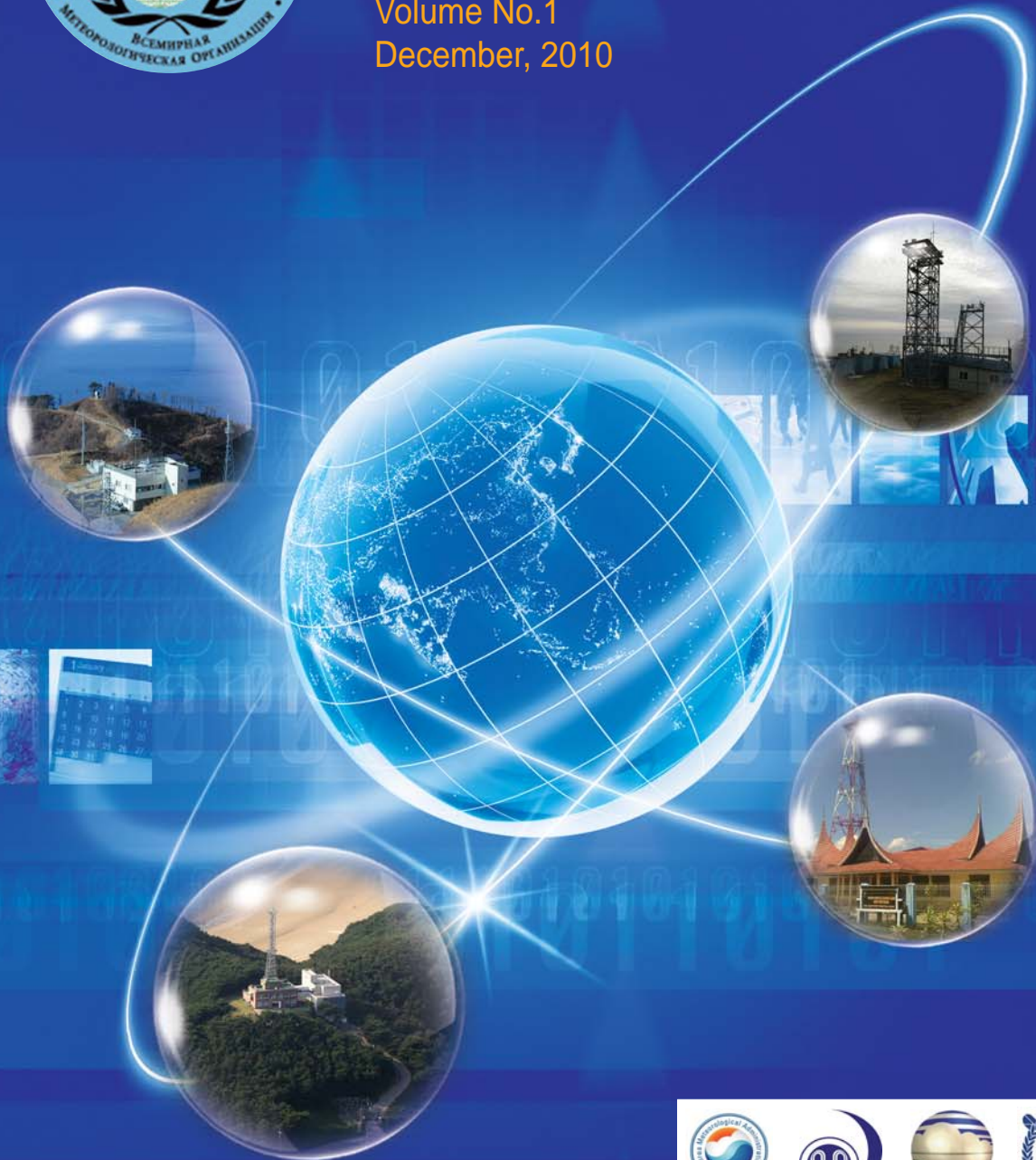


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Asian GAW Greenhouse Gases Newsletter

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Countries are listed in alphabetical order.

This newsletter is made based on mutual agreement by Asian GAW members participating in "the 2nd International Workshop on Atmosphere Watch in Asia" held in Jeju Island, Republic of Korea on October, 2010.

Contents of this article are contributed by participants in the workshop, and the next newsletter will be published in December 2011.

