Estimation of total ozone column using UV spectrum data at Silpakorn University, Nakhon Pathom, Thailand

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Abstract:
In this study, total ozone column (TOC) in the atmosphere at Silpakorn University in Nakhon Pathom, Thailand (13.82°N, 100.04°E) was estimated. In the first step, the Libradtran radiative transfer model under cloudless condition was used to determine the ratio of UV irradiance at 320 nm to that of 305 nm (N value) and to generate a look-up table. The look-up table consists of N values and atmospheric parameters including aerosol properties, surface albedo and TOC. Then the N values from a spectroradiometer installed at Silpakorn University during a three-year period (2010–2012) were calculated. Finally, the comparison between N values from the LUT and N values from the spectroradiometer was carried out. The TOC which gave the closet N in the LUT was retreived. For the validation, the TOC from the LUT was compared with the TOC measured by a Dobson spectrophotometer at Thai Meteorological Department, Bangkok (13.40°N, 100.37°E). The result shows a good agreement between the two data sets with the root mean square difference (RMSD) and mean bias difference (MBD) of 3.8% and 1.6%, respectively.

Keywords: *Total ozone column; spectral UV; Libradtran; look up table*

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1. Introduction

Ozone is an important constituent of the earth's atmosphere although it presents only in small amounts. The atmospheric ozone is most concentrated in the stratosphere at the height of 20-40 km above the earth's surface. The stratospheric ozone plays an important role in modeling solar ultraviolet radiation because it strongly absorbs solar ultraviolet radiation which has detrimental effects on human and ecosystem (Kerr and McElroy, 1993). In 1974, Molina and Rowland reported that chlorofluorocarbons (CFCs) and halons have an effect on the depletion of ozone in the atmosphere (Molina and Rowland, 1974). Later, Farman et al. (1985) discovered ozone hole in Antarctica. These events raise many scientists to realize and be aware the important of ozone in the atmosphere. The amount of the atmospheric ozone can be obtained from ground-based measurements and satellite retrievals. However, the ground-based measurement is very scarce and satellite data still be uncertain. Therefore, in this study, an algorithm based on ground-based spectral UV radiation is introduced to estimate total ozone column.

2. Methodology

2.1 Development of look-up table algorithm

In this study, an algorithm for estimating total ozone column (TOC) is based on different ozone absorption of two spectral UV wavelengths: one wavelength is appreciably absorbed by ozone and another wavelength is not absorbed (Stamnes et al., 1991). In this study, a method to derived TOC from N value was chosen. The N value is defined as the ratio of spectral UV irradiances at 320 to 305 nm. This wavelength was selected because they have different ozone absorption cross section. The spectral irradiance at 305 nm is appreciably absorbed by ozone while that at 320 nm is not absorbed. The N values were determined from the Libradtran radiative transfer model called UVSPEC under cloudless condition and local atmospheric parameters. These parameters consist of a type of the atmospheric profiles (tropical), surface albedo (0.03), single scattering albedo (0.9) and aerosol optical depth at 340 nm (AOD_{340}). Furthermore, solar zenith angle (SZA) and TOC were ranged between 0-50 degree and 200-400 DU, respectively. These parameters are used as input data of UVSPEC and the N values can be calculated as shown in Fig. 1. Then the results were stored in a

series of tables, called look-up table (LUT).

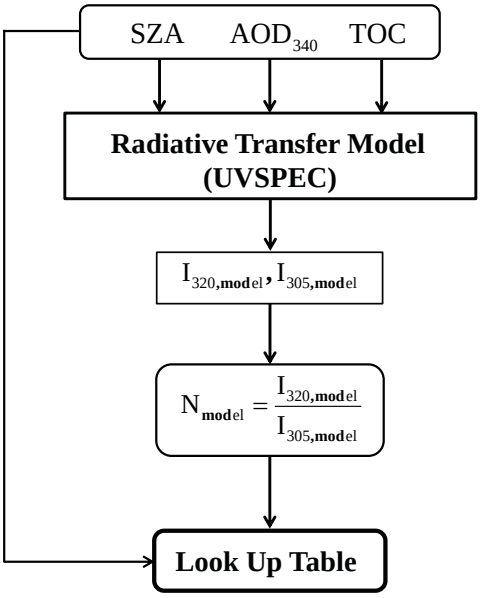

Fig. 1 Diagram for the LUT from UVSPEC. (SZA = solar zenith angle, AOD_{340} = aerosol optical depth at 340 nm, TOC = total ozone column, $I_{320,model}$ = irradiance at 320 nm calculated from UVSPEC, $I_{305,model}$ = irradiance at 305 nm calculated from UVSPEC and N_{model} is the ratio $I_{320,model}$ to $I_{305,model}$).

