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Establishing a Ultraviolet Radiation Observational Network and Enhancing the Study on Ultraviolet Radiation

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ABSTRACT

On the basis of analyzing observational data on solar radiation, meteorological parameters, and total ozone amount for the period of January 1990 to December 1991 in the Beijing area, an empirical calculation method for ultraviolet radiation (UV) in clear sky is obtained. The results show that the calculated values agree well with the observed, with maximum relative bias of 6.2% and mean relative bias for 24 months of 1.9%. Good results are also obtained when this method is applied in Guangzhou and Mohe districts. The long-term variation of UV radiation in clear sky over the Beijing area from 1979 to 1998 is calculated, and the UV variation trends and causes are discussed: direct and indirect UV energy absorption by increasing pollutants in the troposphere may have caused the UV decrease in clear sky in the last 20 years. With the enhancement of people's quality of life and awareness of health, it will be valuable and practical to provid UV forecasts for typical cities and rural areas. So, we should develop and enhance UV study in systematic monitoring, forecasting, and developing a good and feasible method for UV radiation reporting in China, especially for big cities.

Key words: ultraviolet radiation, observational network, variation trend

1. Introduction

With the decrease of total ozone amount, the atmosphere is becoming more and more transparent to ultraviolet radiation. Excessive ultraviolet radiation (UV) can depress the human immune system, and lead to increased incidents of diseases, such as eye damage, especially cataracts and non-melanoma skin cancer. It will accelerate the photochemical reactions in the troposphere, increase the concentration of secondary pollutants, worsen the air mass, and thus cause damage to the human respiratory system and health. Because of the important role of UV in biology, medicine, and environmental sciences, more and more scientists and governments pay attention to UV study and UV forecast. Because of the improvement of people's quality of life, the need for outdoor activity time is increasing. It is essential to study and solve the issue about the relationship between human health, UV, and air quality. The characteristics of UV radiation in populous urban and rural areas are different because of the difference in environmental factors, such as all kinds of pollutants, volatile organic compounds (VOCs), and aerosols in the atmosphere. There are many countries that have developed the forecasting of a UV index, built up a UV observation network, and developed universal education on how to prevent excessive UV exposure. In China, though some UV research has been done by different units and institutes, there are still many aspects to be improved, such as in the standardization and systematicness of UV observation and UV models.

UV at the surface is related to total ozone amount, the time of year, geographical location, aerosols, clouds, albedo, and so on. The calculating method of UV basically can be divided into two ways. One is through all kinds of radiative transfer models, the other is a semi-empirical model, based on observation and radiation transfer theory.

Radiative transfer models can be used to calculate UV radiation. But, those models require a knowledge of the incident radiation at the top of the atmosphere, and their inputs are often based on satellite observations of ozone (Madronich et al., 1996). So, many radiative transfer models are limited by insufficient input values.

Regular high quality spectral observations began

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mostly less than 10 years ago (Blumthaler et al., 1996). There were some upward trends measured with R-B meters on unpolluted sites (Blumthaler and Ambach, 1990; Krzyscin, 1996), and Scott et al. (1988) found a decline of annually integrated irradiance measured by R-B meters between 1974 and 1985. So, some recent studies on long-term UV trends show contradictory results. In fact, UV radiation and its trends are affected by many factors, such as the changes in meteorological conditions, tropospheric ozone and other pollutants, aerosol, clouds, and calibration, besides ozone.

Why have UV long-term trends been contrary in different areas during the last two or three decades? This issue deserves to be studied. The UV radiation in the actual sky over the Beijing area from 1979 to 1996 shows a decreasing trend, the total ozone amount shows a decreasing trend, but the aerosols show an increasing trend; the integrated roles of all factors lead to a UV decreasing trend, not an increasing one. (Bai and Wang, 1998). So, when studying the UV and its long-term trends, all the main factors should be considered fully.

Gantner et al. (2000) developed a method based purely on observation to estimate the UV radiation for the last 30 years. So, it is a practical method to build up an empirical method for calculating UV and its variation based on certain physical principles by utilizing reliable observational data of solar radiation, and meteorological parameters.

It is more important to make a detailed study of UV at the surface under a clear sky, because damage to plants, animals, and human beings are usually caused by excessive UV exposure under clear sky conditions. During the activity peak of the 23rd solar cycle, to enhance the observation, modelling, and forecasting of UV in big cities and rural areas will promote the development of cross subjects related to UV, such as biology, medicine, and the environmental sciences.

