Solar UV-Radiation Absorption by Stratospheric Ozone in Lagos Southwest of Nigeria

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Abstract *Variation in ozone transmittance with altitude in the atmosphere for radiation in the 9.6μm absorption band was studied using Goody model on the data comprising of pressure and temperature at different altitudes (0-26km) for three months (including January, February and March, 2019) in Lagos, southwest of Nigeria. Computed results showed that ozone transmittance increased with altitude, except for the altitudes 8km< Z≤ 12km and 16km< Z≤ 26km for January, 8km< Z ≤ 12km, 14km< Z ≤ 16km and 22km< Z ≤ 26km for February, and 8km< Z ≤ 10km and 14km< Z ≤ 26km for March, due to absorption of solar UV-radiation by ozone (O_3) indicating that stratospheric ozone was effective in the study area preventing living things from being destroyed by this radiation.*

Key Words: *Absorption band, altitude, Goody model, Ozone transmittance*

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1.0 Introduction

Stratospheric ozone is highly essential in the absorption of ultraviolet radiation emission from the sun. However, the presence of some substances in the atmosphere can deplete the ozone layer. Ozone depletion is a serious environmental problem because it can enhance the ultra violet radiation to penetrate the earth leading to several health challenges including non-melanoma skin cancer and plays a major role in malignant melanoma development, eye cataract, genetic and immune system damages (WMO, 2018). In 1970, a steady depletion of ozone layer by about 4 % was observed. The reported depletion was succeeded by a much lowering of stratospheric ozone, which leads to the creation of ozone hole (WMO, 2018).

The emissions and concentrations of ozone depleting substances (ODSs) in the atmosphere have been declining continuously since the mid-1990s because of the success of the 1987 Montreal Protocol. In response to this reduction in ODSs, global (60°S–60°N) column ozone is no longer declining. Small increases of 0.3 to 1.2% per decade since 1997 have been observed but are not statistically significant. Different datasets of satellite and ground-based observations for the period 1997–2016 within 60°S–60°N show close to zero changes in total ozone for the tropics and the northern hemisphere (NH) and increases of 0.6% per decade for the southern hemisphere (SH) (WHO, 2018; Bais *et al*, 2019). In recent years (2014–2017), total ozone has remained below the average of the 1964–1980 period: about 2.2% for the global average (60°S–60°N), about 3.0% for the northern mid-latitudes (35°N–60°N), about 5.0% for the southern mid-latitudes (35°S–60°S), and less than 1% for the tropics (20°S–20°N) (Bais *et al*, 2019; Weber *et al*, 2018). There are some variations in trends in the ozone measured at different altitudes and latitudes, and these are generally consistent with our understanding of the physics and chemistry of ozone (Bais *et al*, 2019; Chipperfield, 2017; Dhomse, 2018).

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According to Brenna *et al*. (2019), explosive volcanic eruption was observed to inject sulphur, chlorine and bromine into the stratosphere that affected the thickness of the ozone layer. Salawitch and Sensitivity (2005) also stated that bromine has the tendency to deplete the ozone layer. According to Sinnhuber *et al*. (2009), anthropogenic bromine can contribute significantly towards the depletion of the ozone layer. In view of future risks associated with the depletion of ozone layer and considering the fact that the impact generated at one spot can exert global risk, there is need to study activities that can contribute to the ozone layer depletion within Nigeria and recommend measures that can be used to abate future risk. Therefore, the present study is aimed at investigating ultra violet radiation in Lagos state. Ultra violet radiation from the outer space is an index that can be used to estimate ozone layer depletion since ozone layer act as a sink for this dangerous radiation.

Ozone transmittance is the ratio of the intensity of radiation (I) passing through it, to the intensity of radiation before it passes through it (I_o). Variation in ozone transmittance with altitude in Lagos for the months January, February and March, 2019 will be considered due to the fact that a lot of industrial activities are taken place with high concentration of manufacturing factories in which exhaust gases could have negative effect on ozone layer.

2.0 Materials and Methods

Goody model reported by Elsasser and Culbertson (1960) and their atmospheric radiation table were used for this study. The model can be expressed according to equation 1, where:

$$\tau = u^*. L \tag{1}$$

where u* is expressed as:

$$u^* = u\,(P/P_o)\{(T_o/T)^{1/2}\} \tag{2}$$

τ is defined as the ozone transmittance, L is the generalized absorption coefficient, u* is the theoretical optical thickness, which also represent the theoretical ozone amount in the atmosphere, within the study area, Lagos in Nigeria. Pressure (P) and temperature (T) represent the pressure and temperature above the surface of the earth at different altitudes. P_o and T_o are pressure and temperature on the surface of the earth. These were obtained from Nigerian Meteorological Agency (NIMET). u represents empirical absorber amount which is empirical ozone amount and its generalized absorption coefficient L, these were obtained from NOAA (2019).

