Study of Erythemal exposure from Daily OMI data for Indo Gangetic Plains of India

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ABSTRACT

The data of erythemal flux, total ozone and aerosol optical depth obtained from the Ozone Monitoring Instrument (OMI) for the years 2012 & 2013 of Indo Gangetic plains have been examined. This area lies between 74^0 E -91^0 E longitude and 21^0 N -31^0 N latitude. This is very fertile region and most densely populated area. The most of the part of the plain area is made up of alluvial soil deposited by the three main rivers and their tributaries. This region is environmentally sensitive, socially significant and economically strategic domain of India where landscape, hydrology and fertility are threatened by climate warming and anthropogenic pressure. Human societies have suffered enormously due to climatic changes but ultimately most were able to adjust by changing their life style and migrating to the hospitable areas. Few centuries back, the impact of climate was not so severe because the population was less, it lived in small groups and economic stakes were low. Their migration to the fertile areas was easier because large areas on the earth were yet to be habited. Today, the societies have grown tremendously and are anchored in areas that are difficult to abandon because of the high economic stakes. Most of the habitable land is occupied. So if a population is forced to migrate under the pressure of global warming, there is not much place left for resettlement (Saini, 2008). Anthropogenic activities have increased concentration of carbon dioxide in the atmosphere (IPCC, 2007). The chef amount of rainfall has occurred during monsoon season (June to September) every year. It affects the economy of the country. The changing climate affects the health and social status, development and sustainability of the people. This depends on the radiation received on the earth and its harmful effects are monitored by monitoring the Ultraviolet Radiation (UV). OMI instrument has the capability to estimate the biologically sensitive radiation part in terms of erythemal flux. The Erythemal flux for the year 2012 and 2013 have been examined with OMI data and shows 1 % decrease for the year 2013 during the summer months (March –May). The possible cause may be do rapid change in the urbanization or anthropogenic activities leads modifying the temperature trend and weather activities.

Key words: Erthemal flux, aerosol optical depth, total ozone and ultraviolet (UV)

1. Introduction

The Indo-Gangetic Plain is a 400-800 km wide, low relief, east-west zone between the Himalaya in the north and the Peninsula in the south. OMI is onboard the NASA Earth Observing System (EOS) Aura spacecraft is a nadir-viewing spectrometer that measures solar reflected and backscattered light in a selected range of the ultraviolet and visible spectrum Ultraviolet radiation is at shorter wavelengths than the visible spectrum (400 to 700 nm) and is divided into three components: UV-A (315 to 400 nm), UV-B (280 to 315 nm) and UV-C (less than 280 nm). The shorter wavelengths that comprise UV-B are the most dangerous portion of UV radiation that can reach ground level. Atmospheric ozone shields life at the surface from most of the UV-B and almost all of the UV-C. UV-A and UV-B are reduced by a small amount from Rayleigh scattering in the atmosphere. Cloud cover reduces all forms of UV radiation. Ozone strongly absorbs UVB, and UVB increased significantly at the surface in the early 1990s because of stratospheric ozone depletion (*Kerr and McElroy*, 1993; *Herman et al*., 1996). Chemical processes in the atmosphere can affect the amount of ozone, and therefore, the level of protection provided by the ozone in the stratosphere and troposphere. This thinning of the atmospheric ozone leads to elevated levels of UV-B at the earth's surface and increases the risks of DNA damage and other cellular damage in living organisms. The OMI instrument employs hyper spectral imaging in a push-broom mode to observe solar backscatter radiation in the visible and ultraviolet. The hyper spectral capabilities improve the accuracy and precision of the total ozone amounts and also allow for accurate radiometric and wavelength self calibration over the long term. OMI continues the TOMS record for total ozone and other atmospheric parameters related to ozone chemistry and climate. An erythemal (or sunburn) action spectrum has been introduced to represent the average skin response over the UVB and UVA spectral regions (*McKinlay and Diffey*, 1987). Weighting the UVB and UVA irradiances by the action spectrum yields the erythemal effective irradiance or "dose rate". This dose rate represents the instantaneous amount of skin damaging UV radiation. OMI produces noontime surface spectral UV irradiance estimates at four wavelengths (305, 310, 324, and 380 nm). The