2. Instruments and observation

The routine observation of solar spectral radiation were carried out at Xianghe station (70 km southeast of Beijing) by the Institute of Atmospheric Physics, Chinese Academy of Sciences from 1 January 1990 to 31 August 1992. The observational instruments are model TBQ-4-1 and as follows. (1) There are three sensors with sensing wavelength ranges of 270–3200 nm, 400–3200 nm, and 700–3200 nm, respectively. The main technical characteristics of the sensors are: sensitivity is 5–10 mV kW^{-1} m^2, response time is $\leqslant$1s (1/e), stability is $\leqslant$2%. UV radiation received at the ground (290–400 nm) can be derived by subtraction of global radiation (270–3200 nm) and radiation over 400–3200 nm. In fact, UV radiation received at the ground is at wavelengths 290–400 nm because UV radiation below approximately 290 nm is absorbed by stratospheric ozone; then most UV radiation at the Earth's surface is between 320–400 nm, and only a small fraction of UV is in the biologically important band, UV-B (290–320 nm). (2) The solar radiation recorder, model RYJ-2, including mainly a PC-1500 computer and interface, is a multichannel high precision recorder, with accuracy of 5% and resolution of 1 W m^{-2} for instantaneous values and 0.01 MJ m^{-2} for accumulative values. The whole measurement system was calibrated at regular intervals. All sensors were installed on the top of the building, so as to avoid the shade from surrounding objects. The observation was measured daily from sunrise to sunset. In order to get reliable UV data, UV radiation measurements near sunrise and sunset were eliminated. During the observation, the cloudiness and cloud type were also observed.

Total ozone amount observed by a Dobson instrument and meteorological parameters from 1 January 1990 to 31 December 1991 were observed at Xianghe station.

3. The characteristics of UV variation

Generally, UV displays an evident diurnal and seasonal variation in different sites. For diurnal variation, UV shows lower values in the morning and in the evening, and higher values around noon. For seasonal variation, UV shows lower values in winter, and higher values in summer. The regularity of diurnal and seasonal variation of UV is more obvious and regular in clear sky conditions, and complex and irregular in cloudy sky conditions, because of the influences of clouds and aerosols. In general, UV and global radiation show the similar characteristics of diurnal and seasonal variation, and their ratio is relatively stable. The UV at the surface is mainly controlled by the regular motion of the sun, then modulated by other factors, such as ozone, aerosols, cloud, albedo, and tropospheric pollutants.

4. The calculation of UV and results

4.1 *Beijing area*

After analyzing the observation data of solar radiation, ozone and meteorological parameters in clear sky (cloudiness$\leqslant$2) from 1 January to 31 December 1990, an empirical model for calculating UV is obtained:

$$\eta = A_1 \cos Z + A_2 \mathrm{e}^{-k_1 a(\mathrm{O_3}) m} + A_3 \mathrm{e}^{-k_2 c_{\mathrm{w}} m} + A_4 \mathrm{e}^{-S/D} + A_0 \qquad (1)$$

Here, $\eta = Q_{\rm UV}/Q, Q_{\rm UV}$ is UV radiation, Q is global radiation, and A_1, A_2, A_3, A_4, A_0 are coefficients. The important factor affecting $Q_{\rm UV}/Q$ is solar motion, which is expressed by the cosine of zenith angle (Z). Besides, there are also other dominating factors affecting $Q_{\rm UV}/Q$: (1) Selective absorption by ozone in the atmosphere, which is expressed as $\mathrm{e}^{-k_1 a(\mathrm{O_3})m}$, where k_1 is the mean absorption coefficient of ozone in the wavelength range of 290.2–400.0 nm, $k_1 = (3.30 \pm 0.07) \times 10^5$ Pa cm^{-1}, $a(\mathrm{O_3})$ is the column total ozone amount in units of DU, and m is the air mass. (2) Absorption by water vapor, which is expressed by $\mathrm{e}^{-k_2 c_{\rm w} m}$, where k_2 is the mean absorption coefficient of water vapor in the wavelength range of 0.70–2.845 μm, $c_{\rm w}$ is the water vapor content in the whole atmospheric column and is calculated from an empirical formula by water vapor pressure ($p_{\rm e}$) at the ground, and $c_{\rm w} = 0.21 p_{\rm e}$. Term $\mathrm{e}^{-k_2 c_{\rm w} m}$ is calculated by an empirical method in this paper. In fact, water vapor does not have direct absorption in the UV band, but has an indirect effect on UV energy through complex chemical and photochemical processes (Bai and Wang, 1995). Water vapor has absorption in the infrared band, so water vapor has the influence on η. (3) The scattering by molecules and aerosols in the atmosphere, and the influence of the earth's albedo on solar UV radiation and on solar radiation, which are expressed by $\mathrm{e}^{-S/D}$, where S is the daily sum of scattered, and D is the daily sum of direct radiation on the horizontal plane. Then, the actual roles of $\cos Z$ and the above three factors to the ratio η can be determined by statistical analysis from observation data.

