Registration No.
11-1360000-000895-10

Summary of Korea Global Atmosphere Watch
2012 Report

Issued on August 31, 2013

KMA Korea Meteorological Administration
GAW Global Atmosphere Watch

Summary of Korea Global Atmosphere Watch 2012 Report

Korea Meteorological Administration
Korea Global Atmosphere Watch Center

393-17, Haeangwangwang-ro, Anmyeon-Eup, Taean-Gun, ChungNam, 357-961, Korea
Office : 82-41-674-6420~1 Fax : 82-41-674-6422 E-mail : clkga@korea.kr

Summary of Korea Global Atmosphere Watch 2012 Report

The Korea Meteorological Administration began global atmosphere watch at Mt.Sobaek Meteorological Observatory, Danyang-gun, Chungcheongbuk-do, in 1995 to ensure a timely national-scale response to the pressing issue of climate change. That is the first site on the Korean Peninsula for continuously monitoring ambient atmosphere.

Observation technology of climate change including on the chemical composition of the atmosphere, its natural and anthropogenic change has been rapidly developed since the relocation of the site to the island of Anmyeon-do in Taean-gun, Chungcheongnam-do (36°32′N, 126°19′E; 45.7 m above sea level) in 1996. The station has been renamed the "Korea Global Atmosphere Watch Center (KGAWC)" in 2008. At present, 37 parameters including greenhouse gases, aerosols, ultraviolet radiation, ozone, and precipitation chemistry, are being measured at the KGAWC.

The KGAWC belongs to the regional GAW station (registration number: 47132) since 1998, and the KGAWC has been actively engaged in international activities, participating in inter-comparison events, organizing international workshops, and sharing data from WDCGG (World Data Centre for Greenhouse Gases). Due to its relatively pollution-free environment, the KGAWC provides an ideal site for observations that are geographically representative of the ambient atmosphere of Northeast Asia including the Korean Peninsula.

Fig. 1. The Korea Global Atmosphere Watch Center is located in the relatively uncontaminated western coastal area.

□ Greenhouse Gases (GHGs)

Since 1999, the KGAWC has observed major greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbon (CFC-11, 12). Since 2007, the KGAWC has been monitoring the sulfur hexafluoride (SF_6) and CFC-113.

In 2012, annual concentration of carbon dioxide was 400.2 ppm indicating that it exceeded 400 ppm for the first time since the Center started monitoring it in 1999. Out of 12 months, seven months recorded more than 400 ppm (Table 1). The annual mean growth rate of carbon dioxide in Korea was 2.1 ppm, a similar level to global average growth rate of 2.0 ppm/yr (Fig. 1.). The figure is higher than the average growth rate of the 1990s (~1.5ppm/yr).

Table 1. Monthly average concentration of CO_2 in Anmyeon-do, Korea

(unit : ppm)

Korea	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
CO_2 (ppm)	402.0	403.4	404.0	404.4	403.2	399.4	394.5	392.2	394.2	399.3	403.0	403.1	400.2

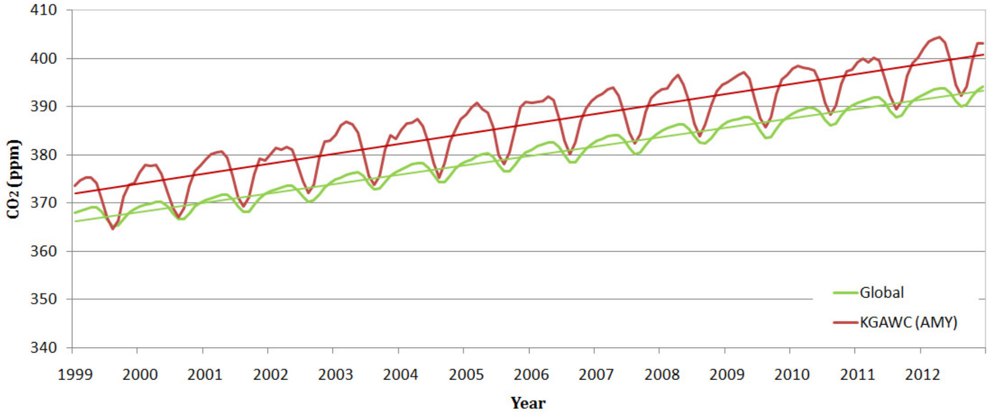


Fig. 2. Global and KGAWC's average CO_2 concentration from 1999 to 2012

Averaged methane was 1,938 ppb in 2012 indicating that it increased by 55 ppb (2.9%) compared to 1,883 ppb in 1999. Before the industrial era, atmospheric methane was at most 700 ppb globally. Methane is released mainly from agricultural and fugitive emission in Korea. Global growth rate of methane has been on the rise since 2006.

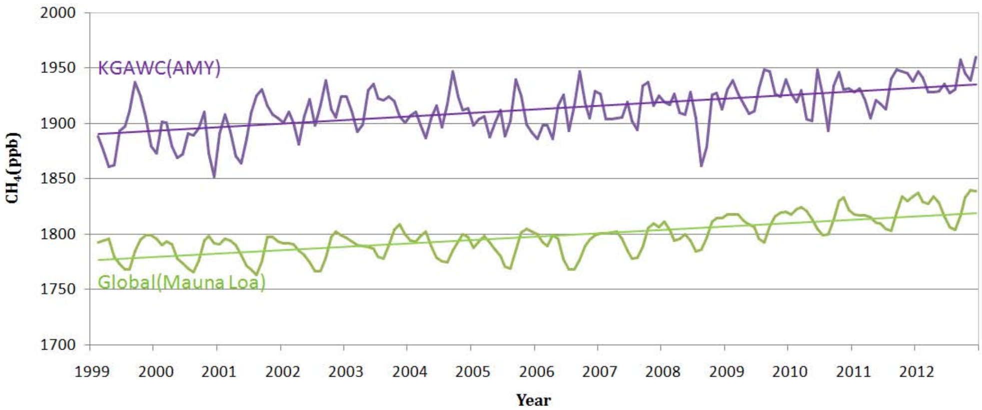


Fig. 3. Averaged CH_4 concentration from 1999 to 2012 in Mauna Loa and KGAWC.

