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Solar UV Index at Different Altitudes of Nepal

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Abstract: The main objective of this research is to study the satellite estimated solar Ultraviolet data alongside the ground based data in Nepal. Kathmandu (27.72^{0}N, 85.32^{0}E), Pokhara (28.22^{0}N, 83.32^{0}E) Biratnagar (26.45^{0}N, 87.27^0 E) and Lukla (27.69^{0}N, 86.73^{0}E) are located at an elevation of 1350m, 800m, 72m and 2850m respectively from the sea level. The ground based measurements and the satellite estimation were performed by NILU-UV irradiance meter and EOS Aura OMI satellite respectively. The NILU-UV irradiance meter is a six channel radiometer designed to measure hemispherical irradiances on a flat surface. Meanwhile the Ozone Monitoring Instrument (OMI) on board, the NASA EOS Aura space craft is a nadir viewing spectrometer that measures solar reflected and back scattered light in ultraviolet and visible spectrum. The study was performed for 3 years Ultraviolet Radiation (UVR) data. This study showed that the ratio of predicted OMI Ultraviolet Index (UVI) to that determined from the ground based measurement was less than 1.21 except in Lukla.

Keywords: Spectrometer, Scattered, OMI, Nadir, UV Index

1. Introduction

The Ozone Monitoring Instrument (OMI) flying on Aura is the latest of a series of ozone mapping instruments. In terms of the long term ozone data record OMI can be considered an advanced version of the total ozone mapping spectrometer (TOMS). A series of TOMS instruments flew on Nimbus 7 (November 1978 to May 1993), Meteor 3 (August 1991 to December 19940 and Earth Probe (August 1996 to December 2005). OMI continues this time series of global total column ozone measurements. OMI is the Dutch-Finnish contribution to EOS-Aura.OMI is a nadir viewing, wide swath, ultraviolet-visible (UV-VIS) imagining spectrometer that provides daily global measurements of the solar radiation backscattered by the Earth's atmosphere and surface, along with measurements of the solar irradiance. Full instrument details of OMI have been given elsewhere [3], but details relevant to ozone retrieval are summarized here. Unlike the heritage TOMS instruments which measure ozone at six discrete wavelengths from 306 nm [4], OMI measures the complete spectrum from 210 nm to 500 nm at an average spectral resolution of 0.5 nm. OMI combines the advantage of GOME and SCIAMACHY [1], measurement of the complete spectrum in the ultraviolet/visible wavelength range, with the advantages of TOMS, complete spatial coverage of the earth. Each of the two OMI optical channels, UV and VIS, has a two-dimensional CCD detector. One dimension of the CCD is used to cover the spectrum, while the other gives spatial coverage. The UV channel consists of two sub-channels: the UV-2 ranging from 310 to 365 nm. The total ozone retrieval is based on measurements from the UV-2 detector. The VIS-channel covers the range from 365 to 500 nm.

The nadir pointing telescope of OMI has a very large field of view of 114^o perpendicular to the flight direction of the satellite. This gives OMI a swath width of 2600 km, consisting of 60 individual pixel along the swath. The instrument achieves complete daily global coverage of the sunlit earth. The state of the art CCD detectors render a very high spatial resolution of 13 km × 24 km at nadir. The small ground pixel size enables OMI to look "in between" the clouds, giving better reach into the troposphere for retrieving tropospheric composition information than any other UV-VIS backscatter instrument flow to date. Ground based (GB) measurement was performed by NILU-UV irradiance meter. The main goal of this paper is to analyze and report the satellite and ground-based data of three years. The purpose of this study is to gauge the quality of the OMI UV data product with ground based NILU-UV data. The ratio and correlation of UVI for the measurement sites is analyzed and reported.

