The 9th Asia-Pacific GAW Workshop on Greenhouse Gases

and the 4th WCC-SF$_6$ Training and Education Course

November 6-9, 2018/ Glad hotel, Republic of Korea

ABSTRACT BOOK

Hosted by **National Institute of Meteorological Sciences**

The 9th Asia-Pacific
GAW Workshop on Greenhouse Gases

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The 9th Asia-Pacific GAW Workshop on Greenhouse Gases

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The Korea Meteorological Administration/National Institute of Meteorological Sciences will hold the 9th Asia-Pacific GAW Workshop on Greenhouse Gases (APGG-2018) and the 4th WCC-SF$_6$ Training and Education Course in Seoul and Anmyeondo GAW station, Republic of Korea on November 6 - 9, 2018.

Since 2009, the APGG has become a venue for cooperation on the greenhouse gases (GHGs) activities, designed to introduce the measurement technologies, quality control/assurance methodologies and new monitoring stations as well as to share major research findings. APGG-2018 will take place at the Glad Hotel in Seoul on November 6-7, 2018. It consists of oral presentations and a technical tour of Anmyeondo GAW station.

For Training/Education Course, it has been hold as one of activities of World Calibration Centre for SF$_6$ (WCC-SF$_6$) from 2014. Asia-Pacific regions are the regions of gaps between in-situ stations while practical techniques to monitor greenhouse gases are required. WCC-SF$_6$ is trying to transfer practical and applicable techniques of greenhouse gas measurements as targeting on in situ stations in those regions. The program will include the theory and practice of GHGs measurement at Anmyeondo station on November 7-9, 2018. And it will also be held in tandem with the APGG.

We hope that many of you participate APGG and GAPTEC

The 9th Asia-Pacific GAW Workshop on Greenhouse Gases (APGG-2018)

Workshop date and venue
November 6-7, 2018 at the Glad Hotel, Seoul, Republic of Korea

Workshop topics
- Current issues and future plans regarding GHGs monitroing
- Major findings on GHGs
- Introduction of new GHGs measurement technologies and new measurement stations
- Quality control and assurance of GHGs monitoring data
- Data processing for calculation of background atmospheric GHG concentration
- Technical tour in Anmyeondo GAW station on November 7, 2018

The 4th WCC-SF$_6$ Training and Education Course (GAPTEC-2018)

Course date and venue
November 7-9, 2018 at the Anmyendo GAW station, Taean-gun, Chungcheongnam-do, Republic of Korea

Training course topics
- Current issue of Greenhouse Gases under the GAW Programme
- Theory and analytical practice of cavity ring down spectroscopy
- Theory and analytical practice of Gas Chromatography with Electro Capture Detector

APGG and GAPTEC

- The APGG and GAPTEC registration deadline:
  October 16, 2018

- All registrations and abstracts should be submitted via
  Jeong Sik Lim

- Inquiries
  Environmental Meteorology Research Division
  National Institute of Meteorological Sciences
  Korea Meteorological Administration
  Haeyoung Lee