Annual concentration of nitrous oxide for 2012 recorded 325.9 ppb with an increase of 11.5 ppb (3.6%) from the averaged concentration, 314.0 ppb in 1999. Meanwhile, three kinds of CFCs which were officially banned in production under the Montreal Protocol are all dwindling. CFC-11 dropped by 27.1 ppt from 270.4 ppt in 1999 to 243.3 ppt in 2012; CFC-12 by 17 ppt from 532.5 ppt in 1999 to 515.5 ppt in 2012; and CFC-113 by 1.7 ppt from 76.4 ppt in 2007 to 74.7 ppt in 2012. Sulfur hexaflouride is one of potent and long-lived greenhouse gases controlled by the Kyoto Protocol to the United Nations Framework Convention on Climate Change. It is artificially produced and mainly used as an electrical insulator in power distribution equipment. Its annual averaged concentration is on the slight increase every year from 2007 to 2012. It recorded 8.24 ppt in 2012, 0.14 ppt higher than 2011.

Table 2. GHGs annual mean concentrations in Anmyeon-do, Korea

GHGs	CO_2	CH_4	N_2O	CFC-11	CFC-12	CFC-113	SF_6
Annual mean concentration	400.2 (ppm)	1,938.0 (ppb)	325.9 (ppb)	243.3 (ppt)	515.5 (ppt)	74.7 (ppt)	8.24 (ppt)

□ Reactive Gases

According to the result of observed surface O_3 in 2012, it recorded the highest of 50~60 ppb during the period of May to June while December showed the lowest level of 23.3 ppb. It is caused by photochemical reaction which was active during that period. Annual mean concentration of surface O_3 in 2012 was 39.8 ppb, 3.7 ppb decrease from 43.5 ppb in 2011. However, annual mean concentration from 2004 to 2012 remains steady around 40 ppb.

Regarding CO, monthly concentration from June to August showed 190~220 ppb while the rest of months posted between 260 and 440 ppb. Seasonal mean concentration was high in winter and spring; however, relatively low in summer. January recorded the highest concentration with 448.3 ppb. Its annual mean concentration increased to 304.9 ppb, 10.8 ppb higher than 294.1 ppb in 2011.

Monthly average of NOx reached the high of 9.6 ppb in December, and lowest in April and June of 3.8 ppb and 4.0 ppb respectively. Annual mean concentration of NOx in 2012 amounts to 6.1 ppb, 1.4 ppb lower than 7.5 ppb of 2011. Since 2004, it has been gradually decreasing.

With regard to SO_2 monthly average, high concentration episodes frequently occurred during winter period (January through February and December) recording concentration higher than 3.5 ppb while April and June through October showed low concentration of 1.0~1.4 ppb. Annual concentration of SO_2 was 2.4 ppb in 2012, 0.5 ppb lower than 2.9 ppb in 2011.

Table 3. Annual mean concentration of reactive gas during recent 9 years

(unit : ppb)

Year	O_3	CO	NOx	SO_2
2004	37.6	255.4	9.7	2.0
2005	35.4	240.3	9.8	2.9
2006	44.7	233.1	8.0	2.9
2007	38.6	212.4	8.2	3.7
2008	45.0	247.8	8.1	3.2
2009	41.0	244.2	7.5	2.6
2010	43.3	253.4	6.8	2.4
2011	43.5	294.1	7.5	2.9
2012	39.8	304.9	6.1	2.4

□ Aerosol

Aerosols in the ambient atmosphere have an extensive impact on climate change, visibility reduction and human health depending on size and composition of aerosol. Aerosols can alter the climate system causing changes in atmosphere radiative forcing by absorbing or scattering solar radiation, and aerosols also affect to cloud albedo by changing cloud condensation nuclei. Recent research shows that aerosol number concentration observed by 16 GAW sites which have long-term data of United States and Europe is on the declining trend (A. Asmi et al., 2013). It explains that the cause of this trend lies in the decrease of anthropogenic emission of aerosol.

The KGAWC observes not only physical property of aerosol such as its mass concentration and number concentration but also its vertical and optical properties. In particular, the KGAWC retains aerosol mass concentration data of 14 years since its first observation in 1999. Figure 4 describes monthly average mass concentration observed by β-ray PM_{10} between 1999 and 2012. Aerosol mass concentrations observed in the KGAWC are also showing the decreasing trend as is a global trend in other GAW sites of the northern hemisphere. It implies that air quality of the ambient atmosphere around Korea has been improved. Figure 5 indicates seasonal variation of averaged aerosol mass concentration from 1999 to 2011 and monthly average of 2012 in Anmyeon-do site. It reflects general seasonal variation in the ambient atmosphere over the Korean Peninsula, where aerosol concentration is high in spring and low in summer. But observations in 2012 do not follow such seasonal variation because Asian dust, a driver of high concentration of aerosol was less severe in 2012. Average aerosol mass concentration for 2012 recorded 34.7 ㎍/m³, lower than 54.3 ㎍/m³, average concentration of the past 13 years. Changes in aerosol concentration in Northeast Asia have been mainly attributed to natural emission sources such as frequency and intensity of Asian dust as well as reduction in anthropogenic emissions in the Northern hemisphere. However, more research is required to clarify the exact cause of declining trend of aerosol mass concentration in Korea. The Center also operates SMPS[1] and APS[2] to measure aerosol number concentration. Relatively short observation period leads to the need of continuous monitoring and data accumulation to identify the trend and characteristics of physical property of aerosol.

