International Journal of Pure and Applied Physics
ISSN 0973-1776 Volume 5, Number 3 (2009), pp. 183–194

http://www.ripublication.com/ijpap.htm

Total Column Ozone Measurements at Visakhapatnam Using Microtops - II Sun-photometer

G. Bharathi and B. Mahendranath

Department of Meteorology & Oceanography, Andhra University,
Visakhapatnamt-530003, A.P., India
E-mail: mahendranth@gmail.com

Abstract

The results of the continuing systematic measurements of the total column ozone over Visakhapatnam are given. It has been shown that the total column ozone varies within a wide range during a day, a season, and from year to year. It is found that the total column ozone is minimum in winter and maximum in summer. Measurements of atmospheric total column ozone over Visakhapatnam (17.43N, 83.14E) are being carried out first time using Microtops – II (sun photometer) for the period from February 2005 to till date, but the results are presented for three years (i.e.) from February 2005 to December 2007, to study the systematic behavior of the total column ozone. The data obtained during the study period, have been analyzed to study diurnal and seasonal variations of the total column ozone over Visakhapatnam. The results show that the total column ozone is maximum at noon time and minimum in the evening time in almost all the cloud free days. The daily and seasonal variations of total column ozone over Visakhapatnam indicate that total ozone values are low in winter season and high in summer season. It is observed that the monthly averaged column ozone over Visakhapatnam is maximum (336.0Du (Dobson Units)) in May and minimum (273.8 Du) in December. The monthly variations in the column ozone mostly depend on temperature which controls the chemical and dynamical processes related to the photochemical reactions in the atmosphere.

Keywords: Total Column Ozone, Sun-Photometer, Dobson Unit (DU), diurnal and seasonal variations.

Introduction

Ozone is one of the naturally occurring trace gas that make up our atmosphere. The atmosphere serves three critical functions: it provides life-giving oxygen, keeps the earth warm, and protects us from deadly ultraviolet (UV) radiation from the sun. Most of the atmosphere consists of nitrogen and oxygen (the air we breathe). These gases do not hold heat so they do not keep us warm. They also do not protect the earth from UV rays. For those functions you have to turn to the trace gases found in the atmosphere, commonly referred to as greenhouse gases. They are: water vapor, carbon dioxide, methane, ozone, and nitrous oxide. These trace gases function like the transparent covering of a greenhouse, allowing sunlight to filter through to the earth's surface, and then trapping the heat. Without the greenhouse effect the earth's temperature would drop far below zero each night. One of the most important constituents in the middle atmosphere is ozone, because it is the only atmospheric species that effectively absorbs ultraviolet solar radiation from 2000 ^{0}A to 3000 ^{0}A, protecting plant and animal life from exposure to harmful radiation. (Brasseur & Solomon1986).

Ozone is the key trace constituent that participates in the chemistry and radiation of the earth’s middle atmosphere. Hence a decrease in stratospheric ozone will result in increase in ultraviolet B radiation, which will have negative impacts on human health. UV rays are associated with skin cancer. The "UV index" is used in summer months to let people know how long it is safe to stay in the sun. A decrease in the ozone correlates to an increase in skin cancer. This is important because the ozone has been in a steady rate of depletion and holes in the upper ozone layer have developed. However as ozone is toxic to the living system (Nandita D.Ganguly and K.N.Iyer 2005). Thus there is a great need to monitor the atmospheric ozone concentration.

The significant depletion of the stratospheric ozone layer, which shields the earth from much of the biologically effective solar ultra-violet radiation, is mainly due to anthropogenic activity on the earth. This has become a major scientific concern (Bener 1972; Dave and Halpern 1976; Halpern et al. 1974). Solar radiation is unevenly distributed throughout the world and it shows wide variability with latitude, altitude and season in addition to its dependence on ozone and other factors like solar zenith angle, air pollution, humidity, clouds etc. Since solar ultraviolet radiation is the prime energy source, its variability is expected to cause changes in the atmospheric temperature (Brasseur and Simon 1981). It is reported that a 1% decrease in stratospheric ozone could cause about 2% increase in UV-B radiation (Cutchis 1974). This increase may vary depending on specific wavelength, season and solar zenith angle (Bais et al. 1994).

About Instrument

The Microtops II Sun photometer is a portable instrument (Morys et al., 2001). It is designed for use as a hand-held manually operated instrument. The physical and operational characteristics of the instrument are detailed in the ‘‘User’s Guide,’’ which is publicly accessible on the Internet (http://www.solar.com/manuals.htm). The Sun photometer measures solar radiance in five spectral wave bands from which it automatically derives Total columnar ozone. The five wavelengths may be specified while ordering the instrument, such that appropriate filters are custom designed and installed by the manufacturer.

Experimental set-up

The MICROTOPS-II is a five-channel hand-held microprocessor based sun-photometer with a full field of view of $2.5^{0.}$ The instrument has five optical collimators aligned to aim in the same direction. A narrow-band interference filter and photodiode suitable for the particular wavelength range are fitted with every channel. All the channels face directly the solar disc simultaneously, when the image of the sun is centered at the cross-hairs of the sun target. When the radiation capture by the collimators falls on to the photodiodes, it produces an electrical current proportional to the received radiant power, which is amplified and is converted into digital form in a high resolution A/D converter. Signals are processed in a series of 20 conversions per second. Out of the five channels at 305, 312, 320, 940 and 1020nm, the first three filter channels are used to derive atmospheric total column ozone and the other two for water vapour and aerosol optical thickness.