accuracy of the algorithm developed by Tanskanen et al,2006 for measuring the surface UV estimates depend on UV wavelength and atmospheric and other geolocation specific conditions ranging from 7% to 30. Arola et al. 2005, evaluated the effect of absorbing aerosols on TOMS UV bias using direct measurements of aerosol optical properties and found that, TOMS/Brewer bias on aerosol absorption optical depth is significant. Crotcov et al. 1998, algorithm for determining spectral UVA (320–400 nm) and UVB (290–320 nm) flux in cloud-free conditions is discussed, including estimates of the various error sources (uncertainties in ground reflectivity, ozone amount, ozone profile shape, surface height, and aerosol attenuation). Crotcov et al. 2001, showed that The daily irradiance values at a given location show that short-term variability (daily to annual) in the amount of UV radiation, 290–400 nm, reaching the Earth's surface is caused by (1) partially reflecting cloud cover, (2) haze and absorbing aerosols (dust and smoke), and (3) ozone. Solar zenith angle, clouds, ozone, aerosols and surface albedo are the predominant factors that interact with UV radiation determining its variability at the surface (Kerr, 2003). The results of the validation exercise of OMI-TOMS showed satisfactory agreement between OMI and Brewer total ozone data with bias of –1.8 % (Lalongo et al, 2008). Aerosols play an important role in radiative budget of atmosphere with both direct and indirect effects, by absorbing and scattering the incoming solar radiation (Mallet et al., 2005; Chou et al., 2006) and modifying cloud properties acting as cloud condensation nuclei (Charlson et al., 1992; Schwartz et al., 1996). Atmospheric aerosols can influence UV radiation masking the increase of UV irradiance due to the stratospheric ozone depletion (Meleti and Cappellani, 2000; WMO, 2007).

Ground-based measurements show that summertime erythemal UV irradiances in the Southern Hemisphere exceed those at comparable latitudes of the Northern Hemisphere by up to 40% (Seckmeyer et al., 1995), whereas corresponding satellite-based estimates yield only 10 to 15% differences (WMO, 1998). Atmospheric pollution may be a factor in this discrepancy between ground-based measurements and satellite-derived estimates. UV-B measurements at more sites are required to determine whether the larger observed differences are globally representative.

The work carried out by Herman and Celarier, 1997 algorithm based on the amount of ultraviolet radiation in the UVA (320 nm – 400 nm) and UVB (290 nm - 320 nm) spectral ranges that reach the surface of the Earth is determined by Rayleigh scattering from the molecular atmosphere, the absorption of ozone, scattering by clouds, both scattering and absorption by aerosols and reflection from the surface. The algorithm is based on corrections to calculated clear-sky UV irradiance; *EClear* The calculation procedure is based on table lookup and either cloud/non-absorbing aerosol correction or absorbing aerosol correction (Figure 6). The type of correction is selected based on the two threshold values of the aerosol index (AI) (calculated from 331 nm and 360 nm radiances) and Lambertian Equivalent Reflectivity (LER) (360 nm) as described below. The surface albedo and snow effects are estimated using the TOMS monthly minimum Lambertian Effective surface Reflectivity (MLER) global database.

2. Data and methodology

The data used in the present study has been taken from the global web site, using the giovanni web visualization tool. http://disc.sci.gsfc.nasa.gov/giovanni

For Erythemal flux measurement, ozone-monitoring instrument (OMI) UV-B algorithm inherits from the TOMS UV algorithm. In this algorithm clear sky UV irradiance is first estimated using the total ozone column and other geophysical data. By correcting the clear sky UV irradiance with the aerosol and cloud information, the surface UV irradiance is obtained. The UV products that are produced are

UV irradiances at four wavelengths (305, 310, 324, 380 nm), noontime erythemal UV dose rate and the erythemal UV daily dose.

The operational algorithm given by Tanskanen, A, 2008, is based on the fact that the photon energy in action spectrum part, which is essential to initiate the activity.

Erythemal irradiance (D) is given by:

$$D = \int E(\lambda) A(\lambda) d\lambda$$

Where, $A(\lambda)$ is the action spectrum, i.e relative effectiveness of the photon of certain wavelength to cause the effect being studied.

Clear sky UV radiance = $E = E_{CS}(z, \Omega, R_s, \theta) * CMF(\tau_c, \theta, R_s) * ACF(\tau_a, \omega, \theta, R_s)$

where, CMF is cloud modification factor and ACF is aerosol correction factor, τ_c and τ_a are the cloud and aerosol optical depth .