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Asian Greenhouse Gases Newsletter for GAW

KOREA (Anmyeon-do)

Han-Cheol Lim (Korea Meteorological Administration)

Anmyeon-do (36°32'N, 126°19'E; 45.7m above sea level) is a regional GAW stations located on the west coast of the Korean Peninsula (Figure 1). The observatory has been operated by the Korea Global Atmosphere Watch Center (KGAWC) of KMA since 1996, and presently, 36 parameters, including greenhouse gases, aerosols, ultraviolet radiation, ozone, and precipitation chemistry, are being measured.

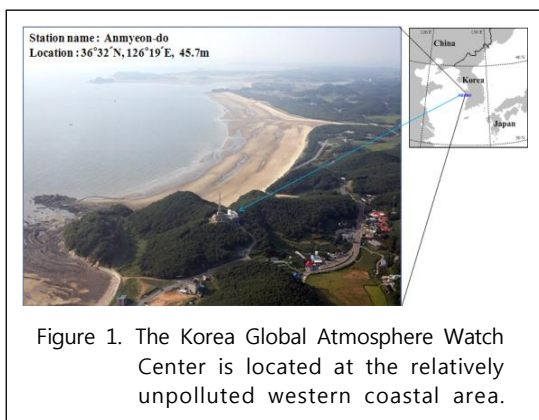


Figure 1. The Korea Global Atmosphere Watch Center is located at the relatively unpolluted western coastal area.

The center is actively engaged in international activities, participating in intercomparison events, organizing international workshops, and sharing data from WDCGG (World Data Centre for Greenhouse Gases). Due to its relatively pollution-free environment, KGAWC provides an ideal site for observations that are geographically representative of the background atmosphere of Northeast Asia, including the Korean Peninsula. Since 1999, the center has been monitoring major greenhouse gases (GHGs) such as carbon dioxide

(CO₂), methane (CH₄), nitrous oxide (N₂O), and chlorofluorocarbons (CFC-11, CFC-12). In 2007, the number of GHGs monitored at the Center was increased to seven, with the addition of chlorofluorocarbon (CFC-113) and sulfur hexafluoride (SF₆). Figure 2 shows the concentration levels for the five GHG types observed at Anmyeon-do from 1999 to 2009, along with the NOAA/GMD global CO₂ concentration trends (CFC-113 and SF₆ are not shown). The CO₂ concentrations at Anmyeon-do are substantially higher than the global average and the concentrations of both N₂O and CH₄ are steadily increasing, while CFCs exhibit a continuously declining trend (Table 1).

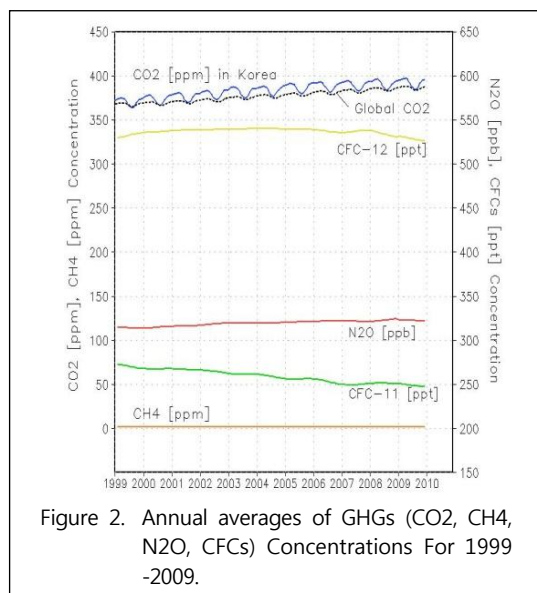


Figure 2. Annual averages of GHGs (CO₂, CH₄, N₂O, CFCs) Concentrations For 1999 -2009.

Table 1. Average concentrations for 2009 and annual mean growth rates for the 11-year period from 1999 through 2009 of major GHGs in the background atmosphere of the Korean Peninsula.

GHGs	CO ₂	CH ₄	N ₂ O	CFC-11	CFC-12
Average concentrations in 2009	392.5 (ppm)	1.906 (ppm)	323.9 (ppb)	249.3 (ppt)	528.9 (ppt)
11-year avg. growth rates	+2.15 (ppm/year)	+0.00246 (ppm/year)	+0.97 (ppb/year)	-2.26 (ppt/year)	-0.43 (ppt/year)

KGAWC also participated in the Global Round Robin inter-comparison held by WMO/CCL (NOAA/ESRL/GMD). We made the analysis of 5 types of greenhouse gases (CO₂, CH₄, N₂O, CO, SF₆) in the three near ambient cylinders of undisclosed trace gas mole fractions and the analyzed results were submitted to WMO/CCL. (Figure 3, left).