The 9th Asia-Pacific
GAW Workshop on Greenhouse Gases

6 November (Tue), Glad Hotel in Seoul

Time	Agenda	
8:30-9:00	**Register**	
9:00-10:00	**Opening session:** M.C. Dr. Sang-Boom Ryo	
	(10')	Welcome remark: KMA Administrator
	(10')	Photo
	(40')	Keynote speech
		Interpreting observed mixing ratios of long-lived trace gases and the advantages of redundancy in measurement: *Bradley Hall, NOAA*
10:00-10:20	**Coffee Break**	
10:20-11:20	**Asia-Pacific WMO/GAW activities:** Chair Dr. Sang-Ok, Han	
	(15')	KMA (Korea Meteorological Administration activities) in WMO/GAW Programme: *Sang-Ok Han, KMA/NIMS*
	(15')	Atmospheric Greenhouse Gas in Common Era: *Jinho Ahn, SNU*
	(15')	Renewal of World Data Centre for Greenhouse Gases (WDCGG) Website: *Mikio Ueno, JMA*
	(15')	Activities of WCC for Methane in Asia and the South-West Pacific: *Teruo Kawasaki, JMA*
11:20-12:30	**Lunch**	
12:30-14:00	**Special Lectures:** Chair Dr.Jeong-soon, Lee	
	(30')	Measurement uncertainty: *Ed Dlugokencky, NOAA*
	(30')	Working standard preparation and scale update: *Bradley Hall, NOAA*
	(30')	A combined observation and modeling approach for estimation of CO_2 and CH_4: *Gordon Brailsford, NIWA*
14:00-14:15	**Coffee Break**	
14:15-16:15	**Asia-Pacific Greenhouse Gas monitoring activities:** Chair Dr.Bradley Hall	
	(15')	Indian Greenhouse Gases Observational Program: *Yogesh Tiwari, Indian Institute of Tropical Meteorology of India*
	(15')	New Zealand GAW activities: *Gordon Brailsford, NIWA*
	(15')	Long-term study of greenhouse gases emissions in Brazilian Amazon Basin and next step: *Caio S.C.Correia, Instituto Nacional de Pesquisas Espaciais in Brazil*
	(15')	Monthly and Seasonal Analysis of Atmospheric Greenhouse Gas Concentrations at the Danum Valley Global Atmospheric Watch Station: *Mohan Kumar a/I Sammathuria, Malaysian Meteorological Department of Malaysia*
	(15')	First 4 years of greenhouse gases monitoring activities at the Pha Din GAW Regional station, Viet Nam: *Nguyen Nhat Anh, Hydro-Meteorological Observation Center of Viet Nam*
	(15')	Greenhouse Gas Monitoring Activities in Bukit Kototabang: *Tanti Tritama Okaem, Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) of Indonesia*
	(15')	CH_4 and N_2O flux measurements from local sources in Fiji Island: *Francis Mani, The University of the South Pacific in Fiji*
	(15')	Background and Non-background Ozone Variation in the 22st Century at Cape Point Global Atmosphere Watch (GAW) Station: *Thumeka Mkololo, South African Weather Service of South Africa*
16:15-16:30	**Coffee Break**	
16:30-17:45	**Recent Greenhouse Gas studies in Korea:** Chair Dr. Yogesh Tiwari	
	(15')	Understanding Carbon Cycle from Urban to the Entire Globe by Intergrating Data and Model: *Sujong Jeong, SNU*
	(15')	Measurements of atmospheric CO_2 columns using ground-based FTS spectra: *Young-Suk Oh(KMA/NIMS)*
	(15')	Multipoint Normalization of δ18O of Water Against the VSMOW2-SLAP2 Scale with Uncertainty Assessment: *Jeongsik Lim (KRISS)*
	(15')	In-situ Observation of Atmospheric CO_2 Isotopologues at the Korean Antarctic Station, Jang Bogo, in Terra Nova Bay, Antarctica: *Tae-Siek Rhee (KOPRI)*
	(15')	Understanding on atmospheric oxidation capacity changes in latest few decades: *Kyung-Eun Min (GIST)*
18:15-20:00	**Banquet**	

November 6-9, 2018/ Glad hotel, Republic of Korea

7 November (Wed), Seoul to Anmyeondo

Time	Agenda	
8:00-10:30	**Seoul to Anmyeondo GAW station**	
10:30-12:00	(10')	Introduction of Anmyeondo GAW station
	(80')	Technical tour
12:00-13:30	**Lunch**	
13:30-18:30	**WCC-SF6 Training and Education Course by KRISS**	
	(120')	GC-μECD calibration and analysis for Atmospheric SF_6 and N_2O
	(120')	Practice exercise with GC-μECD (I) *The members who are not trainees come back to the Glad Hotel after lunch*
18:30-19:00	**Dinner**	

8 November (Thu), Anmyeondo

Time	Agenda	
8:30-9:00	**Coffee Break**	
9:00-12:00	**WCC-SF6 Training and Education Course by KRISS**	
	(180')	Molecular spectroscopy for greenhouse gas analysis
	(120')	Cavity Ring Down Spectroscopy for greenhouse gas analysis
12:00-13:00	**Lunch**	
13:00-18:00	**WCC-SF6 Training and Education Course by KRISS (A)**	
	(180')	Practice exercise with GC-μECD and data handling (II)
	WCC-SF6 Training and Education Course by KRISS(B)	
	(180')	Practice exercise with CRDS and data handling
18:00-19:00	**Dinner**	