Data and analysis

The total column amount of ozone at Visakhapatnam and its variations have been studied using Ozone Monitor sun-photometer (Microtops - II) data respectively over the period from 2005 Feb to 2007 Dec. The columnar unit of ozone is measured in Dobson unit (DU). It represents the height of a stack of ozone molecules at the surface of the Earth at 00 C and 760 mm of Hg, collected from a column of air above the stack. It cannot measure nighttime ozone. This technique works only during daytime and can be used to measure total ozone columns and vertical distribution. A hot summer and dryness in non- rainy seasons characterize the climate of Visakhapatnam.

Results and Discussion

Diurnal variation

The effect of photochemical production of ozone on diurnal variations in the total column ozone is observed every day. The total column ozone maximum is observed between 11:30 and 12:30 IST and the minimum in the evening time. It is observed that the evening time total column ozone lies within the range of 260 to 290 Du throughout the year except in May where the average is about 300 Du. It is noted that the total column ozone decreases rapidly in the evening time mostly in the dry season, whereas it decreases gradually in the wet season. The rapid increase in the total column ozone is observed after sunrise and may be attributed to vertical mixing. During the period from 2005 to 2007 it is observed that the diurnal variation of total column ozone is increasing from February to May after that it shows a decreasing trend up to the month of December. This type of increasing and decreasing trend is continued to all the observed years but the amount of total column ozone has been changing year by year.

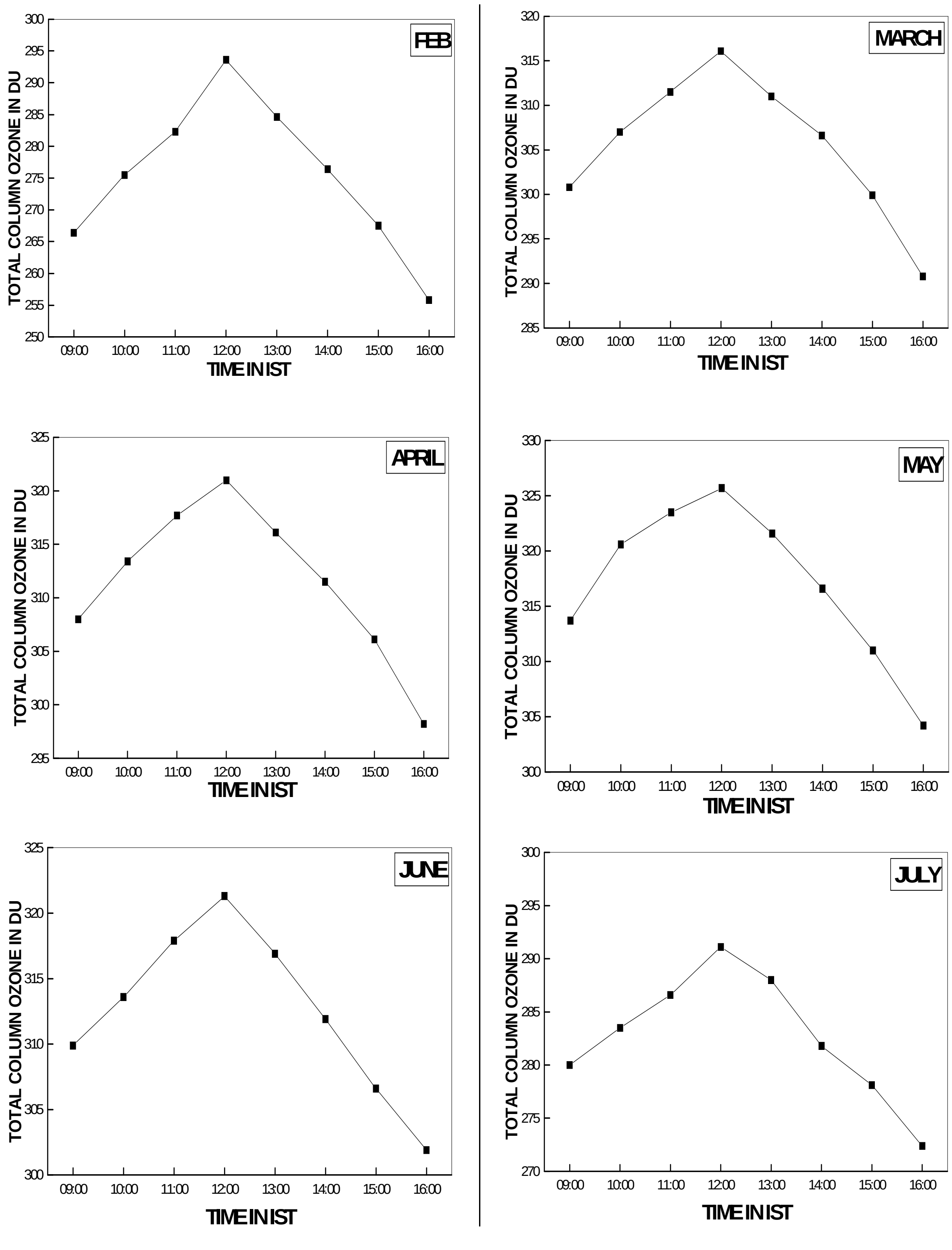
Seasonal variation

The monthly mean total column ozone data shows seasonal variations in the similar manner in every year with maximum in summer, whereas it decreases during monsoon and reaches minimum in December. Thereafter it gradually increases throughout the winter and reaches the peak in summer. This trend is consistently observed in all the years from 2005 to 2007. The monthly mean Total Column Ozone data values are plotted against months for the years Feb.2005 to Dec.2007. (Fig.2). Chakrabarty & Chakrabarty (1979) have observed similar results for other Indian stations. Table 1 gives the monthly averaged values of total column ozone at Visakhapatnam during the period from 2005 to 2007.