Figure 3. KGAWC participated in the Global Round Robin held by WMO/CCL on October, 2010. The 5 types of greenhouse gases (CO₂, CH₄, N₂O, CO, SF₆) were analyzed and the results were submitted by KGAWC in the world inter-comparison. The right is the cover of the 'Summary of Korea Global Atmosphere Watch 2009 report' published by KMA/KGAWC in 2010.

All the activities of KMA/KGAWC for 2009 were reported in 'Korea Global Atmosphere Watch 2009 Report' and the summary was also published in an English version in September 2010 (Figure 3, right). On Jeju Island, the 2nd International Workshop on Atmosphere Watch in Asia was held by KMA and

KRISS on October 21st and 22nd, 2010 to enhance international cooperation among Asia GAW stations.

Mr. Kang-Dong Hun, who is one of the KGAWC members, participated in the 19th Greenhouse Gases training course of GAWTEC, which was held by GAWTEC (Global Atmosphere Watch Training & Education Centre) on October 2010, for providing scientific guidance and instructions to GAW station personnel from worldwide global and regional stations. He learned how to measure GHGs as well as characteristics of various types of GHGs. Data evaluation tools and data handing methods were also introduced in the training course (Figure 4).



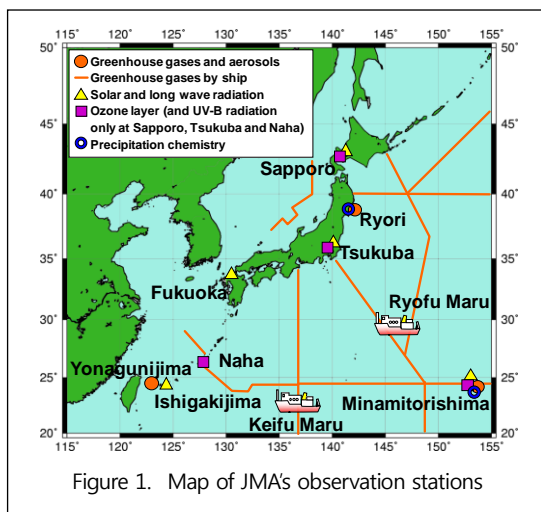
Figure 4. The 19th GAWTEC training course on Greenhouse Gases was held by GAWTEC on October 17th-30th.

References KMA, 2010, *Summary of Korea Global Atmosphere Watch 2009 Report*, 8pp.

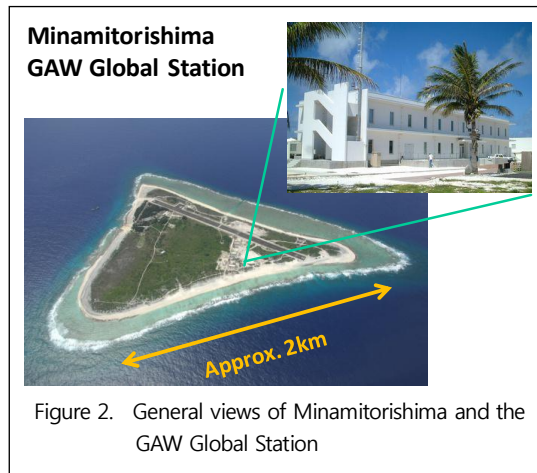
JAPAN (Minamitorishima, Ryori, Yonagunijima)

SUDA Kazuto (Japan Meteorological Agency)

The Japan Meteorological Agency (JMA) conducts observations of greenhouse and reactive gases, the ozone layer, aerosols, precipitation chemistry and radiation as part of worldwide observation networks including the Global Atmosphere Watch (GAW) and Baseline Surface Radiation Network (BSRN). The stations include the GAW Global Station at Minamitorishima, Regional Stations at Ryori and Yonagunijima for greenhouse gases (Figure 1).



The GAW Global Station at Minamitorishima is located near the eastern coast of an isolated island in the North Pacific Ocean formed by a coral reef and with a coast line of about 5.5 km and an area of about 1.4 km² (Figure 2). The observations were started for CO₂ in 1993, extended for CH₄, CO and O₃ in the following year. Access to the island is limited to staff and visitors involved with JMA and the Ministry of Defense, and the site, exposed to the prevailing wind from the east, is free from local sources of pollution and significant change in the land use in the next several decades.



For ensuring quality assurance of observations pursuant to the GAW standards, JMA maintains standard references for CO₂, CH₄, N₂O, CO and O₃ that are traceable to the primary standards of the respective WMO Central Calibration Laboratories (CCLs) through regular calibrations. It also participates in inter-laboratory comparison activities, including the WMO Round-Robin Reference Gas Intercomparison organized by NOAA and the Methane Reference Gas Intercomparison organized by the World Calibration Centre for methane (WCC) at JMA.