According to the stepwise regression analysis, good results can be obtained under clear sky from January to December 1990. Within the confidence level of α=0.01, η and $\cos Z$ are highly correlated, and their F-test value is 1103.5, the other F-test values for ozone, water vapor, and S/D are 2.554, 2.314, and 0.025, respectively. The correlation coefficient between η and the four factors is 0.997, and the standard deviation is 0.128. The observed and calculated UV (monthly mean daily sums) and their relative biases in 1990 under clear sky are reported in Table 1.

The calculated values agree well with those observed, with an average relative bias of 1.3%. In order to test the reliability of this method, the monthly mean daily sums of UV in 1991 under clear sky are calculated by formula (1); Table 2 gives the results.

Table 1. The observed and calculated UV (MJ m^{-2}) and their relative biases δ (%) in 1990 under clear sky

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$\mathrm{UV_{obs.}}$	0.95	1.27	1.37	1.48	1.54	1.65	1.52	1.48	1.44	1.36	0.98	0.82
$\mathrm{UV_{cal.}}$	0.96	1.25	1.35	1.52	1.57	1.63	1.54	1.46	1.43	1.37	0.99	0.82
δ	1.2	–1.3	–1.6	2.3	1.5	–1.2	1.4	–1.7	–1.3	1.0	0.4	–0.5

Table 2. The observed and calculated UV (MJ m^{-2}) and their relative biases δ (%) in 1991 under clear sky

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$\mathrm{UV_{obs.}}$	0.95	1.15	1.20	1.49	1.56	1.67	1.71	1.52	1.31	1.31	1.05	0.84
$\mathrm{UV_{cal.}}$	0.96	1.22	1.25	1.57	1.57	1.64	1.64	1.50	1.38	1.41	1.08	0.85
δ	0.9	6.0	3.5	5.3	0.5	–1.7	–4.4	–1.0	5.1	8.0	3.0	1.2

Table 3. The observed and calculated UV (MJ m^{-2}) and their relative biases δ (%) of 24 months from 1990 to 1991 under clear sky

Month	Jan 1990	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$\mathrm{UV_{obs.}}$	0.95	1.15	1.20	1.49	1.56	1.67	1.71	1.52	1.31	1.31	1.05	0.84
$\mathrm{UV_{cal.}}$	0.94	1.22	1.31	1.49	1.55	1.65	1.55	1.46	1.40	1.35	0.97	0.82
δ	–0.4	–3.5	–4.5	0.3	0.8	0.1	1.7	–1.9	–3.0	-1.1	-1.6	–0.6
Month	Jan 1991	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$\mathrm{UV_{obs.}}$	0.95	1.15	1.20	1.49	1.56	1.67	1.71	1.52	1.31	1.31	1.05	0.84
$\mathrm{UV_{cal.}}$	0.95	1.18	1.22	1.55	1.58	1.65	1.66	1.50	1.36	1.39	1.06	0.84
δ	–0.2	3.0	1.2	4.2	1.0	–0.8	–3.3	–1.2	3.7	6.2	1.1	0.3

Table 4. The observed and calculated UV (daily sums) and their relative biases (δ)

Date	UV_{obs} (MJ m^{-2})	UV_{cal} (MJ m^{-2})	(%)
1	0.375	0.391	4.35
2	0.389	0.360	-7.43
3	0.410	0.417	1.71
4	0.486	0.481	-1.08
5	0.376	0.375	-0.21
7	0.441	0.461	4.53
8	0.454	0.461	1.44
9	0.441	0.416	-5.69
10	0.451	0.434	-3.80
11	0.484	0.497	2.70

Table 5. The observed and calculated UV (monthly mean daily sums, MJ m^{-2}) in actual sky in 1990 and their biases δ

