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A Qualitative Study of Ozone and UVIndex over a Period at Bhopal (23.28° N, 77.47° E)

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ABSTRACT

The research interest in Ozone and UV Index studies from the scientific community and the general population has risen significantly in recent years because of the increased UV levels at the Earth's surface and depletion of ozone in the stratosphere. In this paper we concentrated on Ozone and UVIndex variation as diurnal and comparative diurnal over a periodicity of 5 years (2005-2015) at Bhopal.
Keywords : Ozone, UV Index, Diurnal variation, Periodicity

I. INTRODUCTION

Ozone : Ozone is one of the most naturally available trace gases that make up our atmosphere. The atmosphere performs three critical functions: it provides us life-giving oxygen, as well as keeps the earth warm, and also it protects us from dangerous ultraviolet (UV) radiation from the sun. Most of the atmosphere however consists of nitrogen and oxygen. These gases do not hold heat so that they do not keep us warm. In fact they do not protect the earth from UV rays. For those functions you have to turn to the trace gas found in the atmosphere, commonly referred to as greenhouse gases. Ozone is one of the key trace gas constituent that participates in the process of radiation of the earth's middle atmosphere. Ozone is actually tri-oxygen inorganic molecule with the chemical formula O_3. It is a pale blue gas with a distinctive smell. Ozone is much less stable than the Oxygen, which breaks down in the lower atmosphere to normal di-oxygen.

Ozone is formed from di-oxygen with the interaction of ultraviolet light and also atmospheric electrical discharges, and is present in low concentrations throughout the Earth's atmosphere (stratosphere). Approximately, ozone makes up only 0.6 parts/million of the atmosphere.

Ozone's odour is sharp and detectable by many people at concentrations of as little as 10 parts/billion in air. The molecule was proven to have a bent structure and diamagnetic in nature. Ozone is colourless or slightly bluish gas (blue when liquefied), more soluble in inert non-polar solvents such as carbon tetrachloride or fluorocarbons where it forms a blue solution and slightly soluble in water. At 161 K, Ozone condenses to form a dark blue liquid. It is not recommended to allow this liquid to warm to its boiling point, because both concentrated gaseous ozone and liquid ozone can detonate. At temperatures below 80 K , it forms a violet-black solid.

II. METHODS AND MATERIAL

A. U V Index

Brewer spectrophotometers in the NOAA-EPA measure total horizontal irradiance at 154 wavelengths($\Delta\lambda$=0.5nm) over the 286.5nm-363.0nm spectral range. The irradiance is calibrated in mW/m2/nm. The UV Index is defined as follows:

$$UVI = 1/(25)(\text{ mW }/\text{m}^{2)}\int_{286.5\text{nm}}^{400\text{nm}} I(\lambda).w(\lambda)\, d\lambda$$

Where the weighting function for erythema is given as

$$
w(\lambda) = \begin{cases} 1 & 250 < \lambda <= 298 \\ 10^{0.094(298-\lambda)} & 298 < \lambda <= 328 \\ 10^{0.015(139-\lambda)} & 328 < \lambda <= 400 \\ 0 & 400 < \lambda \end{cases}
$$

After McKinlay-Diffey (1987).

Note 1: Because of the 1/25 coefficient the UVI is dimensionless.

Note 2: The McKinlay-Diffey definition has a discontinuity at 328nm. However minor, this seems to be an oversight.

Note 3: Weighting functions other than erythema could be used (see Biospherical web site). The formulas that follow can easily be modified to accommodate other action spectra.

For $\lambda \leq 363$ *UVI* is calculated using the measured irradiance and for $\lambda > 363$ it's estimated :

$$UVI = UVI_{\lambda<=363} + UVI_{\lambda>363}$$

To calculate the first component we use the trapezoid rule of integration:

$$UVI_{\lambda<=368} = 1/25[1/2\sum_{i=0}^{152} (I(\lambda_i).w(\lambda_i) + I(\lambda_{i+1}).w(\lambda_{i+1})).(\lambda_{i+1} - \lambda_i)]$$

where $\lambda_i = 286.5 + 0.5 * i$ for $i = 0$ *to* 153.

The $UVI_{\lambda>363}$ amounts to less than 10% of the total UVI and often it is a much smaller fraction.

The UV index is a standard measurement of erythemal (sun-burn causing) UV intensity that gives a more objective measure than the old "time to burn" (which cannot account for skin tone). The scale is open-ended, but a UV index of greater than 10 is extreme and a UV index of less than 3 is low. For clear skies, the UVI depends mainly on the sun elevation angle and the ozone amount.

