The 8th Asia-Pacific GAW Workshop on Greenhouse Gases

October 17-18, 2016, Seoul, Republic of Korea

Korea Meteorological Administration

GAW Global Atmosphere Watch

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Date		Program
17. Oct	09:00	Registration and Coffee Break
	09:30	**Opening speech** *Jae-Cheol Nam, Vice administrator of KMA, Vice president of WMO/CAS
	09:40	Photo time
		Keynote
	09:50	What can we learn from global measurements of SF_6? *Brad Hall (NOAA)
	10:20	Updates from WMO/GAW and new GAW implementation plan *Oksana Trasova (WMO)
		Session 1: GAW activities and standards (Chair: Sang Ok Han)
	10:50	1.1 30 years of GAW activities in Korea *Chulkyu Lee (KMA)
	11:10	1.2 The GAW traning and Education centre (GAWTEC) and German GAW activities and monitoring *Mirella Glor (UBA)
	11:30	1.3 The evaluation of JMA's standard gas scale for measurements of atmospheric methane *Shuichi Hosokawa (JMA)
	11:50	1.4 Accuracy Validation of a Spectroscopic Gas Analyzer using Gravimetric Standard Gas Mixtures: Impact of Background Gas Composition on CO_2 Measurement by Cavity Ring-Down Spectroscopy *Jeongsoon Lee (KRISS)
	12:10	Lunch
		Session 2: Monitoring activities (Chair: Gordon Brailsford)
	13:20	2.1 Atmosphere watch results for year 2015 in Korea *Sang-Ok Han (KMA/NIMS)
	13:40	2.2 Continuos trace gas monitoring at Cape Point Global Atmosphere Watch (GAW) station in South Africa: Last trends and findings *Lynwill martin (SAWS)
	14:00	2.3 Recent progress on greenhouse gas measurements at Mt. Lulin and Dongsha Island, Taiwan *Chang-Feng Ou-Yang (NCU)
	14:20	2.4 Greenhouse gas monitoring in Bukit Kototabang *Yosfi Andri (BMKG)
	14:40	2.5 Kenya's contribution to Global Atmosphere Watch Activities *Zablon W. Shilenje (KMD)
	15:00	2.6 The ozone monitoring activities and its trend analysis in Malaysia during El Nino/ La Nina phenomena *Maznorizan Mohamd (MMD)
	15:20	2.7 An Investigation on carbon dioxide (CO_2) levels over Madurai, India *Indira Gunaseelan (MKU)
	15:40	Coffee Break
		Session 3: Emissions and inventories (Chair: Brad Hall)
	16:00	3.1 Toward resolving the mysterious budget discrepancy of ozone-depleting CCl_4 : Top-down emissions in China *Sunyoung Park (KNU)
	16:20	3.2 Observations and modeling combine to inform network developments *Gordon Brailsford (NIWA)
	16:40	3.3 Monitoring of atmospheric carbon dioxide and other GHG's in India: Implications for constraining Indian emissions *Yogesh Tiwari (IITM)
	17:00	3.4 Estimation of surface CO_2 fulx by assimilating GOSAT XCO_2 retrievals in Carbon Tracker *Hyun Mee Kim (YSU)
	17:20	3.5 Greenhouse gases inventory in Viet Nam *Tong Thi Van Anh (NHMS)
	17:40	Break
	18:00	Banquet
18. Oct	09:00	Excursion to the Anmyeondo GAW regional station

What can we learn from global measurements of SF_6?