9 November (Fri), Anmyeondo to Seoul

Time	Agenda	
8:30-9:00	**Coffee Break**	
9:00-12:00	**WCC-SF6 Training and Education Course by KRISS (B)**	
	(180')	Practice exercise with GC-μECD and data handling (II)
	WCC-SF6 Training and Education Course by KRISS(A)	
	(180')	Practice exercise with CRDS and data handling
12:00-13:00	**Lunch**	
13:00-18:00	**Anmyeondo GAW station to Seoul**	
18:00-19:00	**Dinner**	

Glad Hotel

The hotel is located at 16, Uidsang-daero, Yeongdeungpo-gu, Seoul. It is about 53 kilometers away from the Incheon International Airport (ICN) and 13 kilometers away from the Gimpo International Airport.

http://www.glad-hotels.com/en/web/yeouido-en

16, Uidsang-daero, Yeongdeungpo-gu, Seoul, 150-874, KOREA

Tel: +82 2 6222 5411 Fax: +82 2 6222 5731 Contact: Henry Oh

1. Direction by subway

- Get off at National Assembly Station" (Exit #4)
- Route: Incheon International Airport Station (Airport Railroad) →
  Gimpo International Airport Station (Transfer to Line 9/Take the all Stop train) →
  National Assembly Station → By walk (1 min) → GLAD hotel

* http://www.arex.or.kr   * http://www.seoulmetro.co.kr

2. Direction By bus

- At terminal 1, take a limousine bus #6030, suppose to come out the gate 7A or 3B.
- And for terminal 2, you need to get to "B1" floor, then buy a bus ticket for #6030.
  You can take a limousine bus at the platform 32.
- 6B → #6030 (06:20~23:00, arrives intervals 20-30 minutes, KRW 15,000) →
  1 hour (approximately) → Stop at the "National Assembly subway station",
  which is Exit no.1 and GLAD is right in front of Exit no.4. →
  5 minutes (By walk) → GLAD hotel

* http://www.seoulbus.co.kr

Anmyeondo GAW station (AMY)

AMY (Anmyeondo GAW station), which is located on the west coast of the Korean Peninsula, has monitored the greenhouse gases from 1999. About 160 km away from Seoul, it takes two and a half hours drive for one way trip.

Keynote speech

Interpreting observed mixing ratios of long-lived trace gases and the advantages of redundancy in measurement:

Bradley Hall, NOAA

ABSTRACT

Interpreting observed mixing ratios of long-lived trace gases and the advantages of redundancy in measurement

Bradley Hall[1], Ed Dlugokencky[1], Geoff Dutton[2],
David Nance[2], Stephen Montzka[1]

[1] NOAA Global Monitoring Division, Boulder, CO USA
[2] University of Colorado (CIRES), Boulder, CO USA

NOAA and other laboratories make routine measurements of long-lived greenhouse gases, such as chlorofluorocarbons, N_2O, and SF_6, at a number of surface sites. These observations have been used to infer sources and sinks and offer constraints on global budgets. These records are strengthened by redundancies in measurement: using different measurement techniques, different observing networks, and independent/interconnected calibration pathways. In this presentation we examine select cases in which redundancy in measurement was critically important for interpreting the data and reaching a conclusion. A prominent example is the recently observed change in the growth rate of CFC-11. Atmospheric mixing ratios of CFC-11 are not decreasing as fast as expected. Confidence in observed trends is enhanced through multiple data records. We also examine the influence of transport on surface mixing ratios of long-lived gases.

Asia-Pacific WMO/GAW activities:

Chair Dr. Sang-Ok, Han

![abstract icon] **ABSTRACT**

KMA (Korea Meteorological Administration) activities in the WMO GAW Programme

Sang-Ok Han

Environmental Meteorology Research Division, NIMS/KMA

KMA operates several observatories for both environment and climate-change watch purposes in Korea. Among the observatories are 3 major sites which make continuous measurements on atmospheric elements in 6 main categories of WMO GAW program. The 3 major sites include Anmyeondo (AMY), Gosan Jeju (JGS), and Ulleungdo (ULD) site as illustrated in the photograph below. Additional sites are Pohang site for ozone sonde launch and ultraviolet ray watch and Gangneung, Mokpo, Seoul sites each of which is for ultraviolet ray watch.