The amount of total column ozone is found to be increased in 2006 compared to the year 2005 and it slightly decreased in 2007 as compared to 2006. It is observed that the amount of annual mean total column ozone is 300.0 Du in 2005, 316.2 Du in 2006 and 315.6 Du in 2007. The variations in the total column ozone (low/ high) would be caused by chemical and dynamic destruction processes related to the low/ high temperatures and weak/ active photochemical reactions due to less/ high intense solar radiation. The annual variations in the temperature over the earth's surface are controlled by the sun-earth relationship. The same mechanism controls variations in the ozone production/ loss in the atmosphere.

Table 1: Monthly averaged values of Total Column Ozone in Du at Visakhapatnam from February 2005 to December 2007.

MONTH	2005 (Du)	2006 (Du)	2007 (Du)
JAN		*301.1*	*301.8*
FEB	275.3	311.1	307.6
MAR	305.3	325.2	315.1
APR	311.8	330.1	331.5
MAY	316.6	336.0	336.6
JUN	313.5	324.0	325.7
JUL	299.4	323.0	323.1
AUG			
SEP	294.6	317.1	318.4
OCT	291.0	313.2	313.2
NOV	288.0	299.4	300.3
DEC	287.0	298.5	298.3


FEB
MARCH
APRIL
MAY
JUNE
JULY
TOTAL COLUMN OZONE IN DU
TIME IN IST
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00

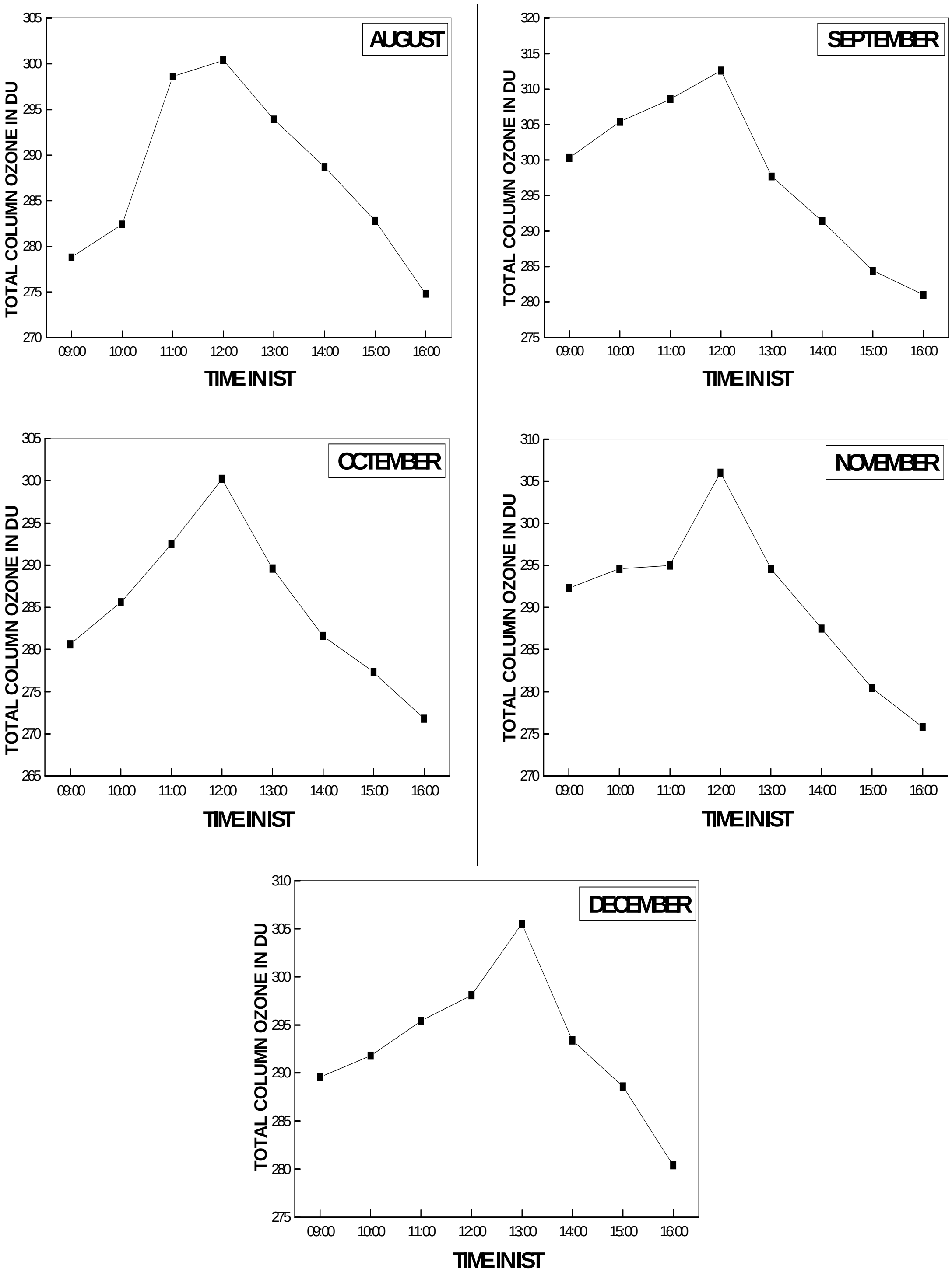
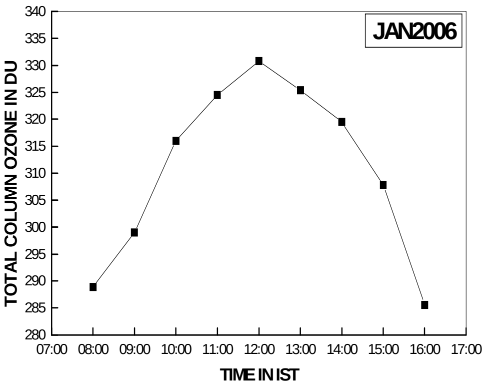
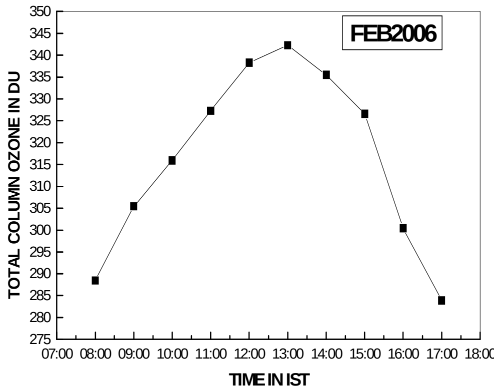
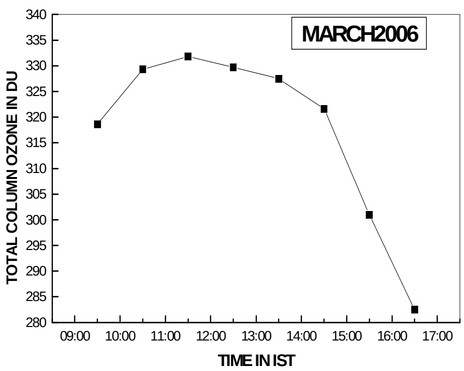
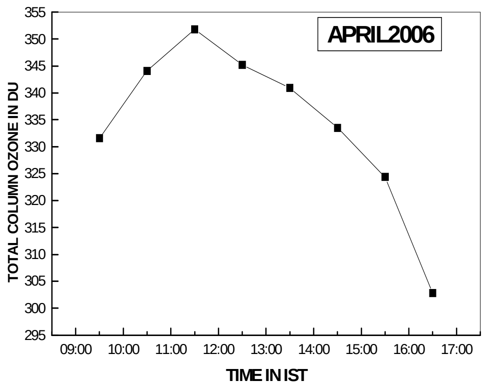


