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SOLAR ULTRAVIOLET IRRADIANCE INCIDENT ON A HORIZONTAL SURFACE AT TAEGU IN KOREA DURING 1995-1998: (I) ULTRAVIOLET-A

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Abstract – Solar ultraviolet-A (UV-A) irradiances incident on a horizontal surface at Taegu of Korea during 1995-1998 were calculated with 5 min averages of measurements taken every 30 seconds by a broadband UV-A sensor. The maximum and minimum of monthly averages of daily UV-A dose were 499.37 KJ m^{-2} day^{-1} in July and 171.09 KJ m^{-2} day^{-1} in December for 4 years of the observation period. The maxima of daily UV-A dose and instantaneous UV-A were observed as 846.46 KJ m^{-2} day^{-1} on June 7, 1998 and 37.22 W m^{-2} at 12:15, July 16, 1998, respectively. Increasing trends in annual maxima of daily UV-A dose and instantaneous UV-A were averaged to 6.4% and 6.7%, respectively, per year during 1995-1998 at Taegu, Korea.

INTRODUCTION

The ultraviolet component of sunlight, comprising wavelengths shorter than 400 nm, accounts for 8-9% of the total energy emitted by the sun. The ultraviolet A radiation (UV-A), from 320 nm to 400 nm, represents approximately 6.3% of the sun's total emission, while the most energetic component, UV-B radiation (290-320 nm), is about 1.5% of the total.1 On the earth's surface, UV-A radiation constitutes more than 90% of the terrestrial UV solar energy and penetrates more efficiently than UV-B in the proliferative basal layers of the epidermis2. UV-A radiation has been shown to induce oxidative damage to nucleic acids in mammalian cells and skin,3 and to inhibit the growth of cucumber up to 22%.4 UV-A radiation is important in the generation of photochemical smog and also in fading and damage to plastic, paints and fabrics.

Since discovery of the ozone hole over Antarctica5 in 1985, the spring time depletion of ozone over Antarctica has continued to heighten. The depletion reached 71% during several days in 1993 and 1994 which is the globally most pronounced stratospheric ozone depletion.6 However, even at mid-latitudes (30-60°) a substantial decrease in the total ozone column was shown.7,8 Global UV levels are predicted to peak around the turn of the 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.9

Reductions in stratospheric ozone allow more solar ultraviolet radiation to reach the earth's lower atmosphere and surface. UV wavelengths most affected by ozone reductions are in the UV-B band with some effect also in the UV-A.9 Measurements of UV-A irradiance are scarce in spite of its importance in many chemical and biological process. Here I report results from solar UV-A measurements on a horizontal surface at Taegu, Korea during 1995-1998.

MATERIALS AND METHODS

Measurements were done at kyeongsan campus of Taegu university in Korea (35° 53′ 45″ N, 128° 50′ 56″, 70m above sea level) for 1,157 days from Jan. 1, 1995 to December 31, 1998 except the days of raining, snowing and calibration.

Solar UV-A irradiances were measured with a SKU 420 UV-A sensor and a SDL 2500 data-logger from Skye Instruments (U. K.) which has 340 nm of center wavelength and 57 nm of full width half maximum wavelength. The sensor installed horizontally on the roof of Life Science building at Taegu university was inspected and cleaned regularly. Raw signal voltages from the sensor were converted to the units of watt m^{-2} by the simple linear relationship. 5 min averages of instantaneous values taken every 30 seconds were registered and stored in the logger.

Daily UV-A dose was regarded as the sum of instantaneous 5-min averages from sunrise to sunset time which was calculated everyday with the equation describing the elevation angle of the sun on a day in a year at the measuring site.[10]

RESULTS AND DISCUSSION

Monthly averages of daily UV-A dose

The monthly and annual averages of daily UV-A dose are shown in Table 1. During this period of 1178 days, daily UV-A dose was averaged to 367.74 KJ m^{-2} day^{-1}.

The maximum and minimum of monthly average of daily UV-A dose were 499.37 KJ m^{-2} day^{-1}in July and 171.09 KJ m^{-2} day^{-1}in December for 4 years of the observation period. The month of maximum UV-A dose was July instead of June which includes summer solstice because the rainy season usually starts at the middle of June in Korea.