Erythemal dose rate (EDR watt/m^2)= $EDR = UCfn(\theta, TO_3) Coscor(\theta)$ [Webb et al. 2006]

Where, where *U* is the raw signal of the instrument (*V*); *C* is the calibration coefficient

(*C*=0.1104W $m^{-2} V^{-1}$) $fn(\theta, TO_3)$ is a function of solar zenith angle θ and the total column ozone TO_3. $Coscor(\theta)$ is the cosine correction function.

3. Results and discussions

Figs (1-3) show mean variation of ultraviolet Erythemal (UVER) flux from OMI for the year 2012 and 2013. It is seen that the annual average for both the years over Indo Gangetic plains is almost the same; there is no significant change except approximate of the order of 1 % increase in summer (March –May) for the year 2013. Erythemal flux (J/m^2) standard deviation (STD) values which are sensitive to instrument and solar geometry parameters almost invariant for both the years, Figs (2,4). Figure 5 from the courtesy of NASA's Goddard Space Flight Center by Jay/ Herman shown that the largest increase in UV (shown in white, red, orange and yellow) have occurred in the southern hemisphere during April, May and June. In the tropics, increases in UV have been minimal (shown in blue). Though the size of UV wavelengths ranges from 290 to 400 nm, 305 nm UV is one of the most damaging types for humans. Report says that, in the tropics, the increase has been minimal, but in the mid-latitudes it has been more obvious. Longer wavelengths (from 320 to 400 nanometers) called UV-A cause sunburn and cataracts. Yet, UV-A can also improve health by spurring the production of Vitamin D, a substance that's critical for calcium absorption in bones and that helps stave off a variety of chronic diseases. UV-B, which has slightly shorter wavelengths (from 320 to 290 nanometeredamages DNA by tangling and distorting its ladder-like structure, causing a range of health problems such as skin cancer and diseases affecting the immune system (source: http://www.nasa.gov/topics/solarsystem/features/uv-exposure.html.). The ground radiative flux change is attributed due changing the stratosphere and tropospheric ozone and aerosol distributions. The changes of the mean UVER for the year 2012 and 2013 may be due to increase the concentration of more abundance of hygroscopic type of nuclei in the atmosphere. Figures (7,8) shows the total ozone distribution for the year 2012 and 2013. No significant change is observed in total ozone content for both the years. In the year 2013, during the summer month the total ozone is more organized and lesser fluctuation. The standard deviation values almost the same variation for both the years, figures (9,10).

4. Concluding remarks

The value of ultraviolet Erythemal (UVER) flux is affected by the ozone concentration and ozone reduces the UVER as shown the Figures (1,3) and this will help to protect the harmful radiation at the surface which is responsible for skin or cancer diseases. Aerosol optical depth play a negative role in this case because of most of the radiation is scattered and absorbed by the aerosols. The amount of solar radiation (200-400 nm) affected mainly by ozone absorption, cloudiness and aerosols. Changes in UV radiation at surface may strongly affect the human health and the terrestrial and aquatic ecosystem (UNEP, 1998,2003,2007). The mean values of UVER for the year 2012 and 2013 is not shown much change. During the summer time (March –May) the UVER values for the year 2013 is approx 1 % lower than the year 2012 summer season.