Observational data obtained from JMA's network of stations are reported to the data centres established in GAW for different parameters; data for greenhouse and reactive gases are submitted to the World Data Centre for Greenhouse Gases (WDCGG) operated by JMA in Tokyo (<http://gaw.kishou.go.jp/wdccc/>). Data are also provided to the NOAA Earth System Research Laboratory (ESRL) in Boulder, USA, for its GLOBALVIEW projects for CO₂ and CH₄.

JMA analyzes the data to be published in its regular reports such as "Climate Change Monitoring Report" and "Annual Report on Atmospheric and Marine Environment Monitoring" and its website (<http://www.jma.go.jp/jma/indexe.html>), which include time-series plots of concentrations and growth rates of greenhouse gases (Figure 3). It also produces global distribution maps for CO₂ calculated by transport and inverse models based on data provided through the WDCGG, which are published on JMA's website.

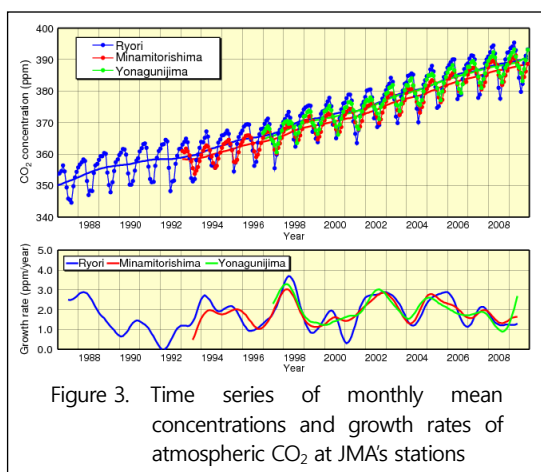


Figure 3. Time series of monthly mean concentrations and growth rates of atmospheric CO₂ at JMA's stations

Besides the monitoring at fixed stations on land, JMA has research vessels observing greenhouse gases in the air and the seawater of the western North Pacific. The Meteorological Research Institute (MRI) has lead several research projects on greenhouse gas monitoring, including radon-222

observation at JMA's greenhouse gas stations (Wada *et al.*, 2010) and the monitoring of greenhouse gases in the upper troposphere at altitudes of 8–13 km using commercial passenger aircraft, with the collaboration of MRI, National Institute for Environmental Studies (NIES), and Japan Airlines (JAL) (Figure 4). The MRI and JMA collaborate in the research and development of new measurement technologies to be applied in future operational projects. Currently, a new air sampling project for greenhouse gases on board aircraft between mainland Japan and Minamitorishima is in a final test to be started in early 2011.

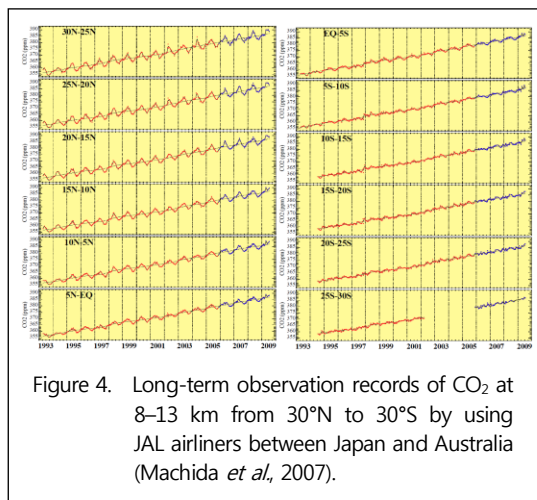


Figure 4. Long-term observation records of CO₂ at 8–13 km from 30°N to 30°S by using JAL airliners between Japan and Australia (Machida *et al.*, 2007).

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Wada *et al.*, 2010, *Journal of the Meteorological Society of Japan*, **88**, 123-134.

INDONESIA (Bukit Kototabang)

Alberth Christian Nahas (The Indonesia Agency of Meteorology Climatology and Geophysics)

INTRODUCTION

Global GAW Station Bukit Kototabang is located in the equatorial zone (0.2 S and 100.3E) on the ridge of high plateau (864.5 m a.s.l.) about 17 km North of Bukittinggi and 120 km North of Padang, the capital city of West Sumatra Province. Surrounding condition is dominated with tropical rainforest with minimum human activities which are mainly from farming. The station can be reached via small access road, about 3 km from the main road between Padang and Medan. Average temperature is 21.6°C and high humidity that is ranging from 80-100% with average is 89.6%. Air pressure at the station is 917.6 hPa and total annual rainfall is 2560 mm. Wind direction is influenced by monsoon pattern. During summer monsoon period, wind moves from South East which brings air mass from Southern Indian Ocean and Australia. Meanwhile, during winter monsoon period, air mass comes from North East, bringing air from Asia.