3.0 Results and Discussion

Fig. 1 shows a plot for the variation of theoretical concentration of atmospheric ozone with altitude for the month of January 2019.

From the plot, it is evident that the concentration of ozone increases with altitude up to about 8 km above sea level and then decreases between 8 and 12 km and started increasing slightly before decreasing continuously with altitude. The sharp drop within the range of $8km< Z\leq 12km$ (Fig 1.) lead to decrease in concentration of ozone from 0.00798 atm-cm to 0.00661 atm-cm. However, ozone transmittance (τ) dropped from 0.00638 to 0.00529 (Fig. 2.).

On the other hand, between the range, $16km< Z\leq 26km$ concentration of ozone decreases from 0.00773 atm-cm to 0.00487 atm-cm while ozone transmittance dropped from 0.00619 to 0.00390. These were due to absorption of ultraviolet radiation from the sun by stratospheric ozone.

In the month of February, concentration of ozone (u*) and ozone transmittance (τ) were observed to increase with altitude as shown in Fig. 3 and Fig. 4 respectively. However, at the following altitudes $8km< Z \leq 12km$, $14km< Z \leq 16km$ and $22km< Z \leq 26km$. At $8km< Z \leq 12km$, concentrations of ozone decreased from 0.00805

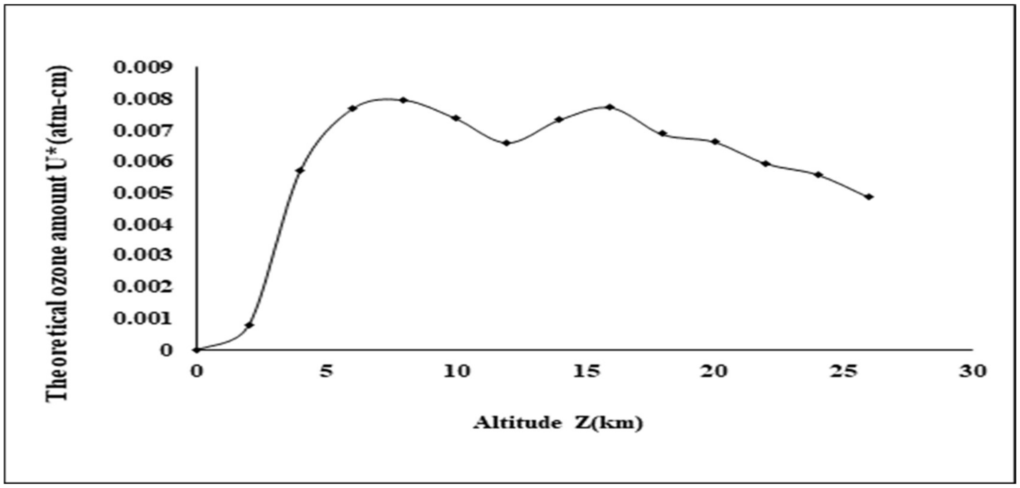

Fig. 1: Variation of theoretical concentration of ozone with altitude for the month of January 2019

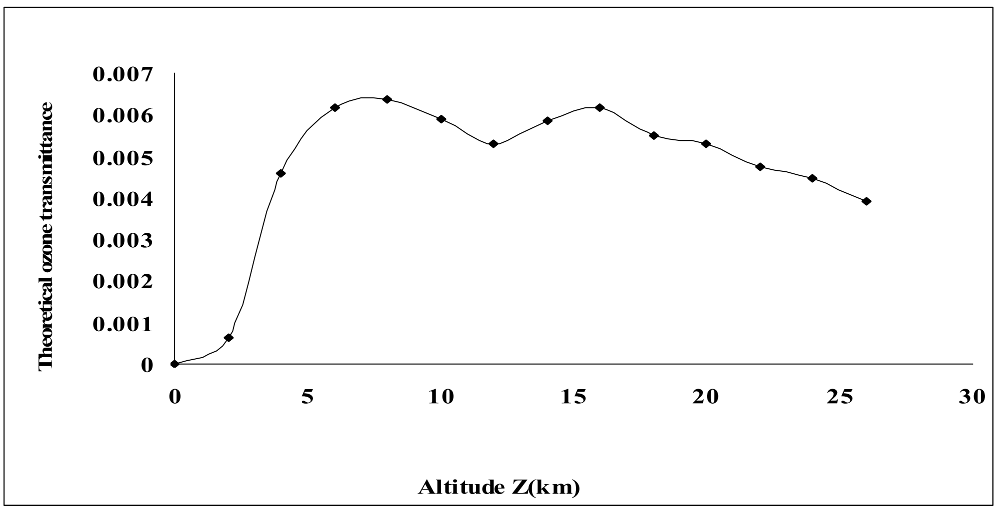

Fig. 2: Variation of theoretical ozone transmittance with altitude for the month of January 2019