KMA is rooted its GAW activities to the Sobaek mountain observatory where initial form of background atmosphere monitoring has begun in 1987. Then, the function at the Sobaek mountain site moved to present AMY site in 1996, enlarging its functional status. The AMY site has been designated as a regional WMO GAW site in 1998 and has the longest history of measurements conducted under KMA bodies for most of GAW elements. The JGS and ULD sites began operational in 2009 and 2014, respectively. As seen in the photograph below, the 3 major sites are located on the coastal and island areas such that local sources and sinks are avoided as best as they can.

As of 2018, 36 atmospheric watch components in total are observed at those 3 major sites using 92 numbers of instruments in total. At both AMY and JGS sites, there are at least more than one watch components for each of the 6 main categories of WMO GAW: greenhouse gases, reactive gases, aerosols, Ozone & UV, precipitation chemistry, and atmospheric radiation. At ULD sites, even though the number of watch components are far less than AMY and JGS sites, 14 components are observed in 5 out of 6 categories except for atmospheric radiation.

As of June, 2018, the combined data quality management and data base system has been built to facilitate QC and QA tasks for the produced measurement data at the 3 major sites mentioned above. The system has been designed such that those measurement data collected in the system on line are firstly auto-quality controlled, then flagged manually by instrument-operating staffs, and lastly confirmed by instrument-managing researchers. The QCed data are archived in the data base system for several kinds of services such as submission of measurement data to WMO data centers and research purposes.

KMA has also been contributing to the WMO GAW program since 2012 by running the WMO world calibration center for SF6 (WCC-SF6). The main activities of the WCC-SF6 are to provide working standard gases, to provide training courses on SF6 measurement, to conduct audits on other SF6 measurement sites, and to host workshops on the SF6 related topics.

<The location of KMA's 3 major GAW sites in Korea>

ABSTRACT

Atmospheric Greenhouse Gas in Common Era

Jinho Ahn*, Yeongjun Ryu and Ed Brook

Seoul National University, Korea

Over the last decade, several new ice core records with 10-20 year sampling resolution were obtained for the last 2000 years (Common Era). Combined with firn air records, the ice core records increased integrity and confidence level about the speed and changing trend of the greenhouse gases. In this talk, we will present recent findings in ice core CO_2, CH_4 and N_2O records with focus on centennial variations and discuss climate-greenhouse gas feedbacks. Several features associated with anthropogenic control will be also discussed.

ABSTRACT

Renewal of World Data Centre for Greenhouse Gases (WDCGG) Website

*Mikio Ueno

Japan Meteorological Agency (JMA), Tokyo, Japan

The World Data Centre for Greenhouse Gases (WDCGG) is a World Data Centre (WDC) operated by the Japan Meteorological Agency (JMA) under the Global Atmosphere Watch (GAW) programme of the World Meteorological Organization (WMO). WDCGG was established in October 1990 and has served to collect, archive and provide data on greenhouse gases (CO_2, CH_4, N_2O, CFCs, etc.) and other related gases (CO, etc.) in the atmosphere. The WDCGG website is used to provide and update greenhouse gas observation data contributed by organizations and individual researchers worldwide. Thanks to the generous support of these data contributors, WDCGG has built an extensive archive of data along with the development of the GAW network.

The new WDCGG website (https://gaw.kishou.go.jp/) was launched on 31 August 2018. JMA has strengthened links between measurement data and metadata by renewing the website and data submission procedures. The introduction of user registration before downloading data files has made it possible to provide contributors with feedback of information on data downloading. The data file format has changed for users to facilitate data processing.

The former website (http://ds.data.jma.go.jp/gmd/wdcgg/) is still available at present but will be closed in late November 2018.

Activities of WCC for Methane in Asia and the South-West Pacific

*Teruo Kawasaki[1], Masamichi Nakamura[1], Kazuyuki Saito[1], Kentaro Kozumi[1], Genta Umezawa[1], Kazuya Yukita1, Shigeharu Nishida[1], Megumi Yamamoto[1], Yousuke Sawa[2], Kazuhiro Tsuboi[2], Kentaro Ishijima[2] and Hidekazu Matsueda[2]

1. Japan Meteorological Agency (JMA), Tokyo, Japan,
*Meteorological Research Institute (MRI), Tsukuba, Japan

The Japan Meteorological Agency (JMA) serves as the World Calibration Centre (WCC) for methane (CH_4) and the Quality Assurance/Science Activity Centre (QA/SAC) in Asia and the South-West Pacific within the framework of the Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO).

