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Total Column Ozone over Kathmandu using OMI Satellite

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1. Introduction

Monitoring Ultraviolet Radiation and Ozone measurements is necessary to establish the UV environment at a place. Humans are exposed to solar UV during their daily activities in different ways. The interactions between solar UV and clouds, ozone, aerosols and so on can be understood with a large number of sites equipped with a well calibrated UV and Ozone measuring instruments (Bais et al., 1993). The importance of harmful solar radiation, solar UV, for living organisms and its relation with atmospheric total ozone content stimulate work in this field (Mendeva et al., 2005).

Ozone in the stratosphere is the major atmospheric absorber of solar ultraviolet radiation (UV) that can be transmitted through the atmosphere. The observed decrease in ozone column in recent decades is expected to lead to an increase in UVB levels at the earth's surface (Farman et al., 1985; WMO, 2003; Kerr, 2003). The increase in UV dose on the ground leads to a number of negative health and environmental effects which include higher incidence of skin cancer, cataracts and reduced biomass production (Leun and Gruijl, 1993; Caldwell et al., 1998; Urbach, 1997).

Changes in ozone column play a significant role in the variability of UV dose at the surface of the earth, along with solar elevation, aerosols, clouds, ground albedo and altitude. Although the inversely proportional correlation of ozone column with surface UV level is well established, the effects of clouds, aerosols and albedo are complicated (Kerr, 2003; Grant and Heisler, 2000). In sub arctic regions the amount of total ozone decreases rapidly with increasing altitude up to 7 km above sea level (Gelsor, 2004). This indicates that for a higher altitude, the amount of total ozone column is lower, leading to higher UV doses at such high altitude surfaces. Furthermore, the higher the altitude is, the drier and the less polluted the air is, which causes higher UV radiation level at ground.

UV radiation at ground level can be measured with a variety of ground based instruments. However, these instruments are not widely distributed globally. Because of this, estimates of surface UV radiation based on satellite data have been extensively used over the past years to establish global UV climatology and to study trends due to stratospheric ozone depletion (Arola et al., 2005; McKenzie et al., 2001; Kalliskkota et al., 2000; Peeters et al., 2000; Krotkov et al., 1998). On the basis of satellite intercomparison with ground based data, TOMS retrievals are in agreement with ground based measurements at dry sites (McKenzie et al., 2001). However, satellite data systematically overestimates UV doses in more polluted locations (McKenzie et al., 2001; Kalliskkota et al., 2000; Arola et al., 2004).

There is no long term monitoring record of total column Ozone or UV in Kathmandu, the capital city of Nepal. The continuous monitoring of solar UV with NILU UV meters was started recently in 2008. However, longer term data of Ozone and solar UV is available from the OMI satellite, started in 2006. Total ozone column has not been studied on a long term.

Such kind of investigations at low latitudes, which are densely populated, is of primary importance. This paper presents results of Total Ozone column data from OMI. The ground based measured Ozone column is also compared with OMI.

2. Methods

The one minute average spectra obtained in all sky conditions by a broadband multifilter instrument, NILU UV SN 136 was operated in Kathmandu at Pulchowk Campus, 27.72N, 85.32 E. This instrument was calibrated in May 2008 by the manufacturer. The total ozone content is calculated using an algorithm based on the Beer's law.

The OMI satellite ozone data for Kathmandu was requested from NASA. This data is available since 2006. Since the satellite overpass mostly once over Kathmandu, the ozone is retrieved with an algorithm with irradiances at two wavelengths, one that is UV absorbing and other not. More information on satellite methodology is available at the NASA webpage.