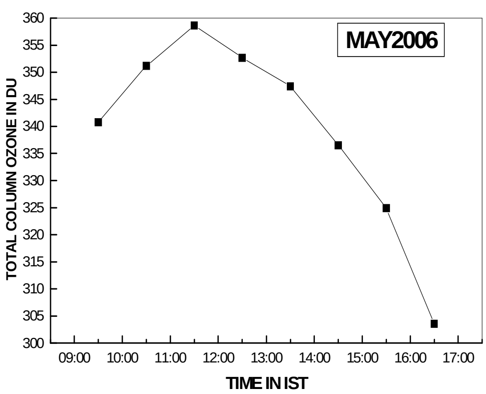
Figure 1a: Diurnal variations of Total column ozone at Visakhapatnam during the year 2005.

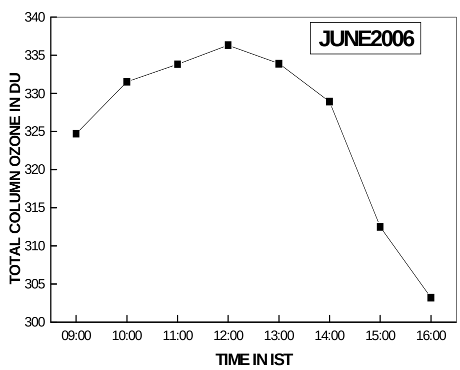

JAN2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
280 285 290 295 300 305 310 315 320 325 330 335 340
07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00

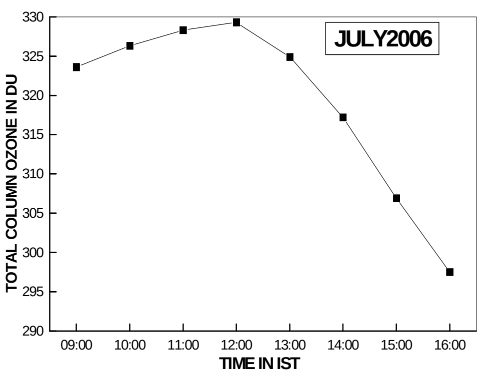

FEB2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350
07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00

