RADIATION AMPLIFICATION FACTOR (RAF) AND ULTRAVIOLET INDEX (UVI) OVER INDO GANGETIC PLAINS

Satish Prakash*

Amit Singhal*

Rahul Sharma**

R.K. Giri***

Abstract: *Ultraviolet Index (UVI) form Ozone Monitoring Instrument (OMI) is used to see the possible changes in radiation amplification factor (RAF) for the year 2005, 2009 and 2010. The selection of the years is based on the criteria of the temperature trend observed over the Indo Gangetic plain area 71^0 E -91^0 E longitude and 21^0 N -31^0 N latitude during last decades. April and May month is taken as the representative months of summer season over Indo Gangetic plains. The yearly variation of RAF is not showing any significant change, which in turn related to the ozone content over the area. The values of RAF are slightly higher during the month of May.*

Key words: *Radiation Amplification Factor, total ozone and UV index*

*Department of Physics Meerut College Meerut, India

** IBS, CCS University Campus, Meerut, India

*** India Meteorological Department, Lodi Road New Delhi, India

INTRODUCTION:

The solar radiation at the top of the Earth's atmosphere contains a significant amount of radiation of wavelength (l) shorter - and therefore more energetic - than visible light (400-700 nm). Wavelengths in the range 100-400 nm constitute the ultraviolet (UV) spectral region. The shortest of these wavelengths (UV-C, 100-280 nm) are blocked (absorbed) essentially completely by atmospheric oxygen (O_2) and ozone (O_3). Wavelengths in the UV-B range (280-315 nm) are absorbed efficiently though not completely by O_3, while UV-A wavelengths (315-400 nm) are absorbed only weakly by O_3 and are therefore more easily transmitted to the Earth's surface. Erethemal flux can be easily estimated with the help of Ozone Monitoring Instrument (OMI).

Climate change could stress an additional pressure on its overall ecology and socio-economic system. Increasing global warming has caused various climate-related disasters thereby adversely affecting agriculture, health, food security, water resources, and biodiversity as a whole. The area chosen for the study is most fertile and in stress of anthropogenic changes. The Indo-gangetic plains are home to 40% of India's population, being comprised of the states of Punjab, Haryana, Uttar Pradesh (UP), Bihar and West Bengal. Climatic stress and drought type of situation may increase the UVI values and consequently increase of anthropogenic activities will deplete more ozone and it will increase the risk of cancer and heart attacks over the areas. In this connection UVI and RAF for the years 2005, 2009 and 2010 along with the total ozone and RAF series is examined. The results show that there is nota significant increase of these values for the given years.

DATA AND METHODOLOGY:

Radiation Amplification Factor (RAF)

It is the relation between biologically active radiations, Erythemal irradiance (E) and total column ozone (Booth and Madronich, 1994). It is a correction for solar zenith angle and ozone column. This is required because these two factors strongly influence the ultraviolet (UV) measurement. The dangerous consequences when biologically damaging solar UV radiation reaching the ground increases are more pronounced. Normally, RAF = 2 means, for example, that a 1% ozone depletion will result in a 2% increase in damaging UV dose at ground level (Gerstl et al , 1981).

$$\text{RAF} = -\left(\frac{\Delta E}{E}\right) / \left(\frac{\Delta O_3}{O_3}\right)$$

The relationship between ozone and erythemal irradiance is nonlinear; the RAF is not a constant in all conditions but depends on factors that change the shape of the solar spectrum, primarily solar zenith angle and ozone column (WMO, 2008). Ozone is a powerful oxidant, and, as such, it can react with a wide range of cellular components and biological materials.

Biological effectiveness of the radiation is quantified with Radiation Amplification Factor (RAF), RAF = 2 means, for example, that a 1% ozone depletion will result in a 2% increase in damaging UV dose at ground level. Previous studies of (Molina & Rowland, 1974, Gerstl, et al, 1981, Panel NRC, 1979, Panel SCT, 1979) indicate that releases of chlorofluoro-carbons (CFCs)—mainly chlorofluoromethanes (CFMs)—into the atmosphere deplete the stratospheric ozone layer. Potentially dangerous consequences of these ozone depletions, such as increases in skin cancer, are expected due to a subsequent increase in biologically damaging solar UV radiation reaching the ground.

Empirically,

$$UV_{bio} \sim (Ozone)^{-RAF}$$ **(Booth & Madronich**, 1994)

Instrument Used: Ozone monitoring instrument (OMI)

The instrument observes Earth's backscattered radiation with a wide-field telescope feeding two imaging grating spectrometers. Each spectrometer employs a CCD detector. Onboard calibration includes a white light source, LEDs, and a multi-surface solar-calibration diffuser. A depolarizer removes the polarization from the backscattered radiation.

Specifications:

Item	**Parameter**
Visible:	350 - 500 nm
UV:	UV-1, 270 to 314 nm, UV-2 306 to 380 nm
Spectral resolution:	1.0 - 0.45 nm FWHM
Spectral sampling:	2-3 for FWHM
Telescope FOV:	114 (2600 km on ground)
IFOV:	3 km, binned to 13 x 24 km

Detector:	CCD: 780 x 576 (spectral x spatial) pixels
Mass:	65 kg
Duty cycle:	60 minutes on daylight side
Power:	66 watts
Data rate:	0.8 Mbps (average)

Pointing requirements (arcseconds) (Platform+instrument, pitch:roll: yaw, 3s):

Accuracy:	866:866:866
Knowledge:	87:87:87
Stability (6 sec):	87:87:87
Physical Size:	50 x 40 x 35 cm

(Source : http://aura.gsfc.nasa.gov/instruments/omi.html)

RESULTS AND DISSCUSSIONS:

It is expecting that sunlight-induced cancers probably arise by the action of sunlight on DNA or compounds of analogous sensitivity to different wavelengths. It may be due to increased skin cancer, including melanoma, observed in people who have DNA repair defects (xeroderma pigmentosum). Essentially no UV radiation of wavelengths less than 290 nm currently reaches the ground, and UV radiation of wavelengths above 320 nm (UV-A--320 to 400 nm) does not attack DNA seriously. Accordingly, whenever sunlight stimulates skin cancer, DUV (defined as UV-B in the wavelength range 290-320 nm, weighted in accordance with its effectiveness in altering DNA) should be the portion of the UV that is effective. Both biological photochemical reactions and the spectral irradiance from the sun change so rapidly as a function of wavelength, all would agree that total irradiance, or fluence rate, is of little value in determining UV-B dosage (Martyn, 1982). Chlorofluorocarbons (CFCs) play an eminent and catalytic role in ozone depletion process (Kerman et al, 1985, Stolarski, 1988, Lindley, 1988 & Barrettm et al, 1988). This will affect the UV-B exposure to reach the earth. This will affect the rate of Damaging Ultraviolet (DUV) radiation intensity or biologically active radiation on human beings.