2.2 Determination of total ozone column

To obtain TOC from the LUT, the N values from spectral UV irradiance data measured by using a solar UV spectroradiometer (Bentham, model DMc150) installed at Silpakorn University in Nakhon Pathom, Thailand (13.82°N, 100.04°E) during the year 2010-2012 were calculated. The instrument is shown in Fig. 2. The N value can be written as (Dahlback, 1996)

$$N = I_{320}/I_{305} \quad (1)$$

where I_{305} is the spectral UV irradiance at 305 nm (mW/m^2) and I_{320} is the spectral UV irradiance at 320 nm (mW/m^2).

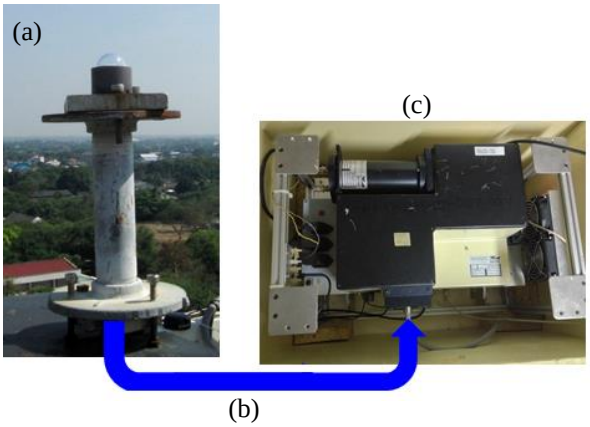

Fig. 2 The UV spectroradiometer installed at Silpakorn University. ((a) Input optics (b) Optic fiber and (c) Monochromator, detector and control system)

For AOD_{340}, it can be measured by a sunphotometer (Cimel, model CE-318) at the monitoring site, which is included in the Aeronet Robotic Network (AERONET). All input data of the algorithm

were prepared and used in the algorithm to obtain the TOC values at this site under cloudless conditions during 2010-2012. The condition which gave the closet N value was used to determine TOC from the LUT. The processing of TOC retrievals can be shown in Fig. 3.

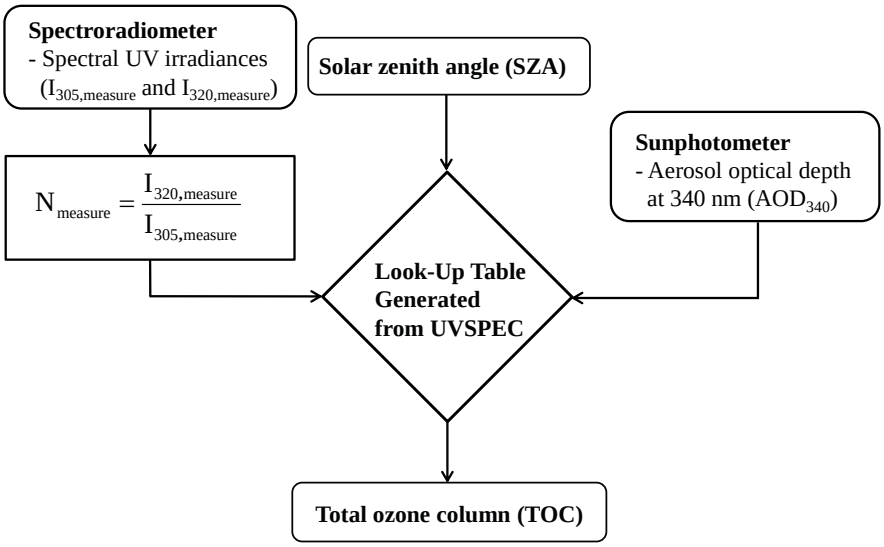

Fig. 3 The retrieval process of TOC from LUT and the N values from the spectroradiometer together with aerosol optical depth from the sunphotometer.

3. Results and discussion

From the algorithm, TOC at Silpakorn University during the three-year period were calculated. To validate the algorithm, the TOC from the LUT was compared with the observed TOC from a Dobson spectrophotometer installed at Thai Meteorological Department, Bangkok (13.40°N, 100.37°E) which is located about 80 km far from Silpakorn University. The comparison results during the three year period (2010-2012) show a corresponding seasonal variation (Fig. 4). It can be seen that the TOC has the highest value in the rainy season (April-October) and the lowest value in the winter (November-March). The comparison result also shows a reasonable agreement with the root mean square difference (RMSD) and mean bias difference (MBD) of 3.8% and 1.6%, respectively (Fig. 5).