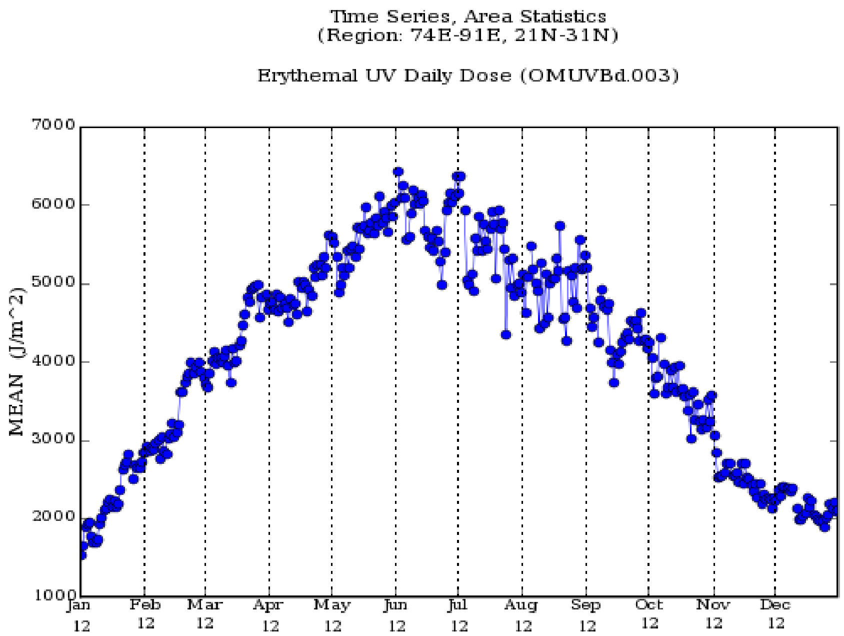

Fig 1: Erythemal flux (J/m2) over Indo Gangetic plains (2012) from OMI

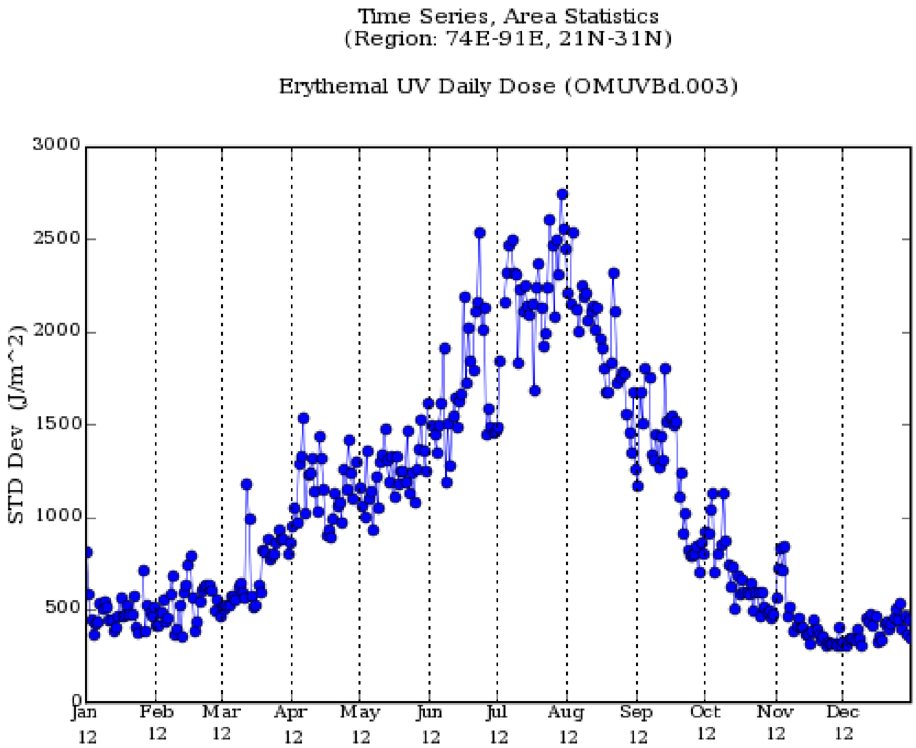

Fig 2: Erythemal flux (J/m2) STD over Indo Gangetic plains (2012) from OMI