Table: UV-Index range and action:

UV -Index	Range	Action
1	0-2	Little danger
2	3-4	Low risk
3	5-6	Moderate risk
4	7-8	High risk
5	9-10	Very high risk
6	>11	Extreme

(Source: http://enhs.umn.edu/current/5103/uv/measurement.html)

RAFs are useful indicators of the sensitivity of a particular effect (i.e., a particular action spectrum) to ozone changes. Large RAF values indicate that the radiation associated with a particular effect is strongly sensitive to changes in atmospheric ozone, while small RAF values indicate that the relevant $UV_{bio}$is less sensitive to ozone changes. Values of RAF ~ 0 mean that the UV_{bio} for that particular effect is not dependent on ozone, as occurs in cases when an action spectrum shows strong sensitivity to longer UV-A and visible wavelengths, but not to UV-B radiation. Figures (1,3,5,7 ,9 & 11) represents the UV index values derived from Ozone Monitoring Instrument (OMI) for the month of April and May of the year 2005, 2009 and 2010 respectively. Local noon time UV index (UVI) is slightly higher in the month of April for the year 2009 as compared to the year 2005 and 2010. On the month of May for the years 2005, 2009 and 2010 the UVI values are not showing any significant change. The standard deviation for each year is depends on the sensitivity of the instrument, calibration mechanism and stable response of the detector. The standard deviation of the years 2005, 2009 and 2010 are given in the figures (2,4,6,8,10 & 12) below. The orders of the values of the standard deviation are about 2 to 4 for both the months (April Na May). The total amount of Ozone in figure(13) shows no significant change for the years 2005, 2009 and 2010.The standard deviations of the total ozone is of the order of 10 -30 Dobson Unit (DU) figure (14). The RAF values derived from empirical relation proposed by **Booth & Madronich**, 1994 are shown in the figures 19 & 20 respectively. The RAF values are slightly higher during the May month of each year. Yearly variation of RAF from 2005 to2013 is also shown in Fig 21 and it shows no significant increase of RAF. This means that the ozone production and destructions are in balance over the area. UVI values for the years 2005, 2009, 2010 and their departure from the year 2005 are shown in the figures (15,16,17 & 18) respectively. The departure values show consistent trend and not abrupt variation of UVI index. The possible reason may be that the area of Indo Gangetic plain is most fertile and experiences normal rainfall and temperature values during the above said years.

There was slight more temperature for the year 2005 as compared to the year 2009 and 2010.