Month	UV_{obs} (MJ m^{-2})	UV_{cal} (MJ m^{-2})	δ (%)
Jan	0.50	0.51	1.69
Feb	0.46	0.44	–3.88
Mar	0.58	0.60	2.76
Apr	0.50	0.50	0.89
May	0.89	0.88	–0.57
Jun	0.98	0.96	–2.50
Jul	1.10	1.08	–1.50
Aug	1.17	1.22	3.92
Sep	1.07	1.06	–0.87
Oct	1.06	1.06	0.22
Nov	0.78	0.80	2.23
Dec	0.78	0.77	–1.88
Average			1.91

It can be seen that the calculated values also agree well with the observed, with an average relative bias of 3.2%. In order to obtain more reliable results, the 24 months data of clear sky from January 1990 to December 1991 are analyzed by the same method, and a similar formula as (1) is obtained, with the difference being the minute differences in coefficients and constant. Within the confidence level of α=0.01, η and $\cos Z$ are also highly correlated, their F-test value is 764.4, and the other F-test values of water vapor, S/D and ozone are 5.24, 2.1, and 0.05 respectively. The correlation coefficient between η and the four factors is 0.990, and the standard deviation is 0.208.

Table 3 shows the calculated UV (monthly mean daily sums) for 24 months under clear sky by using new coefficients obtained from the 2–year data, and the relative biases of the 24 months are also given.

The calculated values are also close to the observed, and their average relative bias is 1.9%; therefore, this method is feasible to calculate UV radiation.

4.2 *Mohe area*

A synthetic solar eclipse observation was carried out from 1 March to 12 March 1997 in Mohe county (52°59'N, 122°33'E, 430 m), Heilongjiang Province. The observation items were global radiation, direct and scattered radiation, UV, total ozone amount, and meteorological parameters (Bai and Kong, 1998). All radiation sensors were the same as before and installed on the top of the building of Mohe nursery. The ground was covered by snow during the observation period. According to the UV calculation method in the Beijing area, the results of Mohe were obtained. The correlation coefficient between η and the four items of ozone, aerosol, and water vapor is 0.953. Table 4 shows the observed and calculated UV (daily sums) and their relative biases δ.

The calculated UV agrees well with the observed, the maximum of their relative bias is 7.43%, and the average of their relative biases is 3.29%.

4.3 *Guangzhou area*

We applied this UV calculation method to the Guangzhou area (23°11′N, 113°20′E, 35.8 m), Guangdong province. Good results are also obtained; the observed and calculated UV and their relative biases δ are reported in Table 5.

The maximum relative bias between calculated and observed UV is 3.92%, and the average relative bias for the 12 months is 1.91%.

We also made observations of solar spectral radiation in the Antarctic and Inner Mongolia, and the variation characteristics of UV in those areas was analyzed. For the sake of saving space, the results are omitted.

5. The variation trends of UV in the Beijing area during the last two decades

Because of the lack of long-term and systematic observation of UV in Beijing, we applied formula (1) and coefficients obtained from two years of observation data to calculate the UV in clear and actual skies over the Beijing area. For the last two decades, all the observation data was obtained from Beijing observatory, and total ozone amount was observed by the Dobson instrument of the Institute of Atmospheric Physics, Chinese Academy of Sciences.

The calculated result shows that UV (monthly mean daily sums) from January 1979 to June 1996 in actual sky is in a decreasing trend (Bai and Wang, 1998). During this period of is in time, total ozone amount is in a decreasing trend, S/D a small increasing trend, and water vapor content in the whole atmospheric column shows no obvious variation. The variation rates for the yearly averages of UV, $a(O_3)$, p_e, and S/D from 1979 to 1995 are –10.7%±0.5%, –6.2%±0.01%, –3.3%±0.2%, and +5.6%±0.6%, respectively. In Beijing, we do not see a UV increasing trend when total ozone amount displays a decreasing trend. The explanation for this phenomenon is that UV at the surface is affected not only by ozone— the main important factor we recognized— but also water vapor and aerosols we did not pay attention to this before. Based on our previous study on the quantitative relationship between UV and its three factors of ozone, water vapor content in the whole atmospheric column, and aerosols, UV is more sensitive to the S/D factor than total ozone amount and water vapor. As the UV variation caused by the increasing trend of S/D counteracts the decreasing trend of ozone, finally, UV manifests a decreasing trend. Therefore, we should pay more attention to all affecting factors, especially on those factors other than ozone.

