

SUNSHINE ACTIVITY AND TOTAL COLUMN OZONE VARIATION IN LAGOS, NIGERIA

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Abstract

Total column ozone data obtained from Earth Probe TOMS (Total Ozone Mapping Spectrometer) Version. 8 were analyzed for Lagos, Nigeria, a northern tropical station (06.6° N, 03.33° E). It was found that total column ozone thickness has been decreasing at an average rate of about 0.32 DU per year over a nine year period (1997-2005). For the nine years, the minimal annual ozone values were found in the years 2003 and 2005 with a mean value of about 265 DU. Linear regression analysis gives a significant negative correlation between total column ozone and sunshine hours.

1. Introduction

Total column ozone is a measure of the total number of ozone molecules in a column of atmosphere above a particular location. Total column ozone is important because of its direct, measurable effect on the amount of UV radiation reaching the earth's surface.

Thus, it is very important to the terrestrial radiation budget [1]. The same characteristic of ozone that makes it so valuable, i.e., its ability to absorb a range of ultraviolet radiation, also causes its destruction. Over Earth's lifetime, natural processes have regulated the balance of ozone in the stratosphere.

Scientists find that ozone levels change periodically as a part of regular natural cycles such as seasons, periods of solar activity, and changes in wind direction. Concentrations are also affected by isolated events that inject materials into the stratosphere, such as volcanic eruptions.

Solar cycle variations affect stratospheric ozone through changes in the UV fluxes that affects the photo-dissociation of chemical species. The impact on the total ozone column through such variations has been demonstrated through both observations and model studies [2-7]. The ozone response to the solar cycle has also been studied by fully interactive 3-D chemistry-climate models [8, 9].

Increase in Ozone has been found to lead to an enhanced atmospheric trapping of long wave radiation (positive radiative forcing) as well as to absorption of more solar radiation. This implies that an ozone increase in the stratosphere leads to less solar radiation reaching the surface-troposphere system and a negative solar radiative forcing which opposes the positive longwave radiative forcing. The net radiative forcing (sum of solar and long wave radiative forcing) is dependent on the altitude of the stratospheric ozone change [10]. Ozone depletion is greater at higher latitudes (towards the north and south poles) and negligible at lower latitudes (between 30° N and 30° S). Thus, cities at lower latitudes generally receive more sunlight because they are nearer the equator implying an increase in UV radiation [11].

Nigeria is located at the low latitude very close to the equator, where Ozone depletion is supposed to be low and stations in Nigeria are supposed to receive more sunlight.

The purpose of this work, therefore, is to find a relationship between the duration of sunshine (sunshine hours) and Ozone variation in Lagos, Nigeria.

2. Data and analysis

The data set consists of daily ozone values for 1997-2005 for Lagos, Nigeria: Latitude 6.60° N longitude 3.33° E obtained from Earth Probe TOMS (Total Ozone Mapping Spectrometer) Version.8 and Monthly mean Sunshine hours for Lagos From 1997-2005 obtained from Nigerian metrological institute Lagos.

Monthly averages for ozone O_{mi} were calculated as the sum of ozone values observed for the month divided by the total number of days in the month. This monthly average helped to reduce the daily variability in the data and was used to find the monthly variability in ozone. Thus,

$$O_{mi} = \frac{\sum_{i=1}^n O_i + O_{i+1} + \dots + O_n}{n}.$$

Annual averages for ozone O_{ai} were calculated as the sum of the monthly ozone values divided by the twelve (12) months in a year. Thus,

$$O_{ai} = \frac{\sum_{i=1}^{12} O_{mi} + O_{mi+1} + \dots + O_{m12}}{12}$$

Seasonal variability in ozone and sunshine hours was calculated by using the monthly averages of March, June, September, and December to represent March equinox, June solstice, September equinox and December solstice.

The correlation coefficient between the Ozone mean monthly values and the sunshine mean monthly values were calculated using Pearson correlation.

3. Results and discussion

The general picture of how ozone varied from January to December for all the years can be seen from Fig. 1. Ozone levels varied from one month to another throughout the years, increasing generally from January, reaching a maximum value around August and then gradually decreasing down to its December value. For the nine years, the average value for August was about 284 DU about 1.1 times higher than an average value of ozone in January. For the years analyzed, the minimal annual ozone values were found in 2003 and 2005 with a mean value of about 265 DU. 2003 is a heat wave year [14].

Thus, the production of ground level ozone should be high because of an increase in the photochemical production of ozone at lower levels (in the troposphere), although the overall observed trends in total column ozone still show a decrease, largely because ozone produced lower down has a naturally shorter photochemical lifetime, so it is destroyed before the concentrations could reach a level which would compensate for the ozone reduction higher up. The maximum annual ozone value was obtained in 1999 with a mean value of about 275 DU. The trend was found to be decreasing at -0.32 DU per year over the nine year period (Fig. 2). This is a small negative trend compared to what is obtained in non-equatorial regions. This result is in line with what is expected in the equatorial region where depletion in ozone levels is expected to be zero or minimum compared with what is obtained in the mid or high latitudes.