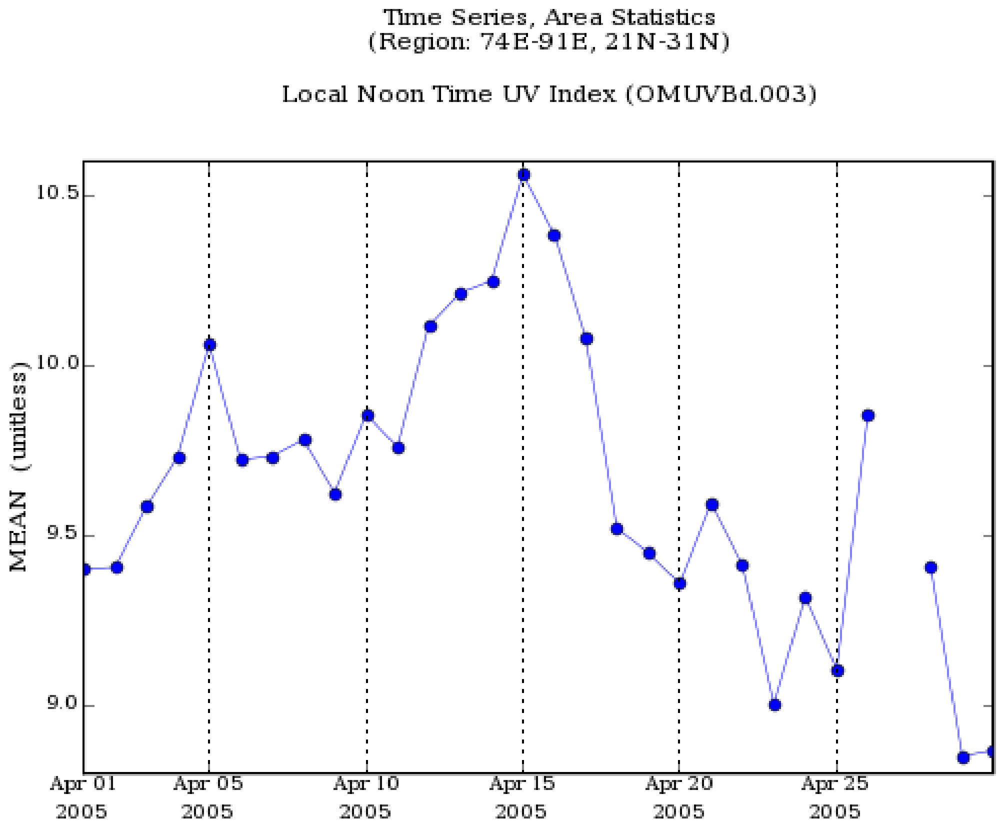

Fig 1: Mean UV Index from OMI for the Month April 2005

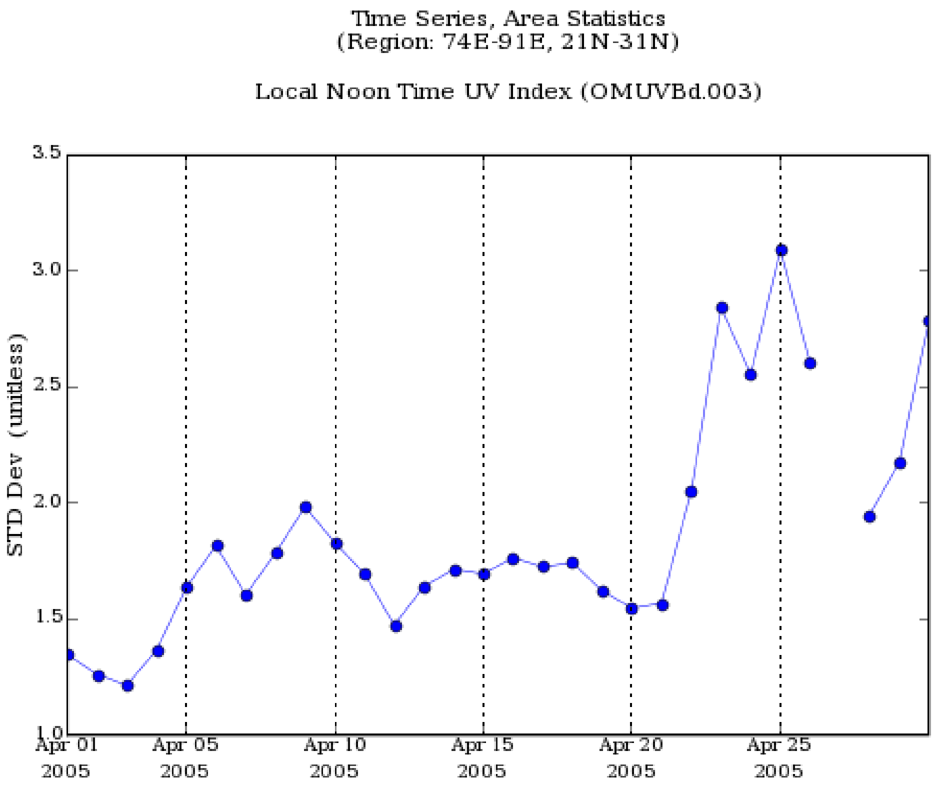

Fig 2 : Mean UV Index standard deviation (STD) from OMI for the Month April 2005

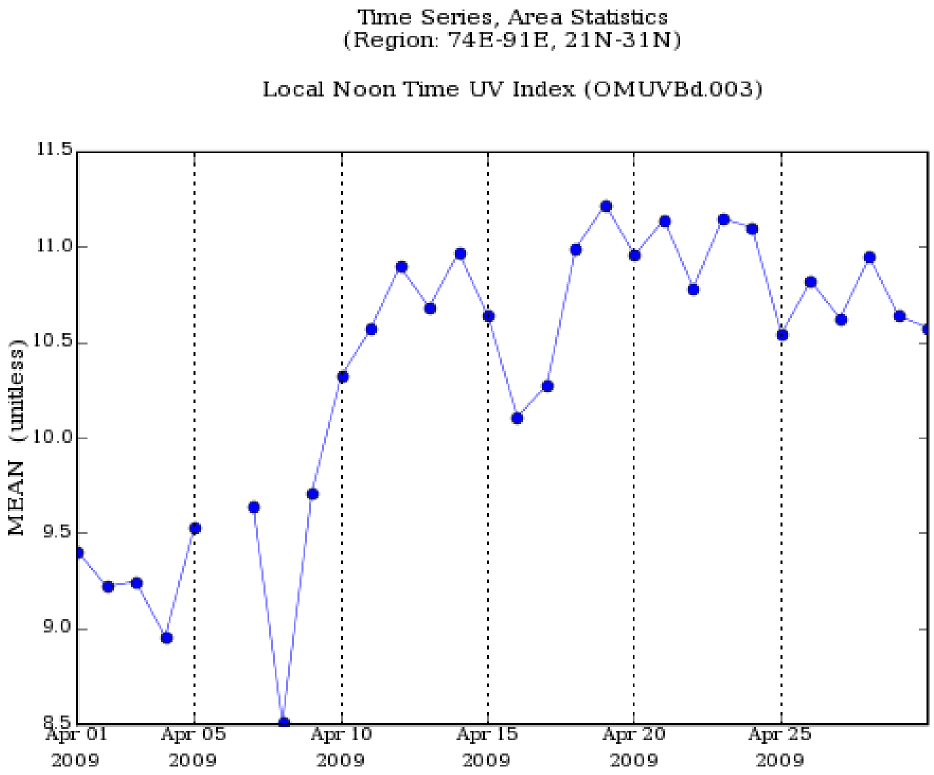

Fig 3: Mean UV Index from OMI for the Month April 2009

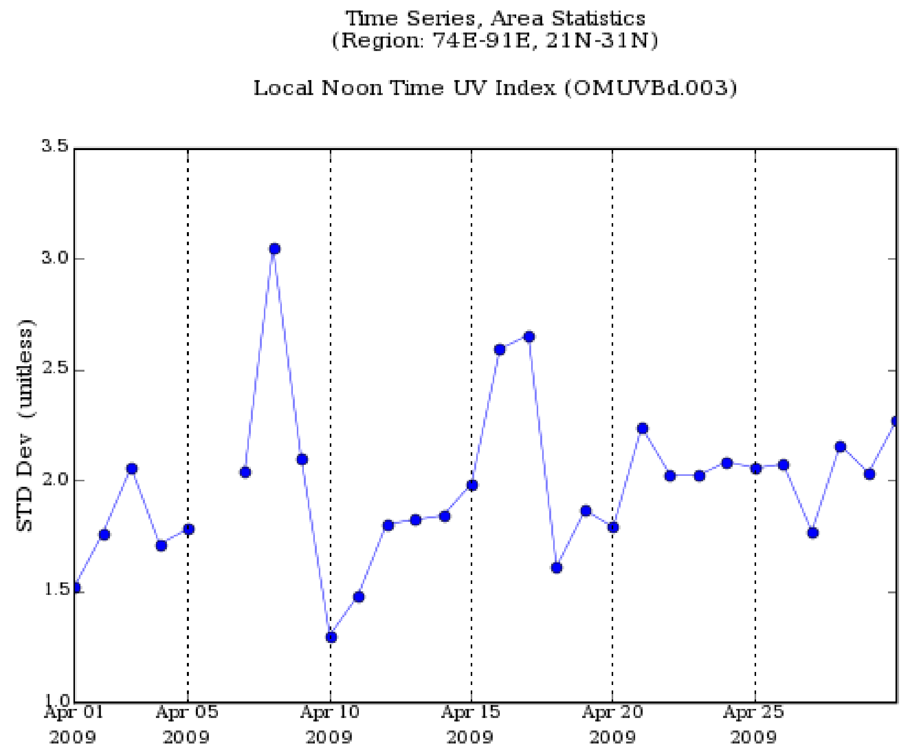

Fig 4: Mean UV Index standard deviation (STD) from OMI for the Month April 2009