2. Methodology

Ground based measurement

Kathmandu (27.72^{0}N, 85.32^{0}E), Pokhara (27.72^{0}N, 85.32^{0}E), Biratnagar (26.45^{0}N 87.27^0 E) and Lukla (27.69^{0}N, 86.73^{0}E) are located at an elevation of 1350m, 800m , 72m and 2850m respectively from the sea level. The instrument used during the measurement periods were the NILU-UV irradiance meter. NILU-UV is a six-channel moderate-bandwidth filter instrument. Five of the channels are in the UV with centre wavelengths at 305, 312, 320, 340, and 380 nm and a bandwidth 10 nm at FWHM. The sixth channel measures the so-called photo synthetically active radiation. It covers wavelengths between 400 and 700 nm with a bandwidth of 300 nm at FWHM. The front optics consists of a flat Teflon diffuser followed by custom-made interference filters from Barr Associates, Inc., Westford, Mass. To minimize stray-light problems the five UV channels in addition have UG-11 and read leak filters. For the same reason the 305, 312, and 320 nm channels are equipped with individual specified short-pass filters. For all channels the radiation is recorded by S1226-8BQ silicium detectors from Hamamatsu. The instrument is the temperature stabilized at 50°C. It records data in a built in data logger within a minute time resolution. The data logger has the capacity to store 3 weeks of 1 min averages. By interfacing the instrument to a computer using a RS-232 port, data with 1-sec time resolution may be recorded. The total weight of the instrument ready for operation is 3.3 kg. The instrument is weatherproof and designed to operate in harsh environments [2].

3. Results and Discussion

The report is mainly concerned with the OMI UVI with GB UVI data of four measurement sites namely Kathmandu (KTM), Pokhara (PKR), Biratnagar (BRT) and Lukla (LUKL), for a time period of three years. The predicted value in turn is obtained by first performing a fourth degree fit on the OMI and Ground based (GB) data for the year 2009 to 2011 generating an equation and then the data of 2012 is fit into it. These fit are performed individually for distinct sites. Alongside, the ratio, correlation and the relative difference under normal distribution between OMI UVI with GB UVI are also analyzed. The analysis was done for all sky conditions.

The ratio between original OMI UVI and GB UVI (2009 – 2011) ranged between 1.88 – 1.99 in

KTM, 2.02 – 2.04 in PKR, 1.62 – 1.81 in BRT and 1.92 – 4.01 in LUKL as shown in Fig. 1 (a), (b), (c) and (d).