3. Results and Discussion

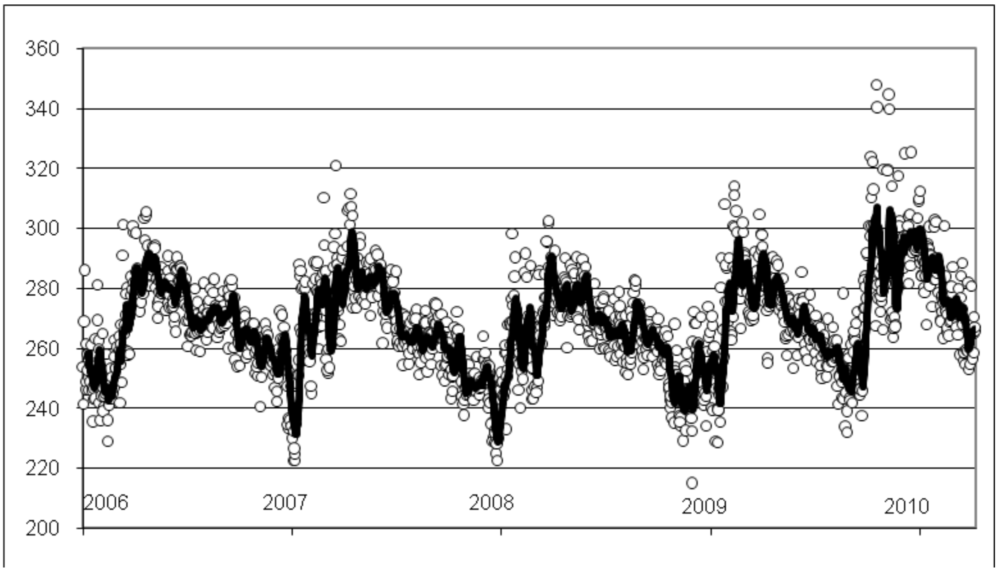

Figure 1. Day to day variation in TOC estimated from OMI. The thick line is the 10 day moving average.

The results of satellite derived Total Ozone Concentration (TOC) is shown in figure 1. The 10 day running average TOC values are also shown in the same figure. The highest ozone concentration is during May in Kathmandu. The lowest value of TOC is in January. The least ozone concentration during May was recorded in 2008. Since then the TOC was increased about 4.3%. Figure 2 shows the TOC averaged for each month during the study period from 2006 to October 2010. It is to be noted here that the value of total column ozone has increased since 2008.

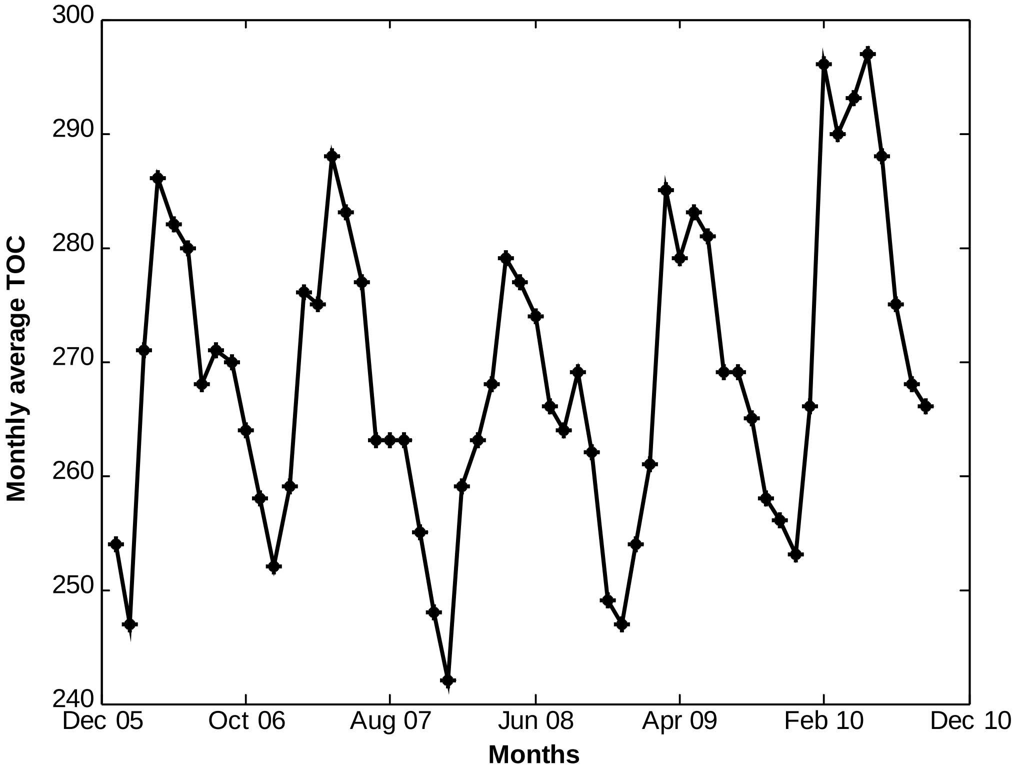

Figure 2. Monthly averaged TOC from 2006 to 2010.

In order to validate the satellite estimation, a comparison with ground data must be made. As mentioned earlier the NILU-UV was operated since August 2008. By the measurement of UV irradiance at 305 nm and at 320 nm, one can evaluate the total ozone column (Dahlback, 1996). In this way the ozone concentration over Kathmandu was compared with OMI data for the mentioned period (figure 3). It is observed that on most days the ground measured ozone level and satellite derived ozone concentration matches. For ground based TOC values, the obtained values are averaged for one hour mid-day when the OMI satellite passes over Kathmandu. The compared TOC from these two methods is shown in figure 4. The thick solid line in figure 4 is a one to one plot. Most of the data lies above the ideal line indicating the OMI derived ozone is higher that the ground measured data by about 4%. However, on a few days the data does not agree that much with the ground measured ozone column.