The severe damage of UV to plants, animals, and human beings usually happens in clear sky, so, it is the focus to study UV and its long-term variation in clear sky in the Beijing area, and it is also the key to forecast UV or the UV index.

Month-mean daily sums of UV from January 1979 to December 1998 in clear sky is calculated and shown in Fig. 1. In clear sky, the yearly averaged UV from

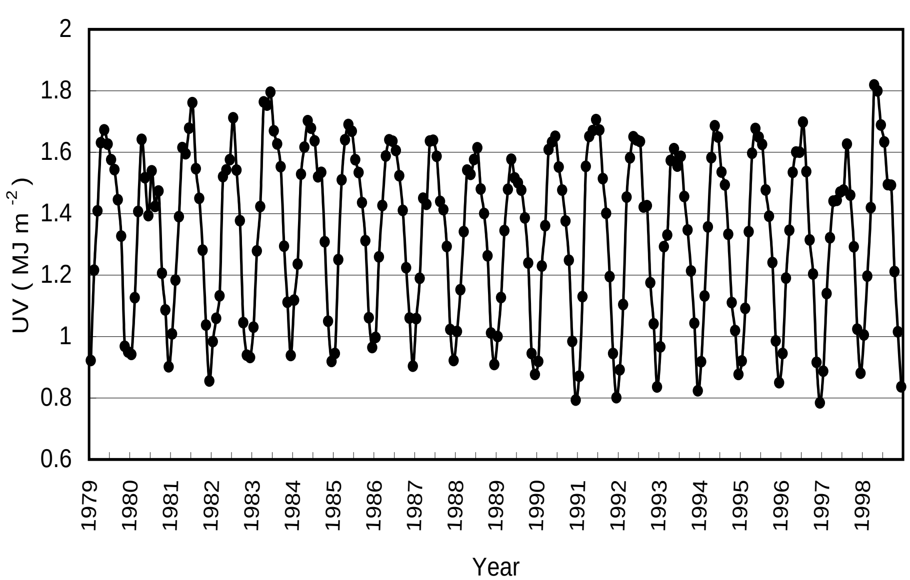

Fig. 1. Month-mean daily sums of UV from 1979 to 1998 in clear sky in Beijing.

Table 6. Variation rates of seasonal averages of all quantities in the last two decades (%)

Season	UV	$a(O_3)$	p_e	S/D	Q
Spring	–2.07	–7.58	3.41	–24.84	–1.14
Summer	–0.71	–4.01	–3.49	–14.72	0.01
Autumn	–3.47	–2.33	4.34	–9.66	–3.26
Winter	–7.36	–3.29	17.35	–26.89	–7.56

1979 to 1998 shows a decrease trend, with a decreasing rate of 3.09%±0.07%. During the last two decades, the variation rate of yearly averaged $a(O_3)$, p_e, and S/D are –4.48%±0.03%, +1.42%±0.01%, and –19.69%±0.27%, respectively. So, we still see the similar phenomenon that UV shows a decreasing trend as that in actual sky, but not an increasing trend, when total ozone amount is in a decreasing trend. This result is caused by the synthesis of all affecting factors.

Based on the variation characteristics of UV radiation, the maximum of monthly averaged UV can be separated into two phases, one from 1979 to 1991, and the other from 1991 to 1998. These two phases basically agree with the 11-year cycle of solar activity, and this can be seen in Fig. 1.

UV radiation in summer is the strongest in the year, and excessive UV reaching the lower troposphere can accelerate photochemical reactions in the atmosphere, and then cause much severe damage to human health and the atmospheric environment. So, it is important to study UV variation in summer. The seasonal mean UV variation in the four seasons in the last two decades are calculated, and the variation rates of UV and other quantities, including $a(O_3)$, $p_e, S/D, Q, S$, and D for the four seasons are given in Table 6.