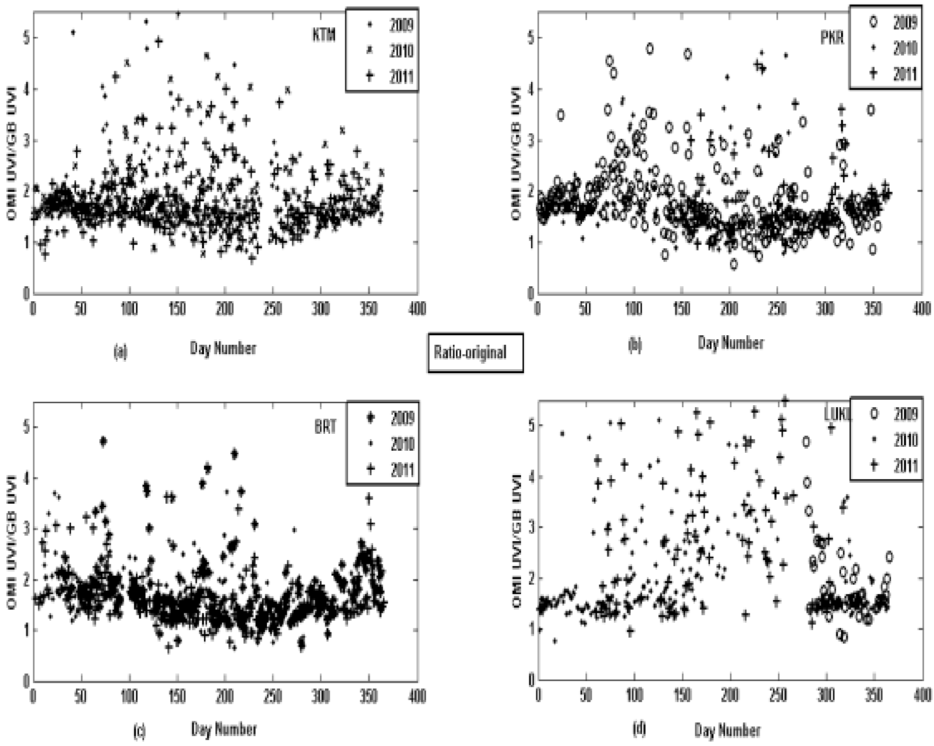

Fig 1: Ratio of original OMI UVI with ground based UVI versus day number in (a) Kathmandu (b) Pokhara (c) Biratnagar and (d) Lukla

The above result shows that the noon time UVI obtained from OMI generally overestimate the noon time ground based UVI. Also the Fig 1 shows some scatter in all measurement sites which are obvious but the scatter of LUKL was far greater in comparison. After correction this ratio dropped and the new ratio between the corrected OMI UVI and GB UVI were found to be between 1.08 - 1.14 in KTM, 1.16 - 1.20 in PKR, 1.06 – 1.12 in BRT and 1.05 - 1.43 in LUKL which are shown in Fig. 2(a), (b), (c) and (d).

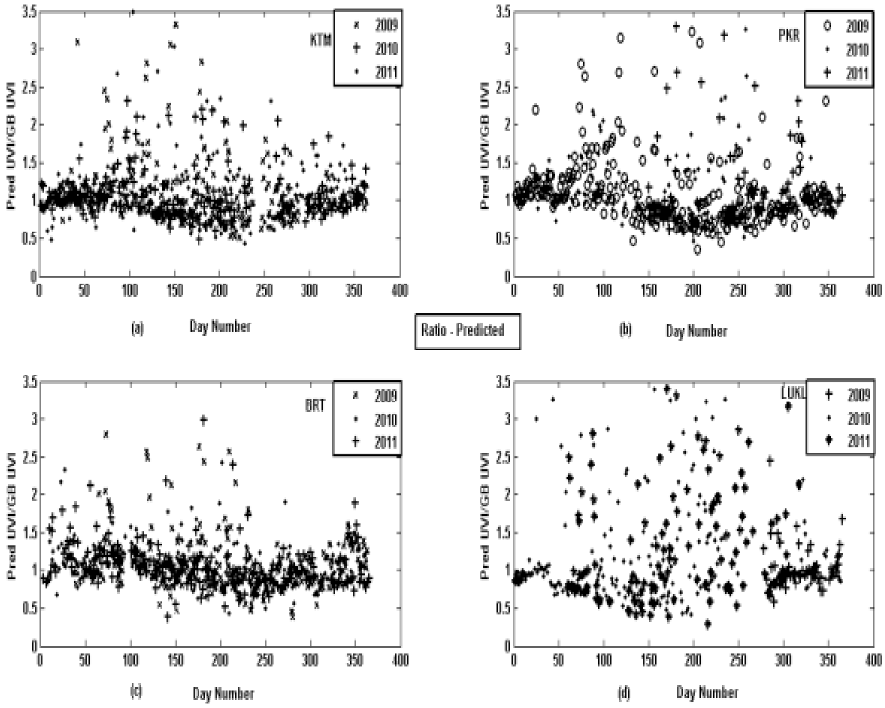

Fig 2: Ratio of predicted OMI UVI with ground based UVI versus day number in (a) Kathmandu (b) Pokhara (c) Biratnagar and (d) Lukla.

The high mean UVI ratio 1.31 and 1.43 in 2010 and 2011 respectively in LUKL is due to the variation of clouds. The above observation clearly shows that the ratio for the considered sites lied very close to 1 which enables us to conclude that the corrected OMI UVI data obtained after prediction are valid. This fact is also confirmed by [6] which states that the ratio of OMI to ground measured UV lies between 0.9 and 1.5 and strongly depends on the aerosol optical depth. Also the statement of [5], that the median ratio of the OMI derived dose to the ground based dose in Boulder (39.99^{0}N, -105.26^{0}E, 1650m.a.s.l) is 1.15 aids our finding.