Fig. 4. Monthly mean time series of mass concentration observed by β-ray PM_{10} in the KGAWC from 1999 to 2012. Black line indicates the linear regression for mass concentration in ambient air over the Korean Peninsula.

1) Scanning Mobility Particle Sizer, Aerosol Measurement Range: 0.01 ㎛~0.5 ㎛ in diameter
2) Aerosol Particle Sizer, Aerosol Measurement Range: 0.5 ㎛~20 ㎛ in diameter

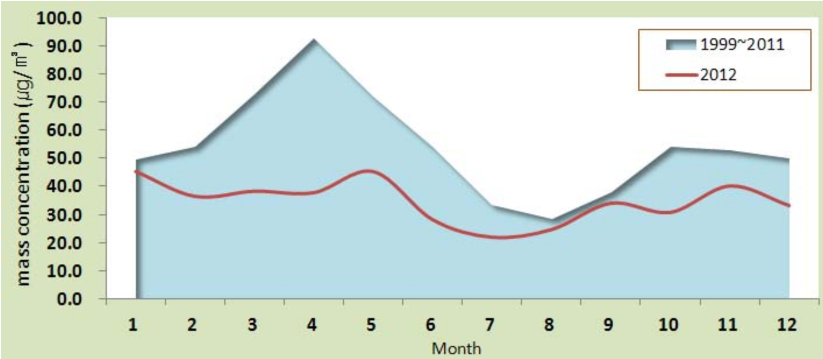


Fig. 5. Seasonal variation of aerosol mass concentration in the KGAWC averaged for 1999~2011 (blue area) and monthly mean of mass concentration in 2012 (red line).

To monitor optical property of aerosol, the KGAWC operates Nephelometer[3)] and Aethalometer to measure scattering coefficient and absorption coefficient in Anmyeon-do. Observatories worldwide with a long history have diverse aerosol observation environments including ocean, mountain and desert. Analysis of optical property of aerosol has shown no distinctive and statistically significant global trend. Different regions demonstrate different optical properties. For example, negative trend is detected in the North Pole while Mauna Loa GAW station located in the middle of North Pacific observes positive trend(M. collaud Coen et al., 2013). Scattering coefficients and absorption coefficients observed at Anmyeon-do site are showing sample linear relationship. It is one of the typical aerosol optical properties among the most of GAW sites located in the area free from anthropogenic emissions, except the extra-ordinary weather conditions. Scattering coefficient averaged 113.1 Mm- and absorption coefficient 8.91 Mm-1 for aerosol (520mm), 4.59 Mm-1 for soot (880mm) in the KGAWC for 2012.

Monitoring vertical property of aerosol is carried out by LIDAR observation and for more detailed analysis, aerosol discrimination method is applied. in 2012, five Asian dust cases were recorded. The KGAWC not only relies on surface observation data but also monitors vertical property of Asian dust layer. Figure 6 shows an Asian dust case which passed across the Korean

3) Measuring Device of Aerosol Light Scattering Coefficient

Peninsula in spring. It was an unusual case because the amount of collected aerosol was relatively small although it was one of the strongest Asian dust cases. Monitoring vertical property of aerosol by Lidar enables more detailed observation of aerosol and better data analysis.

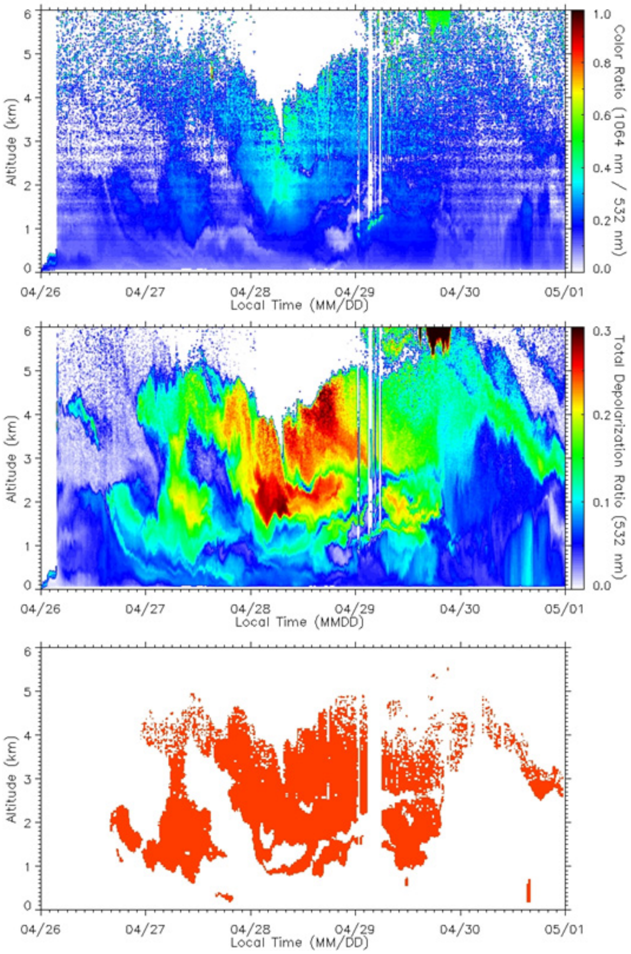


Fig. 6. Color ratio and depolarization ratio data of Anmyeon-do Lidar system and the result analyzed by aerosol discrimination method in case of sever Asian dust observed in April 2012.

Reference

M. Collaud Coen et al., 2013. Aerosol decadal trends– Part 1: In–situ optical measurements at GAW and IMPROVE stations. Atmos. Chem. Phys., 13, 869–894.