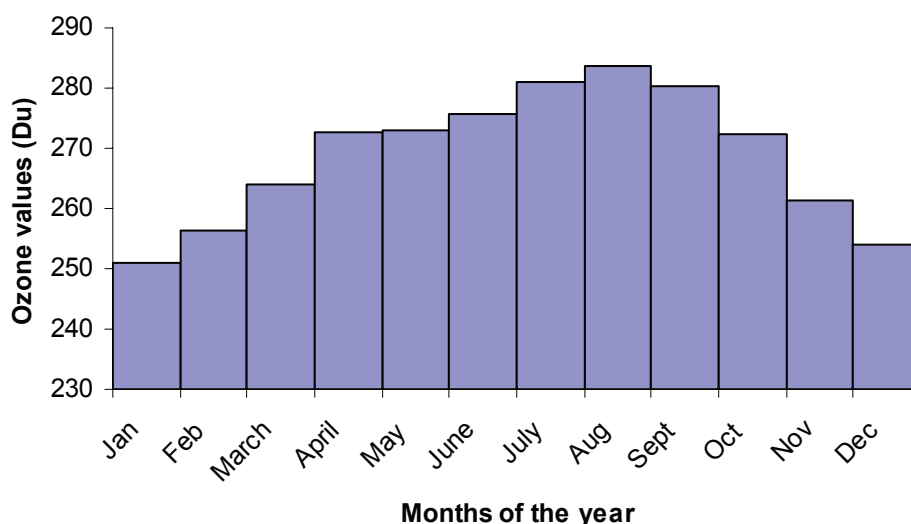


Fig. 1. Monthly average of ozone for all the years 1997-2005.

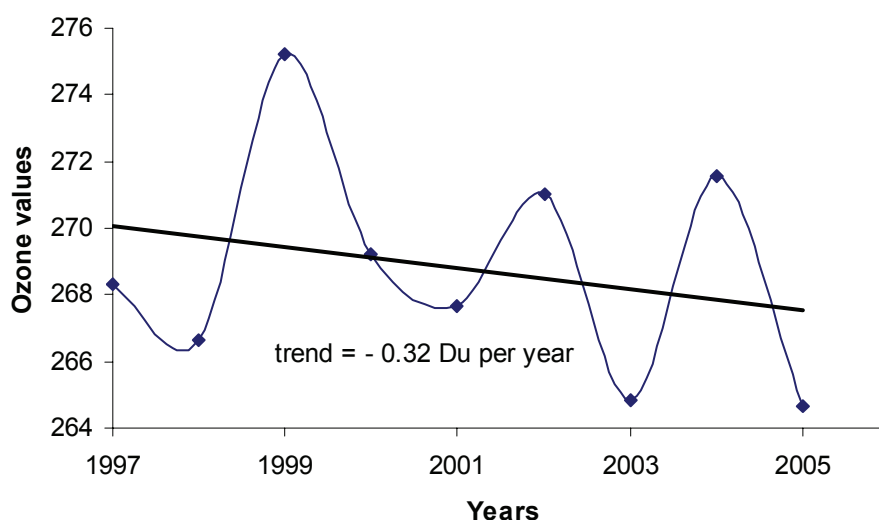


Fig. 2. Annual average of ozone for all the years 1997-2005.

The negative trend could be attributed to atmospheric dynamics most especially the extra-tropical suction pump, which causes large-scale upward transfer of air mass from the tropics into the mid and high latitudinal regions. A wave induced phenomenon has been observed to dominate the atmospheric circulation especially in the stratosphere and mesosphere; previous studies have established the fact that the tropical upwelling is primarily controlled by the extratropical suction pump action on the tropical stratosphere [12, 13].

The linear regression analysis describes the strength or degree of linear relationship between two variables. The linear regression analysis shows a significant negative correlation between total column ozone and sunshine hours both at monthly level ($r = -0.6305$, $r^2 = 0.3975$) and annual level ($r = -0.3012$, $r^2 = 0.0907$). As such, the regression result of a negative correlation between total column ozone and sunshine hours implies that the total column ozone decreases as the sunshine hours increase; thus, an inverse relationship exists between total column ozone and sunshine hours. This could be the reason why in the heat wave year 2003 the total ozone value is found to be small compared to other years. This result is in line with the results obtained by [7, 10, 11].

4. Conclusions

The results of this work reveal that total column ozone changes regularly from one month to another each year during the nine year period investigated. It is found that the maximum average value occurred in August, which is about 1.1 times higher than the minimal average value, which occurred in January. From the result obtained here, it is concluded that total column ozone concentrations in Lagos Nigeria are either stable or have a small negative trend.

The regression analysis results reveal that the total column ozone decreases with increasing sunshine hours in Nigeria. Thus, more sunshine hours lead to less total column ozone in Lagos, Nigeria.

The implication of the negative trend and the inverse relationship in ozone and sunshine hours suggests that tropospheric (ground level) ozone production is favored.

Therefore, it is suggested that ozone depleting substances should be guarded against in Nigeria to limit the production of ground level ozone which is the bad ozone. Constant monitoring of ozone levels is also recommended to check ozone depletion.

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