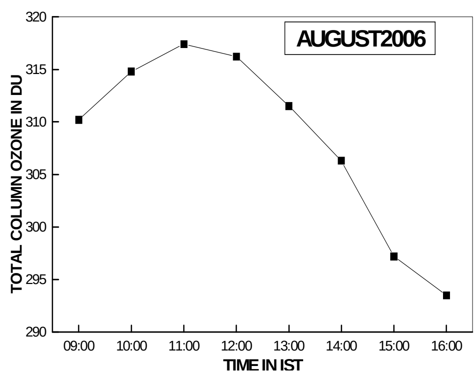

MARCH2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
280 285 290 295 300 305 310 315 320 325 330 335 340
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00


APRIL2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
295 300 305 310 315 320 325 330 335 340 345 350 355
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00


MAY2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
300 305 310 315 320 325 330 335 340 345 350 355 360
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00


JUNE2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
300 305 310 315 320 325 330 335 340
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00


JULY2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
290 295 300 305 310 315 320 325 330
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00


AUGUST2006
TOTAL COLUMN OZONE IN DU
TIME IN IST
290 295 300 305 310 315 320
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00

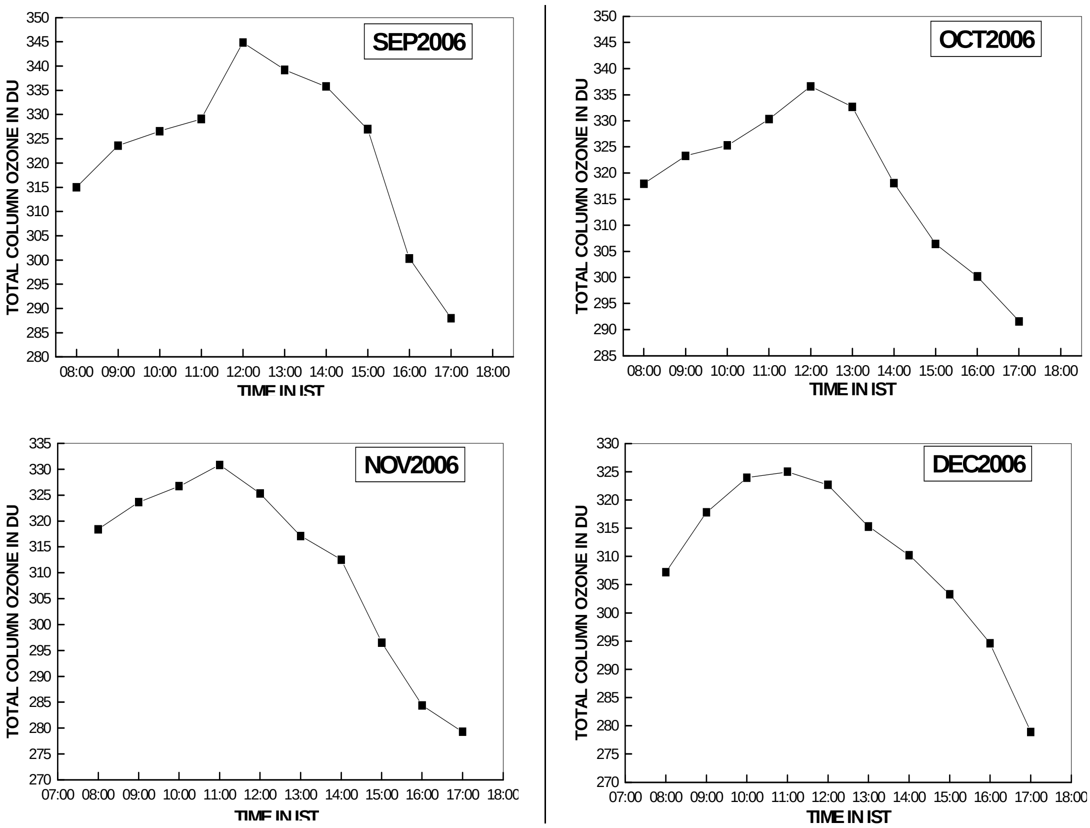
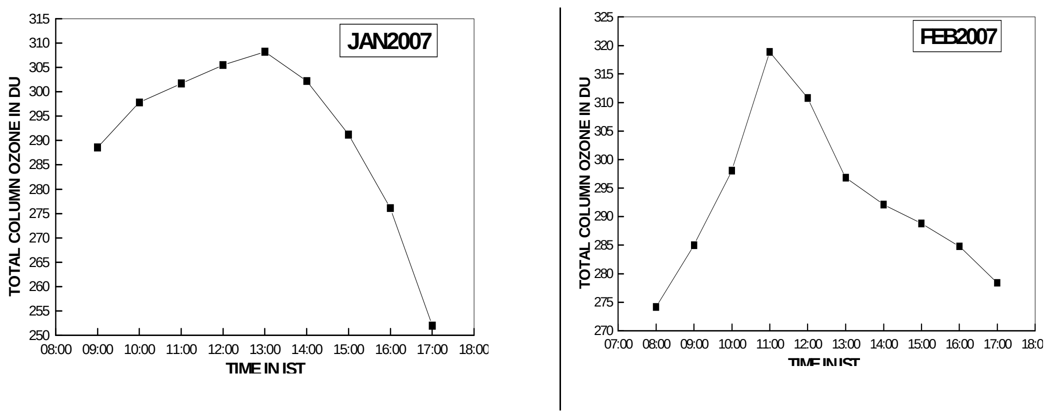
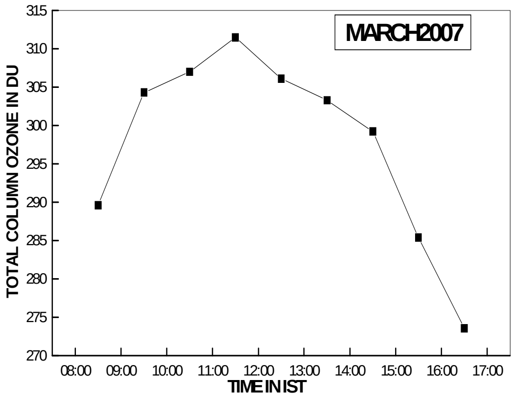
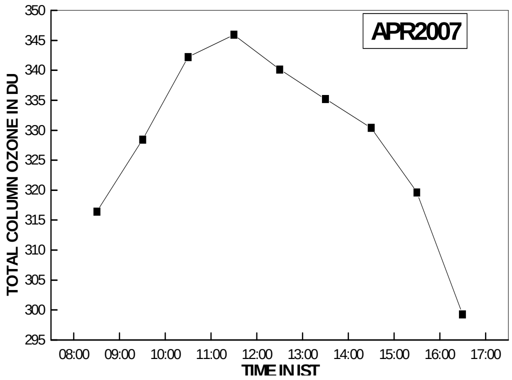
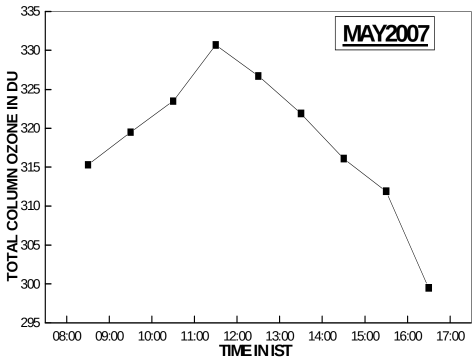