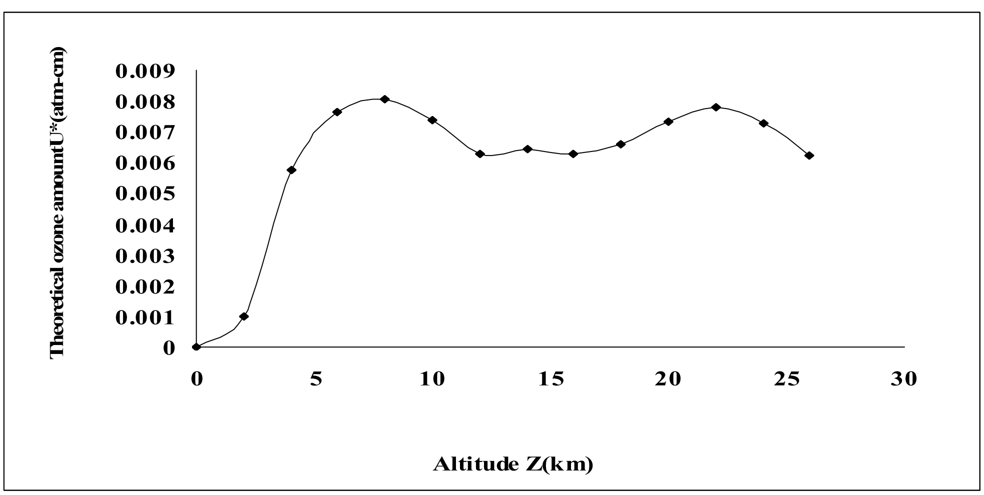

Fig. 3: Variation of theoretical concentration of ozone with altitude for the month of February 2019

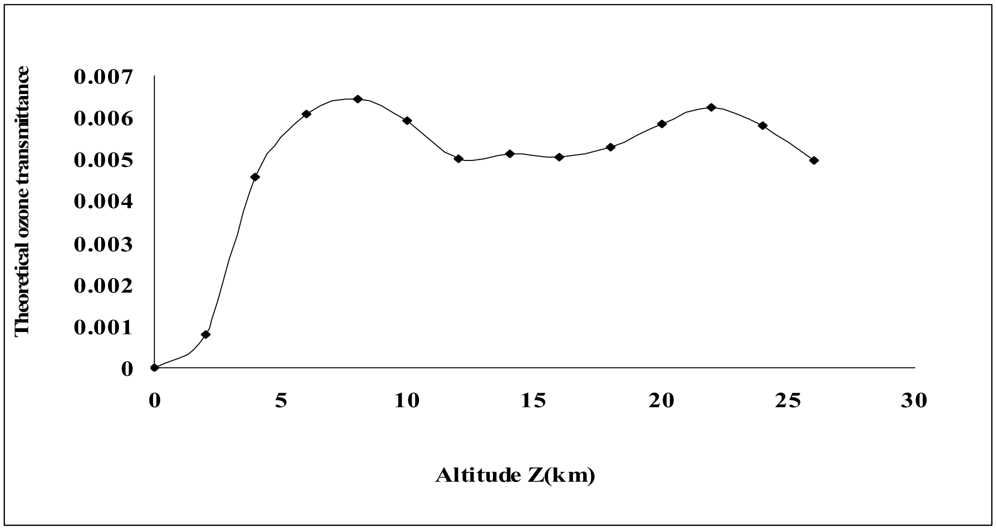

Fig. 4: Variation of theoretical ozone transmittance with altitude for the month of February 2019

atm-cm to 0.00627 atm-cm while ozone transmittance dropped from 0.00644 to 0.00501. At the altitudes within the range, 14km< Z≤ 16km, ozone concentration dropped from 0.00642 atm-cm to 0.00629 atm-cm while ozone transmittance also decreased from 0.00513 to 0.00503. Within the altitude range, 22km< Z ≤ 26 km, concentration of ozone was observed to dropped from 0.00782 atm-cm to 0.00623 atm-cm with ozone transmittance dropped from 0.00626 to 0.00499. In the month of March, slight decrease in concentration of atmospheric ozone from 0.001012 atm-cm to 0.001005 atm-cm (Fig. 5.) within the altitude range of 8km< Z ≤ 10km from also at altitudes 14km< Z ≤ 26km from 0.01281 atm-cm to 0.00617 atm-cm. Also, at this altitude range, ozone transmittance (Fig. 6.) reduced slightly from 0.00809 to 0.00804 at altitudes 8km< Z ≤ 10km. The observed reduction in concentration of ozone within the altitude range 14km< Z ≤ 26km from 0.01025 to 0.00494 can be attributed to the absorption of ozone depleting gases (which cause photodissociation of ozone into oxygen molecule and oxygen atom) which can lead to transmission of ultra violet radiation to the earth (Oluwafemi, 1980; Sowole and Ayedun, 2010; Sowole, 2011).