From the establishment of the WCC-JMA in 2001 until only recently, its methane calibration system was based on a gas chromatograph equipped with a flame ionization detector (GC/FID) to analyze CH_4 mole fractions of standard gases. However, over the past few years laser-based spectroscopic techniques such as wavelength-scanned cavity ring-down spectroscopy (WS-CRDS) have become commercially available for the measurement of atmospheric CH_4. These techniques provide higher precision, improved stability, lower maintenance, and easier operation than the GC/FID method. Thus, the WCC-JMA replaced the existing GC/FID system with a new calibration system using WS-CRDS analyzer in 2017 (Matsueda et al., 2018).

The WCC-JMA has two sets of CH_4 primary standards that were assigned on the WMO CH_4 mole fraction scale at NOAA/ESRL. Using these standard gases, we tested the performance of the new calibration system and also examined the CH_4 mole fractions calibrated by both the GC/FID and WS-CRDS systems in order to assess the consistency in the continuity of CH_4 calibration. We report the results of the performance test and the comparative measurements.

The WCC-JMA has so far carried out 4 rounds of inter-comparison experiments of CH_4 reference gases from 2001 to 2016 as well as ongoing 5th and 6th rounds as one of the WCC activities in co-operation with NOAA/ESRL (WMO/CCL,USA), CSIRO (Australia), NIWA (New Zealand), CMA (China), KMA/KRISS (Republic of Korea), IITM (India), and several Japanese laboratories. The purpose of the inter-comparisons is to understand the differences between the participants' CH_4 standard scales as well as to monitor the long-term stability of standard gases in Asia and the South-West Pacific regions. We also report all the results of the previous inter-comparison experiments, which are posted on the WCC-JMA website (https://ds.data.jma.go.jp/gmd/wcc/wcc.html).

Abstract

Asia-Pacific Greenhouse Gas monitoring activities:

Chair Dr.Bradley Hall

Indian greenhouse gases observational program

Yogesh K. Tiwari

Indian Institute of Tropical Meteorology, Pashan, Pune, INDIA

Greenhouse gases observations in India were started in late 2009 and are continuing. Though a coastal site Cape Rama (CRI), in collaboration with CSIRO Australia, was operational during 1993-2002 and 2009 - 2012, this was only site operational in entire Indian sub-continent. CRI observations were based on flask sampling and analysis at CSIRO Gaslab. Later, we have established flask analysis lab in India and started flask collection at a mountainous western boundary of India located at Sinhagad (SNG) near Pune. This lab is part of calibration tank inter-comparison program among the Asian labs. At present, observations are based on flask as well as in-situ monitoring techniques and measurements are traceable to NOAA calibration standards. Also, GHGs are monitored using airplane campaigns during 2014, 2015, and 2018 by using Picarro G2401-m and calibrations using NOAA standards. We are in the processes of installing tall tower GHGs observatory located over central India which is test bed monitoring facility for soil to atmosphere using in-situ instruments such as Picarro etc. Apart from these monitoring activities, we have established various sites over India for GHGs flux monitoring over evergreen and deciduous forests as well as coastal locations. Various research publications are available using above monitoring activities.

ABSTRACT

New Zealand GAW activities

Gordon Brailsford

National Institute of Water and Atmosphere

The observation of greenhouse gas species in New Zealand has had a long history with observations of CO_2 starting in Wellington in 1970. Over time the range of greenhouse gas species monitored has increased to include the dominant species (CO_2, CH_4 and N_2O) at two GAW stations, Baring Head (BHD) and Lauder (LAU), and an additional in situ observation site, Maunga Kakaramea (MGK), for CO_2 that is now producing data of GAW quality. In addition to observations within New Zealand, NIWA also operate a GAW station in Antarctica at Arrival Heights (ARH).

Initial observations were focused on understanding the seasonality, trends and interannual variability of baseline air for the individual species at the sites, and in many cases isotopic species have been measured to support and enhance the interpretations. More recently, with the development of a strong inverse modelling component to the programme, there has been a move to utilise all observations to better understand the local and regional contributions to observed mole fractions.

The programme that NIWA operate across the New Zealand observation network will be described along with the range of species and recent trends.

ABSTRACT

Long-term Study of Greenhouse Gases Emissions in Brazilian Amazon Basin and Next Steps

C. S. C. Correia[1,2]*; L. V. Gatti[1,2]; L. G. Domingues[1,2]; R. S. Santos[1,2]; S. P. Crispim[2], R.A.L. Neves[2]; L. Marani[2], E. U. Gloor[3]; J. B. Miller[4]; W. Peters[5].