A bar plot of monthly averaged ozone column from 2008 to late 2010 over Kathmandu is plotted in figure 5. The figure indicates the highest ozone level in Kathmandu is in the month of April. This is nearly equal to the figure 1 result of May. The result also shows the average value of TOC in Kathmandu is about 268 DU as indicated in figure 5.

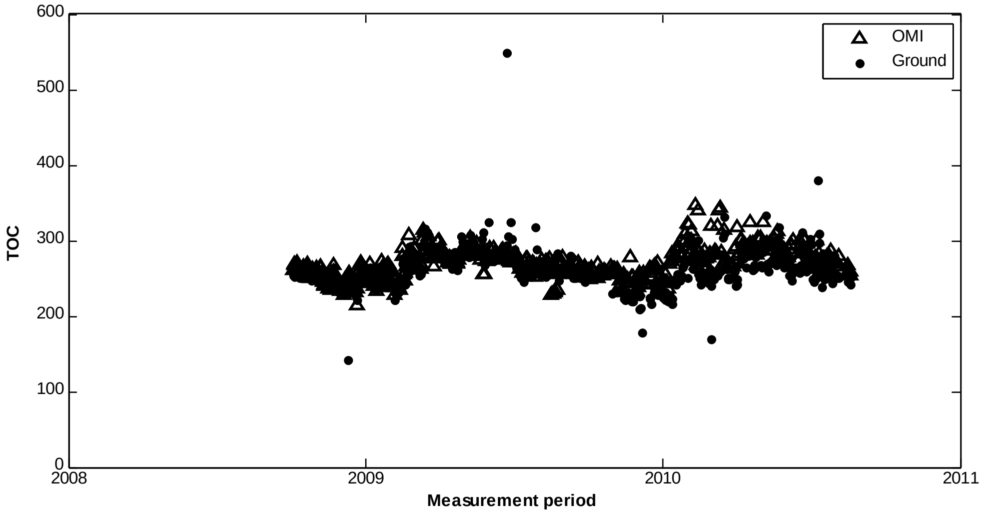

Figure 3. A plot of satellite and ground measured ozone concentration.

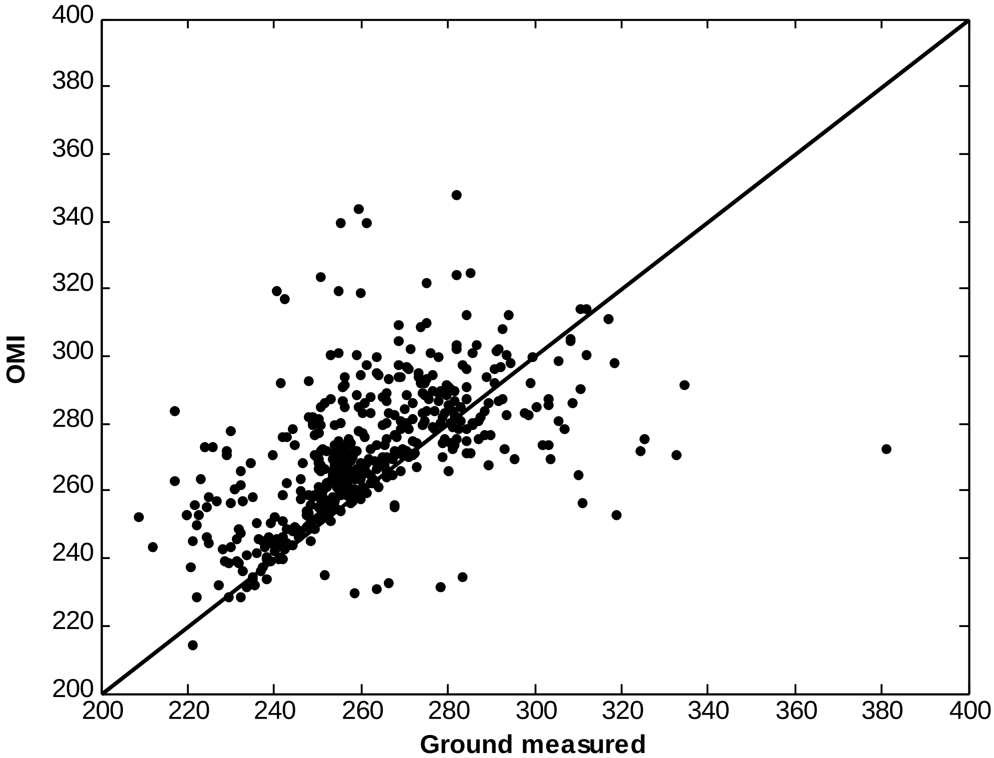

Figure 4. Comparison of satellite and ground measured TOC over Kathmandu.

