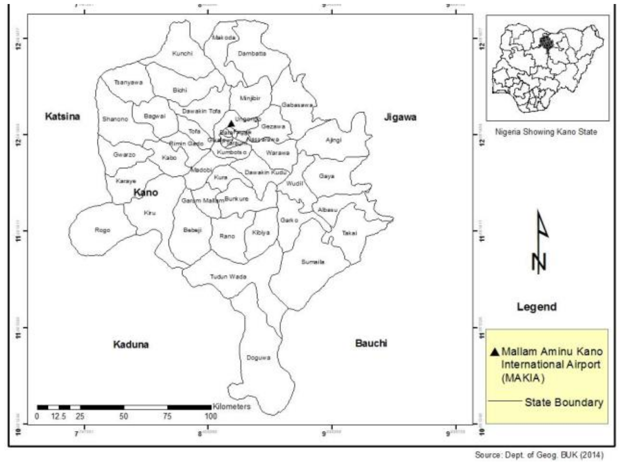



**Figure 1.** Map showing the research area in Kano State (Source: Abdulhamid, 2013).

## RESULTS AND DISCUSSIONS

The data extracted from the climate time series browser system (CTSBS) was analyzed graphically as presented using Minitab statistical software.

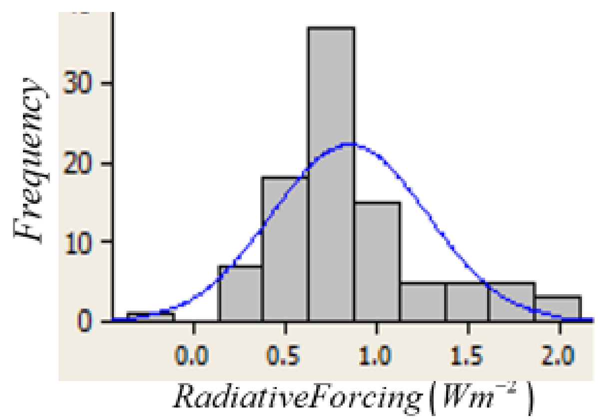



**Figure 2.** The variations of mean radiative forcing over Kano due to high emissions aerosols effects. With the mean and SD of 0.8487 and 0.4296 $Wm^{-2}$ respectively. The smooth curve is for the normalized distributions.

**Figure 3.** The variations of mean temperature over Kano due to natural aerosols effects. With the mean and Standard deviation of 24.86 and 0.4663 $^{0}$C respectively. The mooth curve is the normalized distributions.

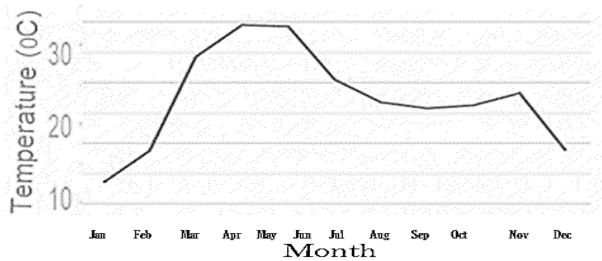
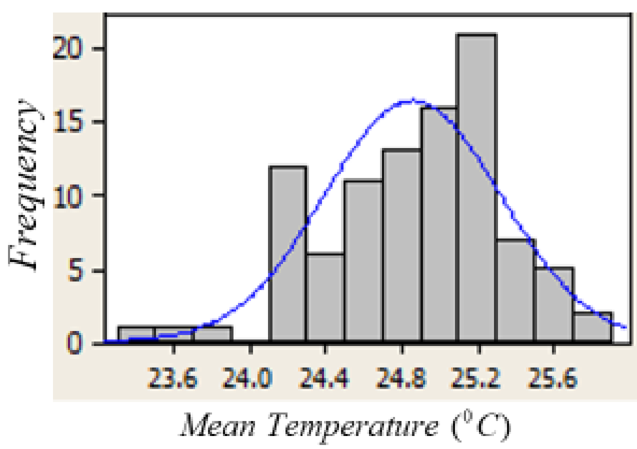



**Figure 4.** The variations of historical monthly mean temperatures over Kano. The highest mean temperature was




recorded from March to June (33.4 $^{0}$C) annually and the lowest temperature were recorded from November to February annually.

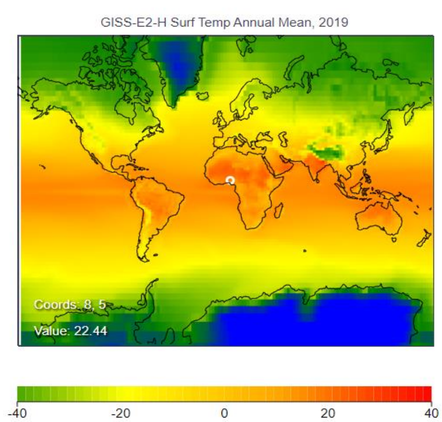



Figure 5(a)

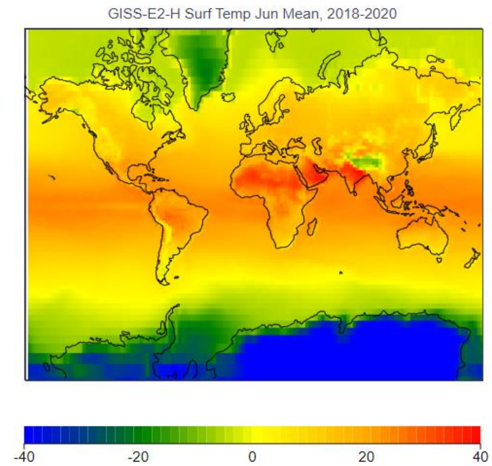



Figure 5(b)

**Figure 5.** The anomalies of global annual mean surface temperature variations (a) for the month of July 2019. (b) For the month of June over two years 2018- 2020.

## CONCLUSION

The major radiative forcing influential sensitive factor in weather and climate effects over Kano were due to high emissions aerosols from both natural and anthropogenic sources. Whereas the highest monthly mean temperatures over Kano recorded from March to June annually of 34.6 $^{0}$C with the lowest mean temperature recorded from November to February 21.4$^{0}$Cannually signify the temperature variations. The results is in good agreement with the regional annual mean high temperature record of 36.3 $^{0}$C and coldest month (January) of 22.5$^{0}$C (https://weatherandclimate.com/nigeria/kano ).

The RF is positive for all the periods and was increasing from 0.3 to a value greater than 0.86 Wm$^{-2}$ as such; average annual temperature in Kano has generally increasing. Hence, warming effect in Kano increasing annually. There is need for Nigerian meteorological agency and non-governmental organizations to joint hand together in funding related research by creating awareness and enforce laws to both industries and general public on how to reduce the continues increase in radiative forcing due to anthropogenic and natural aerosol emission in Kano.

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