LONG TERM TRENDS IN TOTAL OZONE CONTENT AT NORTH TEMPERATE AND AN EQUATORIAL STATION.

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Abstract : *Long term trends in total ozone have been computed for different stations like North Temperate station viz. Issykul, Russia (42.62^{0}N,76.0^{0}E) and an Equatorial station viz. Nairobi Islands (1.271^{0}S , 36.83^{0}E). Using the total ozone content data obtained from the OMI database for the period 2004-2018, the ozone trends at a North temperate and an equatorial station are found to be 3.074% and 2.127 % per decade, respectively.* **.**

IndexTerms **- Total Ozone Content, solar radio emission.**

I. INTRODUCTION

Although, the role of Antarctica hole in decreasing global ozone is relatively small, the ozone hole has generated a great deal of interest. A number of scientists have been worried that ozone hole might start to appear over other areas of globe. However, the only other large scale depletion observed during Arctic spring over the North Pole is a smaller ozone dimple. Ozone mini holes and substantial depletion of ozone over vast territories of Siberia (Harris et al., 1998; Pyle et al., 1991) have been reported.
Some scientists have also reported small but positive ozone trends over the three Indian stations (Kundu et al., 1993).Observation and model studies are also now indicating that healing of ozone has now emerged (Solomon, 2016, Reinsel et.al.,2002).
Depletion of ozone leads to relative cooling (Pandey and Vyas, 2004) and increased UV radiation, which in turn would lead to serious diseases like skin cancer and eye cataract, damage to immune system, damage to aquatic ecosystem, lower productivity of crops, and adverse impact on animals (Zerefos et al., 1998; Ziemke et al., 1999).
Using multi-satellite observations the long-term data constructed from multi-satellite (Upper Atmosphere Research Satellite (UARS MLS and HALOE, 1993–2005), Aura Microwave Limb Sounder (MLS, 2004–2015), Sounding of the Atmosphere using Broadband Emission Radiometry (SABER, 2002–2015) on board TIMED (Thermosphere-Ionosphere Mesosphere Energetics Dynamics)), long-term trends in stratospheric ozone along with temperature, and water vapor over the Indian region during the time period 1993–2015 were investigated. Ozone showed a significant decreasing trend (5 % per decade) in the lower stratosphere (20 to 24 km) during 1993–2015.The trend becomes positive above 24 km over Trivandrum and New Delhi, which are near tropical stations (S.T. Akhil Raj et. al.,2018).
We have determined the recent ozone trends over stations at North temperate and an equatorial zone.

II. OBSERVATIONAL DATA & METHODOLOGY

The OMI (Ozone Mapping Instrument) is one out of the four instruments flown on board the National Aeronautics and Space Administration Earth Observing System (NASA-EOS) Aura spacecraft which was launched on 15 July, 2004 into a near polar sun-synchronous orbit at 705 km. It is a compact nadir-viewing instrument for measuring backscattered solar radiances and irradiances in the wavelength range from 270 to 500 nm with two spectral UV–visible channels spectrometer, i.e. UV (270–370 nm).The UV channels are again divided into two parts, UV-1 (270–311 nm) and UV-2(307–383 nm) and visible (350–500 nm). Detailed descriptions about the OMI are given in Dobber et al. (2006), Levelt et al. (2006) and Bak et al. (2015).

The daily values of total column ozone at different stations are obtained using OMI for the period 2004 to 2018. TOC is known to have a number of periodicities, among which the annual and quasi-biennial oscillations (QBO) are the most dominant periodicities (Angell and Korshover, 1973, Roshni Dave & R. Pandey, 2007). For any trend analysis, these periodicities need to be eliminated. Therefore, the TOC data of these stations was first subjected to a 12-month moving average. This eliminates the strong natural annual variation. The other known dominant periodicity relates to the quasi-biennial oscillation, QBO. But the period of the QBO varies from 22 months to about 30 months (Reed et al., 1961). The annually moving averaged data for each station was therefore further moving averaged as per the mean QBO periodicity of 26 months. Data thus obtained was subjected to 600 month running average (which is related to component of periodicity of solar cycle) in order to remove component of solar radio emission. Thereafter, a linear least square fit is made to the averaged data, from which percentage change of ozone per decade is obtained.