The correlation between corrected OMI UVI with GB UVI for a period of three years for the matching data pair is shown in Fig. 3 (a), (b), (c) and (d).

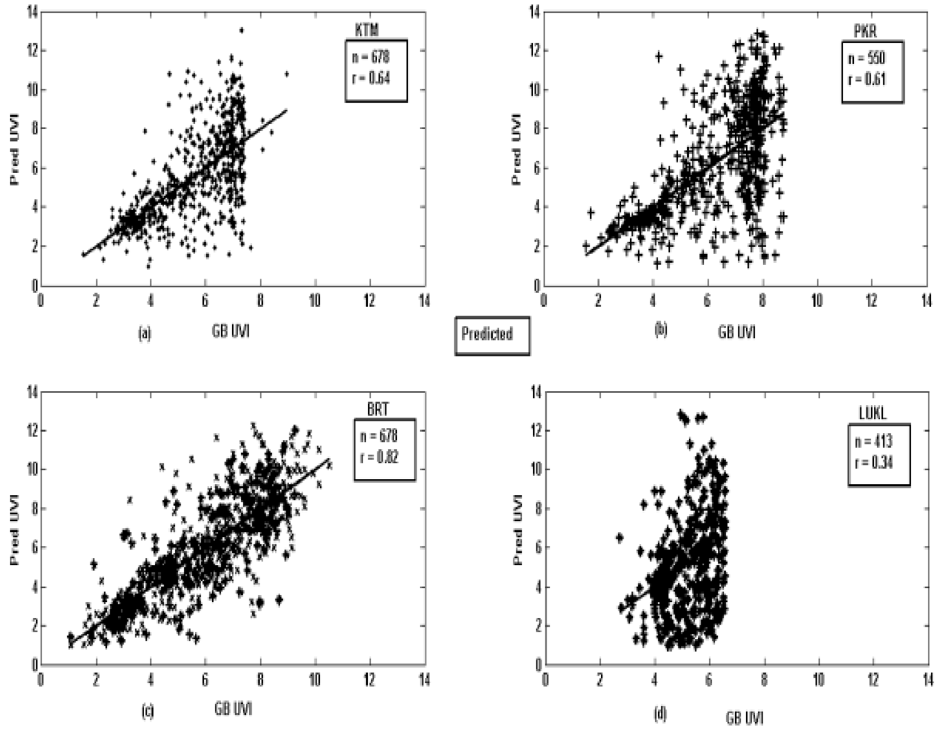

Fig 3: Scatter plots of predicted OMI UVI and GB UVI in (a) Kathmandu (b) Pokhara (c) Biratnagar and (d) Lukla. The solid line indicates the linear trend line.

The correlation coefficient (r) was found to be 0.64 in KTM, 0.61 in PKR, 0.82 in BRT and 0.34 in LUKL. Similarly the average difference of UVI for the corrected data was – 4.49% in KTM, -6.05% in PKR - 3.86% in BRT and – 10.40% in LUKL.

4. Conclusion

In this paper, the corrected OMI and GB data for three years (2009 - 2011) were studied, analyzed and reported. In an average, the ratio of corrected OMI with GB data for all measurement sites was found to lie near 1 and this observation provided sufficient evidence to consider the validity of our GB data. On analysis, the correlation coefficient for the predicted condition was found to be 0.64 in KTM, 0.61 in PKR, 0.82 in BRT and 0.34 in LUKL. Likewise, three years corrected mean UVI ratio ranged between 1.08 – 1.14 in KTM, 1.16 – 1.20 in PKR, 1.06 – 1.12 in BRT and 1.05 – 1.43 in LUKL.

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