The UVI also depends on cloud cover, sun-earth separation, altitude, pollution, and surface reflections (e.g., snow cover). The highest values in the world occur in the tropics at high altitudes, where the UVI can exceed 25.

Bhopal is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal district and Bhopal division. Bhopal is known as the City of Lakes for its various natural as well as artificial lakes. It is the 17th largest city in the country and131st in the world.

Bhopal has an average elevation of 500metres (1401 ft). Bhopal is located in the central part of India, and is just north of the upper limit of the Vindhya mountain ranges. The city has uneven elevation and has small hills within its boundaries. The prominent hills in Bhopal are Idgah hills and Shyamala hills in the northern region, Katara hills in southern region. City's geography has in it two lakes namely upper lake and lower lake.Bhopal has a humid subtropical climate, with cool, dry winters, a hot summer and a humid monsoon season. Summers start in late March and go on till mid-June, the average temperature being around 30 °C (86 °F), with the peak of summer in May, when the highs regularly exceed 40 °C (104 °F). The monsoon starts in late June and ends in late September. These months see about 40 inches (1020 mm) of precipitation. Temperatures rise again up to late October when winter starts, which lasts up to early March. Winters in Bhopal are cool, sunny and comfortable, with average daily temperatures around 16 °C (61 °F) and little or no rain. The winter peaks in January when temperatures may drop close to freezing on some nights. Lowest temperature ever recorded was 0.3°C. Total annual rainfall is about 1146 mm (46 inches).

The city attracted international attention in December 1984 after the Bhopal disaster, when a Union Carbide India Limited (UCIL) pesticide manufacturing plant leaked a mixture of deadly gases composed mainly of methyl isocyanate, leading to one of the worst industrial disasters in the world's history.

B. Data Base

For this paper we collected the entire data from Internet. Data used in this paper mainly comprises of columnar ozone and UV Index derived from satellites with the help of official websites given by http://www.temis.nl/ (TEMIS – Troposphere emission Monitoring Internet Service),

These web sites are hosted by KNMI (National reference laboratory for weather, climate and seismology, The

Netherlands) and http://www.esrl.noaa.gov which is hosted by Earth System Research Laboratory (ESRL) under | National Oceanic & Atmospheric Administration | NOAA Under U.S Department of Commerce.

III. RESULTS AND DISCUSSION

Diurnal variations of ozone and UVI at Bhopal

In this section we will discuss about the diurnal variations of Ozone and UV Index over a periodicity of 5 years.

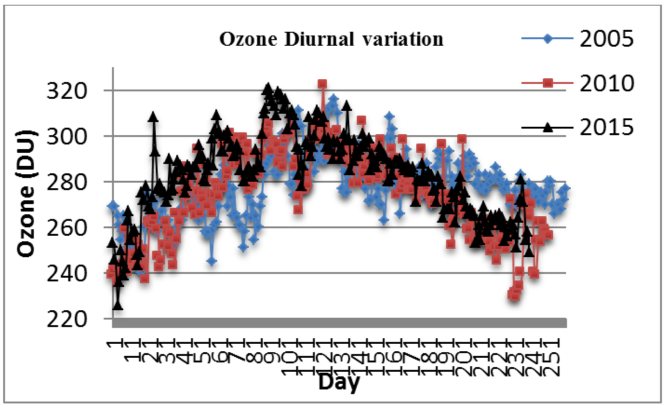

Figure 1 : Diurnal Variation of Ozone

In Fig.1 we presented Ozone diurnal variation. It is clearly observable that Ozone is fluctuating not only with season but also over periodicity.

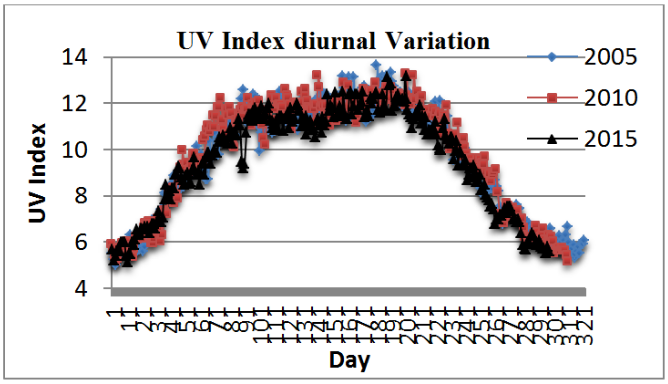

Figure 2 : Diurnal Variation of UV Index

In Fig.2 we presented UV Index diurnal variation. It is clearly observable that UVI is not fluctuating as much as Ozone over periodicity. To make this point more clear we drawn comparative curves for Ozone and UV Index.