A. Asmi et al., 2013. Aerosol decadal trends – Part 2: In–situ oaerosol particle number concentrations at GAW and ACTRIS stations. Atmos. Chem. Phys., 13, 895–916.

□ Ozone and Ultraviolet Radiation

Ozone in the stratosphere absorbs some of the Sun's biologically harmful ultraviolet radiation. Because of this beneficial role, stratospheric ozone is considered "good" ozone. In contrast, excess ozone at Earth's surface that is formed from pollutants is considered "bad" ozone because it can be harmful to humans, plants, and animals(WMO/GAW).

The KMA stratospheric ozone observing system comprises 4 stations, which are located in Anmyeon-do, Pohang, Gosan and Seoul (Yonsei University, a contributing station) that measure total column ozone and ozone profiles in the stratosphere.

The daily maximum value of total column ozone measured in 2012 by a Dobson spectrophotometer (Beck #124) in Seoul amounts to 448 DU (6 April) and the daily minimum, 253 DU (16 October). The average annual variation of total column ozone for 1985-2012 recorded 324 DU and the highest value in March (361 DU), and the lowest in October (291 DU) with an annual range of 70 DU.

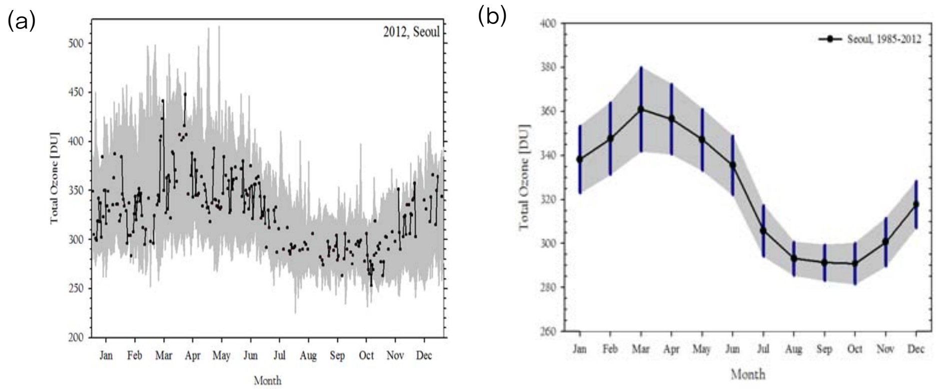


Fig. 7. (a) Changes in total column ozone (TCO) in Seoul (Grey area indicates the range of averaged daily fluctuation of TCO from 1985 to 2011) (b) Annual change in long-term monthly average (1985~2012).

Inter-annual change in total column ozone average recorded the highest in 2010 (343 DU) and the lowest in 1988 (313 DU).

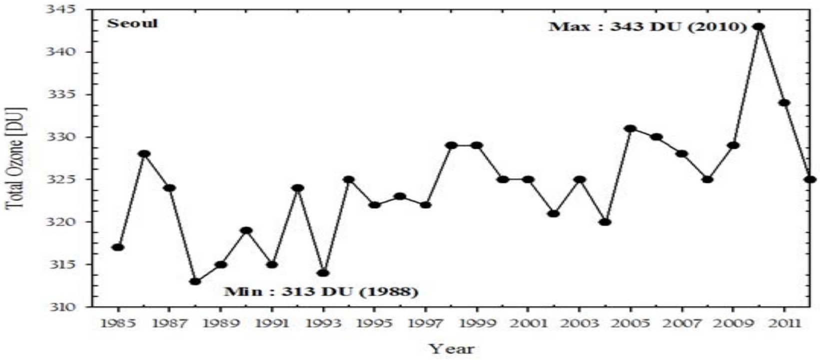


Fig. 8. Changes in annual average of every two years from 1985 to 2012

As for the total column ozone measured in Pohang using a Brewer spectrophotometer (#161), the average for 1994-2012 was 313 DU. Inter-annual change in total column ozone increased after 1994 and 1995, peaking at 336 DU in 2001, after which it showed a sharp drop, recording the lowest value of 303 DU in 2003, and subsequently alternating rises and falls.

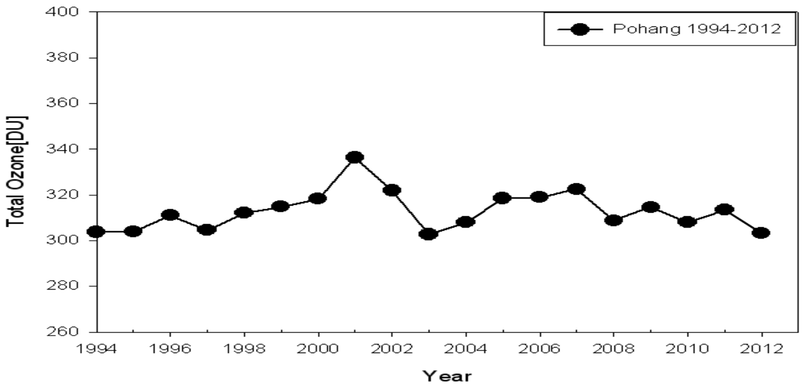


Fig. 9. Annual average of total column ozone in Pohang from 1994 to 2012

The intra-annual change of monthly total column ozone averages was the highest in April with 349 DU, and the lowest in October with 284 DU. Seasonal changes were pronounced with the peaks concentrated in the spring and the lowest values in autumn.