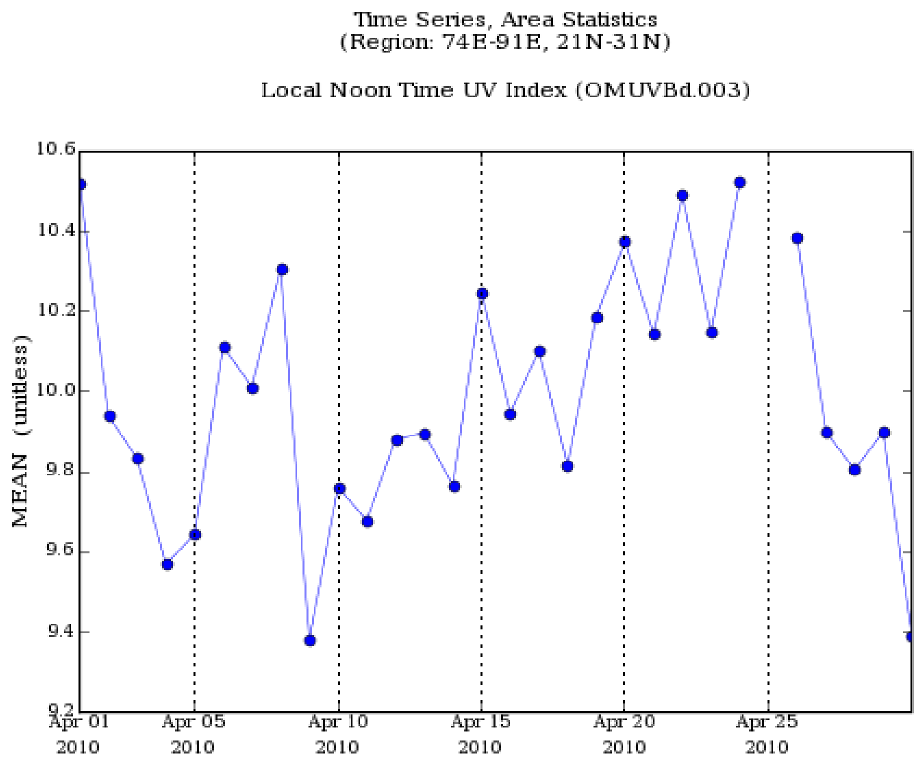

Fig 5: Mean UV Index from OMI for the Month April 2010

ISSN: 2278-6252
Impact Factor: 4.817

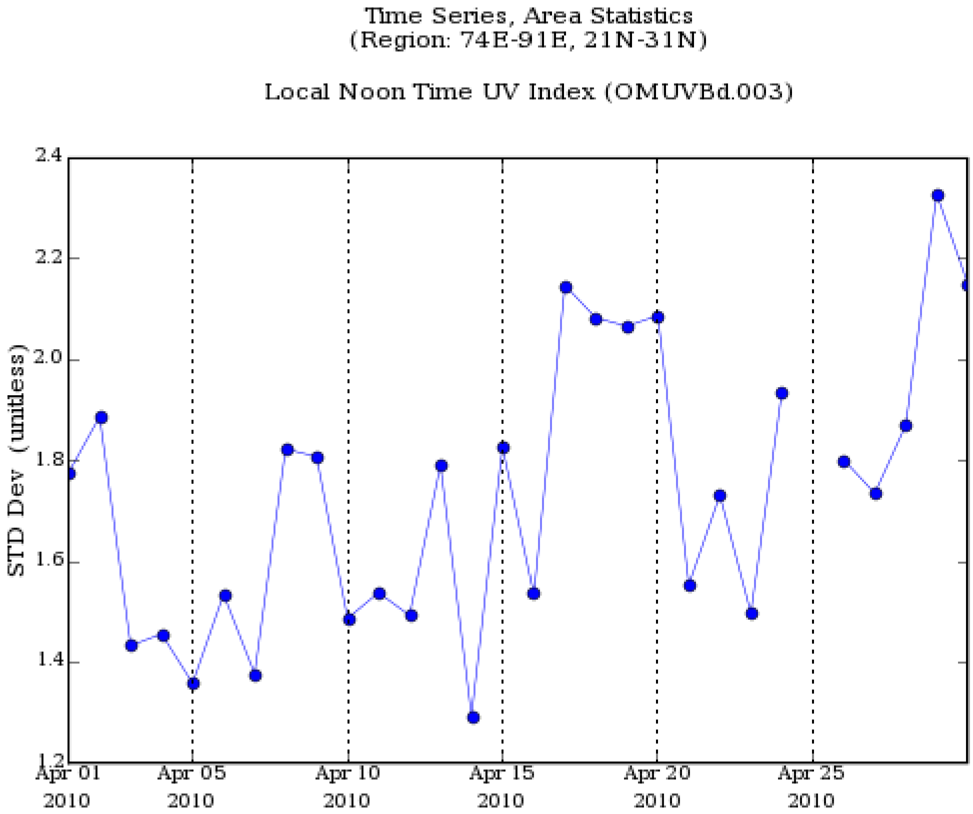

Fig 6: Mean UV Index standard deviation (STD) from OMI for the Month April 2010

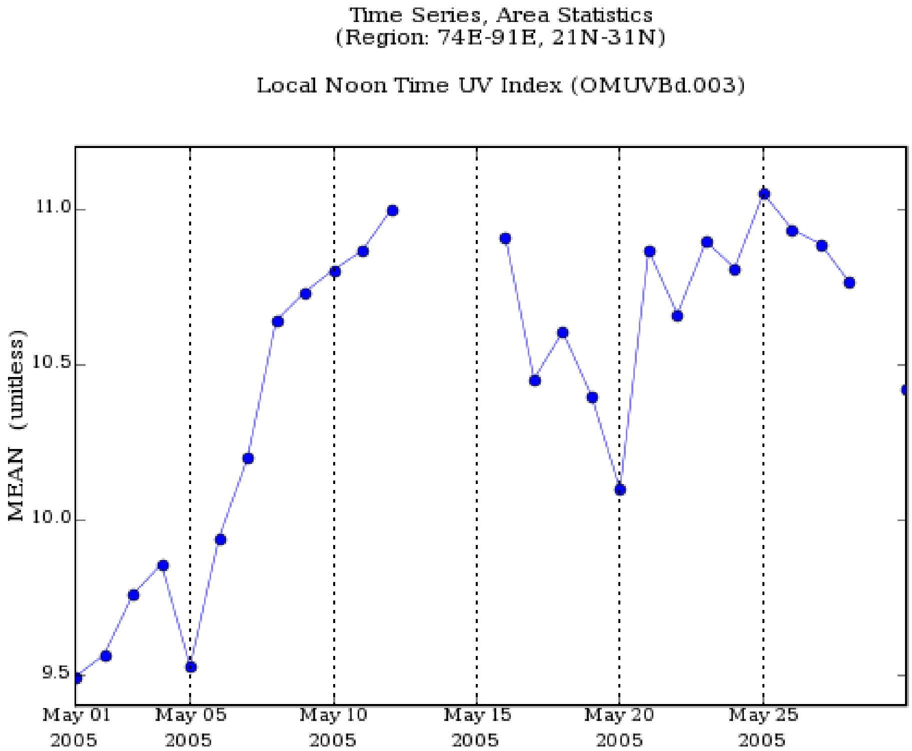

Fig 7: Mean UV Index from OMI for the Month May 2005

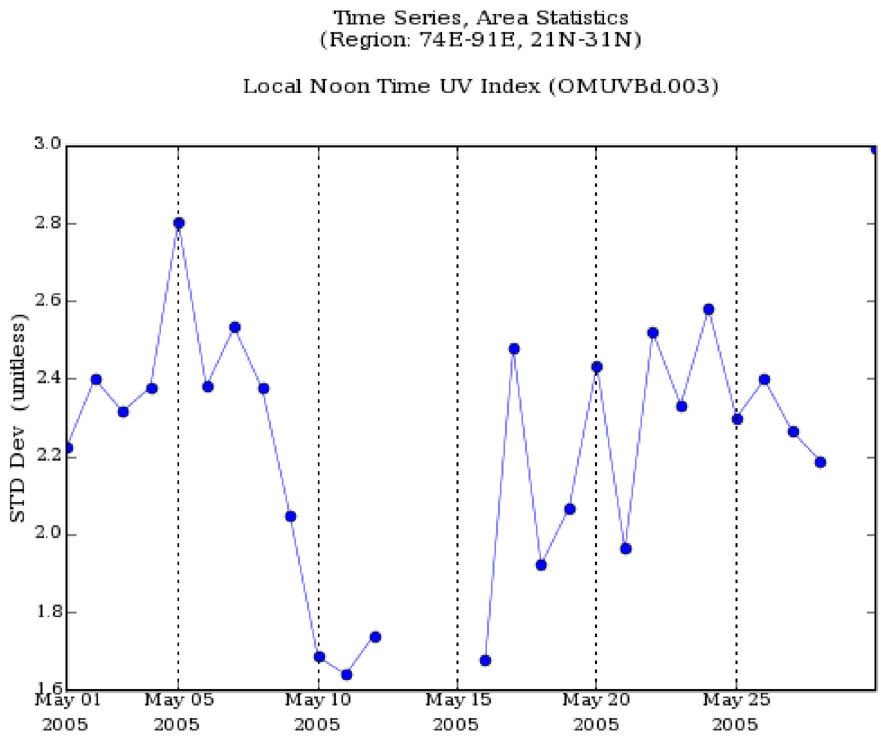

Fig 8: Mean UV Index standard deviation (STD) from OMI for the Month May 2005