Greenhouse gases (GHGs) monitoring activity in the station has been began in 2004. This monitoring is a part of Global Air Sampling Monitoring Network, with the collaboration between Indonesia Agency for Meteorology Climatology and Geophysics (BMKG) and National Oceanic and Atmospheric Administration (NOAA) – Earth System Research Laboratory (ESRL). Today, the network consists of 65 cooperative fixed sites and 2 commercial ships. Measurement of GHGs concentration in Bukit Kototabang is conducted by air flask sampling method. Sampled air conducted

on weekly-time base is collected in a pair of 2.5 L flasks. Flasks are flushed and pressurized to ~1.2 atm with a portable sampler. Sampled flasks are then shipped to NOAA ESRL for further analysis.



Figure 1. Main building of Global GAW Station Bukit Kototabang

RESULT

Carbon Dioxide

Despite its small concentration in the atmosphere (~0.04%), carbon dioxide (CO₂) is of the greatest concern because of its contribution to the greenhouse effect and climate change (Jacob, 1999). CO₂ concentration is steadily increasing since the 18th century that has sparked several debates among those who concern on this issue. Because of its characteristic as a well-mixed gas in the atmosphere, CO₂ concentration trend is found similar in almost every observation location in the world. This increasing trend is also observed at Bukit Kototabang as it is showed on Figure 2.

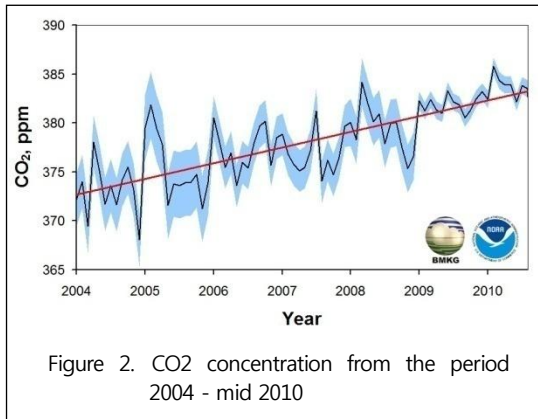


Figure 2. CO₂ concentration from the period 2004 - mid 2010

From the above figure, it can be seen that CO₂ concentration is continuously increasing since the beginning of measurement. From that figure, it also can be found seasonal pattern of this gas. There is a period, commonly found in the early months of the year, when the concentration is higher than other months. This is due to air mass transport that is coming to the station. Because the station is located almost on the equator line, it receives both of Northern and Southern Hemisphere influences. When air mass comes from the Northern Hemisphere, the air mass brings more polluted air to the station because most of CO₂ and other air pollution emission are greater from this region. As the result, CO₂ concentration during this time is found higher. On the contrary, when air mass comes from the Southern Hemisphere, CO₂ concentration observes lower during this time. This is happened commonly in the middle of the year.

CO₂ annual average concentration in Bukit Kototabang has been increasing from 373.1 ppm in 2004 to 381.9 ppm in 2009. Average growth rate for this period is ~1.8 ppm/year. Particularly for last two years (2008 and 2009), CO₂ growth rate was ~2.5 ppm, indicating higher CO₂ being emitted on these years. In 2010, however, CO₂ growth rate for first semester decreased to ~1.8 ppm. Heavy

precipitation in Indonesia and in Sumatra in particular, is very likely affecting CO₂ emission on this year.

Methane

Methane (CH₄) is the most abundance hydrocarbon found in the atmosphere though its concentration is very small (~0.00017%). Its concentration has increased dramatically after industrial revolution in 1750 to the early 1990's. Since that, the concentration tended to be at steady state (Dlugokencky *et al.*, 2003). It was until 2007 that CH₄ concentration started to increase again. Several factors has been suggested for the cause of this increasing such as high temperature anomaly in the Arctic and high precipitation in the tropics (Dlugokencky *et al.*, 2010). Observation in Bukit Kototabang showed a slight increasing of CH₄ concentration as it is seen on Figure 3 below.