In spring, in autumn, and in winter, the decrease of $a(O_3)$ and S/D leads to UV increase, the increase of p_e leads to UV decrease, and their synthesis results in a UV decreasing trend. In summer, $a(O_3)$, p_e, and S/D show a decreasing trend, and UV also a decreasing trend, with a rate of 0.7%. This phenomenon deserves to be studied seriously. The decrease of all affecting factors, $a(O_3)$, p_e, and S/D, leads to UV increase, but in fact, we see a UV decreasing trend of 0.7% in summer, which is strange and different from the other three seasons. In summer, the decreasing trend of S/D and p_e represent the decrease of aerosols and water vapor in the atmosphere, which implies the atmosphere is becoming cleaner. But global radiation does not significantly change in this period. The most probable reason is the increase of all kinds of tropospheric pollutants such as NO_2, SO_2, and O_3 in the Northern Hemisphere (Houghton et al., 1995) and the increase of volatile organic compounds (VOCs) emitted from natural and anthroprogenic sources. Some of these can absorb UV directly, and most can absorb UV indirectly in the photochemical reactions related to OH and H_2O_2 radicals. In the last two decades, with the fast development of all kinds of vehicles and planting trees and grass in Beijing and its rural areas, there are more and more VOCs emitted into the atmosphere, especially in summer, because the emission peak of VOCs comes from the vegetation.

As the diameter of these gases is much smaller than that of the particles, the increasing trend of the gases cannot be reflected by the S/D factor obviously. At present, we cannot find a better indicator than S/D to describe the changes or characteristics of these gases. But, we should find a better indicator in the future. Therefore, in the last two decades, the direct and indirect UV absorption by all kind of gases, pollutants, and non-pollutants may gradually become more and more important, and should be studied in the future. The systematic and simultaneous measurement of these gases, especially for thousands of VOCs, and UV should be made in the field, and an in-depth study should also be made in the laboratory.

Analyzing the variation rate of UV and its factors seriously, we find the variation rate of UV is highly anticorrelated with that of p_e, the correlation coefficient is –0.986. But, the variation rate of UV does not show high correlation with that of $a(O_3)$ and S/D, where their correlation coefficients are 0.39 and 0.48, respectively. It is an interesting and strange phenomenon, as far as we know by our current knowledge, that there should not be a high correlation between UV and p_e, because water vapor does not absorb UV radiation. According to the observation data of UV and water vapor pressure p_e at the ground in clear sky from January 1990 to December 1991, their correlation coefficient is only +0.71. But the variation rates for all quantities are calculated from the 20-year data, and the influence of seasonal variation of UV and its factors are eliminated in this condition, so this phenomenon implies that the UV at the surface should have some close relationship with water vapor content in the whole atmospheric column. According to the correlation analysis on the variation rate of UV and that of Q (correlation coefficient is 0.998), it is reasonable, because UV is a component of Q. Why is the UV variation rate highly anticorrelated with that of p_e? The possible mechanism is of two aspects. (1) The source of OH radicals. When the $O(^1D)$ atom is produced from O_3 photolysis in the UV band, it can react with H_2O, and produces the OH radical. In this process, the concentration of OH radicals in the troposphere relies on UV intensity and the concentration of H_2O. (2) OH radicals can participate in almost all chemical and photochemical reactions in the atmosphere, and play a very important role in the transportation and reutilization of UV energy in those reactions. Their behavior in synthesis in the real atmosphere makes UV and water vapor inseparable.

6. Expectation

Atmospheric science is a multi-subject science, and the processes of solar radiation transfer and photochemistry are closely related. In addition, the impact of human activities are mainly in the troposphere, so it is very important to study the UV radiation reaching the ground, the complex relationship between UV intensity and all kinds of gases, such as O_3, NO_x and VOCs, the variation regularity of surface O_3, NO_x, and VOCs and so on. In fact, actinic radiation plays an important role in the process of photochemical reactions, and visible radiation should be measured when UV is measured so as to completely study the characteristics and relationship between the actinic radiation and ozone photochemistry. Due to the different effects of UV on human health, plant growth, and atmospheric environment, a deepened UV study will promote the mutual penetration and mutual development in photochemistry, medicine, biology, and environmental sciences. As far as we know, UV-A is not affected very much by ozone, and UV-B has the strong biological effects. The method here in this paper determines total UV which is dominated by UV-A wavelengths and has only minor contributions from UV-B wavelengths. Therefore the results are much less sensitive to decreases in ozone than for the biologically more important UV-B wavelengths. It is important to measure UV-B radiation, apart from UV radiation in the future, because high UV-B radiation exposure is very harmful to humans, plants, and animals.