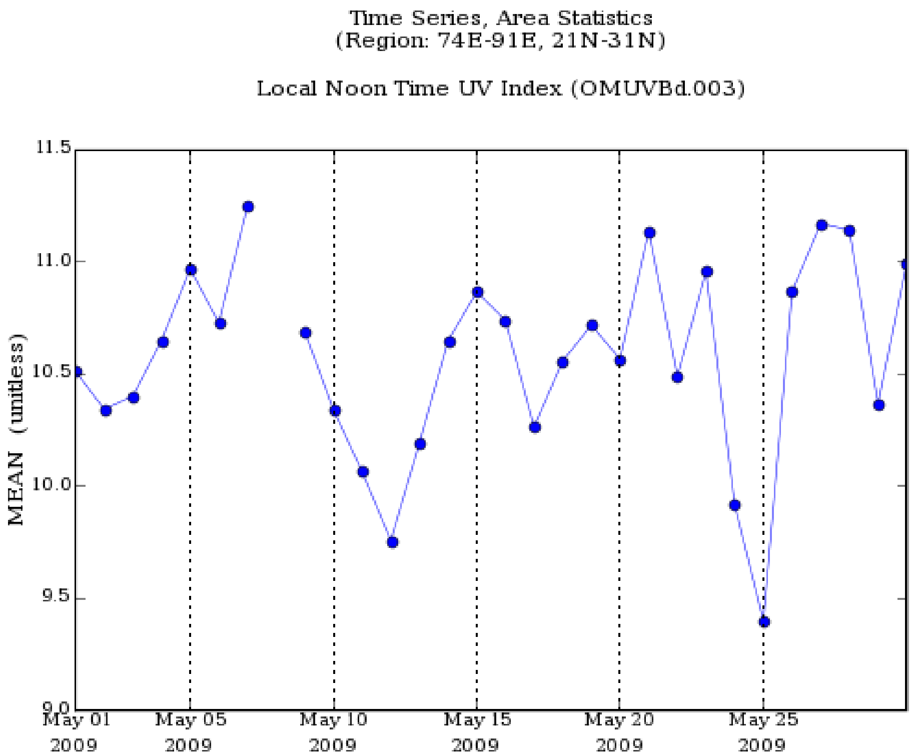

Fig 9: Mean UV Index from OMI for the Month May 2009

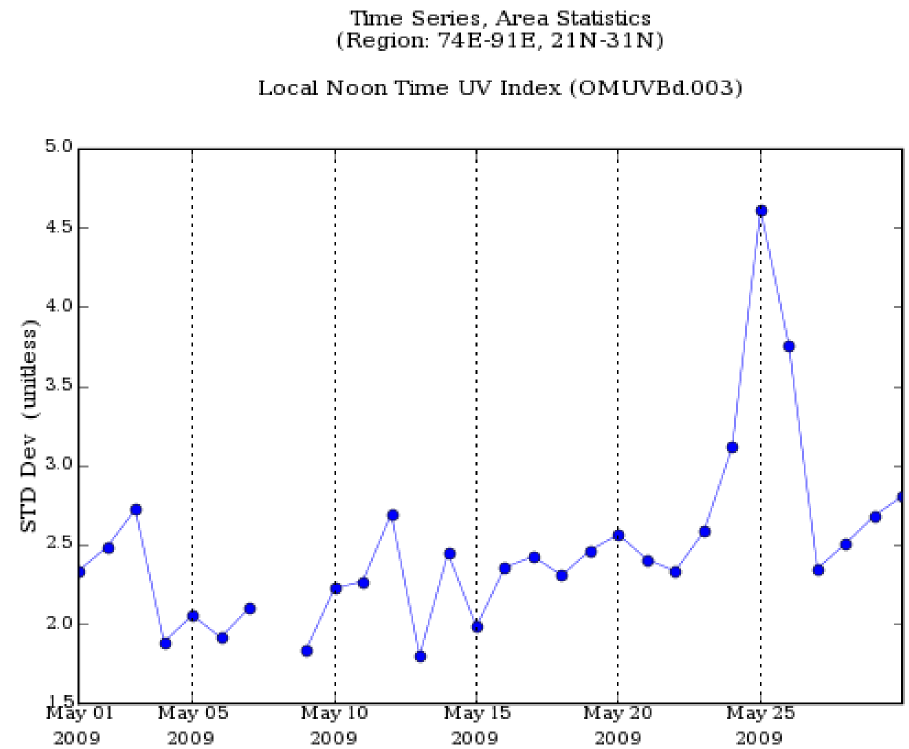

Fig 10: Mean UV Index standard deviation (STD) from OMI for the Month May 2009

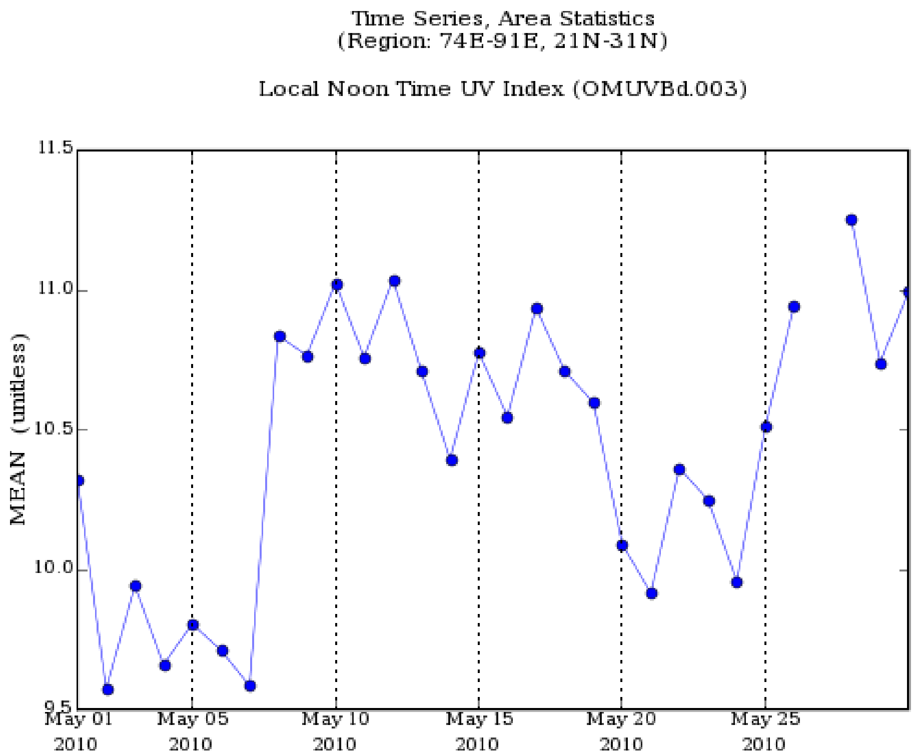

Fig 11: Mean UV Index from OMI for the Month May 2010

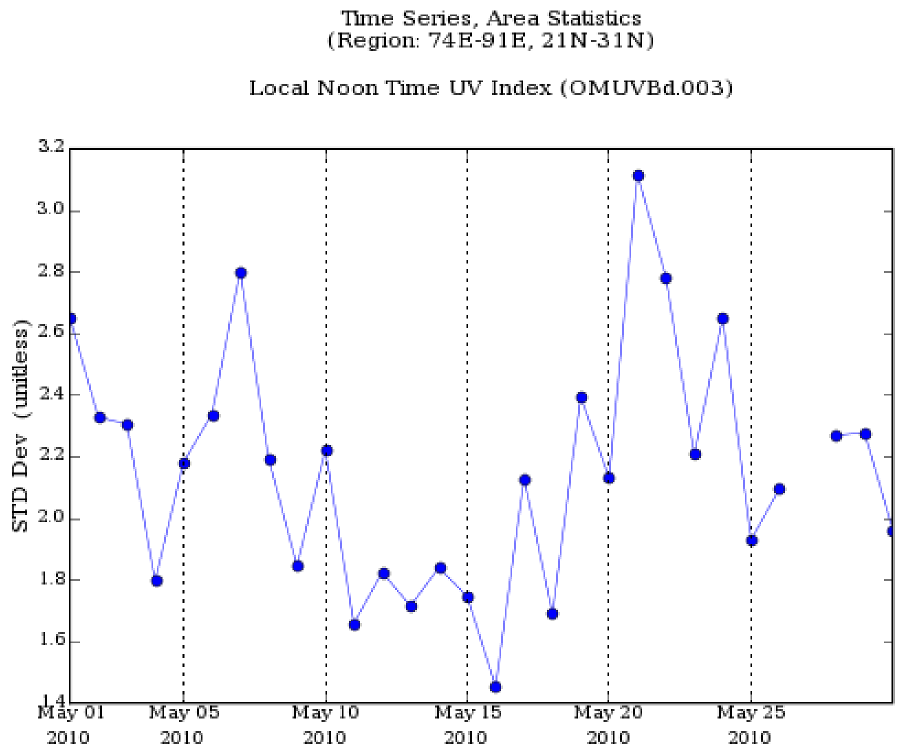

Fig 12: Mean UV Index standard deviation (STD) from OMI for the Month May 2010