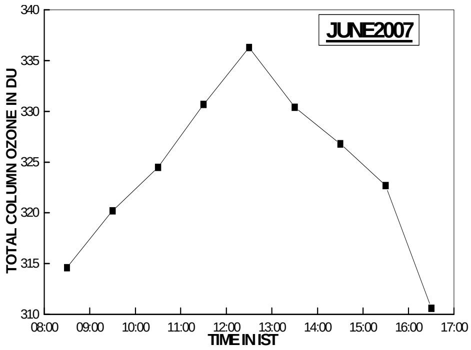
Figure 1b: Diurnal variations of Total column ozone at Visakhapatnam during the year 2006.

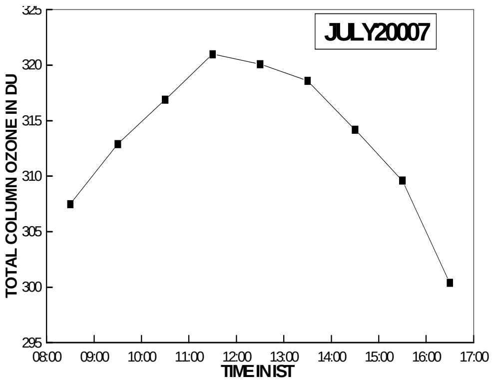


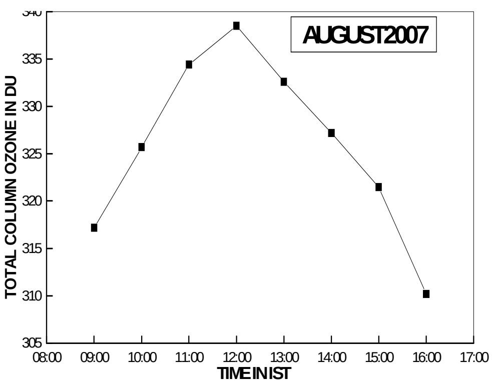

MARCH2007
TOTAL COLUMN OZONE IN DU
270 275 280 285 290 295 300 305 310 315
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST

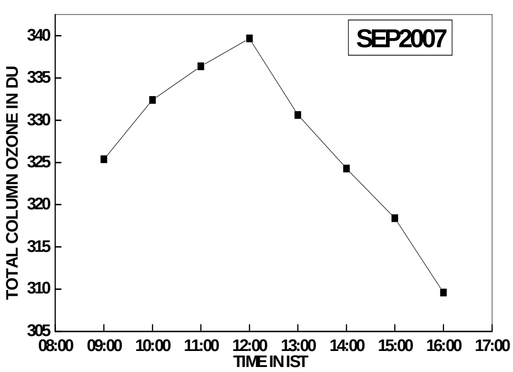

APR2007
TOTAL COLUMN OZONE IN DU
295 300 305 310 315 320 325 330 335 340 345 350
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST

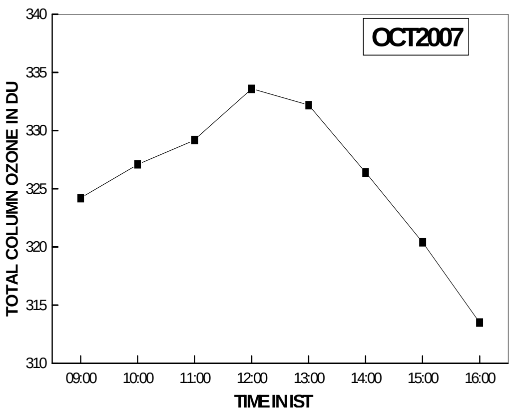

MAY2007
TOTAL COLUMN OZONE IN DU
295 300 305 310 315 320 325 330 335
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST