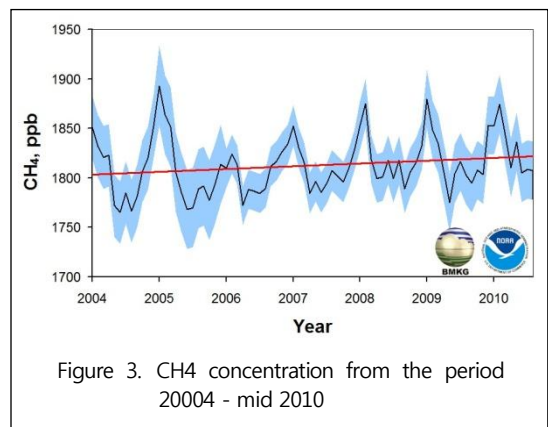


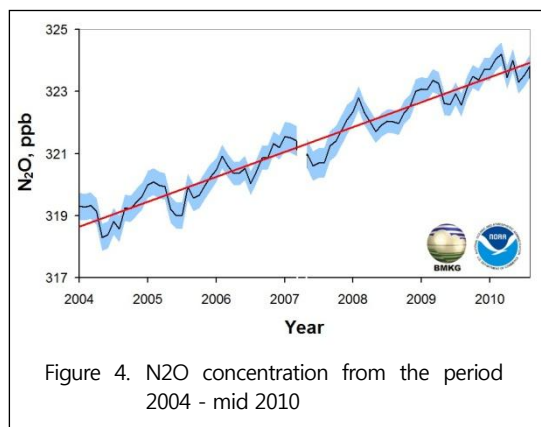
Figure 3. CH₄ concentration from the period 20004 - mid 2010

CH₄ shows a seasonal pattern with cause is very likely the same of that influenced CO₂ concentration. Its dependency with other gases concentration is also affecting the variation. In the early 2005, Indonesia was experienced severe wildfires that were very likely enhancing CH₄ emission. CH₄ concentration on that time was recorded as the highest concentration on the period.

CH₄ annual growth rate from the period 2004-2009 is ~2.5 ppb/year. In the first semester of 2010, CH₄ growth rate jumped to ~18.3 ppb. However, it can not be inferred as continuous trend because in 2009, CH₄ growth rate decreased to ~0.1 ppb lower than that of 2008. Fluctuation of CH₄ growth rate observed at Bukit Kototabang suggested that CH₄ emission is strongly influenced by local condition.

Nitrous Oxide

Similar to CO₂ and CH₄, concentration of nitrous oxide (N₂O) measured at Bukit Kototabang is continuously increasing. This trend is showed on the Figure 4 below.

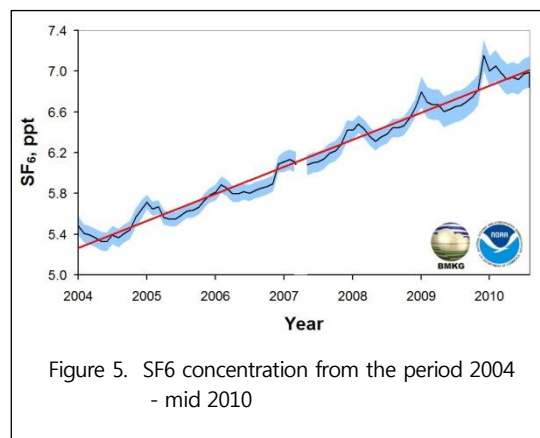


N₂O concentration has increased from its initial concentration of 319.1 ppb in 2004 to 323.1 ppb in 2009. Annual growth rate of this gas is ~0.8 ppb/year and this rate found almost consistent for each year. Largest growth was measured in 2008 when N₂O annual concentration increased about 1 ppb. In the first semester of 2010, N₂O concentration growth rate is ~0.7 ppb.

Sulfur Hexafluoride

Despite having the smallest concentration, sulfur hexafluoride (SF₆) concentration measured at Bukit Kototabang has the largest increasing percentage.

It can be showed from Figure 5 that SF₆ concentration increased from 5.43 ppt in 2004 to 6.73 ppt in 2009 or almost 24% higher than its initial value. SF₆ is one of gases that can not be made by nature and its emission is entirely from man-made activity.



Average annual growth rate of SF₆ is ~0.26 ppt/year, with 2007 marked as the highest growth rate recorded (~0.31 ppt). Meanwhile, growth rate of this gas on the first semester of 2010 is ~0.24 ppt.