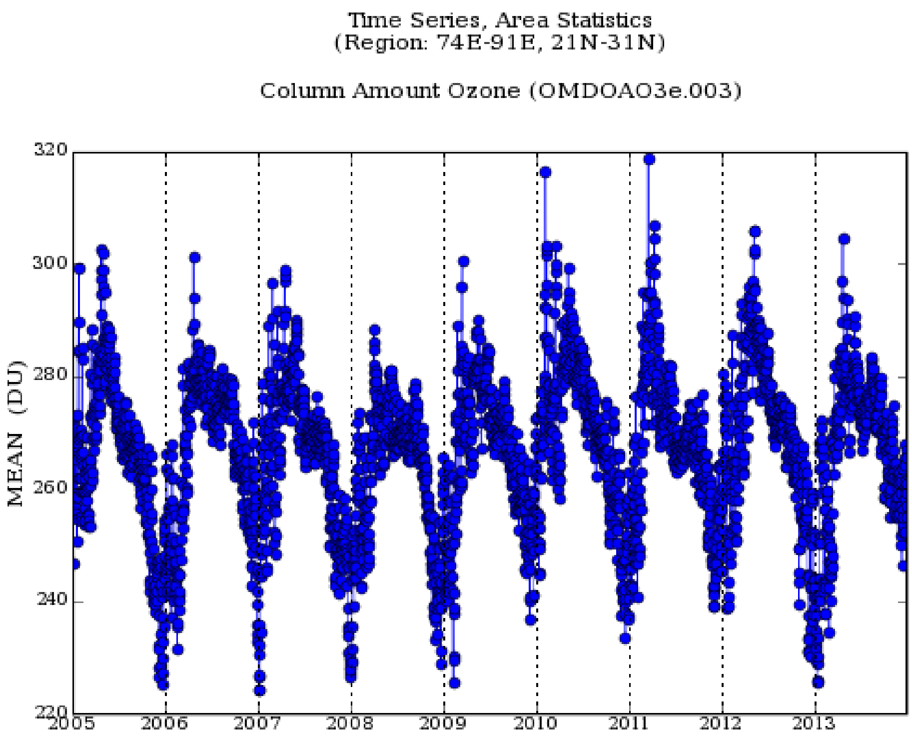

Fig 13: Total column Ozone (Dobson unit) from 2005-2013 from OMI

ISSN: 2278-6252
Impact Factor: 4.817

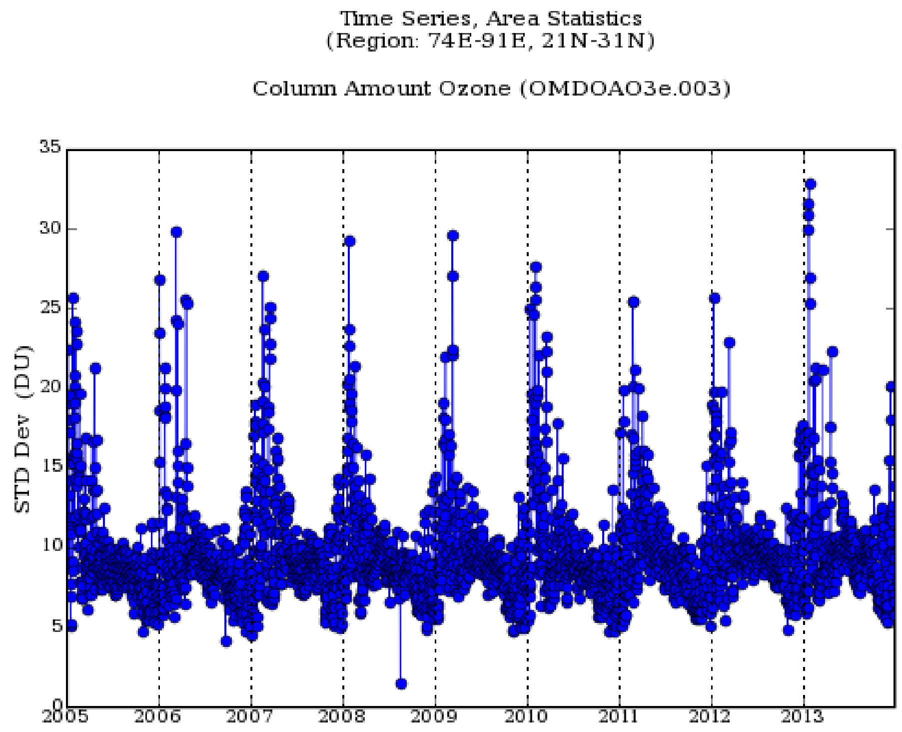

Fig 14: Total column Ozone (Dobson unit) standard deviation (STD) from 2005-2013 from OMI

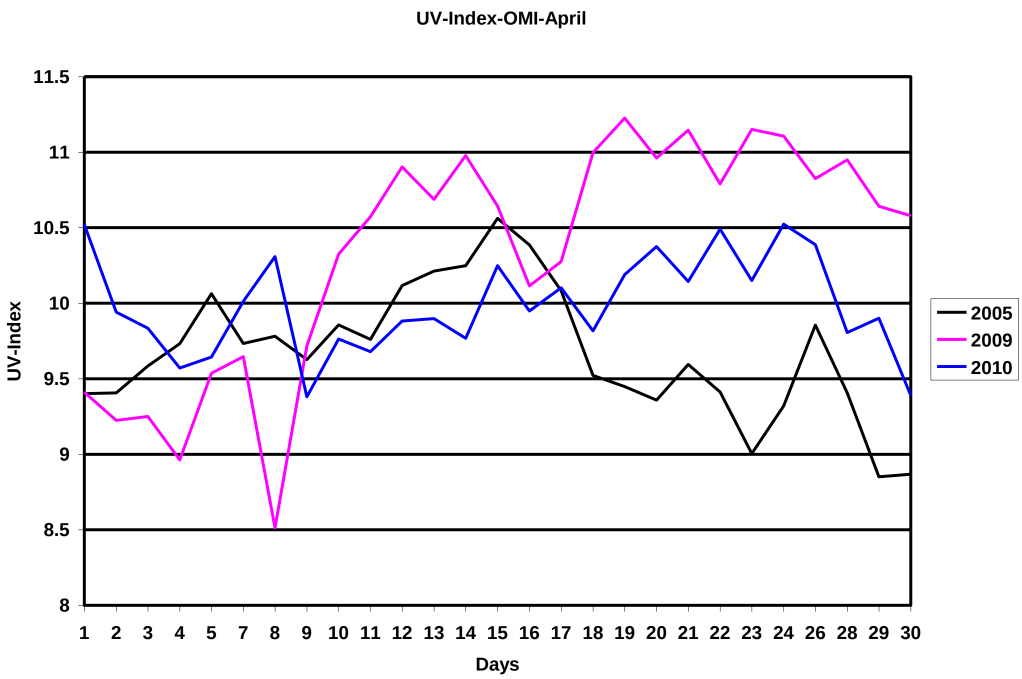

Fig 15: OMI UV Index April (2005,2009 and 2010)

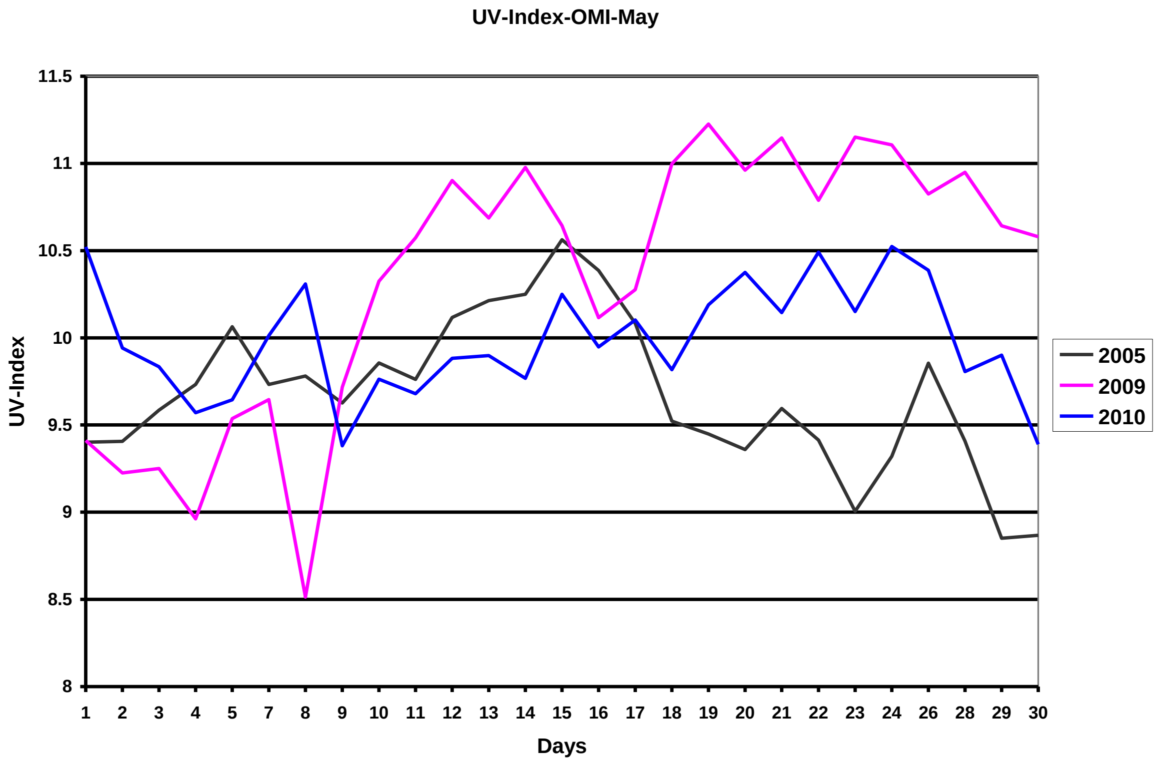

Fig 16: OMI UV Index May (2005,2009 and 2010)

