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<Short Communication>

Relationship between Stratospheric Ozone and Solar Ultraviolet B Irradiance in Taegu, Korea

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ABSTRASCT: Solar ultraviolet-B (UV-B) irradiances incident on a horizontal surface at Taegu, Korea during 1996-1998 were calculated with 5 minute averages of measurements taken every 30 seconds by a broadband UV-B sensor. The average, maximum and minimum of daily UV-B dose were 11.31, 22.04 and 3.20kJ m^{-2} day^{-1}, respectively, for the measuring period. Variations in stratospheric ozone concentration measured from space explain 85% of changes in the daily UV-B dose. It was expected that decrease of 50 Du in stratospheric ozone cause increase of 24.1% in daily UV-B dose in this study.

***Key Words*:** Daily ultraviolet B irradiance, Korea, Stratospheric Ozone

INTRODUCTION

The ozone reduction in the stratosphere over Antarctica (Farman *et al.* 1985) has produce public concern about the increase in ultraviolet-B radiation reaching the earth surface (Crutzen 1992) because UV-B radiation effects on living organism at all levels, ranging from molecules, cell organelles and plant organs to the whole plant. The depletion reached 71% during several days in 1993 and 1994, which is the globally most pronounced stratospheric ozone depletion over Antarctica(Jones and Shanklin 1995). An abrupt 50% reduction in stratospheric ozone could inhibited photosynthesis of Antarctic phytoplankton up to 8.5% by increased near-surface UV-radiation (Neal *et al.* 1998).

However, the ozone loss is not restricted to Antarctica but has also been shown in the Arctic (Hoffman and Deshler 1991) and at mid-latitudes in both hemisphere (Madronich *et al.* 1995, Kirchhoff 1996). Kerr and McElroy (1993) reported that in Toronto (44°N) UV-B (300 nm) increased by 35% per year in winter and 6.7% per year in summer between 1989 and 1993. In Korea, Increasing rate of 12% was observed in annual maxima of instantaneous UV-B radiation during 1995-1998 (Suh 1999).

Global UV levels were predicted to peak around the turn of the 20th century in association with peak loading of chlorine in the stratosphere and the concomitant ozone reductions. The recovery to pre-ozone depletion levels is expected to take place gradually over the next 50 years (Hoffman 1996, WMO 1998). A recent study suggest that the recovery of the ozone layer may be delayed significantly by interactions with increasing greenhouse-gas concentrations (Shindell *et al.* 1998).

Environmental UV-B radiation is highly variable. Some of these variations due to changes in the solar elevation with latitude, time of day, and season. Other factors, such as clouds and aerosol in troposphere, are much less predictable and their spatial and temporal distributions are still poorly characterized, especially on local scales and for short-term fluctuations. Additional localized perturbations may stem from surface elevation and reflections, and from variable atmospheric turbidity associated with air pollution (Madronich *et al.* 1998). However variations in stratospheric ozone column amount are of direct importance to surface UV radiation.

The object of this study is to test the predictability of solar UV-B irradiance with stratospheric ozone concentration over Taegu, Korea during 1996-1998 by statistical analysis of the two variables.

METHODS

UV measurements were done at Kyeongsan campus of Taegu university in Korea (35°53′ 45 ″ N, 128°50′ 56 ″, 70 m above sea level) for 251 days from August 2, 1996 to July 23, 1998 except the days of raining, snowing and calibration. Solar UV-B irradiances were measured with a SKU 430 UV-B sensor and a SDL 2500 data-logger (Skye Instruments, U.K.) which has 293 nm of center wavelength and 27 nm of full width half maximum wavelength. The UV sensor installed horizontally on the roof of Life Science building at Taegu university was inspected

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and cleaned regularly. Raw signal voltages from the sensor were converted to the units of watt m^{-2} by the simple linear relationship. Five minute averages of instantaneous values taken every 30 seconds were registered and stored in the logger.

Daily dose of UV-B irradiance was regarded as the sum of instantaneous 5-minute averages from sunrise to sunset determined with the equation describing the elevation angle of the sun on a day in a year (Suh 1996).

Total column ozone amounts over the location (36°N, 129°E) were obtained from the Total Ozone Mapping Spectrometer (TOMS) aboard satellite Earth Probe provided by NASA, USA.