Near Real Time Monitoring of CO₂, CH₄, and H₂O

Besides sampling, another method being used to measure GHGs concentration at Bukit Kototabang is Cavity Ring Down Spectrophotometry (CRDS). Picarro Model G1301 is used to carry out this measurement. There are three gases measured: CO₂, CH₄, and water vapor (H₂O). The measurement was started in 2008 and in 2009, calibration unit completed with standard gases had been added. Unfortunately, as of May 2010, the measurement was temporarily terminated due to instrument failure. Instrument was sent back to the manufacturer and it is expected that the measurement will be start again in late 2010 or early 2011. Data produced on the measurement period were considered preliminary.

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KOREA (Gosan)

Jooil Kim (Seoul National University)

Seoul National University operates measurements of important greenhouse gases (GHGs) at Gosan, located on the southwestern tip of Jeju Island (Korea), with the purpose of identifying and quantifying the outflow of pollution from East Asia, where large emissions are expected from the various industrial activities in this region. The remote coastal location of Gosan allows for minimal effects from any local pollution, and wind conditions (northerly winds in the cold season, and southerly winds in summer) are favorable for observing pollution events from the surrounding regions.

The longest GHG measurement record at Gosan is the CO₂ monitoring program, based on flask sampling and measurement in cooperation with the Scripps CO₂ program (http://scrippsco2.ucsd.edu/research/atmospheric_co2.html) for measuring ¹²C, ¹³C, and ¹⁴C isotopes of atmospheric CO₂. Since November 2007, the flask measurements have been

reinforced with high-frequency measurements using the LOFLO CO₂ analyzer, developed at the Australian Commonwealth Scientific and Research Organization (CSIRO). Together, a detailed record is being compiled of both the long and short term variability in atmospheric concentrations of CO₂ in East Asia.

Measurements of halogenated compounds started at Gosan on November 2007 through the Advanced Global Atmospheric Gases Experiment (AGAGE, <http://agage.eas.gatech.edu/>). The "Medusa" GC-MS system, developed in AGAGE, allows for high-frequency measurements of almost all halogenated compounds important in the Montreal and Kyoto Protocols, at precisions better than 1% of ambient concentrations. These measurements have provided valuable insight into the emissions of halogenated compounds in East Asia, and some of the recent findings are summarized below.

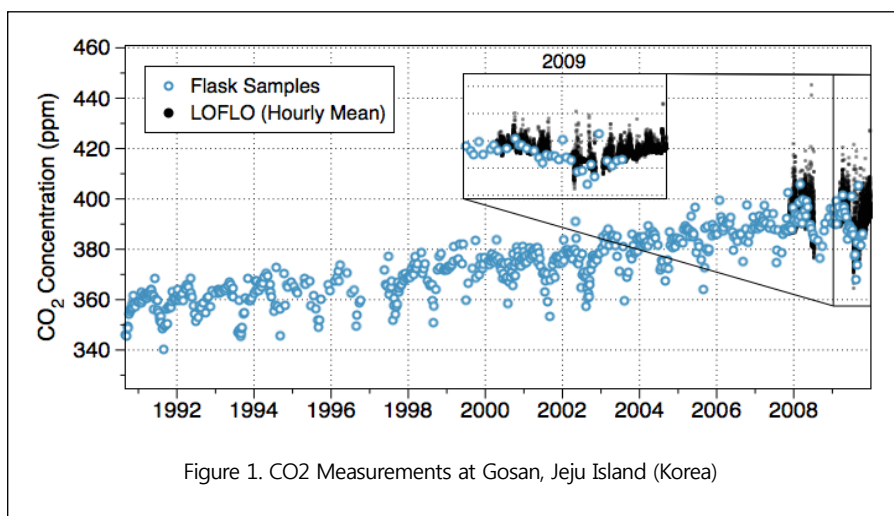


Figure 1. CO₂ Measurements at Gosan, Jeju Island (Korea)