JUNE2007
TOTAL COLUMN OZONE IN DU
310 315 320 325 330 335 340
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST


JULY20007
TOTAL COLUMN OZONE IN DU
295 300 305 310 315 320
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST


AUGUST2007
TOTAL COLUMN OZONE IN DU
305 310 315 320 325 330 335
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST


SEP2007
TOTAL COLUMN OZONE IN DU
305 310 315 320 325 330 335 340
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00
TIME IN IST


OCT2007
TOTAL COLUMN OZONE IN DU
310 315 320 325 330 335 340
09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00
TIME IN IST

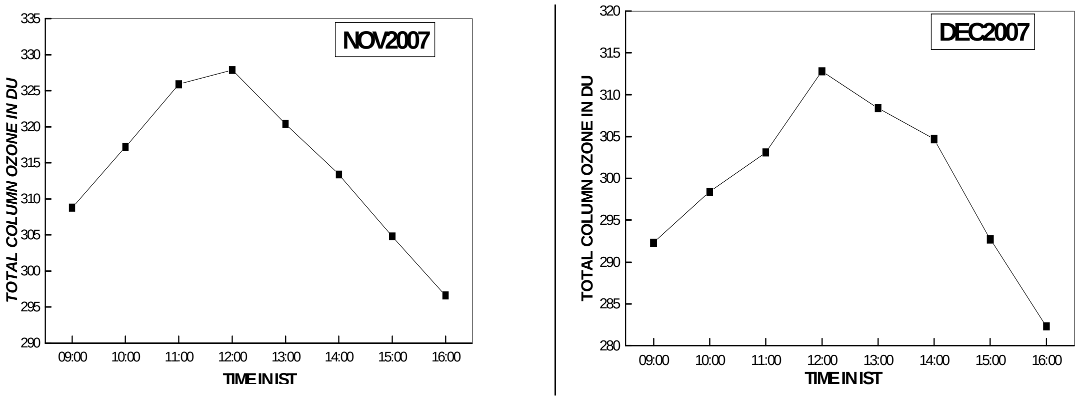


Figure 1c: Diurnal variations of Total column ozone at Visakhapatnam during the year 2007.

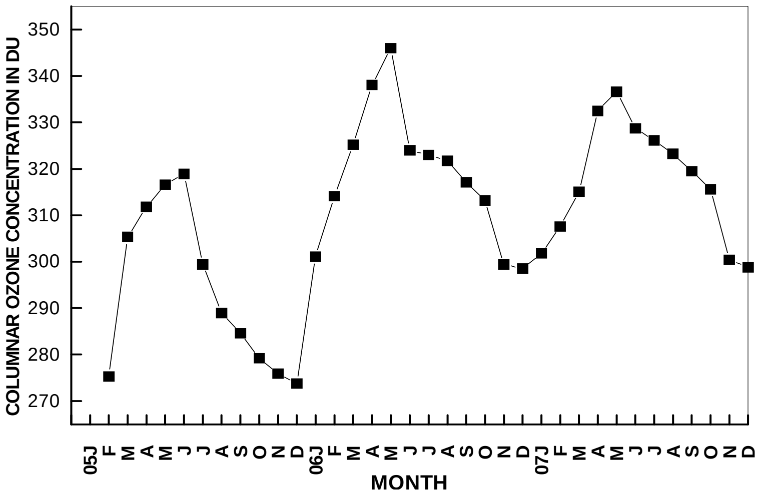


Figure 2: Total columnar ozone measured by Microtops – II at Visakhapatnam from February 2005 to December2007.

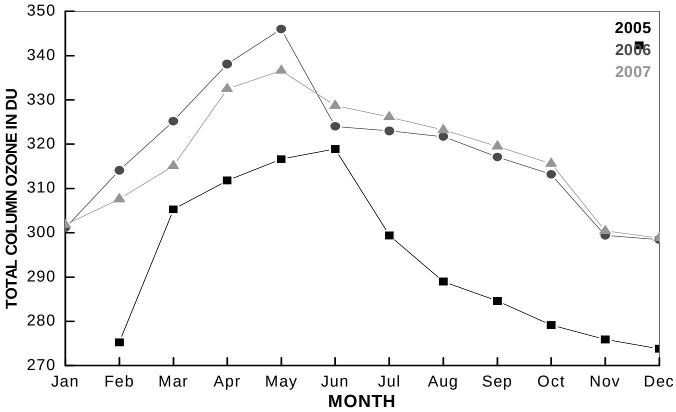


Figure 3: Variation of total column ozone from Feb-2005 to Dec-2007 observations at Visakhapatnam.