III. Results and Discussions

Figure 1 gives the daily TOC values, along with annually and QBO averaged variation for a North temperate station Issyk-kul (42.3^{0}N, 76.5^{0}E), Russia for the period 2006-2018. Annual variation is clearly seen in the top panel of the figure. TOC value can

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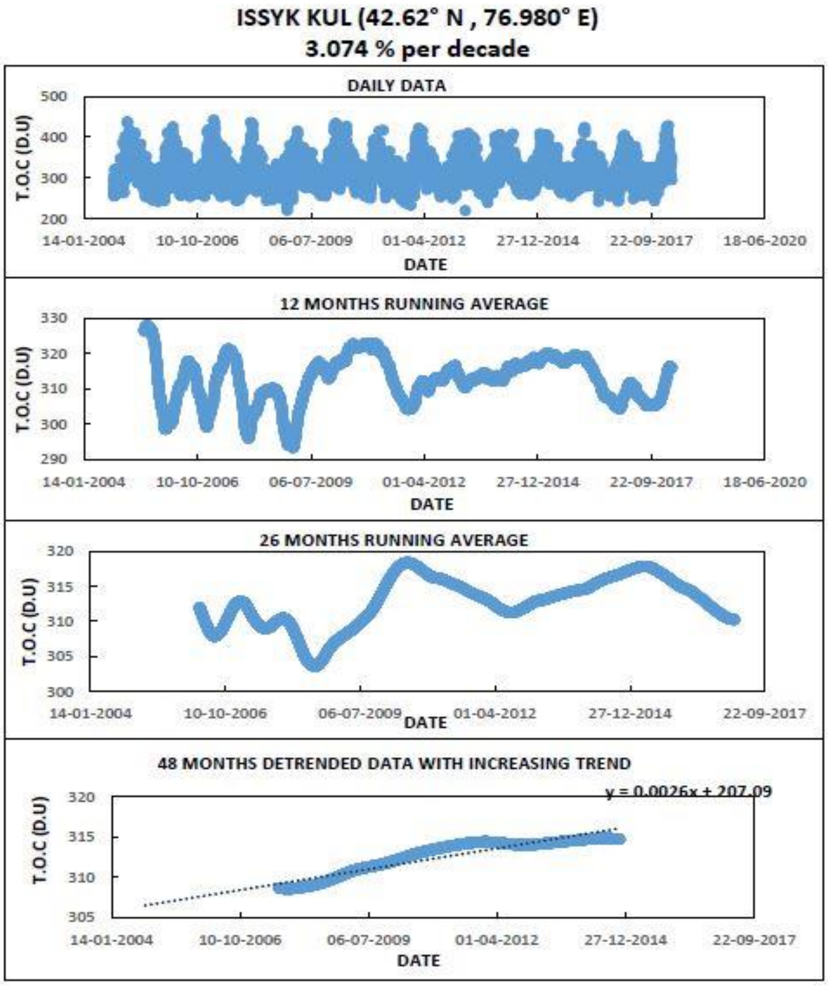

Figure 1: Total ozone content measured by TOMS over the period of 2004-2018 for Issyk-kul, Russia (42.3^{0}N, 76.58^{0}E), a North temperate station. Linear trend line fitted shows increasing trend of 3.07% per decade.

be seen to be at peak value of 450D.U. during April-June and at its minimum value of 220 D.U. around November-December. Along with this, many large and small periodicities may be hidden, which need to be eliminated. As discussed earlier, the data in each panel is subjected to moving average in order to remove periodicity of that particular interval. Bottom most panel is data from which all dominant periodicities have been removed. A least square straight line is fitted to this plot to obtain the ozone trend in the TOC. The trend line with slope of 0.0268 reveals a increase of the TOC from the year 2006- 2018. Thereafter, per decade incline in TOC is calculated and is found to be 3.078 %.

The top panel of figure 2 shows daily values of TOC for an equatorial station, Nairobi Islands (1.271^{0}S , 36.83^{0}E), for the period 2006- 2018.