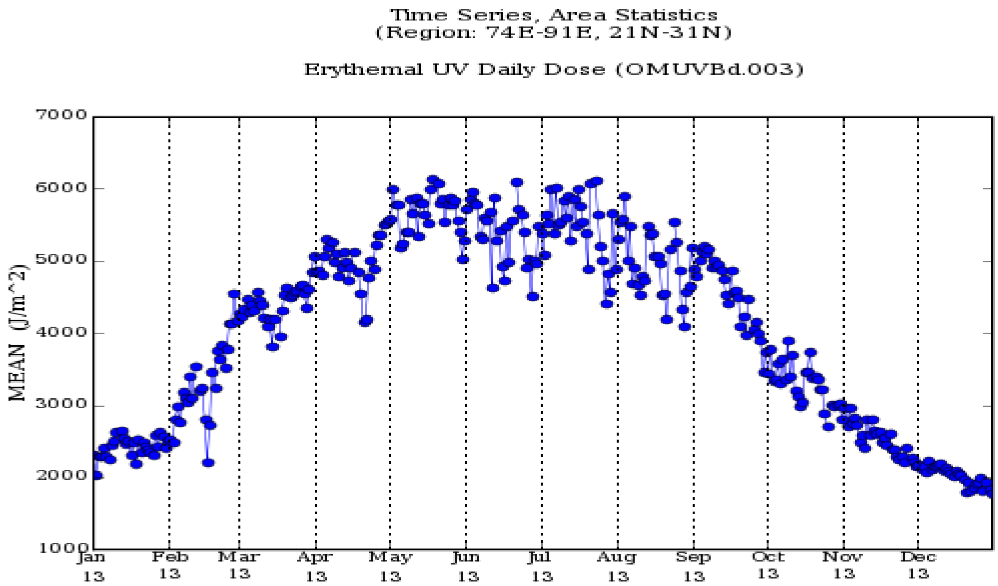

Fig 3: Erythemal flux (J/m2) over Indo Gangetic plains (2013) from OMI

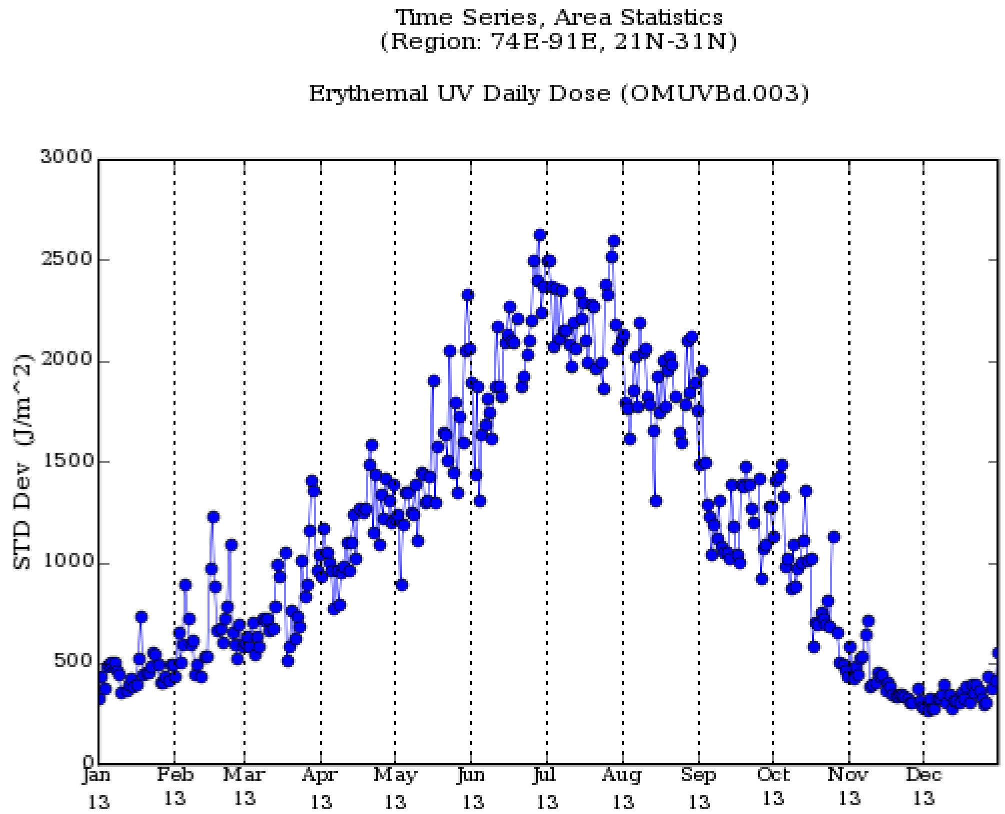

Fig 4: Erythemal flux (J/m2) STD values over Indo Gangetic plains (2013) from OMI

