Characteristics on the Variations of the Total Ozone over Pohang (1994~2004) using the Brewer Spectrophotometer and TOMS

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ABSTRACT:

The characteristics of the total ozone variations measured by the ground-based Brewer Ozone Spectrophotometer and the Total Ozone Mapping Spectrometer (TOMS) over Pohang are statistically examined from January 1994 to December 2004. First of all, in the correlation analysis of the total ozone measured from the Brewer Ozone Spectrophotometer and the TOMS, the correlation coefficient was 0.88 and the used data were 2190. The annual mean value of the total ozone is 311 DU with the standard deviation of 13 DU. The maximum and the minimum value were found in March (343 DU) and in September (282 DU), respectively. It was also revealed that the longest seasonal variation is in Spring (341 DU) and the smallest is in Autumn (283 DU). The time series data of the total ozone indicates that the annual variation is significant and the variations for three months and six months are relatively weak. Finally, the annual mean total ozones in Pohang (Brewer), Seoul (Brewer) and Busan (TOMS) are 312 DU, 324 DU and 304 DU, respectively.

KEY WORDS: Brewer Ozone Spectrophotometer, Total Ozone, Dobson Unit (DU)

1. Introduction

It has been widely accepted that the ozone absorbs well ultraviolet radiation and has a direct influence on the thermal structure of the Stratosphere. In addition, the ozone plays an important role in point of climatological and biological view because it prevents the harmful ultraviolet radiation to damage the ecosystem from arriving at the surface. Some researches related to the ozone layer and EUV-B irradiance in the Stratosphere have been recently reported (Kerr, 1991; Cho et al., 1994; Kim et al., 2005).

The ozone observation has been conducted in Pohang Station (WMO/GO3OS Station No. 332) since 1994 to monitor the ozone layer and its distribution in the stratosphere, total ozone and its vertical profile in the atmosphere measured by the Brewer Spectrophotometer (Kipp & Zonen Co.).

In this study, the monthly, seasonal and annual variation and their features are investigated in terms of the total ozone measured from the Brewer Ozone Spectrophotometer at Pohang and the Nimbus7/TOMS satellite. The local features of the total ozone in Pohang, Seoul and Busan are also compared with each other.

2. Instruments and Data

2.1 Brewer Spectrophotometer system

The Brewer Ozone Spectrophotometer is a scientific instrument which measures ultraviolet radiation in the solar spectrum. By examining the differential absorption of selected wavelengths in the UVB portion of the spectrum, determined of total column ozone and total column sulfer dioxide are inferred. In addition, the accurate spectral intensity profiles of UVB radiation in the range 290 nm to 325 nm are measured. It is well recognized by the scientific community that the marked fluctuations of atmospheric ozone and sulphur dioxide concentrations are linked to a variety of adverse environment conditions. The ozone layer, which shields the Earth from the harmful effects of solar ultraviolet radiation, is believed to be vulnerable due to fluorocarbons and other effluents.

The Brewer Spectrophotometer system is comprised of a spectrophotometer, a solar tracker, and computer controlling the instruments and data logging software (refer to Fig. 1). More detail description of the instruments is available from SCI-TEC instruments Inc. The Brewer Spectrophotometer is supplied with a complete set of program which controls all aspects of data collection and some analysis.

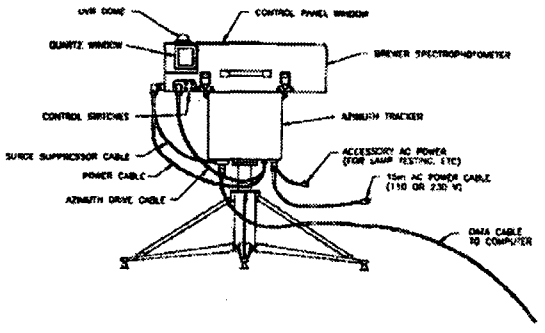

Fig. 1. Brewer Spectrophotometer System

2.2 Data

Total ozone measurements are classified with direct sun ozone observation (DS) and zenith sky observation (ZS). This study used the measurement values of direct sun ozone observation. Among these measurement values, the value that the daily variation of the total ozone is more than 20% is removed through in the quality control program.