Bradley Hall*, Ed Dlugokencky, Geoff Dutton, David Nance, Pat Lang

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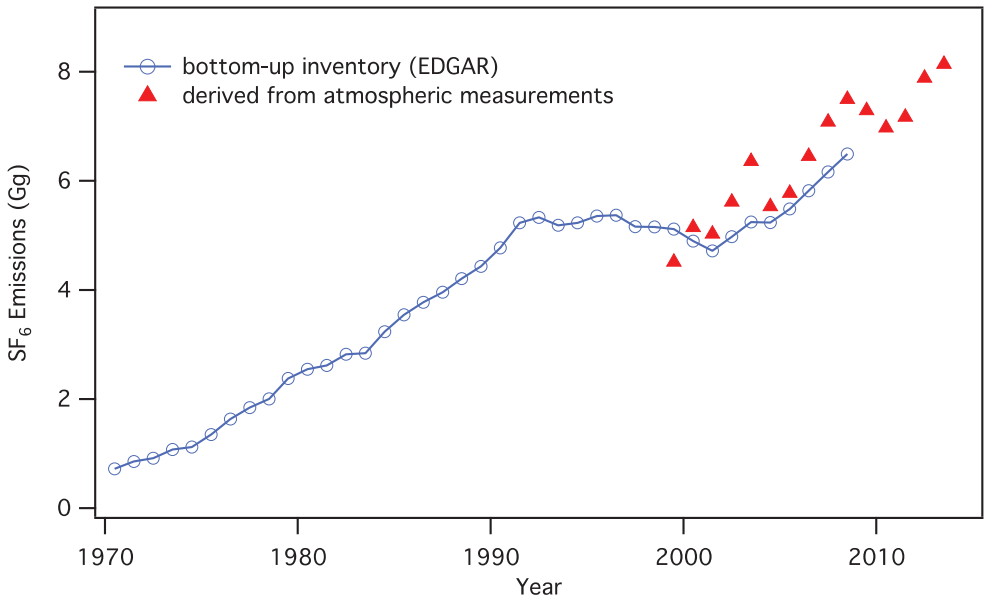
Sulfur hexafluoride (SF_6) is a long-lived greenhouse gas used primarily in high-voltage electrical systems, metal production, and as an insulator. Because of its long atmospheric lifetime, the atmosphere essentially serves as a reservoir of SF_6 emitted. High-precision measurements of SF_6 at various sites around the globe provide data that can be used to estimate emissions and improve inventory-based emissions estimates.These data also provide information about atmospheric transport and can be used to test transport models. NOAA has been making measurements of SF_6 at a number of background sites since 1995. Measurements from archived air samples date to the mid-1980s. Improvements in measurement precision and calibration strategies have enabled us extract more information from our atmospheric data in recent years. We will present results derived from global and regional measurements.



30 Years of GAW Activities in Korea

Chulkyu Lee*, Sunae Jeong, Hye-Young Go, Sang-Rae Lee, Haeyoung Lee, Ho-Jeong Yang, Eun-Hye Lee, Hyo-Jin Park, Mi-Ae Jang, Dong-Hyun Shin, Jun-Seok Chung

Korea Meteorological Administration

Regarding to the GAW-related activities, many institutes in Korea including the Korea Meteorological Administration (KMA) has focused on measurements of atmospheric chemical composition and its long-term variations. The Global Environment Laboratory at Yonsei University has carried out the ozone layer research and monitoring program over Korea in Seoul in the framework of WMO/GO3OS (Global Ozone Observing System) since May 1984. In 1987, KMA established an atmospheric observatory at Mt. Sobaek for atmospheric composition watch, which was located in the middle of the Korean Peninsula, collecting observational data of reactive gases. After that, KMA got started with greenhouse gas (GHG) measurements at Gosan, Jeju using a flask sampling method in 1990 in cooperation with Seoul National University. In-situ monitoring of GHGs began at the Muan meteorological station, which was located at the south-western of the Korean Peninsula. The Anmyeondo station, one of the GAW regional stations in Korea, was established in 1996. The measurements of the Sobaek observatory and Muan station were integrated into the Anmyeondo station in 1997. Ozone sonde measurements have been carried out at Pohang station, located in the south-eastern coast of Korea, since 1994. Total atmospheric deposition (Precipitation chemisty) began at 4 sites (Anmyeondo, Gosan, Ulleungdo, and Pohang) in 1997. The two stations in the south (at Jeju) and east (at Ulleungdo) of Korea were established in 2009 and 2014, respectively, in aim of monitoring of transportation of the atmospheric substances and their variation in the atmospheric composition over the Korean Peninsula. From these measurement stations, KMA has collected the atmospheric observation data of 37 components in the fields of GHGs, aerosols, reactive gases, stratospheric ozone, precipitation chemistry, and atmospheric radiation including UV radiation, in accordance with the measurement recommendations of the GAW program. To enhance the effectiveness and application of the long-term measurements within GAW, KMA cooperates with the atmospheric measurement networks domestic/worldwide along with focusing on the quality assurance and control. KMA has also focused on integration of GAW-related activities in the

Korean Peninsula, and sharing their measurement data. These data are expected to be used to cope with environmental and climate issues over Korea. The Asia-Pacific GAW Workshop on Greenhouse Gases (APGG) has annually been held by KMA since 2009. The APGG has been designed to introduce the measurement technologies, quality control/assurance methodologies, and new monitoring stations as well as to share major research findings. WCC-SF6, one of the GAW central facilities, has been operated by KMA since 2013. It currently covers the round-robin experiment, technical training/education course, performance audit, and publication of its measurement guidelines to secure the traceability and compatibility of SF_6 measurements in the GAW network. KMA currently get started with focusing on the essential climate variables to analyze the effect of climate change drivers, e.g. GHGs and aerosols, on climate system around the Korea Peninsula.