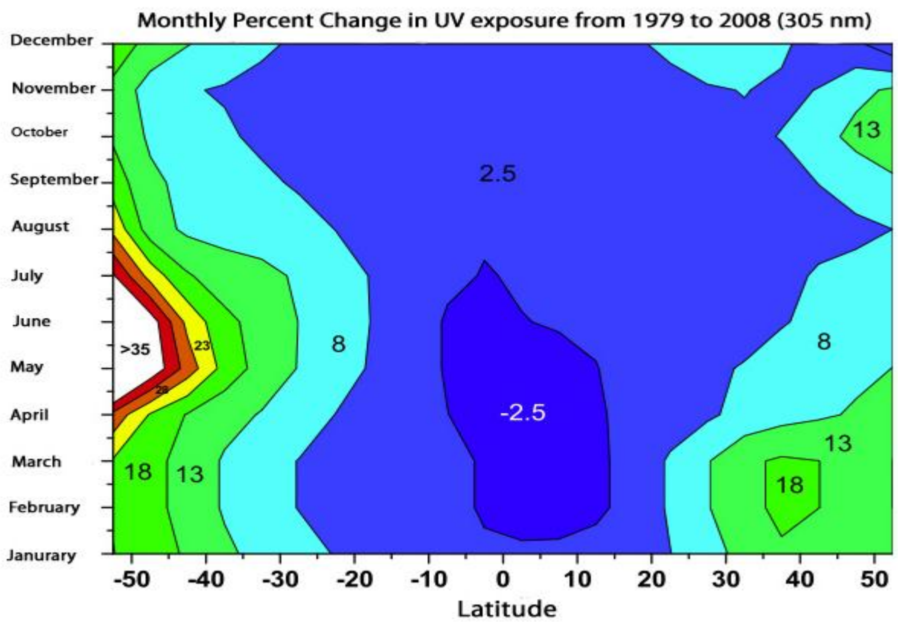

Fig 5: UV exposure from 1979 –2008 (courtesy NASA's Goddard Space Flight Centre by Jay Herman)

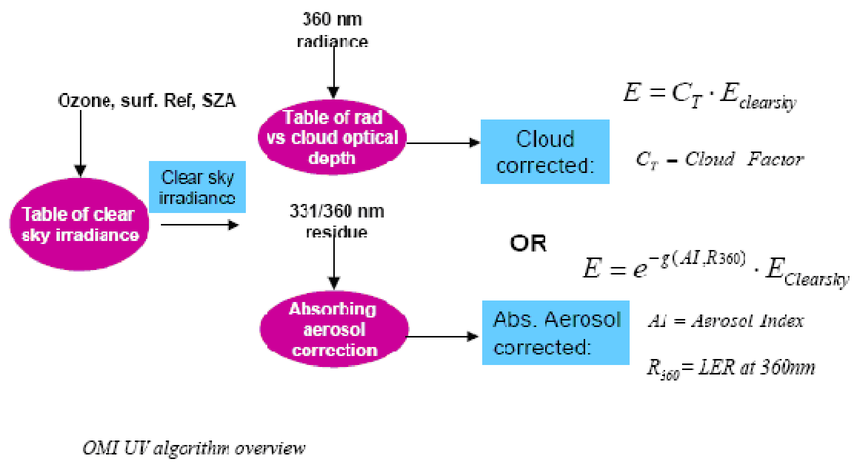

Fig 6: OMI UV algorithm (Herman and Calarier, 1997, ATBD)

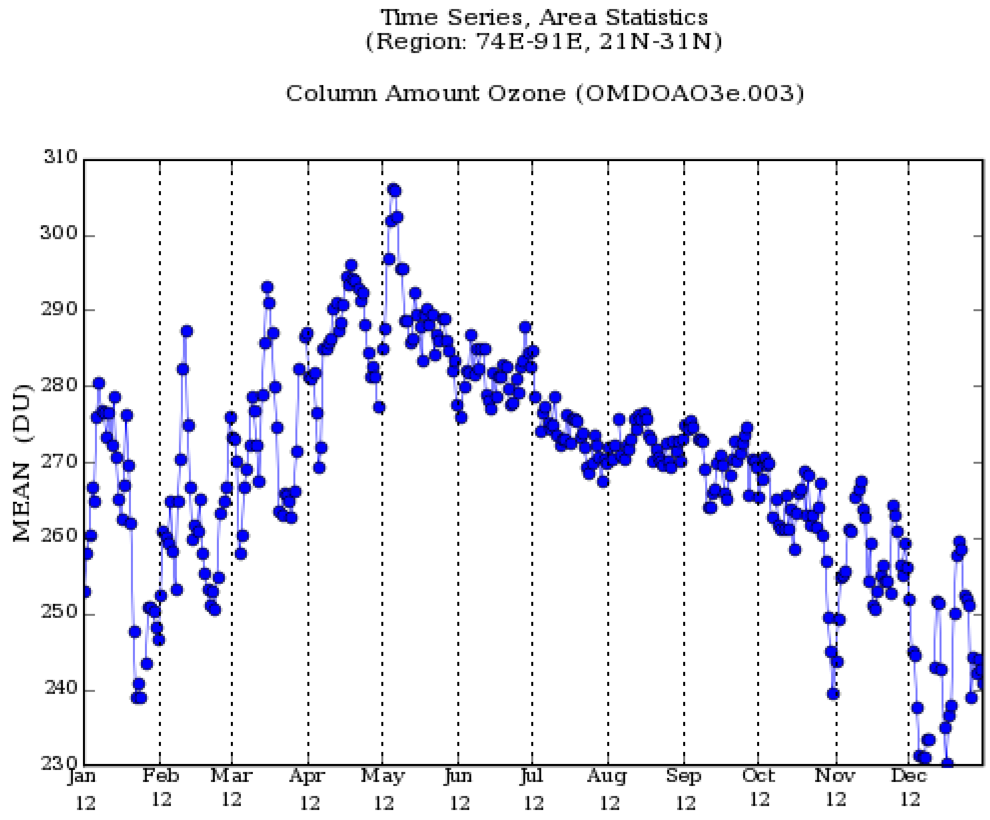

Fig 7: Total Ozone (Dobson unit) values over Indo Gangetic plains (2012) from OMI