To examine the variation of the total ozone, the total ozone data measured by the Brewer Spectrophotometer were analyzed from January 1994 to December 2004 and the Nimbus7/TOMS (Total Ozone Mapping Spectrometer) satellite data from January 1997 to December 2004. To compare the latitudinal features of total ozone, the daily data of Yonsei University in Seoul (1998-2004) and total ozone of Nimbus7/TOMS satellite data near Busan (1997-2004) were used. The erythemal ultraviolet-B data were also analyzed in order to calculate the correlation between the total ozone and the surface ultraviolet radiation (1994-2004). The Pohang data in the year of 2000 and 2002 measured by the Brewer Spectrophotometer in Pohang were excluded from this research because of the insufficiency samples.

3. Results and Discussion

The monthly, seasonal and annual variation and their features were examined in terms of the total ozone using the Brewer Spectrophotometer and the Nimbus7/TOMS satellite data.

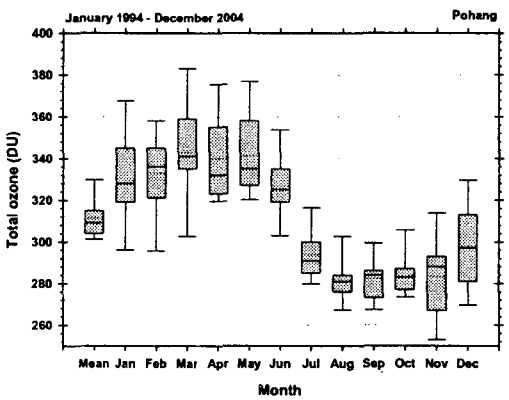

Fig. 2. Monthly variation of the total ozone measured from the Brewer Spectrophotometer over Pohang. The dot lines indicate an average

Table 1. Monthly average Total Ozone measured from Brewer Spectrophotometer at Pohang from 1994 to 2004. The unit is Dobson Unit (DU).

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Avg.
1994	[369]	335	359	332	335	325	285	281	289	275	261	267	309
1995	296	330	341	323	327	323	279	272	273	273	292	316	304
1996	335	345	346	352	346	302	286	278	286	283	269	301	311
1997	326	321	321	325	328	320	291	276	284	285	288	296	305
1998	328	346	338	342	321	335	29	283	281	284	[293]	281	310
1999	296	336	298	355	358	319	300	284	281	309	315	333	315
2000	330	361	363	378	372	354	[318]	305	302	292	278	303	330
2001	362	338	388	365	378	353	310	293	284	282	293	297	329
2002	319	318	335	321	331	326	283	277	286	287	309	313	309
2003	345	344	344	319	320	307	291	266	266	277	251	280	301
2004	319	[290]	341	326	337	329	295	283	273	[277]	267	290	302
Avg.	326	333	343	340	341	327	291	282	282	284	282	298	311

[ ] The values in parenthesis are monthly mean values during which observation days numbered less than 10.

Table 1 shows the monthly mean total ozone measured from the Brewer Spectrophotometer in Pohang from January 1994 to December 2004. This indicates that the average of the total ozone is 311 DU from 1994 to 2004, which is smaller by 1 DU than from 1994 to 2003.

The monthly maximum value was 343 DU in March, while the minimum value was 282 DU in November.

Fig. 2 shows the monthly variation of the total ozone measured from the Brewer Spectrophotometer over Pohang. As shown in Fig. 2, the values from January to June were much higher than the annual average. In standard deviation of the monthly mean total ozone the maximum and the minimum value are in March and in October, respectively.

The Scatter plot of the total ozone from the Brewer Spectrophotometer and the TOMS version 7 observation in Pohang from 1997 to 2004 except for 2000 and 2002 is shown in Fig. 3. The total number of used data was 2190. A linear equation was $Y = 0.97X + 8.69$ and the correlation coefficient was 0.88. As shown in Fig. 3, the Brewer total ozone and the TOMS total ozone had a good linear correlation.