The GAW Training and Education Centre (GAWTEC) and German GAW activities and monitoring

MirellaGlor

Environmental Research Station Schneefernerhaus, Zugspitze, Germany

The Global Atmosphere Watch (GAW) program is a worldwide network of measurement stations and related facilities coordinated by the World Meteorological Organization (WMO). The purpose of GAW is to measure the background level of atmospheric pollutants and other trace substances to determine their trends and to analyze the relationship between environment and climate. The goal of GAW is to supply the scientific community with the means to predict future atmospheric states as well as to provide reliable scientific data and information for national and international policy makers. The GAW community has set up high data quality objectives (DQOs) that should be met by all participating stations. Training and Education for GAW station personnel are therefore an integral part of the GAW program and critical to the long-term success of the GAW program. As a part of the WMO's capacity building strategy, the German Quality Assurance/ Science Activity Centre (QA/SAC Germany) has established in 2001 the GAW Training and Education Centre. Courses are offered twice a year and cover measurement technique, lab courses, theoretical background of atmospheric physics and chemistry and data handling and interpretation. Each course deals with two or three major topics, covering all relevant parameters in the GAW measurement program: Physical Properties of Aerosols and Aerosol Optical Depth, UV radiation, Reactive Gases, Precipitation chemistry, Greenhouse Gases and Data evaluation and Quality Control.
Currently (2016) the GAW network consists of 31 Global Stations, more than 400 Regional Stations and 100 Contributing stations. Germany operates two Global Stations (Zugspitze/Hohenpeißenberg and the Antarctic Station Neumayer) and two Regional stations (Neuglobsow and Schauinsland). TheGerman contribution is covering GAWTEC and four World Calibration Centres (WCCs): Aerosol Physics, Volatile Organic Compounds (VOCs), Nitrous oxide (N_2O) and Ozone Sondes (OS). Furthermore the In-service Aircraft for a Global Observing System (IAGOS), the Regional Dobson Calibration Centre Europe (RDCC-E), the

Central Calibration Laboratory for molecular hydrogen in air (CCL H_2) and the Center for Remote Satellite Data (WDC- RSAT) contribute to the GAW activities.

The evaluation of JMA's standard gas scale for measurements of atmospheric methane

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Shinya Takatsuji[1],Susumu Hashimoto[1], Kohshiro Dehara[1], Kentaro Kozumi[1],
HidekazuMatsueda[2], YousukeSawa[2], Kazuhiro Tsuboi[2] and Yosuke Niwa[2]

1. Japan Meteorological Agency, Tokyo, Japan,
2. Meteorological Research Institute, Ibaraki, Japan

Under the WMO GAW program, the Japan Meteorological Agency (JMA) serves as the GAW World Calibration Centre (WCC) for CH_4 in Asia and the South-West Pacific. In order to ensure traceability to GAW international standards and maintain the accuracy of the measurements, JMA has carried out CH_4 reference gas inter-comparisons around Asia and the South-West Pacific since 2002. JMA and 11 laboratories from 6 countries participated in the 1st - 4th rounds CH_4 reference gas inter-comparisons, and 5th round is ongoing now.Furthermore, JMA and 5 major observation laboratories in Japan, including and the National Metrology Institute of Japan (NMIJ), established a domestic alliance to compare the standard gas scales used for measurement of greenhouse gases in Japan; they named the resultant program the inter-comparison experiments for Greenhouse Gases Observation (iceGGO).

To evaluate the quality of CH_4 standard gases and the performance of the JMAcalibration system, JMA have regularlycompared their standard gases with those of the Meteorological Research Institute (MRI),and investigated those long–term (between 2000 and 2014) stability. The CH_4 mole fractions of the MRI standard gases were measured by Gas Chromatography with Flame Ionization Detector (GC/FID) at JMA twiceeach year between 2000 and 2014 by using the JMA calibrationsystem. At the same time, we evaluated the results of comparisons conducted in the past with other organizations. Theseresults indicate that the mole fractions of most standard gases tested were stable and that the JMA CH_4 calibration system has beenwell maintained over the past 14 years and provide an effectivetool for the JMA/WCC inter-comparison experiments. Now,JMA plans to replace the CH_4calibration systems using GC/FIDwiththat using Cavity Ring Down Spectroscopy (CRDS). To check the difference

between GC/FID and CRDS, JMA and MRI have conducted some tests to measure the standard gases and the atmosphere samples using both analyzers.

In the meeting, we will present our experimental results and future plans about the JMA's standard gas scale for measurements of atmospheric methane.