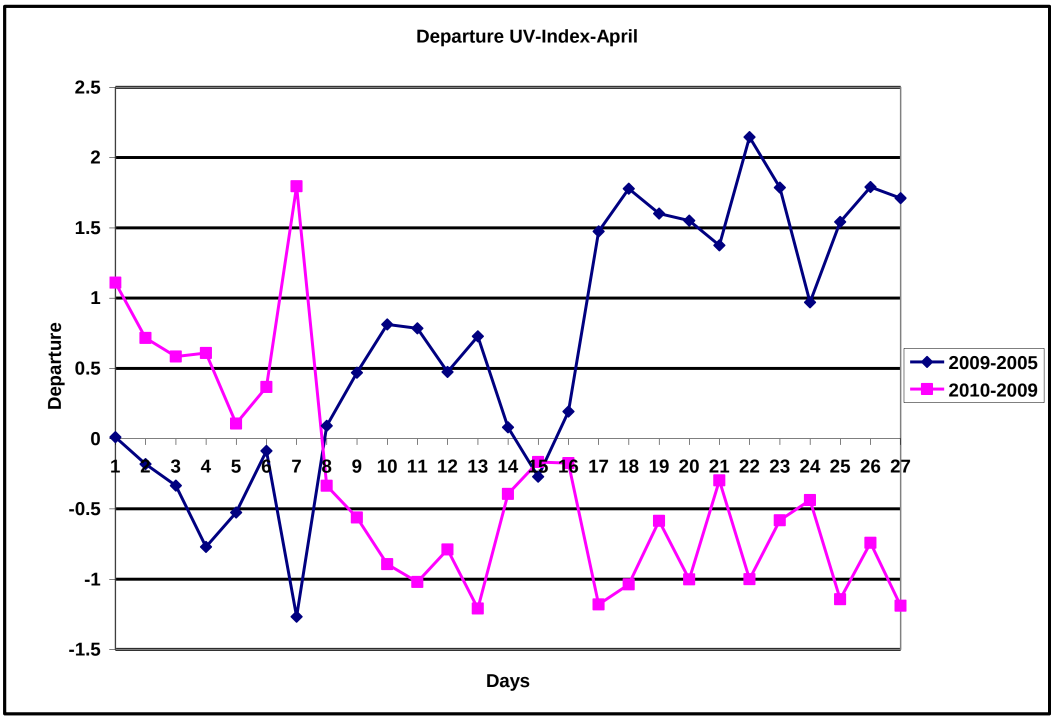

Fig 17: OMI UV Index Departure April (2009-2005 & ,2010-2005)

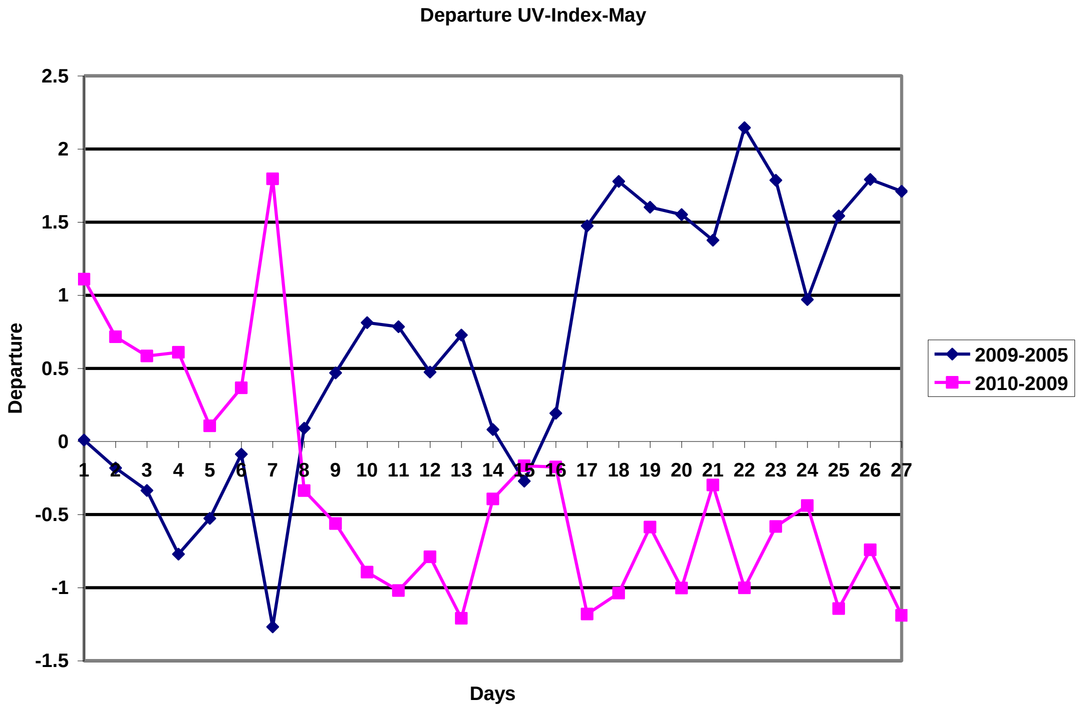

Fig 18: OMI UV Index Departure May (2009-2005 & ,2010-2005)

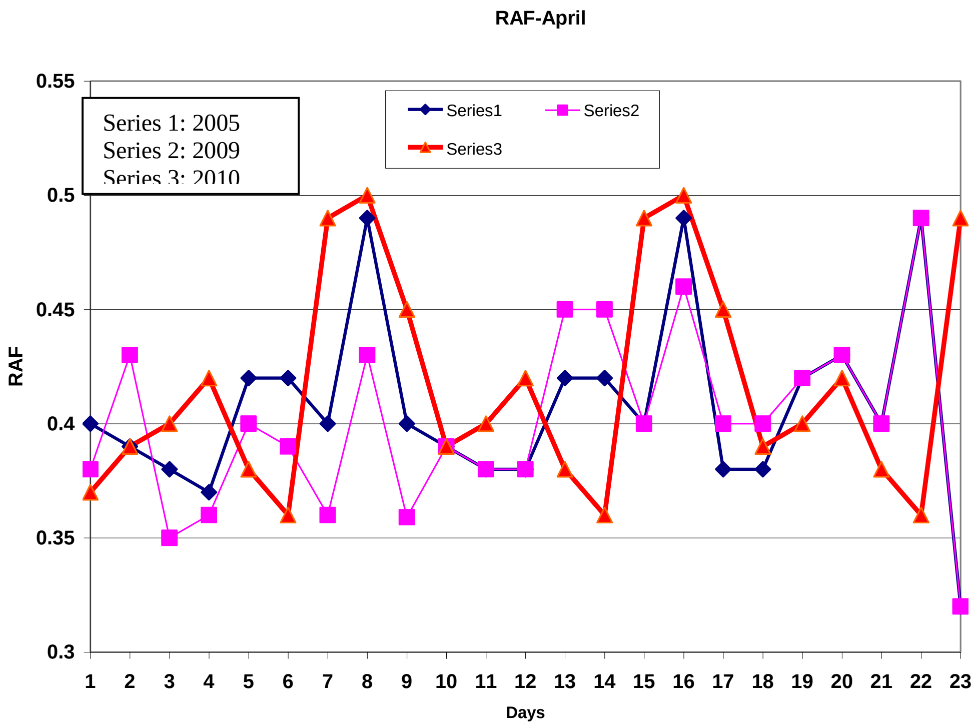

Fig 19: Radiation Amplification Factor (RAF) of April (2005, 2009 & 2010)