Fig. 4 shows the annual variation of the total ozone measured from the Brewer Spectrophotometer in Pohang and Seoul and observed the Nimbus7/TOMS near Busan. The annual mean of the total ozones in Pohang, Seoul and Busan are 311 DU, 321 DU and 304 DU, respectively. The total ozone in the high latitude was relatively larger than in the low latitude. This result indicates that there is a difference about 8 DU per latitude.

Fig. 5 shows the time series data of the daily mean total ozone measured from the Brewer Spectrophotometer and EUV-B measured from the UV-Biometer in Pohang from 1994 to 2004, except for 2000 and 2002. From the result of the time series data analysis, it is found that the total ozone and the EUV-B have the negative correlation. That is to say, the total ozone is large in spring and winter, while the EUV-B irradiance is large in summer season. As a result, the more total ozone decreases, the more EUV-B irradiance increases.

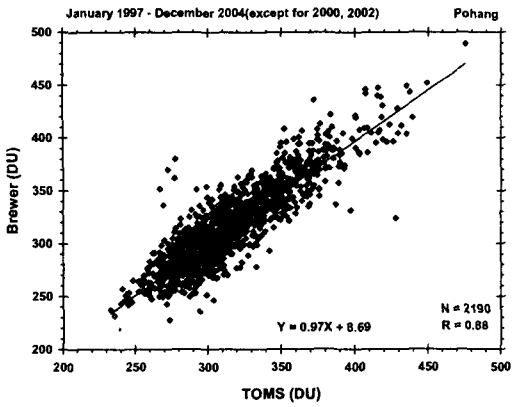

Fig. 3. Scatter plot of the total ozone from the Brewer Ozone Spectrophotometer and the TOMS observation in Pohang (1997-2004, except for 2000 and 2002). A line is the linear regression line.

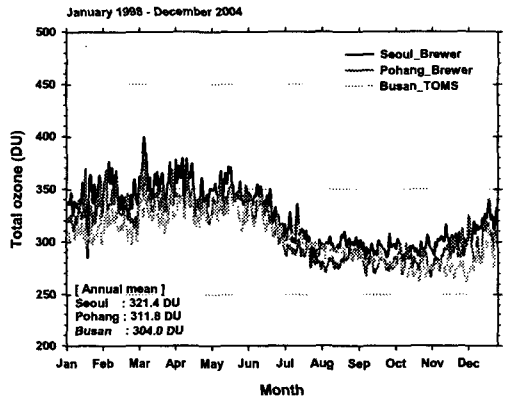

Fig. 4. Annual variation of the total ozone measured from the Brewer Spectrophotometer and the TOMS satellite in Pohang, Seoul and Busan.

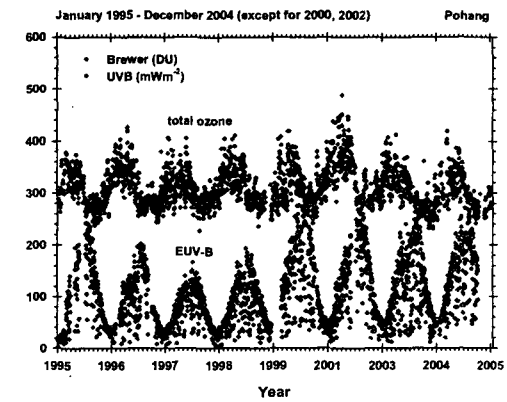

Fig. 5. Time series data of the daily mean total ozone and the EUV-B in Pohang (1994-2004, except for 2000, 2002).

4. Summary

The feature of the monthly, seasonal and annual variation of the total ozone measured from the Brewer Spectrophotometer in Pohang and the Nimbus7/TOMS satellite data from January 1994 to December 2004 is investigated. The average total ozone was 311 DU from 1994 to 2004 which is smaller by 1 DU than from 1994 to 2003. The monthly maximum value was 343 DU in March, while the minimum was 282 DU in November. In the correlation analysis of the total ozone from the Brewer Ozone Spectrophotometer and the Nimbus7/TOMS, the correlation coefficient was 0.88 and a good linear correlation is analyzed. Also, the annual mean total ozone in Pohang, Seoul and Busan are 311 DU, 321 DU and 304 DU, respectively. The total ozone in the high latitude was relatively larger than in the low latitude. This result represents that there is a difference about 8 DU per latitude.

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