Accuracy Validationofa Spectroscopic Gas Analyzerusing Gravimetric Standard Gas Mixtures: Impactof Background Gas Compositionon CO_2 Measurementby Cavity Ring-Down Spectroscopy

JeongSik Lim, MiYeon Park, Jinbok Lee, and Jeongsoon Lee*

Center for Gas analysis, Metrology for Quality of life, Korea Research Institute of Standards and Science (KRISS), Daejeon, Korea

In this study, the effect of background composition on CO2 measurement has been investigated using wavelength-scanned cavity ring-down spectrometry (WS-CRDS), taking a spectral line centered at the R(1) of the (3 00 1)III ← (0 0 0) band. For this purpose, eight cylinders with various compositions were gravimetrically and manometrically prepared with 1σ = 0.1%, and they were introduced to the WS-CRDS analyzer calibrated against standards consisting of ambient air composition. Depending on the gas composition, the deviations between the CRDS responses and gravimetrically (or manometrically) assigned CO2 concentration ranged from −9.77 to 5.36 μmol/mol. Against the assigned values, excess N2 exhibited a negative CRDS response, whereas excess Ar showed a positive deviation. The total pressure broadening coefficient (TBPC) based on the composition of N2, O2, and Ar corrected the deviations to up to 0.15%. Furthermore, this correction linearly drifted the CRDS responses for a wide extent of TPBC ranging 0.065 to 0.081 cm-1 atm-1. To obtain accurate measurements using intensity-based optical measurement techniques such as WS-CRDS, it is imperative to calibrate the instrument based on TBPC.

The Atmosphere Watch Results for Year 2015 in Korea

Sang-Ok Han

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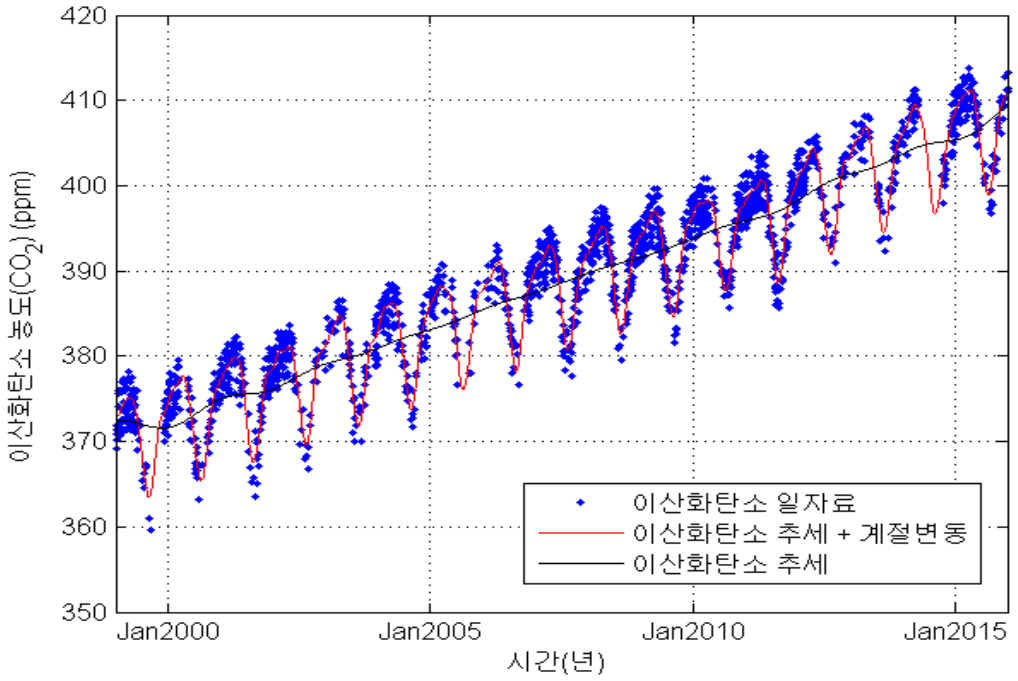
KMA has been operating 3 atmosphere watch stations since 1996 for Anmyeondo station, since 2008 for Gosan station, and since 2014 for Ulleungdo station. There are also some KMA weather stations where some elements of atmosphere watch, such as UV-A and B, and stratospheric ozone, are observed.

The Anmyeondo station, which was designated as the regional GAW station in 1998, has the longest history and most elements of atmosphere watch among the 3 KMA Atmosphere Watch stations (KGAW). At Anmyeondo station, there are 37 elements observed for the atmosphere watch in Korea with the elements grouped into six categories: greenhouse gases, reactive gases, aerosol, atmospheric radiation, stratospheric ozone and ultraviolet rays, and precipitation chemistry.