Table 1. Monthly averages of daily UV-A dose (KJ m^{-2} day^{-1}) incident on a horizontal surface at Taegu in Korea during 1995-1998

Month	1995	1996	1997	1998	Average
1	233.66	176.16	189.27	269.00	217.02
2	277.39	241.40	243.05	261.49	255.83
3	326.84	n/a	346.27	361.84	344.98
4	431.15	439.86	430.96	489.91	447.97
5	462.35	441.74	442.25	596.33	485.67
6	478.82	465.62	552.06	443.80	485.07
7	462.49	522.78	634.01	384.92	501.05
8	511.73	519.73	539.92	412.31	495.92
9	371.18	421.42	453.38	397.11	410.77
10	325.00	334.10	366.10	336.82	340.50
11	225.52	206.30	217.70	208.00	214.38
12	150.19	169.98	185.15	182.37	171.92
Average	356.96	368.74	390.28	356.85	368.21

Annual averages of daily UV-A dose calculated as 356.96, 368.74, 390.28 and 356.85 (100: 103: 109: 100) KJ m^{-2} day^{-1} for 1995, 1996, 1997 and 1998, respectively, increased by 3-6% per year except 1998 that had more days of cloudy and raining especially in June and July.11 Monthly averages of daily UV-A dose ranged from 150.19 KJ $^{-2}$ day^{-1} in Dec. 1995 to 634.01 KJ m^{-2} day^{-1} in July 1997.

Monthly maxima of daily UV-A dose

The monthly and annual maxima of daily UV-A dose are shown in Table 2. During the period, the maximum of daily UV-A dose was observed as 846.46 KJ m^{-2} day^{-1} on June 7, 1998. Annual maxima of daily UV-A dose were recorded as 710.15, 749.04, 808.01 and 846.46 (100: 106: 114: 119) KJ m^{-2} day^{-1} for 1995, 1996, 1997 and 1998, respectively. Increasing trend in annual maxima of daily UV-A dose was averaged to 6.4% per year during 1995-1998 at Taegu, Korea.

Instantaneous UV-A

Table 2. Monthly maxima of daily UV-A dose (KJ m^{-2} day^{-1}) incident on a horizontal surface at Taegu in Korea during 1995-1998

Month	1995	1996	1997	1998
1	313.15	240.47	249.75	317.50
2	363.85	272.36	320.62	372.05
3	501.47	n/a	514.07	559.18
4	610.75	561.77	563.06	655.49
5	658.07	639.77	643.18	815.28
6	641.75	673.62	715.13	846.46
7	710.15	749.04	808.01	658.59
8	693.15	742.90	794.10	706.12
9	598.13	659.86	657.14	593.93
10	390.01	473.11	500.62	475.70
11	312.59	307.92	280.46	359.09
12	189.25	238.88	244.77	224.58

Table 3. Monthly maxima of instantaneous UV-A radiation (W m^{-2}) incident on a horizontal surface at Taegu in Korea during 1995-1998

Month	1995	1996	1997	1998
1	14.87	11.80	12.28	15.25
2	17.08	13.11	17.32	17.66
3	21.62	n/a	21.88	23.76
4	25.18	23.48	23.68	29.24
5	26.70	25.16	27.89	29.90
6	29.70	31.39	30.80	35.33
7	30.70	31.45	32.03	37.22
8	30.08	31.27	34.74	33.59
9	26.26	29.10	28.49	26.62
10	19.27	22.17	22.18	26.18
11	14.74	15.80	14.28	16.57
12	9.79	12.51	13.44	11.48

During the period, the maximum of instantaneous UV-A was observed as 37.22 W m^{-2} at 12:15, July 16, 1998 (Table 3). Annual maxima of instantaneous UV-A were recorded as 30.70, 31.45, 34.74 and 37.22 (100: 102: 113: 121) W m^{-2} for 1995, 1996, 1997 and 1998, respectively (Table 3). Increasing trend in annual maxima of instantaneous UV-A dose was averaged to 6.7% per year during 1995-1998 of observation period. Monthly maxima of instantaneous UV-A ranged from 9.79 (Dec. 04, 1995) to 37.22 (July 16, 1997) W m^{-2}.

Increasing trends are apparent in instantaneous UV-A, but obscure in annual and monthly averages of daily UV-A dose. It seems that ozone forcing is smaller in annual and monthly averages of UV-A dose due to combined effects of the clouds and aerosols.

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