Atmospheric science is also an experimental science. In order to accurately know UV levels (including UV-B and UV-A) in cities and in rural areas, and to quantify the relationship between UV and its affecting factors, it is necessary to build up a UV observational network, unify the observational instruments, and unify the observational criterion. In contrast to China, many countries such as the United States and Australia have UV observation networks, monitor the UV and UV-B radiation, and report or forecast UV and UV-B levels to the public. As for China, UV research is very rare (Zhou, 1986; Wang, 1983; Tian et al., 1982, and so on.), and not systematic. In order to report actual UV/UV-B radiation levels to the public, and to guide the people on how to prevent damage from high UV exposure, it is our duty to push UV study forward in China. China has a large area and more than 1.3 billion in population. So what is the actual UV radiation level and how can we determine the actual UV index for different sites or areas in China? For solving those questions, it is necessary for us to build up a UV observation network in China, and those observation stations should be selected as representative sites distributed in typical regions over China, including big cities, rural areas, background sites, and so on. Then we can know clearly the UV distribution in China. On the basis of observation, UV forecasting can be developed well, and good guidance and services with a certain scientific value can be provided to the public. In the mean time, the other parameters such as meteorological and environmental parameters, including O_3, NO_x, VOCs, and aerosols should be monitored so as to understand and quantify their influences on UV/UV-B.

With the enhancement of the quality of life, people gradually recognize the importance of health and air quality, and urgently need information on UV intensity and the maximum recommeded exposure time outside. So, it will be valuable and practical to provide UV forecasts for typical cities and rural areas. We should develop and enhance UV study on systematic monitoring, forecasting, and developing a good and feasible method for UV radiation reporting in China, especially for big cities. Since it is the activity peak of the 23rd solar cycle, to three years after 2000, this is a good opportunity to monitor UV and its factors. We earnestly hope to promote our UV research through national and international collaboration, make good use of our talents and resources, and provide satisfactory information to the people.

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REFERENCES

Bai Jianhui, and Wang Gengchen, 1995: A possible extinction mechanism of solar ultraviolet radiation by water vapor in the atmosphere. *Chinese Journal of Atmospheric*, **19**(3), 380–384. (in Chinese)

Bai Jianhui, and Kong Qinxin, 1998: Observation and analysis of solar spectral radiation in solar eclipse at Mohe. *Optical Remote Sensing of the Atmosphere and Clouds*, **3501**, 475–483.

Bai Jianhui, and Wang Gengchen, 1998: Variation trends of solar UV radiation in Beijing area during 1979–1996. *Chinese Journal of Atmospheric Sciences*, **22**(3), 302–311.

Blumthaler, M., J. Grobner, M. Huber, and W. Ambach, 1996: Measuring spectral and spatial variations of UVA and UVB sky radiance. *Geophys. Res. Lett.*, **23**, 547–550.

Blumthaler, M., and W. Ambach, 1990: Indication of increasing solar ultraviolet-B radiation flux in alpine regions. *Science*, **248**, 206–208.

Gantner L., P. Winkler, and U. Kohler, 2000: A method to derive long-term time series and trends of UV-B radiation (1968–1997) from observations at Hohenpeissenberg (Bavaria). *J. Geophys. Res.*, **105**(D4), 4879–4888.

Houghton, J. T., L. G. Meria Filho, J. Bruce, H. Lee, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell, 1995: Radiative forcing of climate change and an evaluation of the IPCC IS1992 emission scenariors. *Climate Change 1994*, Cambridge University Press, Cambridge, U. K., 95–105.

Krzyscin, J. W., 1996: UV controlling factors and trends derived from the ground-based measurements taken at Belsk, Poland, 1976–1994. *J. Geophys. Res.*, **101**(16), 16797–16805.

Madronich, S., E. Weatherhead, and S. Flocke, 1996: Trends in UV radiation. *Int. J. Environ. Stud.*, **51**, 183–198.

Scott J., G. Cotton, F. Urbach, D. Berger, and T. Fears, 1988: Biologically effective ultraviolet radiation: Measurements in the United States, 1974 to 1985. *Science*, **239**, 762–764.

Tian Guoliang, Lin Zhenyao, and Wu Xiangding, 1982: Some characteristics of ultraviolet visual and infra-red radiation in Eastern Tibet during the growing season. *Acta Meteorologica Sinica*, **40**(3), 344–352. (in Chinese)

Wang Hongqi, 1983: Ultraviolet irradiance in different regions and different seasons. *Journal of Environment Science*, **4**(5), 13–17. (in Chinese)

Zhou Runhua, 1986: Ultraviolet solar radiation in China. *Acta Geographica Sinica*, **41**(2), 132–146. (in Chinese)