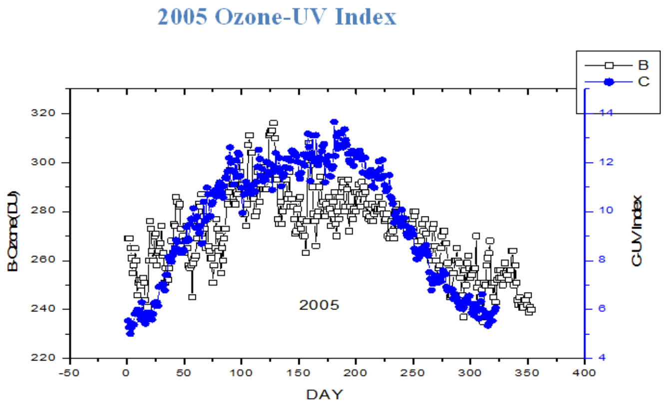

Figure 3 : Diurnal variation of Ozone and a UVI for 2005

In Fig.3 comparative curve is shown for the year 2005 in which it is implicative that UV Index is showing anti correlation with Ozone, which is expected.

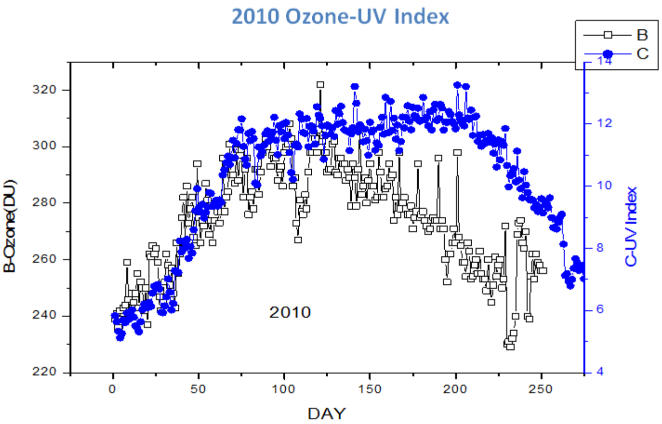

Figure 4 : Diurnal Variation of Ozone and a UVI for 2010

But in Fig.4 it is clearly observable that for the same values of Ozone, UVIndex is showing different values. And also from monsoon through winter UVIndex is showing extreme and very high values compared to 2005.

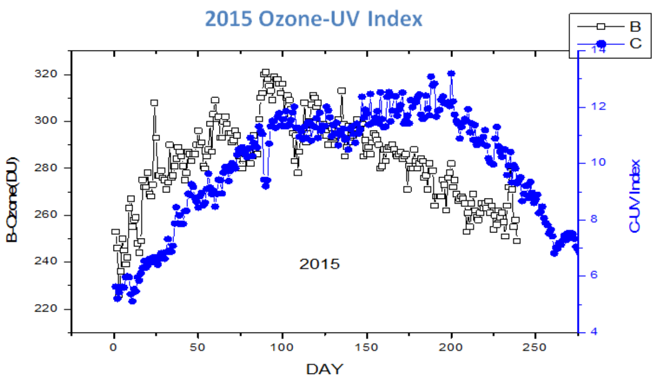

Figure 5 : Diurnal variation of Ozone and a UVI for 2015

Also in Fig.5 it is clearly observable that for the same values of Ozone, UVIndex is again showing different values. And also from monsoon through winter UVIndex is showing extreme and very high values compared to 2005.

This is an adverse effect because starting from high, very high and extreme values of UV Index has severe effects on ecosystem and also causes biological damage.

IV. CONCLUSION

The present paper reports some of the ozone and UV Index measurements made by satellite exclusively for Bhopal during the period 2005 to 2015. With the help of these measurements diurnal variation and Comparative diurnal variation of stratospheric ozone and UV Index over this station for the period 2005, 2010 and 2015 is reported. An attempt was made to analyze the long term variation of estimated UVIndex and its dependence on columnar Ozone. From the above results it is imperative that at this station UVIndex is not only depending on ozone but also strongly depending on other parameters like cloud cover, sun-earth separation, altitude, pollution, and surface reflections .These results may be helpful to further use the data in calculating various biological effects of UV-B radiation and UV Index studies at this central Indian station Bhopal.

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