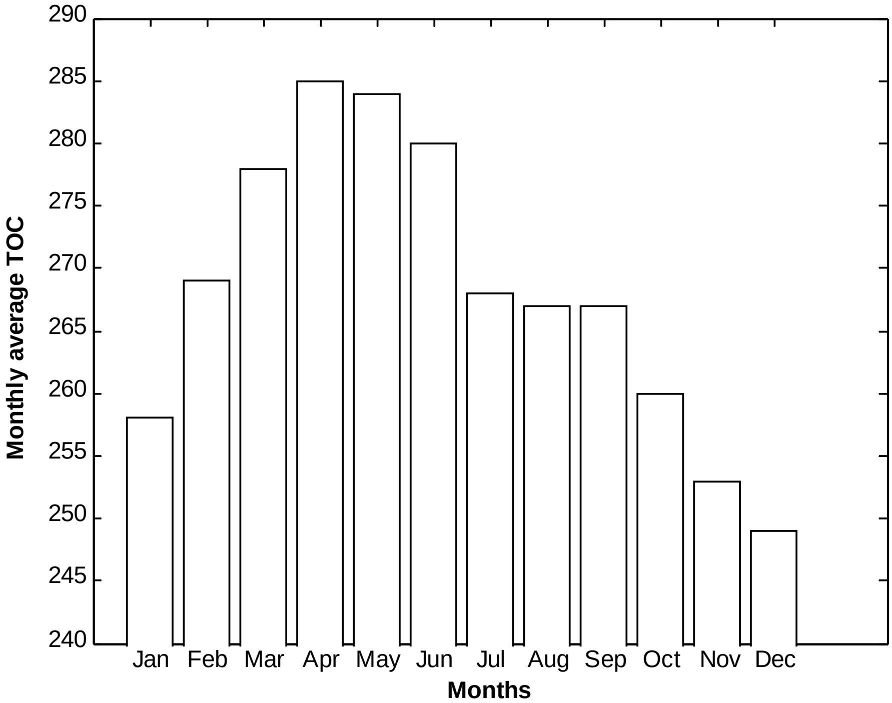

Figure 5. Monthly variation in OMI estimated TOC.

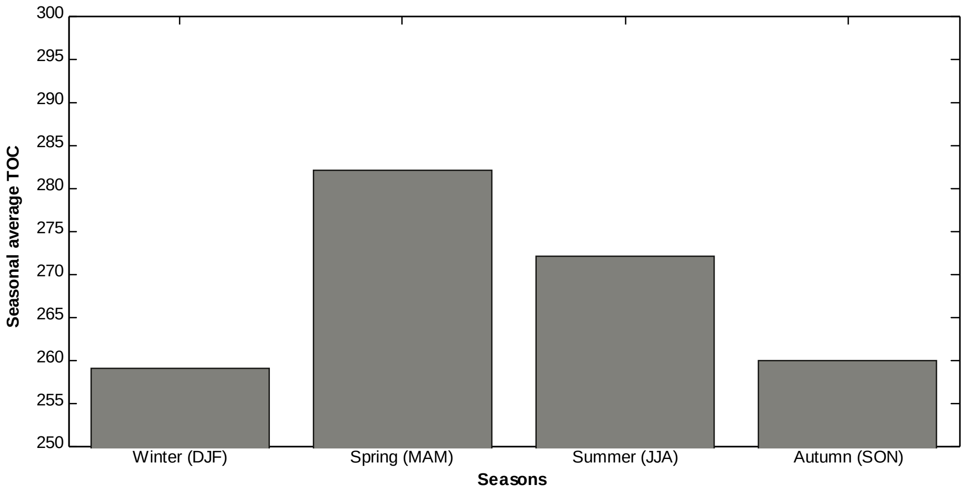

Figure 6. Seasonal variation in TOC estimated from OMI.

An attempt was made to find the seasonal variation of ozone concentration in Kathmandu using the OMI overpass data from 2006 to 2010. It is found that the lowest ozone concentration is during winter season in the month of December, January and February as around 259 DU. Similarly the highest ozone value was in the spring season, 282 DU, during March, April and May months. The summer and autumn TOC, 272 DU and 260 DU, lies in between the winter and spring season values. This analysis shows the winter and autumn TOC in Kathmandu are nearly the same and is less than that during spring and summer.

4. Conclusions

The results of the OMI derived ozone level over Kathmandu are in good agreement (within ±4%) with ground based measurement. For most of the days the OMI satellite overestimates the ground measured data. April and May are the months of higher ozone concentration in Kathmandu. Winter and Autumn TOC are about 11% lower than in spring and summer months. Total ozone column has increased by about 4.3% in 2010 than in the year 2008.

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