The annual average concentration of CO_2 observedat Anmyeondo for year 2015 is 407 ppm, which is increased by 2.4 ppm from that of year 2014. Notice that the average growth rate of the CO_2 concentration over the past 17 years at Anmyeondo station is 2.3 ppm/yr. The annual average concentrations for other greenhouse gases at Anmyeondo station in 2015 are as follows: 1976.6 ppb for CH_4, 327.4 ppb for N_2O, 229.6 ppt for CFC-11, 516.0 ppt for CFC-12, 71.2 ppt for CFC-113, and 9.7 ppt for SF_6. In general, it is shown that the CFC gas species indicated the declining trend of concentration compared to other gases thanks to the global efforts to reduce those gases. As for the reactive gases at Anmyeondo station, the surface O_3 for year 2015 showed 27.9 ppb which is 11.5 ppb lower than recent 10-years average of 39.1 ppb. That sort of illustrates the trend of declination

of surface O_3 concentration in recent years at Anmyeondo station. The annual average concentrations for other reactive gases at Anmyeondo station in 2015 are as follows: 293.5 ppb for CO, 4.5 ppb for NOx, and 1.4 ppb for SO_2. The other observation results at KGAW stations will be presented at the workshop.



Continuous trace gas monitoring at Cape Point Global Atmosphere Watch (GAW) station in South Africa: Last trends and findings

Lynwill G Martin*, Casper Labuschagne, Thumeka Mkololo and Nkanyiso Mbatha

South African Weather Service, Stellenbosch, South Africa

The South African Weather Service's Cape Point (CPT) Global Atmosphere Watch (GAW) program was established in the 1980's to provide long-term information on atmospheric trace gases that have Climate Change significance. Station data are regularly delivered to local (SAAQIS) and international data centres such as the WDCGG in Tokyo, thus providing various end users (modellers) and policy makers alike, with the ability of having near-real time data for the fine-tuning of global climate forecasting models as well as regional scale "event-based" short range forecasting opportunities. From the complex 30-min trace gas results obtained, the distinction can be made between urban-continental signatures (which have a direct bearing on human health risk impacts), as well as clean maritime data (which have global climate change implications) within the same data series. In this way, GAW trace gas data provides valuable input towards enhancing the "now-casting" services of the WMO.

Concentration levels, their seasonality, trends and long-term changes will be presented and discussed. We will report on the Cape Point CO time series which is the longest data set in the Southern Hemisphere with monitoring starting in 1979 as well as for the first time on the CPT N_2O and SF_6 time series which started in 1994 and 2010 respectively at CPT. Finally, a statistical analysis of the Cape Point Radon (^{222}Rn) time series (1999 – 2013) will also be presented.

Recent progress on greenhouse gasmeasurements at Mt. Lulin and Dongsha Island, Taiwan

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The island of Taiwan is situated in a unique position in Western Pacific in terms of observing polluted outflows from Indochinese Peninsula and the East Asian continent. Regional meteorological conditions arefavorable for the transport of air pollutants, such as dusts, acidic pollutants, and biomass burningemissions, from upwind source regions to Taiwan. Thus, a high-elevation baseline station, LulinAtmospheric Background Station (LABS; 23.47°N, 120.87°E; 2,862 m a.s.l.), was established to measure baseline air pollutants and tostudy the atmospheric transport patterns. Official operation of LABS began on April 13, 2006. This station offers agreat deal of opportunities to investigate the atmospheric chemistry of trace gases, aerosols,precipitation, mercury, and radiations, providing a distinctive contrast of atmospheric changes andimpacts by a variety of air masses originated from relatively clean to emission source regions.In March 2010, as part of NOAA/ESRL/GMD's Cooperative Air Sampling Network, flask air sampling at Dongsha Island (DSI; 20.70°N, 116.73°E; 3 m a.s.l.) was launched to measure surface greenhouse gases (GHGs) in the northern South China Sea.

As reported by IPCC in 2013, CO_2 is the largest contributor of the atmospheric well-mixed GHGs, accounting for 64.3% of the total global radiative forcing from 1750 to 2011. During the past decade of GHG measurements, the annual mean CO_2 mixing ratio reached the milestone of 400 ppm at LABS (402.61±3.11 ppm) in 2015 and at DSI (401.67±4.65 ppm) in 2014. Springtime vegetation growth dramaticallydrew down the CO_2 mixing ratiosat both sites in summer. The CO_2 increased at average rates of +2.69±2.30 ppm at LABS and +2.10±1.32 ppm at DSI during the observation period, whereas the CH_4 mixing ratio increased at average rates of +6.91±9.19 ppb at LABS and +6.41±9.22 ppb at DSI. During the same period, N_2O were also increasing at average rates of +0.9±0.3 ppb and +1.1±0.2 ppb at LABS and DSI, respectively.