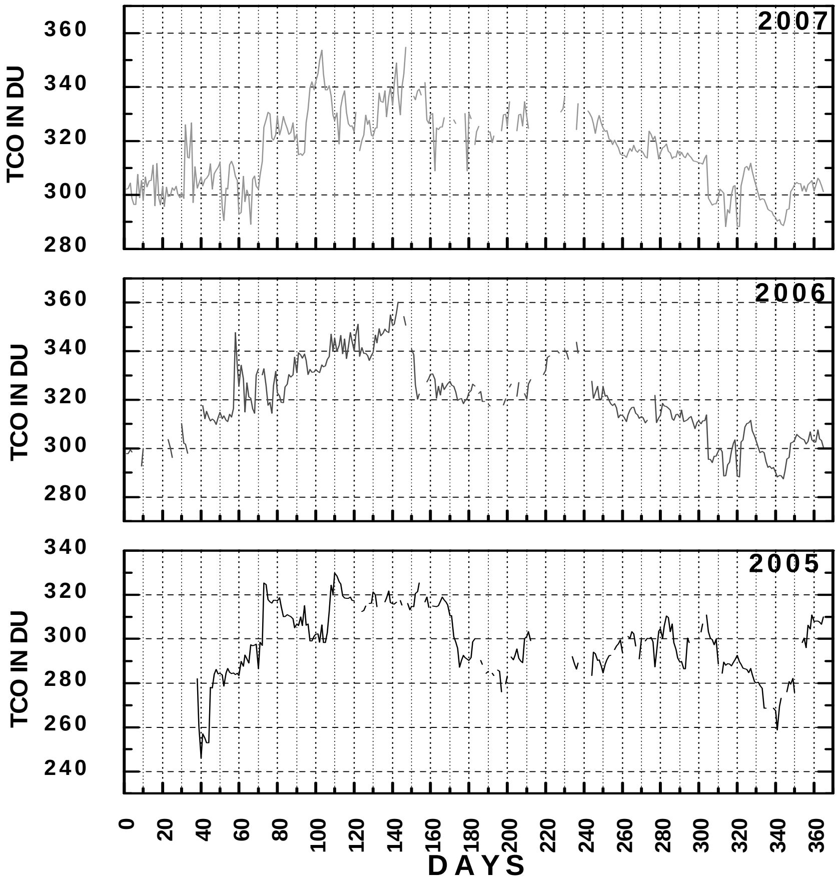


Figure 4: The trend in columnar ozone for the period 2005 to 2007 observations at Visakhapatnam.

Acknowledgements

The authors sincerely acknowledges the Department of Science and Technology (DST), New Delhi for providing the Equipment under FIST programme.

References

[1] Bener, P., 1972: Approximate values of intensity of natural UV radiation for different amounts of atmospheric ozone. Final Tech. Report, US Army, Contract DAJA37-68-C-1017, European Research Office, US Army, London, GBR

[2] Bais, A.F., C. S. Zerefos, C. Meleti, I. C. Ziomas, K. Tourpali, V. Karaouza, and D. Balis, 1993: Variability of solar UV-B radiation at high and middle latitudes during EASOE 1991/92. Journal of Geophysical Research., **98**, 5199-5204.

[3] Brasseur, G. & Solomon, S., 1986. Aeronomy of the middle atmosphere, D.Reidel Publishing Company.

[4] Brasseur, G, and P. C. Simon, 1981: Stratospheric Chemical and Thermal Response to Long-Term Variability in Solar UV Irradiance. Journal of Geophysical Research., 86, 7343-7362.

[5] Chakrabarty, D. K. and Chakrabarty, P., 1979. Ozone results from Indian stations using Dobson instruments, Proceedings of the NATO advanced institute on Atmospheric Ozone, 123-127.

[6] Cutchis, P., 1974: Stratospheric ozone depletion and solar ultraviolet radiation on earth. Science.

[7] Dave, J. V., and P. Halpern, 1976: Effect of changes in ozone amount on the ultraviolet radiation received at sea level of a model atmosphere. Atmospheric and Environment. **10**, 547-555.

[8] Frost, G.J., Trainer, M., Allwine, E., Buhr, M., Calvert, J., Cantrell, C., Fehsenfeld, F., Goldan, P., Herwehe, J. and Hu¨ Bler, G., et al., 1998, Photochemical ozone production in the rural southeastern United States during the 1990 Rural Oxidants in the Southern Environment (ROSE) program. Journal of Geophysical Research, 103, pp. 22 491–22 508.

[9] Halpern, P., J. V. Dave, and N. Braslau, 1974: Sea-Level Solar Radiation in the Biologically Active Spectrum. Science, **186**, 1204-1208.

[10] Kirchhoff, V.W.J.H., 1988, Surface ozone measurements in Amazonia. Journal of Geophysical Research, 93, pp. 15 850–15 860.

[11] Khalil, M.A.K. & Rasmussen, R.A., 1994. Global decrease of atmospheric carbon monoxide. Nature, 370,639-641.

[12] Morys, M., F. M. Mims III, S. Hagerup, S. E. Anderson, A. Baker, J. Kia, and T. Walkup, Design, calibration, and performance of Microtops II handheld ozone monitor and Sun photometer, Journal of Geophysical Research., 106, 14,573–14,582, 2001.

[13] Nandita D.Ganguly and K.N.Iyer., 2005. Study of variations in Columnar Ozone Concentration at Rajkot, Journal of Indian Geophysical Union. Vol.9, No.3, pp.189-196

[14] Subbaraya, B.H. & Lal, S., August 1999. Space Research in India: Accomplishments and Prospects.PRL Alumni Association, Ahmedabad.p.1, 9.

[15] World Meteorological Organization, 1989, Scientific Assessment of Stratospheric Ozone, WMO Report No.20.