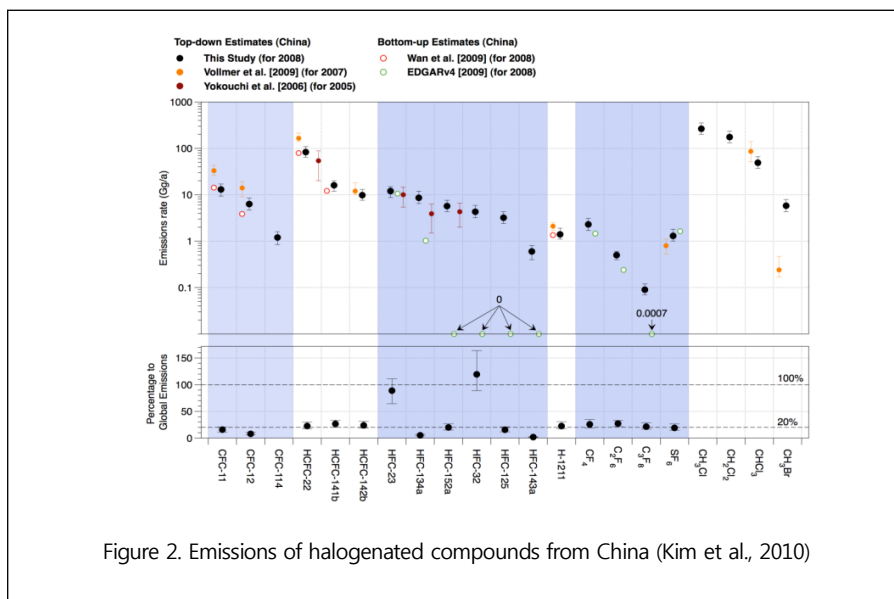


Figure 2. Emissions of halogenated compounds from China (Kim et al., 2010)

Recent analysis in Chinese emissions of halogenated compounds at Gosan (Kim et al., 2010) confirm that China is now a dominant emission source of various anthropogenic halogenated species, including CFCs, HCFCs, HFCs, PFCs, and SF₆. Of note, we find large emissions of some HFC compounds which were known to be used mostly in developed countries and not in China. Continued monitoring and analysis of emissions from China should show future changes in emission patterns as China adapts to the Montreal, Kyoto and future environmental protocols. Advanced inversion modeling analysis of emissions using FLEXPART came to similar conclusions (Stohl et al., 2010), as well as revealing spatial information regarding the emission sources of many compounds. These new analysis methods should help provide a deeper understanding of emission patterns and changes in China as well as in all of East Asia.

A study of global historical SF₆ emissions (Rigby et al., 2010) performed with global measurements of SF₆ in both the AGAGE and National Oceanic and Atmospheric Administration (NOAA) networks as well as Gosan showed that the current discrepancy in top-down and bottom-up emissions of SF₆ are likely to be explained by emissions in East Asia, and calls for regional emission modeling efforts to further verify the SF₆ emissions in this region.

In conclusion, high-quality, high-frequency GHG measurements at Gosan have been shown to be useful in enhancing our understanding of GHG emissions in this region. Measurements at Gosan should continue to provide valuable information in this regard, helping to better define the global budgets of GHGs, and ultimately in helping the global efforts to mitigate climate change.

References

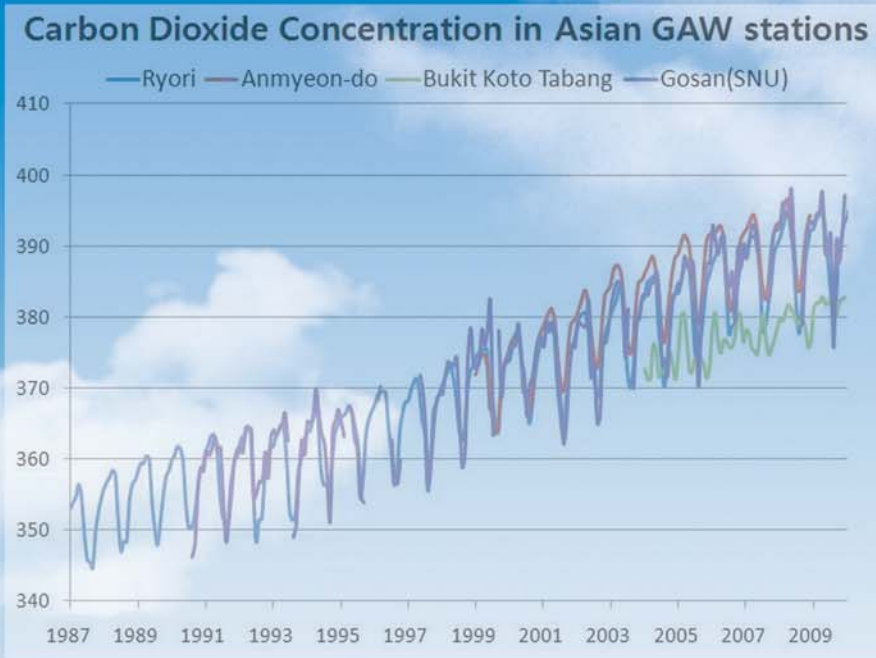
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Participants at the 2nd International Workshop in Jeju Island, Republic of Korea.



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