Greenhouse gas monitoring in Bukit Kototabang

YosfiAndri*, Alberth Christian Nahas, Edison Kurnniawan

GAW Station Bukit Kototabang, Indonesia

Greenhouse gases (GHG) monitoring at Bukit Kototabang, W Sumatra, has provided the longest in-situ measurement data for Indonesia. The monitoring has been started from 2004 by undertaking a passive measurement using flask sampling. This measurement is part of NOAA ESRL Global Monitoring Division on Carbon Cycle Greenhouse Gases (CCGG) program. After temporarily terminated in March 2011, the measurement has been resumed again since February 2013. Meanwhile in 2008, a near-real time measurement of GHG was started to carry out at the site by utilizing Cavity Ringdown Spectroscopy (CRDS) method. The measurement has produced data that can be used for diurnal as well as seasonal analysis purposes. Also, a customized inlet system allows the measurement to analyze air from three different levels (10 m, 20 m and 32 m). From the period of 2011-mid 2013, the average concentrations of CO_2 and CH_4 from the highest intake are 399.1 ppm and 1.835 ppm, respectively. The running two methods is of valuable to enhance the measurement technique as well as to ensure data to be collected continuously. As measurement from the passive method has been resumed and both methods are concurrently undertaken, it is also interesting to compare the result from both methods in the future.

Kenya's contribution to Global Atmosphere Watch Activities

Zablon W. Shilenje*, Kennedy Thiong'o, ColnexOkuku

Kenya Meteorological Department, Nairobi, Kenya

Global Atmosphere Watch(GAW) inKenya, runs environmental and pollution monitoring activities at Mt Kenya site through Kenya Meteorological Department. The establishment of the Kenya GAW came through an agreement between WMO andthe Kenya government in September 1993. The station focuses on providing measurements on some greenhouse gases, aerosols, and the effect of biomassburning in Equatorial Africa. This presentation traces the evolution of GAW work in Kenya from setting up of the Mt Kenya station with the activities carried out at the station to setting up of other supporting stations in Nairobi. Nairobi supporting station has grown from measuring only vertical profile of ozone and total column ozone to ground level ozone, and now has a Mobile Air pollution Laboratory that is capable of sampling various gas pollutants (methane, sulfur dioxide, ozone, nitrogen oxide, benzene aerosols) and particulate matter. In the end, the presentation will examine some of the data sets.

The ozone monitoring activities and its trend analysis in Malaysia during El Nino/ La Nina phenomena

Maznorizan Mohamad*, Mohd Firdaus Jahaya, Hanashariah Hassan, Zamuna Zainal

Atmospheric Science Division, Malaysian Meteorological Department

Even though ozone is only a minor constituent in the atmosphere, its role is important in the photochemical process in the atmosphere. Its' strong absorption of the sun's radiation in the UV wavelength provide shield at the stratosphere that protect life on the earth surface. On the other hand the surface ozone which is considered as bad ozone can be classified as one of the GHG that contributed to the global warming. Observation and analysis of ozone provide important information with regards to the trend of ozone composition in the atmosphere which is beneficial to the policy makers dealing with the environmental issues, planning and policy. MetMalaysia has been engaged with the ozone monitoring namely total column ozone, ozone vertical profile and surface ozone since late 1992 until present.

The study is conducted to investigate the distribution of the O_3 fluctuation from 1995 - 2015 in the Peninsular Malaysia areas. The total amount of ozone in a vertical column from the surface to the edge of the atmosphere (total column) is observed using Brewer Ozone Spectrophotometer, while the surface ozone is monitored using ozone analyzer and finally the vertical ozone profile is recorded by releasing the ozone sonde twice a month to probe the atmosphere.

The O_3 current trend in Peninsular Malaysia (Cameron Highlands) was analyzed with reference to the O_3 global trend (Mauna Loa, Hawaii). It is observed that the monthly average concentration of surface O_3 in Cameron Highlands is generally less than the monthly average concentration of surface O_3 in Mauna Loa. For Cameron Highlands, the concentration fluctuated between 1 - 40 ppb, while for Mauna Loa, the concentration recorded are higher with values fluctuated between 30 - 60 ppb. Ozone data was also analyzed to study the fluctuation pattern during El Nino / La Nina phase as well as during haze period and whether the O_3 concentration will be influenced by these phenomena.

The monthly average of Total Column Ozone (TCO) in Petaling Jaya indicates the highest reading in September 1997 (286.5 DU) and November 2015 (300.7 DU). The prominent

increasing trend of TCO were clearly identified which may well suggest the correlation of the TCO during strong El Nino, in the tropical region. During the prolong La Nina events, recorded from June 1998 to April 2001, it is observed that the TCO is well correlated with the associated Ocean Nino Index (ONI).

An Investigation on carbon dioxide (CO_2) levels over Madurai, India

Indira Gunaseelan* and Vijay Bhaskar

School of Energy, Environment and Natural Resources,Madurai Kamaraj University, India.