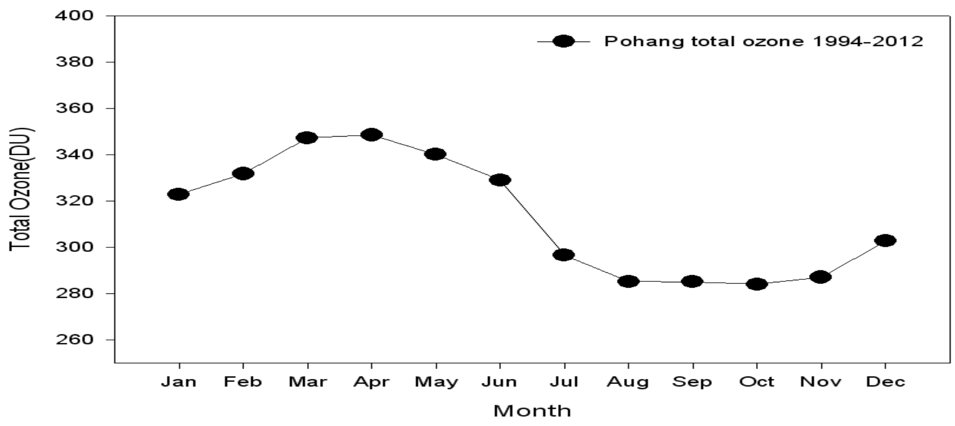


Fig. 10. Monthly average of total Ozone in Pohang (1994~2012)

In Anmyeon-do, vertical profiles of stratospheric ozone concentrations have been documented by an ozone lidar (model: StraZon 3079) since 2002. The annual average marked the highest in February and March around 21 km above ground, and relatively low level in September and October around 25 km above ground.

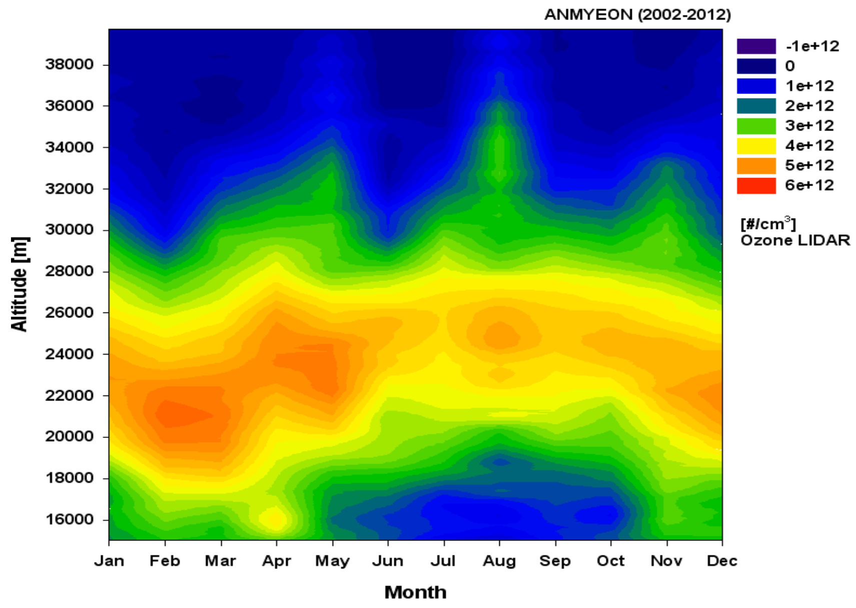


Fig. 11. Monthly changes in vertical profile of ozone in Anmyeon-do (Best profile between 2002-2012)

The KMA ultraviolet radiation is observed by a network of 5 stations, which are located in Anmyeon-do, Pohang, Gosan, Mokpo, Gangneung and Seoul (Yonsei University, a contributing station) that measure UV-B and UV-A in the ground through UV Biometers (Solar Light Co. Model #501). This network serves to monitor harmful surface ultraviolet radiation over the Korean Peninsula since 1999. Annual trend of monthly average UV-A radiation for 2008-2012 in Anmyeon-do is characterized by seasonal variations, with the highest value recorded at 107.5 mW/cm^2 in June and the lowest at 32.6 mW/cm^2 in December. Annual trend of monthly average UV-A radiation for 2010-2012 in Pohang reflects seasonal variations, with the highest value at 99.5 mW/cm^2 in June and the lowest at 21.6 mW/cm^2 in December.

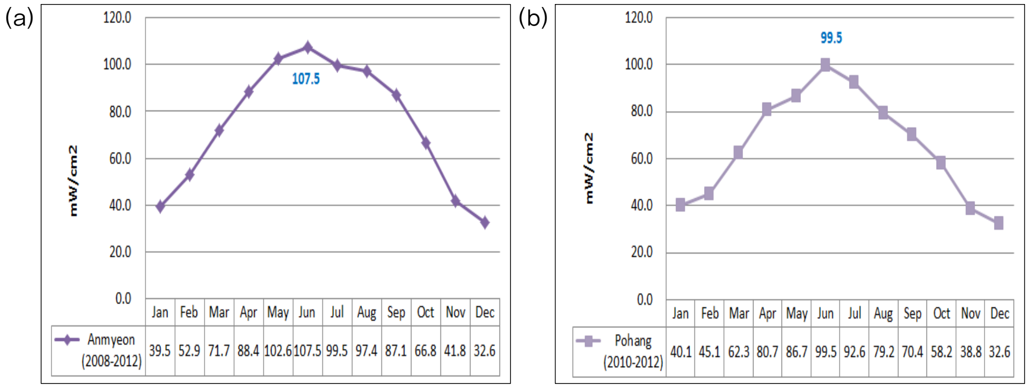
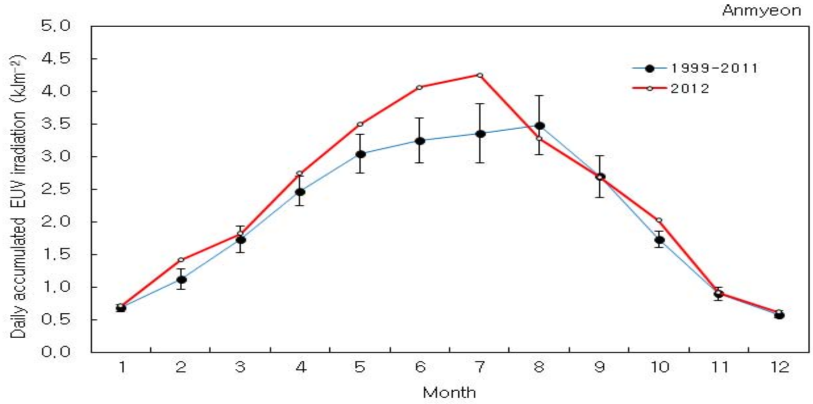