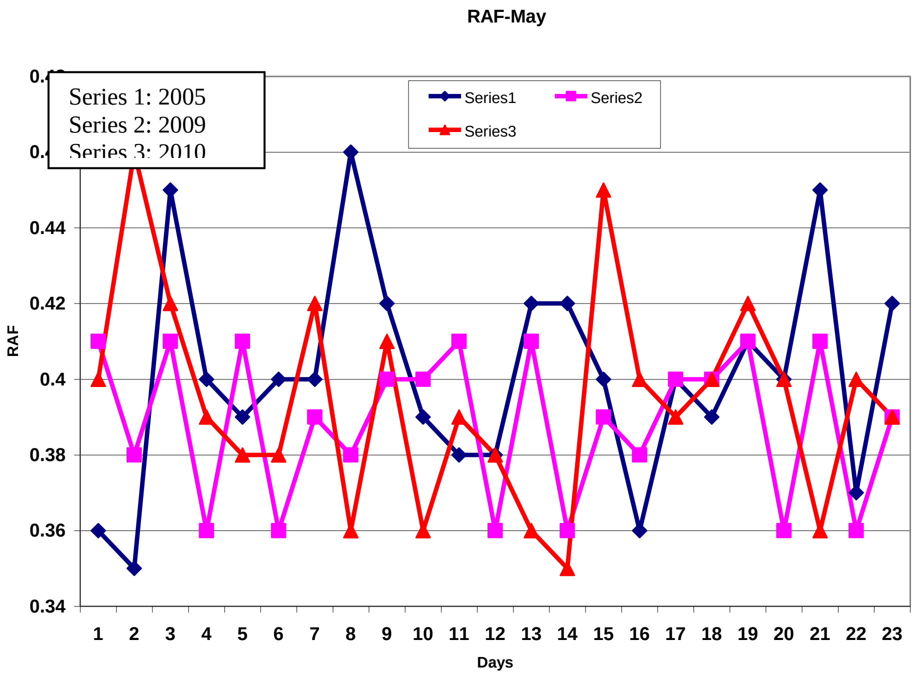

Fig 20: Radiation Amplification Factor (RAF) of May (2005, 2009 & 2010)

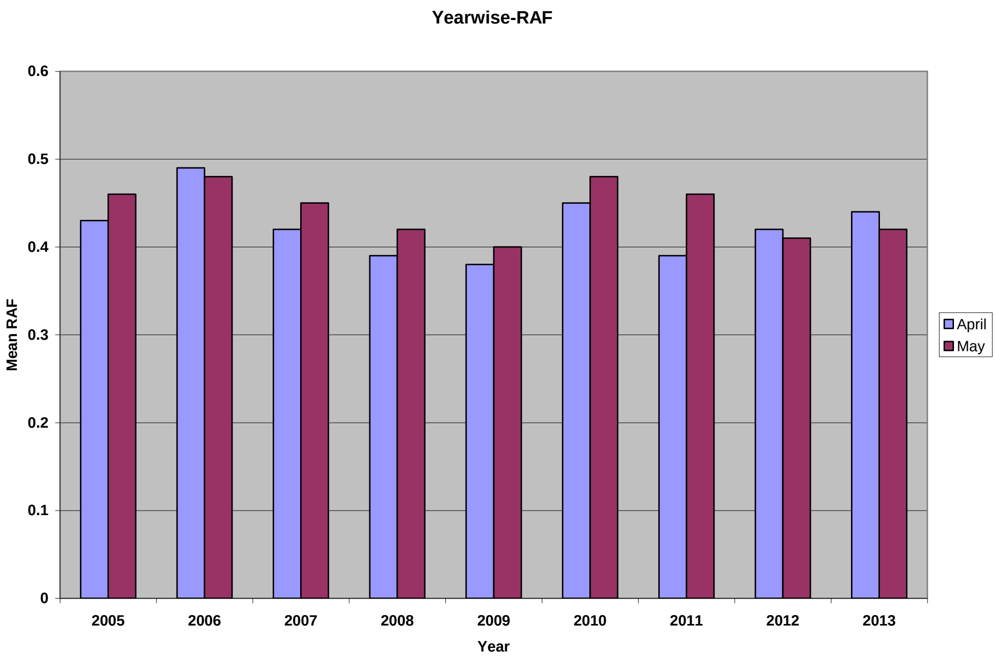

Fig 21: Radiation Amplification Factor (RAF) of the years 2005 to 2013 (April & May)

ACKNOWLEDGEMENT:

Authors are useful for Giovanni global web site for providing the valuable data for the study.

REFERENCES:

1. Molina, M. J. & Rowland, F. S (1974): *Nature* 249,1, 810–812.

2. National Research Council, 1979: Human health effects. Chapter 3 in *Protection against depletion of stratospheric ozone by chlorofluorocarbons*, Washington, D.C.: National Academy of Sciences, 74-119
3. *Panel on Stratospheric Chemistry and Transport, (1979) :Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport* ,National Academy of Sciences, Washington DC, 238
4. Gerstl,S.A.W, Zardecki,A & Wiser, H.L (1981): Biologically damaging radiation amplified by ozone depletions, *Nature* 294, 352 – 354 ; doi:10.1038/294352a0
5. Martyn M. Caldwell, (1982): Dosage Units for Biologically Effective UV-B: A Recommendation (The role of Solar Ultraviolet Radiation in Marine Ecosystems, NATO Conference Series 7), 167-168.
6. Karman, J. C., Gardiner. H and Shanklin, J. D. (1985): Large losses of total ozone in Antarctica reveal seasonal ClOx /NOx interactions. Nature (I mid.). 315: 207-210.
7. Stolarski, R. S (1988): The Antarctic ozone hole. Sci. Am., 258:20-26.
8. Lindley, D (1988): CFCs cause part of global ozone decline. Nature (Lond.), 323:293.
9. Barrett, J. W., Solomon, P. M., de Zafra, R. L., Jaramillo, M., Emmons, L., and Parrish (1988): A. Formation of the Antarctic ozone hole by the ClO dimmer mechanism. Nature (Lond.), 336:455-458.
10. Booth, C.R., and S. Madronich, (1994) Radiation amplification factors: Improved formulation accounts for large increases in ultraviolet radiation associated with Antarctic ozone depletion, in Ultraviolet Radiation in Antarctica: Measurement and Biological Effects, edited by C.S. Weiler and P.S. Penhale, *AGU Antarct. Res. Ser.*, *62*, 39-52.
11. WMO (World Meteorological Organization), (2008) Instruments to Measure Solar Ultraviolet Radiation – Part 2: Broadband Instruments Measuring Erythemally Weighted Solar Irradiance, WMO TD No. 1289, G. Seckmeyer, A. Bais, G. Bernhard, M. Blumthaler, C.R. Booth, K. Lantz, and R.L. McKenzie, 55 pp., Geneva, Switzerland, available: http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html.
12. Gerstl, S.A.W, Zardecki, A & Wiser, H.L, (1981), biologically damaging radiation amplified by ozone depletions, Nature 294**,** 352 - 354; doi: 10.1038/294352a0