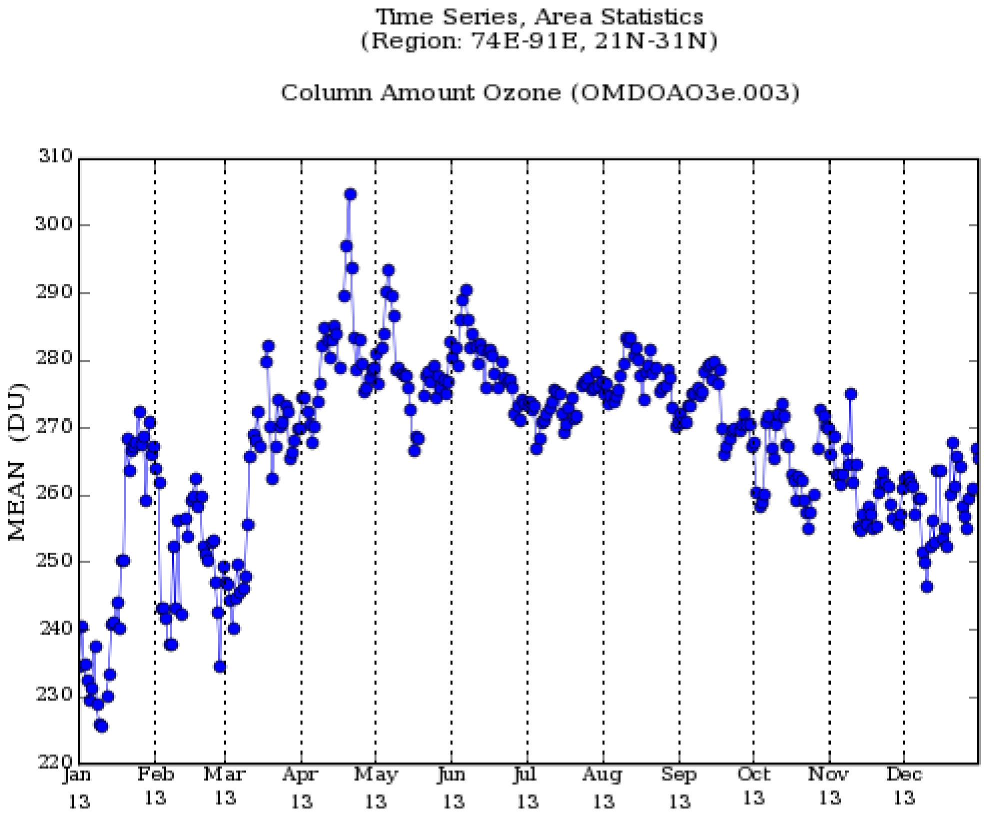

Fig 8: Total Ozone (Dobson unit) values over Indo Gangetic plains (2013) from OMI