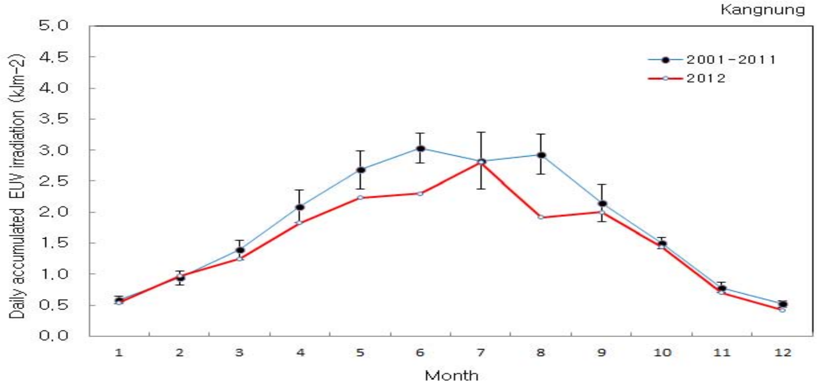
Fig. 12. Monthly amount of UV-A radiation in Anmyeon-do(a) and Pohang(b)

Annual trends of monthly average UV-B radiation for 1999-2012 in Anmyeon-do, Pohang and Gosan show seasonal variations. The highest values posted 198.9 mW/m^2 in August, 197.2 mW/m^2 in August and 204.6 mW/m^2 in June-July and the lowest values, 40.5 mW/m^2, 46.7 mW/m^2 and 49.8 mW/m^2 in December respectively. Annual trends of monthly average UV-B radiation for 2001-2012 in Mokpo and Gangneung with seasonal variations reached the highest values at 182.1 mW/m^2 and 166.7 mW/m^2 in August and the lowest values at 45.3 mW/m^2 and 33.1 mW/m^2 in December respectively.

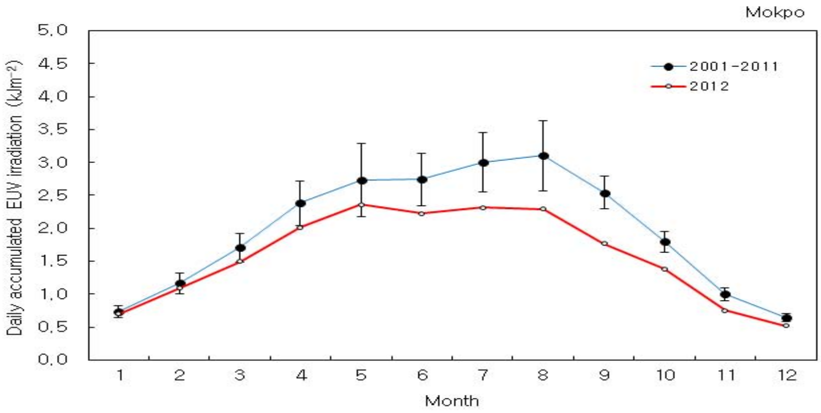
(a)


Anmyeon
1999-2011
2012
Daily accumulated EUV irradiation (kJm^{-2})
Month

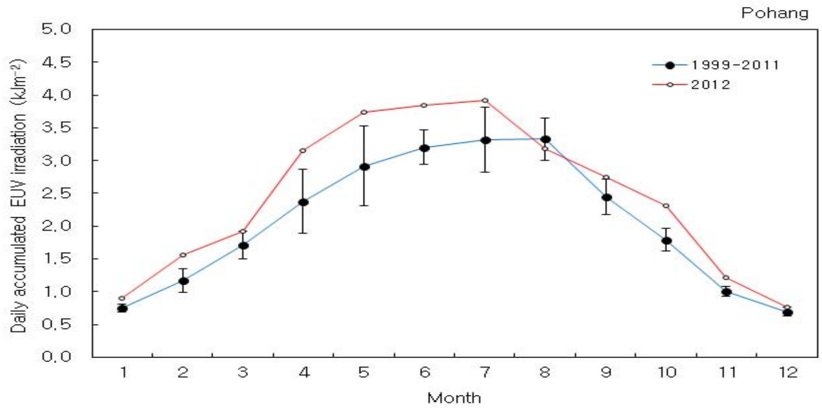
(b)


Kangnung
2001-2011
2012
Daily accumulated EUV irradiation (kJm-2)
Month

(c)


Mokpo
2001-2011
2012
Daily accumulated EUV irradiation (kJm^{-2})
Month

(d)



(e)

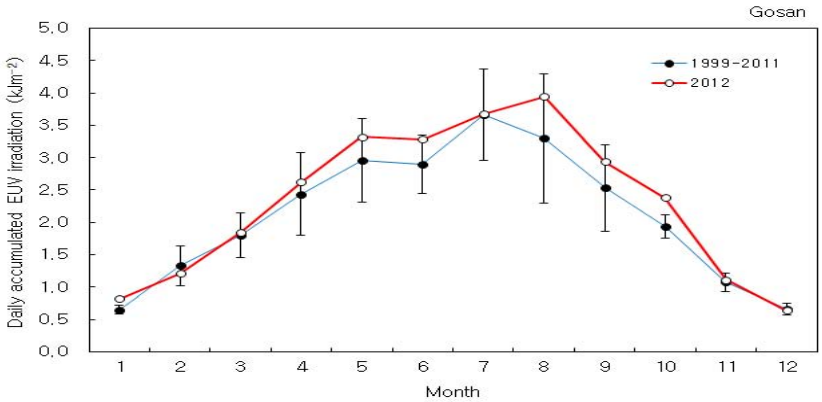


Fig. 13. Monthly average of UV-B in (a) Anmyeon-do (b) Gangneung (c) Mokpo (d) Pohang (e) Gosan