Unlike the earlier station, where the annual variation was so prominent and regular, the plot does not show any dominant annual variation at this station. Here, TOC values vary within a small range from 220 D. U. to 280 D.U. The 12-month moving average of daily values of TOC results in elimination of the annual variation, as is clearly seen in the second panel. However, the second

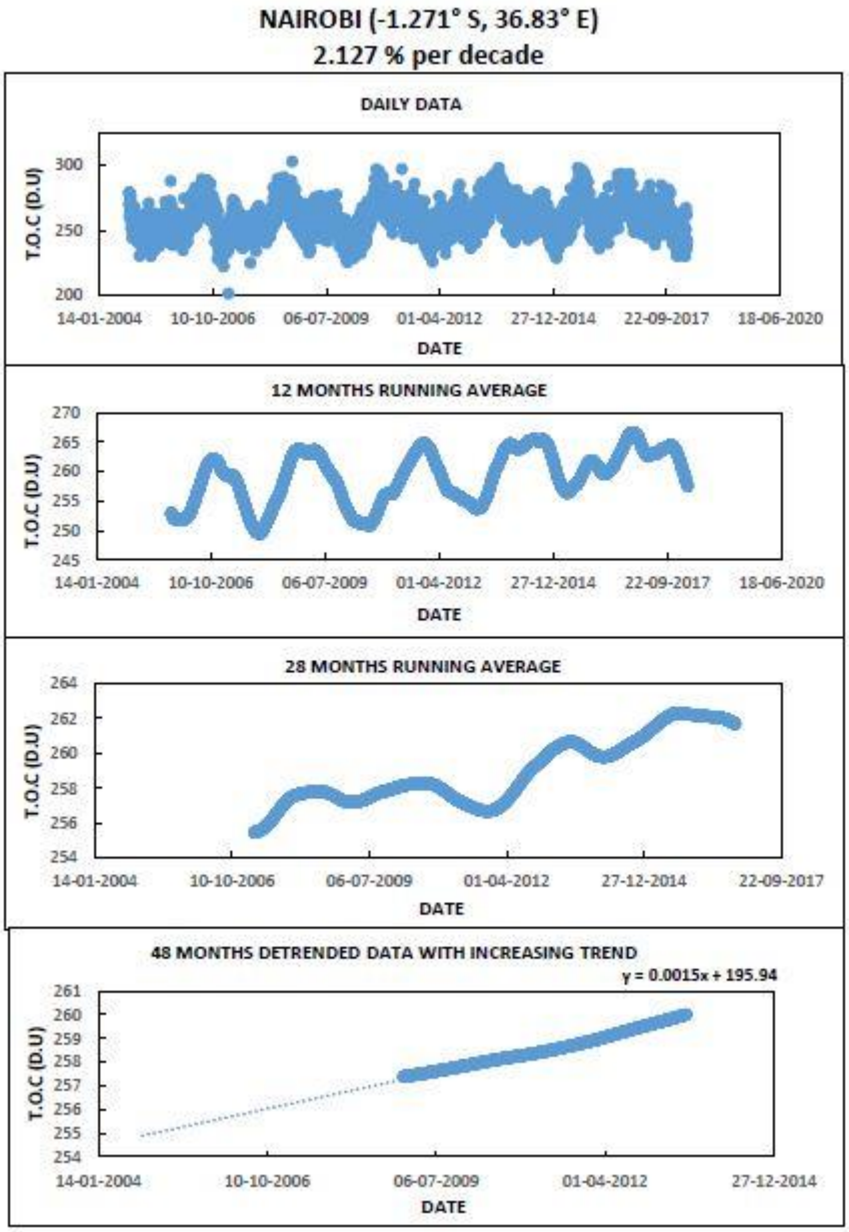

Figure2: Total ozone content measured by TOMS over the period of 2004-2018 for Nairobi Islands (1.271^{0}S , 36.83^{0}E), an Equatorial station. Linear trend line fitted shows increasing trend of 2.12% per decade.

panel also shows a regular QBO variation of 28 month periodicity. In the next step, this variation is removed by subjecting data to moving average with interval equal to that of QBO periodicity. As done for the earlier case, this variation is eliminated by subjecting the data to a moving average of corresponding interval. In final step, a trend line is fitted to this plot and percentage increment per decade is found to be 2.127 %.

The present studies bring out an important feature of the TOC variation. Comparison of present results with the previous studies (Roshni Dave, 2008) reveals a number of differences. The rate of depletion of ozone from 1996-2006 was found to be decreasing progressively from the North temperate zone to the equator in previous study. This increase in ozone trends can be understood in terms of influence of Montreal Protocol which phased out use of chlorofluoro carbon and other ozone depleting gases which can destroy ozone.

IV. CONCLUSIONS

The daily values of TOC for North Temperate and an Equatorial station were subjected to moving average analysis. Trend line is fitted to the plot which is used to find percentage decrement per decade. Values obtained for North temperate and an equatorial station over the period of 2006- 2018 is 3.074 %, and 2.12 % per decade respectively.

V. Acknowledgment

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