Carbon dioxide (CO_2)is the predominant anthropogenic greenhouse gas contributing around 60% of the greenhouse effect which leads to global warming. A study was conducted in five different regions over Madurai, India using CO_2 meter (Model GCH- 2018). Measurements were taken for one year 2015 and the average carbon dioxide concentrations varied from 410.3 to 481.2 ppm. Meteorological statistical analysis showed that CO_2 had a positive correlation with atmospheric temperature (0.71 to 0.91) in most of the sampling stations. Variations of carbon dioxide and its interactions with meteorological parameters were also studied. Statistical analysis showed that, CO_2 had a positive correlation with atmospheric temperature. The rapid urbanization, increased industrialization and improved trade and commerce have resulted in augmentation of mushrooming population, vehicular movement and industrial growth, which in total causing an eternal threat to the ambient air environment of the city.

Toward resolving the mysteriousbudget discrepancy of ozone-depleting CCl_4: Top-down emissions in China

Shanlan Li[1], Sunyoung Park[1,2,*], Mi-Kyung Park[1], Chon Ok Jo[1], Jens Mühle[3], Ray F. Weiss[3], Ronald G. Prinn[4]

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2. Department of Oceanography, Kyungpook National University, Daegu, Republic of Korea;
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4. Center for Global Change Science, Massachusetts Institute of Technology, Cambridge, USA

Atmospheric concentrations of CCl_4 have been decreasing since reaching a peak in 1990, due to the phase-out of CCl_4 use in the Montreal Protocol's non-Article-5 countries. The Article-5 countries, including China had also been required to eliminate CCl_4 by 2010, but as an exemption allowed under the Montreal Protocol to the phase-out, the chemical feedstock use continues with the increasing manufacture of HFC.

In this study, we estimated the emission rates of CCl_4 for China using an interspecies correlation method [Li et al., 2011] based on "top-down" interpretation of atmospheric observations obtained from the Gosan station (33^{o}N, 126^{o}E) on Jeju Island, Korea. The high-precision and high-frequency measurements of CCl_4 were made continuously every two hours from 2008 to 2013 using a GC-MSD coupled with an online cryogenic pre-concentration system ("Medusa") under the AGAGE program. To separate periods of Chinese emission influences from the 6-year time series, we identified air-mass segments originated from China using a back-trajectory analysis. For the interspecies correlation method, the most suitable reference tracer for Chinese emissions was HCFC-22, of which the annual emission rates in China were derived independently from an inversion calculation based on FLEXPART transport model analysis. Then the CCl_4 emission rates were estimated by using the empirical correlations between observed CCl4 and HCFC-22.

Our results show the CCl_4 emissions in China between 2008 and 2010 were in the rangebetween 18.7 ± 2.9 and 23.3 ± 2.7 kt yr^{-1}, and then there was a statistically significant decline by ca. 30% in the emission from 2010 to 2011, in concurrence with the scheduled phase-out of CCl_4. However, it is interesting that the emission rate of the year 2011 had leveled off until 2013, still showing a significant emission rate of 16.2 ± 4.4 kt yr^{-1}, while

post-2010 bottom-up emissions of CCl_4 in China have been reported to be near zero (Wang et al., 2009). This discrepancy may suggest CCl_4 emissions from either non-regulated feedstock use or cleaning solvent source. To identify key industrial sources for CCl_4 emissions and their potential locations, we further analyze the observation data by using a Positive Matrix Factorization model in combination with trajectory statistics [Li et al., 2014]. More details are discussed in the presentation. Overall, CCl_4 emissions from China account for approximately 23% of global top-down emissions derived from AGAGE measurements from 2008-2012 (Fraser et al., 2014).

Observations and modeling combine to inform network developments

Gordon Brailsford[1*], Sara Mikaloff Fletcher[1], Dan Smale[1], Zoë Buxton[1], Kay Steinkamp[2], Sylvia Nichol[1], John McGregor[1], Tony Bromley[1], Graham Timpany[1]

1. National Institute of Water and Atmospheric Research, New Zealand
2. Independent researcher

The New Zealand monitoring network has developed over four decades from a single observation station monitoring CO_2 in baseline conditions to three active in situ stations that now provide continuous observations. These data are utilized at NIWA to, among other things,quantify the regional terrestrial sources and sinks of CO_2. The number of network observations stations will in the coming year be expanded by two stations to enable better national coverage. While traditionally site assessment involves topography, air flows, logistics and some limited observations. We demonstrate how this process can be enhanced by incorporating model simulationsto assist in understanding the source regions and contributions that a range of candidate locations will observe before decisions are made to deploy.