Figure 14 compares the monthly average UV index of Anmyeon-do for 1999-2011 and that for 2012. For 1999-2011, UV index recorded its highest monthly value in August but in 2012, its highest monthly value was shown in July. Overall, the UV index for 2012 was higher than the average value of 2001-2011. Table 4 illustrates dermatological response patterns of each UV index level.

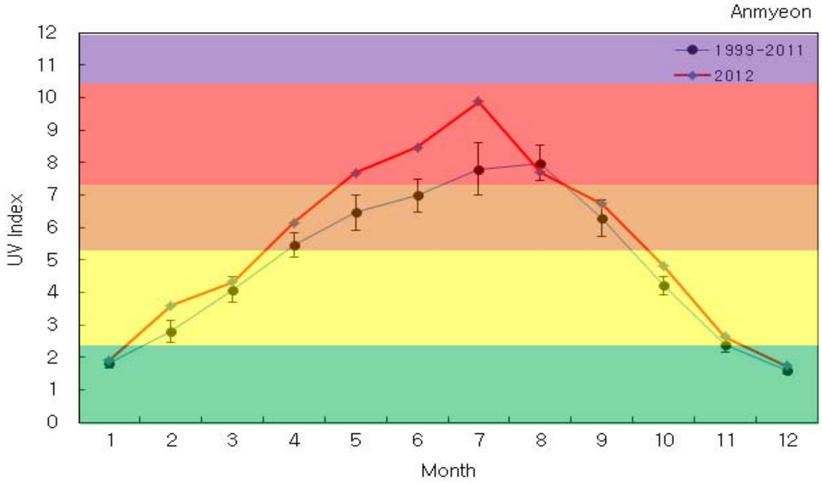


Fig. 14. Monthly averages of UV index in Anmyeon-do GAW station for 1999-2011 and for 2012.

Table 4. Dermatological response according to UV index

UV Index	Description		Media Graphic color
0-2	Low	No danger to the average person	Green
3-5	Moderate	Little risk of harm from unprotected sun exposure	Yellow
6-7	High	High risk of harm from unprotected sun exposure	Orange
8-10	Very High	Very high risk of harm from unprotected sun exposure	Red
≥11	Extreme	Extreme risk of harm from unprotected sun exposure	Violet

□ Precipitation Chemistry

Average precipitation acidity (pH) of ambient air areas for 2012 (January- December) recorded 4.75 in Anmyeon-do, 4.92 in Gosan, 4.90 in Uljin and 4.43 in Ulleung-do. The acidity levels of Anmyeon-do and Gosan were weaker while those for Uljin and Ulleung-do were stronger than the previous year.

Table 5. Average pH of 4 observation areas

Year/Period	Anmyeon-do	Uljin	Gosan	Ulleung-do	KOREA
2011	4.64	4.93	4.64	4.86	4.76
2012	4.75	4.90	4.92	4.43	4.68
1997~2011	4.68	4.88	4.82	4.91	4.82
1997~2012	4.69	4.88	4.84	4.83	4.80

Figure 15 describes annual average precipitation pH values of the four ambient air areas between 1997 and 2012. The blue dotted line (Korea) indicates the average of the four areas. Almost every year Anmyeon-do posted the lowest precipitation acidity; however, in 2012, Ulleung-do recorded the lowest followed by Anmyeon-do, Uljin and Gosan. The average of the four areas (Korea) for 2012 was 4.68, lower than the past average (between 1997 and 2011) of 4.82. The figure was also lower than the previous year (2011) of 4.76.

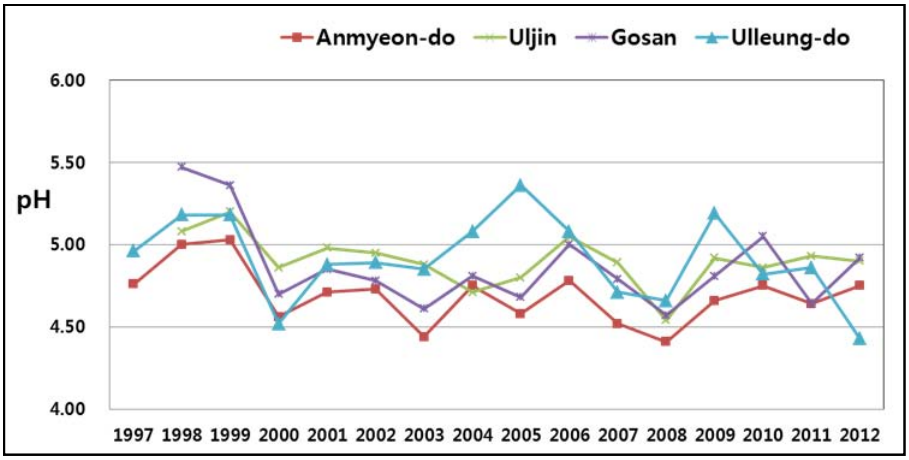
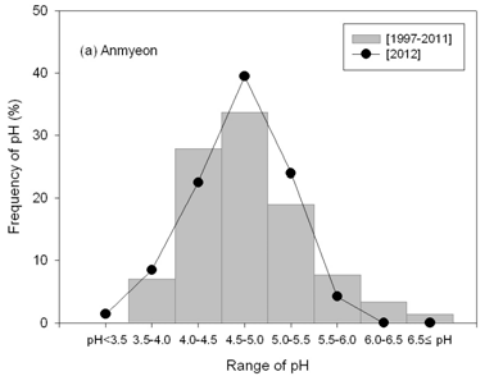