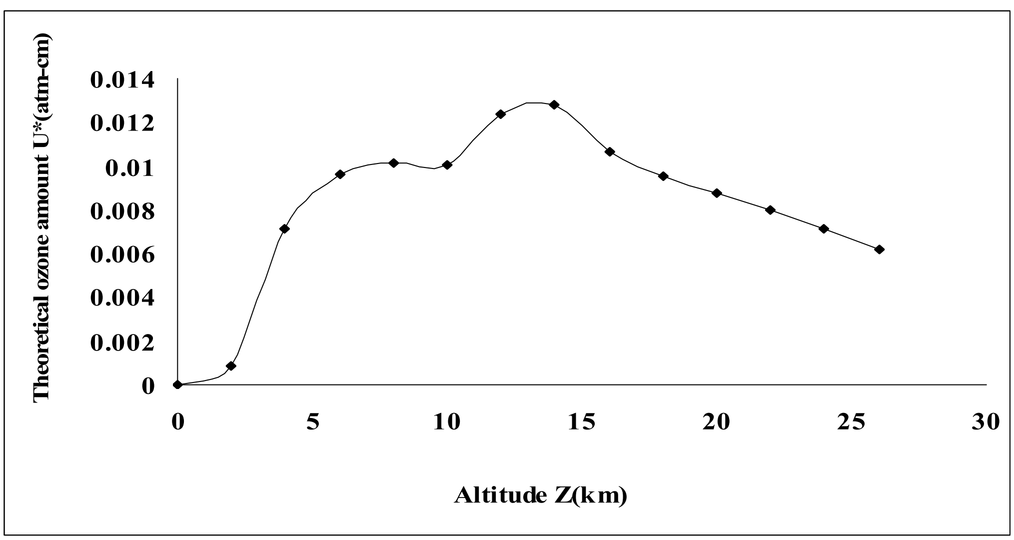

Fig. 5: Variation of theoretical concentration of ozone with altitude for the month of March 2019

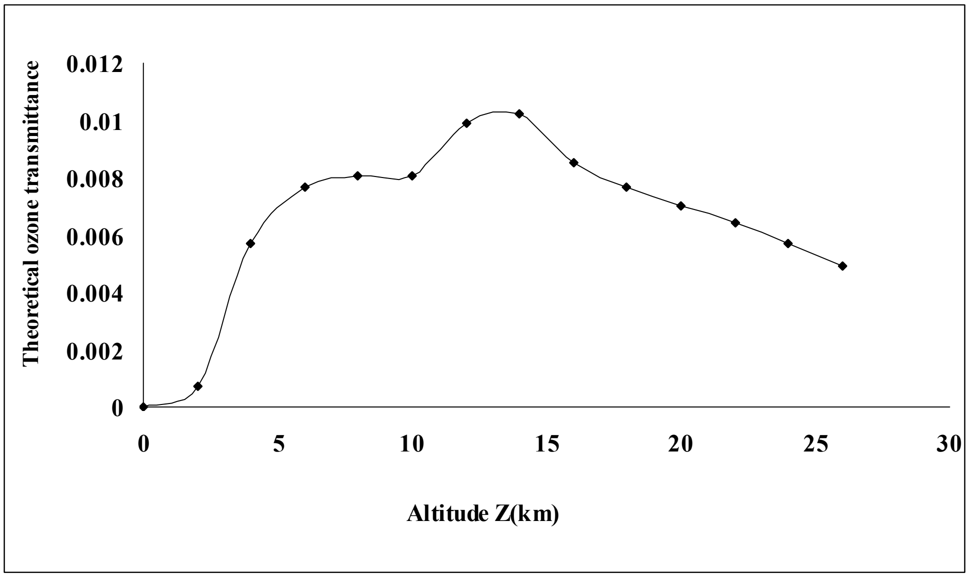

Fig. 6: Variation of theoretical ozone transmittance with altitude for the month of March 2019

4.0 Conclusion

Ozone transmittance had been studied at Lagos in southwest region of Nigeria and the results obtained for January, February and March, 2019 showed that ozone layer is still effective in the absorption of UV- radiation from the sun which is a harmful radiation on living things. However, there is need to continue to protect stratospheric ozone layer.

5.0 Acknowledgement

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Conflict of interest

Authors declared no conflict of interest.