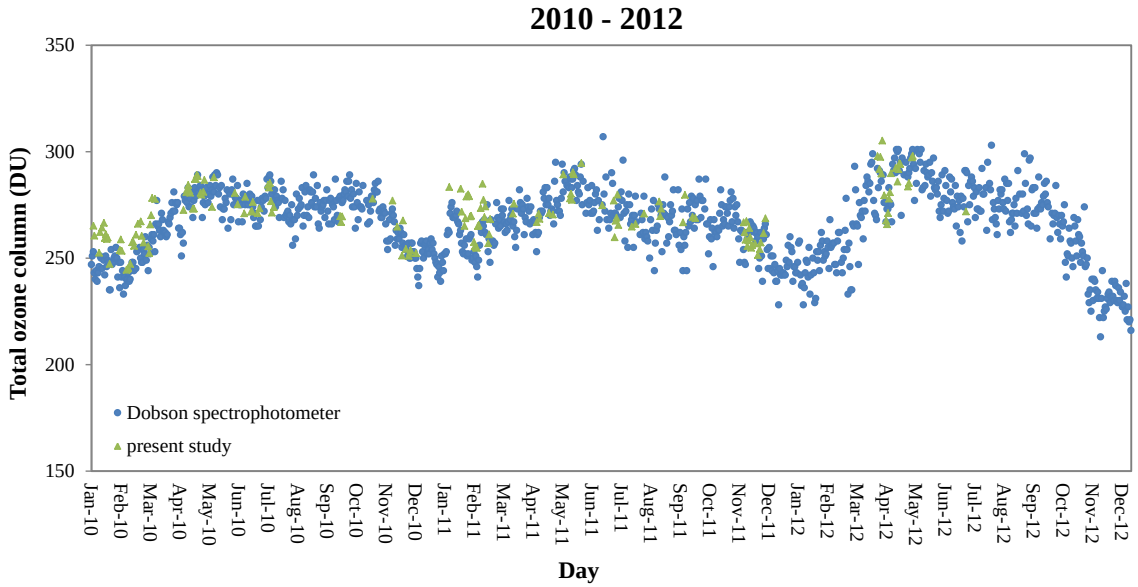

Fig. 4 The Comparison of the daily TOC from the present study (a triangle point) and TOC from the Dobson spectrophotometer (a circle point).

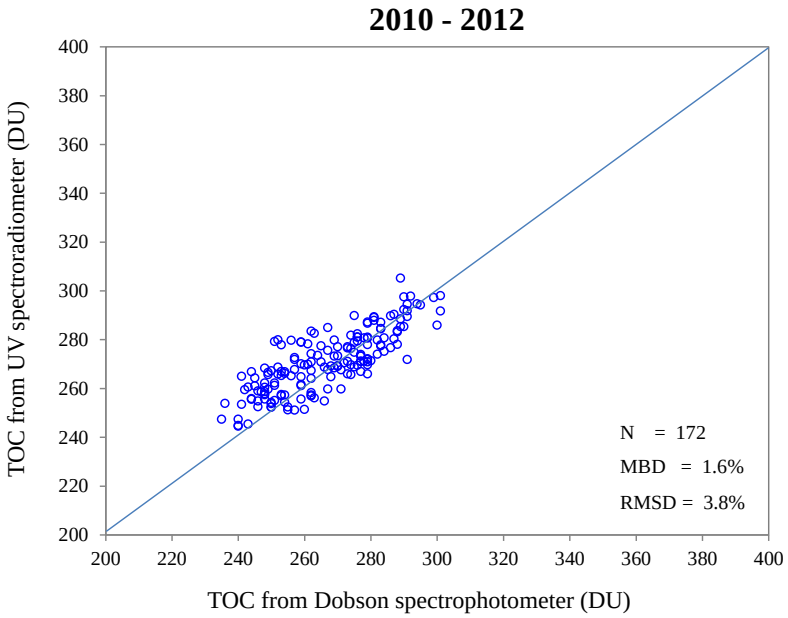

Fig. 5 The comparison between TOC from this study and TOC from the Dobson spectrophotometer.

4. Conclusion

The TOC at Silpakorn University, Nakhon Pathom was estimated by using the LUT technique. This TOC was compared with the TOC measured by the Dobson spectrophotometer at Thai Meteorological Department in Bangkok. The comparison results show good agreement. Seasonal variation of the TOC from the two sites shows a similar pattern with low TOC values in the winter (November-March) and the high TOC values in the rainy season (April-October).

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6. References

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