Monitoring of atmospheric carbon dioxide and other GHG's in India: Implications for constraining Indian emissions

Yogesh K. Tiwari*, Tania Guha, Smrati Gupta, Vinu Valsala

Indian Institute of Tropical Meteorology, Pune, India

India has one of the largest and fastest growing economies in South Asia and is emerging as amajor contributor to CO_2 emissions among developing nations. However, there has been relativelylittle monitoring of atmospheric CO_2 over India to date. The Carbon Dioxide Information AnalysisCenter (CDIAC), USA, estimates the total fossil-fuel CO_2 emissions from India as 189 TgC in1990, 324 TgC in 2000, 385 TgC in 2005 and 508 TgC in 2009, and the annual rate of increase as~7% per year during 2005-2009. Some of these emissions may be compensated by vegetationuptake. According to a report published in May 2010 by the Ministry of Environment and Forest(MoEF), Gov. of India, the total greenhouse gas emissions in India have grown from 1252million tons in 1994 to 1905 million tons in 2007 at a compounded annual growth rate of 3.3%.Between 1994 and 2007, some of the sectors indicate significant growth in GHGs emissions suchas cement production (6.0%), electricity generation (5.6%), and transport (4.5%). In order toimprove our understanding in this field, we are involved in: i) ambient CO_2 and other GHGs monitoring at the surface ii) air sample analytical technique development using WMO/GAWcalibration standards, iii) cruise and airborne campaigns, iv) CO_2 transport as well as lagrangianparticle dispersion model simulations, etc. The present study is an attempt to analyze availableCO_2 and other trace gases observation and model simulations over India which may help improve the flux estimates and GHGs budget over this region.

Estimation of surface CO_2 flux by assimilating GOSAT XCO_2 retrievals in CarbonTracker

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In this study, surface CO2 fluxes were estimated by assimilating column-averaged dry air mole fraction (XCO2) of satellite-based CO2 measurements into the CarbonTracker (CT2013B)which is an inverse modeling system for estimating surface CO2 flux based on an ensemble Kalman filter. The XCO2 used was derived from Atmospheric CO2 Observations from Space retrievals of the Greenhouse Gases Observing SATellite (ACOS-GOSAT). Theinversion experiments were conducted with and without GOSAT XCO2 retrievals in addition to conventional surface CO2 concentration measurements.

The average biosphere and ocean CO2 fluxes from July 2009 to May 2010 show that the global balance of sources and sinks of surface CO2 fluxes was maintained for the experiments with and without GOSAT XCO2, whereas the magnitudes of the optimized surface CO2 fluxes in subcontinental regions were changed. The surface CO2 uptake over Europe increased, whereas the surface CO2 uptake in Eurasian Boreal (Northern part of Asia continent) decreased. These results are consistent with the previous studies using GOSAT XCO2 retrievals to estimate surface CO2 fluxes. The modeled XCO2 simulated by the optimized surface CO2 fluxes with GOSAT XCO2 were more consistent with the GOSAT XCO2 compared to the modeled XCO2 without GOSAT XCO2, which implies that data assimilation system developed for satellite observations performed appropriately.

Greenhouse gases inventory in Viet Nam

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Global warming is considered by many scientists as a serious environmental problem that most people face. Although the planet can create a natural greenhouse effect to maintain the life of the earth, but the climate change caused by humans is considered artificial greenhouse effect and making the atmosphere are increasingly warming.

United Nations Framework Convention on Climate Change (UNFCCC) is considered the first international convention on climate change and is the legal basis for international efforts to combat global climate change.

Vietnam signed UNFCCC on 11 June 1992 and ratified it on 16 November 1994. Viet Nam also signed Kyoto Protocol (KP) on 03 December 1998 and ratified it on 25 September 2002.

Implementing commitments of the Non-Annex I Parties as stated in Article 4.1 of UNFCCC, Vietnam is not required to reduce greenhouse gases (GHG) emission but to implement some common obligations, such as preparing its National Communications, carrying out GHG inventory, developing and accessing GHG mitigation and climate change adaptation options.

Vietnam completed the development of the Initial National Communication (INC) to the UNFCCC and submitted it to the UNFCCC Secretariat in 2003, completed the 2nd National Communication (SNC) under the UNFCCC and submitted in 2010 and completed the 1st Report Biennially Update (BUR1) to the UNFCCC and submitted in 2014.

In this presentation, I will present: i) the results of GHG inventory of Viet Nam in 1994, 2000 and 2010, ii) the comparison of GHG emissions in 1994, 2000 and 2010, iii) predicts GHG emissions coming years. Limitations, constraints in national GHG inventory and some proposals based on these facts will also be put forward in this presentation for the purpose of improving the quality and effect of greenhouse gases inventory in Vietnam.

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