RESULTS AND DISCUSSION

Seasonal changes in stratospheric ozone and UV-B irradiance

The seasonal changes in stratospheric ozone concentration and UV-B irradiance incident on a horizontal surface at Taegu, Korea are shown in Fig. 1. It was apparent that seasonal changes in the solar inclination angle controlled the daily variation in the UV-B dose, since the ozone concentration exhibited different variations from the results at Valdivia, Chile (Lovengreen *et al.* 2000).

The concentration of stratospheric ozone was averaged to 311.7 Dobson Unit (DU) during the period of measurement from August 2, 1996 to July 23, 1998. The maximum and minimum concentration of the stratospheric ozone over Taegu were 401 DU (March 17, 1998) and 246 DU (Nov. 12, 1996), respectively.

The maximum and minimum of daily UV-B dose were observed as 22.04 kJ m^{-2} day^{-1} on June 10, 1997 and 3.20kJ m^{-2} day^{-1} on December 14, 1996, respectively. The months including the two days of the maximum and minimum UV-B dose were consistent with the summer and the winter solstices. The average of UV-B dose were calculated as 11.31 kJ m^{-2} day^{-1} for 2 years of the measurement.

Relationship between stratospheric ozone and UV-B irradiance

For the regression analysis daily UV-B doses were analyzed against stratospheric ozone concentration divided by sine values of the solar inclination angle (Suh 1996), as the length of optical pathway through stratospheric ozone layer is the function of that angle. The statistical parameters for the equations of the relationships were determined by regression analysis as follows:

$$\text{UV-B dose} = 61.266 \times \text{EXP}(-0.004324 \times [O_3] / \text{SIN (inclination)})\ (r=0.8579, n=251)$$

where $[O_3]$ is stratospheric ozone concentration, and SIN (inclination) is the sine value of the inclination of the sun on the measuring day.

Variations in stratospheric ozone concentration measured from space explain 85% of changes in the daily UV-B dose. Unexplained variations may be due to different conditions of weather as described by Nemeth *et al.* (1996)

The statistical analysis indicates that daily UV-B dose would increase up to 200% and 24.1%, respectively, if stratospheric ozone concentration decreases to 160 Du and 50 Du lower than those of the current condition. This expectation is consistent with findings that 35% increase of UV radiation corresponded to 10% decrease of total ozone at Dundee, Scotland (56.5°N, 3°W) (Varotsos *et al.* 1998).

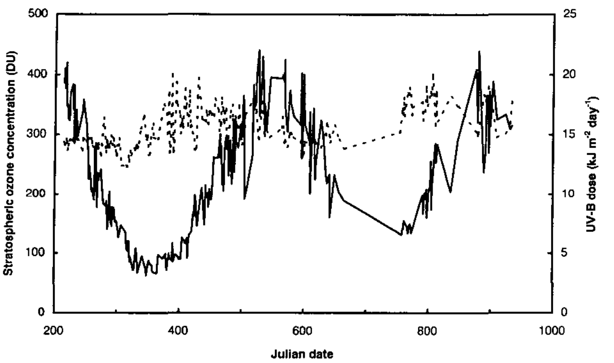

Fig. 1. Seasonal changes in stratospheric ozone concentration (dotted) and daily UV-B dose (solid line) incident on a horizontal surface at Taegu, Korea between August 2, 1996 to July 23, 1998. The first day of Julian date on graph was regarded as January 1, 1996 to clearly present annual trends in stratospheric ozone concentration and UV-B dose. Ozone data were from the Total Ozone Mapping Spectrometer, made accessible by GSFC TOMS Team.

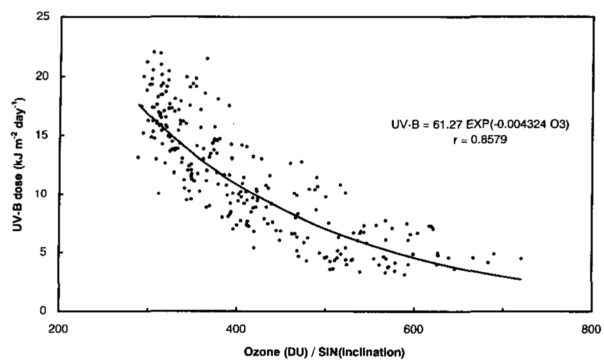

Fig. 2. Relationship between stratospheric ozone concentration and UV-B dose incident on a horizontal surface at Taegu, Korea between August 2, 1996 to July 23, 1998. Note that UV-B doses were plotted against stratospheric ozone concentration divided by the inclination of the sun (Suh 1996) on the measuring day to correct the seasonal fluctuations in the elevation angle of the sun.

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