Fig. 15. Distribution of averaged pH concentration in 4 observation areas between 1997 and 2012

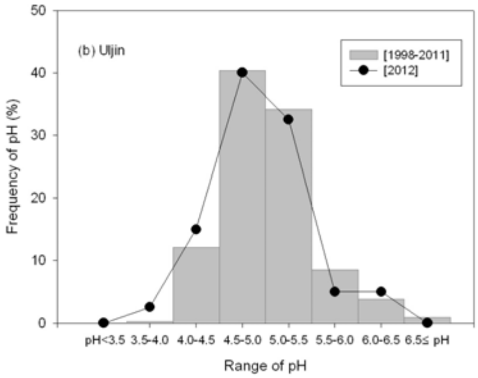
The precipitation pHs (acidity) for Anmyeon-do, Gosan and Uljin most frequently lie within the range of 4.5-5.0 between 1997 and 2011 while most frequent range for Ulleung-do is 5.0-5.5. In 2012, Anmyeon-do and Uljin followed the similar trend to the previous years; however, the frequence of pH

4.5-5.0 fell in Gosan while pH between 5.0-5.5 rose. Meanwhile, Ulleung-do had more frequent precipitation with pH ranged between 4.5-5.0 but less with pH 5.0-5.5 range.

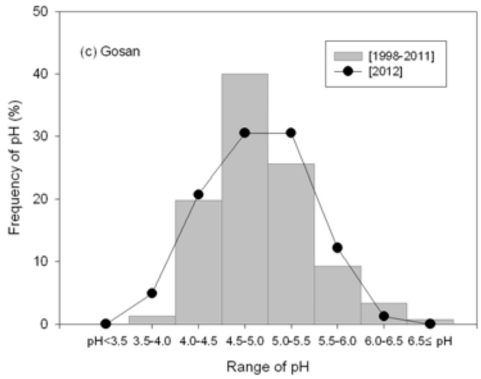
(a) Anmyeon–do



(b) Uljin



(c) Gosan



(d) Ulleung–do

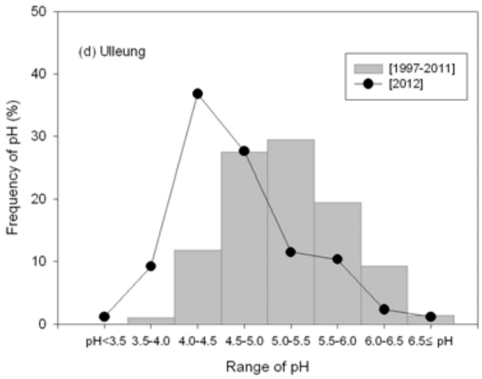
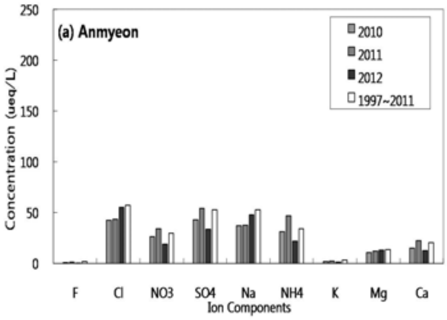


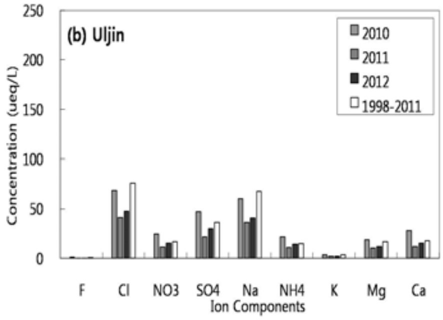
Fig. 16. Frequency of pH concentration range

Figure 17 illustrates averaged concentration of ion components of the four areas for 2012, 2011, 2010 and 1997-2011. It shows characteristics of ion concentration for each area. Gosan and Ulleung-do are characterized by higher concentration of Na and Cl than other areas.

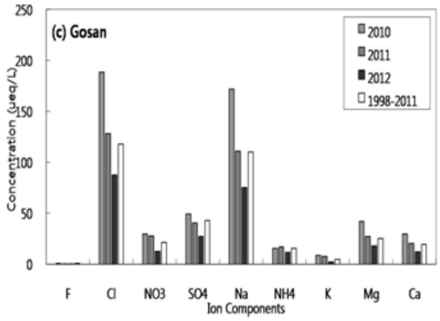
(a) Anmyeon–do



(b) Uljin



(c) Gosan



(d) Ulleung–do

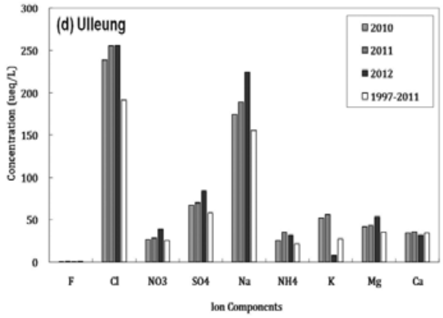


Fig. 17. Averaged ion concentration in Anmyeon-do, Uljin, Gosan and Ulleung-do

Recommended citation:
Korea Meteorological Administration (KMA), 2013. Summary of Korea Global Atmosphere Watch 2012 Report. KMA, 18pp.

Summary of Korea Global Atmosphere Watch

2012 Report

KMA Korea Meteorological Administration

GAW Global Atmosphere Watch