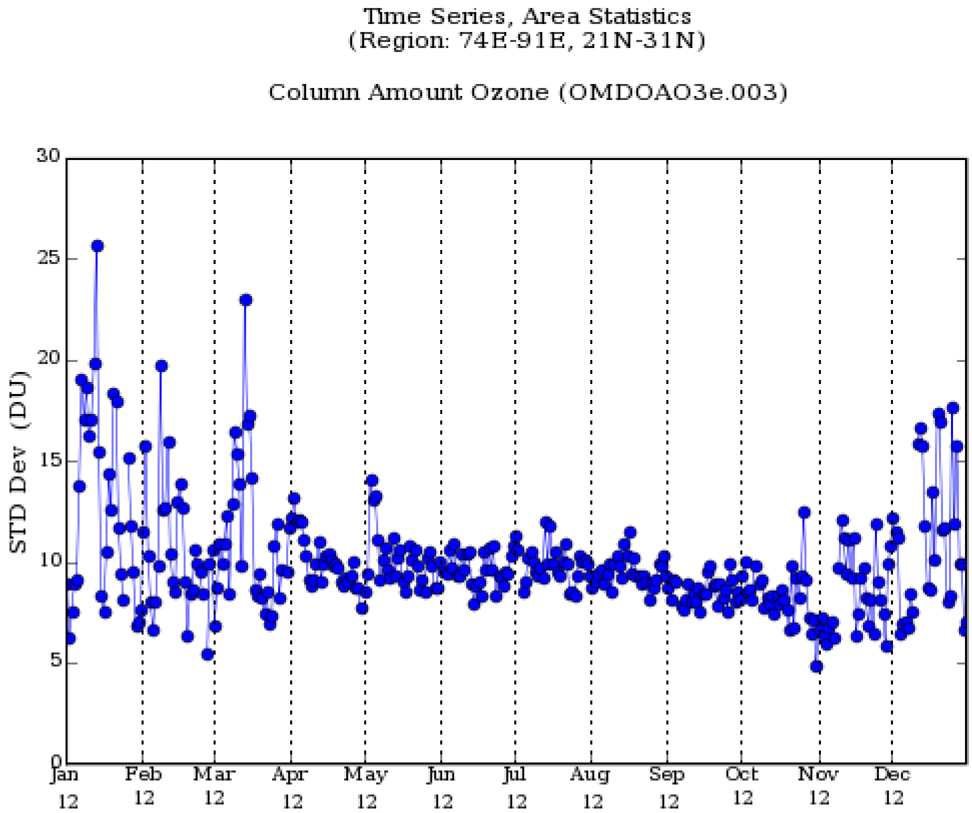

Fig 9: Total Ozone (Dobson unit) STD values over Indo Gangetic plains (2012) from OMI

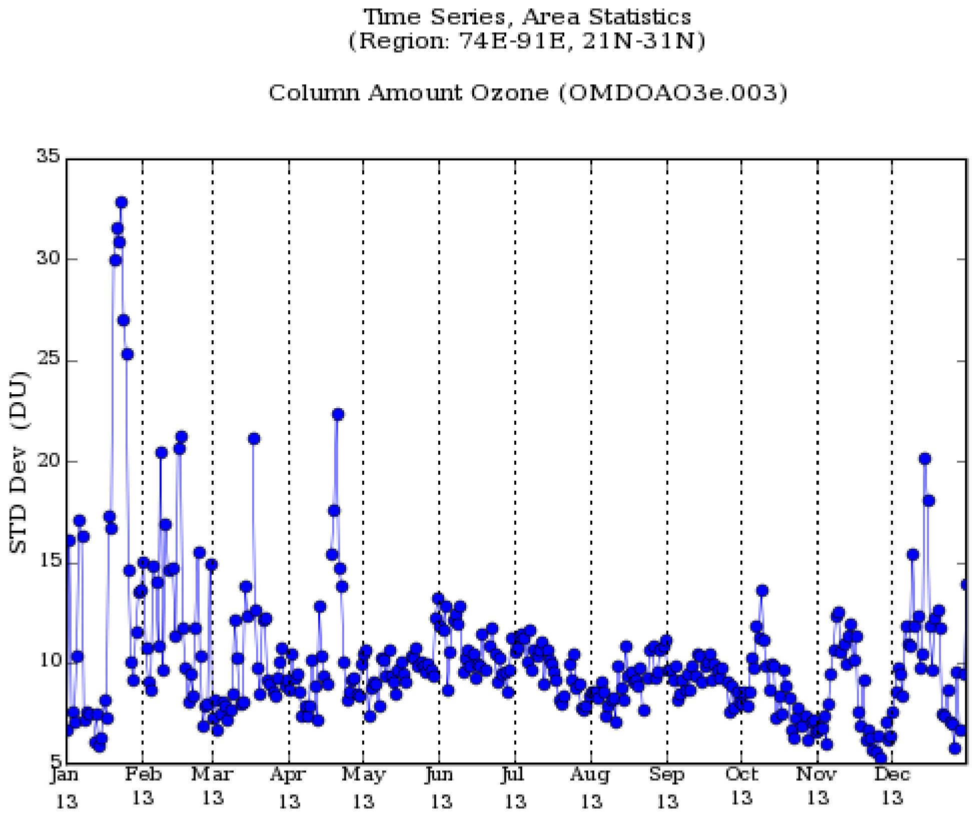

Fig 10: Total Ozone (Dobson unit) STD values over Indo Gangetic plains (2013) from OMI

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