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[2] National Institute for Spaces Research, INPE/CCST, São José dos Campos-SP, Brazil;
[3] University of Leeds, Leeds, United Kingdom;
[4] National Oceanic and Atmospheric Administration, NOAA, Boulder-Colorado, United States.
[5] University of Groningen, Groningen, Netherlands

The Amazon rainforest is one of the vastest tropical forests in the world, corresponding for 50% of this biome in the globe. It has a total area of, approximately, 8 million km^2, which 5 million km^2 are in Brazil (58.74% of the total area in Brazil) and contains one quarter of global biodiversity (Gloor, 2012; MCTIC, 2016).

Since the year of 2000 the LaGEE (Greenhouse Gases Analisys Laboratory) is working in cooperation with NOAA to better understand the Amazon Basin contribution in the global scenario of greenhouse gases (GHG) emissions. Previously the measurements were performed in NOAA laboratory in Boulder, CO, USA, however, since 2004 they are performed in Brazil. For this, natural air was sampled in glass flasks using small aircraft over sites in Amazon, initially in 2000, only in Santarém (SAN; 2.86ºS, 54.95ºW). In 2010 the program included more sites in order to have a great quadrant to better understand the whole Brazilian Amazon Basin area: Alta Floresta (ALF; 8.80ºS, 56.75ºW), Rio Branco (RBA; 9.38ºS, 67.62ºW), and Tabatinga (TAB; 5.96ºS, 70.06ºW). We still perform sampling in these sites, but, the last one changed to Tefé (TEF; 3.39°S, 65.6°W) in 2013 due to technical problems.

The mixing ratios of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Sulfur Hexafluoride (SF_6) and Carbon Monoxide (CO) quantifications are being performed since the laboratory started its activities. This data is being used to better understand the behavior of the studied region and, by the end of 2020, with a 10-year time series, we aim to have enough detailed information which can provide us to set the best strategies of investments and monitoring.

The program now is aiming to expand to other biomes, Pantanal measurements already started, this region is characterized by seasonal floods and also intense human activities. Other goals of the running projects are to quantify Carbon and Oxygen isotopes as well as Carbonyl Sulfide.

This work is going to show an overview of the current network, the mixing ratios timeseries of the studied gases and the future objectives.

References:

E.U. Gloor, et al., The carbon balance of South America: a review of the status, decadal trends and main determinants, Biogeosciences, v.9, p.5407-5430, 2012.

MCTIC - Ministério da Ciência, Tecnologia, Inovação e Comunicação. Third National Communication of Brazil to the United Nations Framework Convention on Climate Change. Brasília, 2016.

Monthly and Seasonal Analysis of Atmospheric Greenhouse Gas Concentrations at the Danum Valley Global Atmospheric Watch Station

Mohan Kumar Sammathuria[1], Maznorizan Mohamad[1], Norazura Zakaria[1]

Malaysian Meteorological Department, Petaling Jaya, Malaysia[1]

The Danum Valley Global Atmospheric Watch (GAW) is among the limited number of GAW stations within the tropical region. Greenhouse gas concentrations at the Danum Valley GAW station were monitored using both the LoFlo MARK2 analyzer approach and regular weekly measurements using the flask sampling approach. The measurements were conducted for a six year period from 2011 to 2016. Monthly boxplots demonstrate a relatively steep increase in carbon dioxide concentrations between the months of February to June 2015. The lack of clarity for a more definitive period is due to the lack analyzer data for the months of March to May of 2015. A reduction in CO_2 concentrations is observed from around April 2013 to December 2013 compared to the expected annual increase of global atmospheric CO_2. Among all the monthly boxplots, the month of June 2016 demonstrates the highest monthly variation throughout the six year analysis. In general the highest and lowest monthly variations are demonstrated by October and November respectively over the analyzed duration. Comparison of the combined data of the particular months during the analyzed timeline indicates that lowest concentrations of CO_2 are observed during the month of September. A contradicting trend between the analyzer and flask sampling based observations for the months of March and April have been observed as they represent a local minimum for the former and a global maximum for the latter. A 7-day and 15-day running mean analysis of the LoFlo analyzer CO_2 data and a seasonal analysis of both LoFlo MARK2 driven analyzer and flask sampling CO_2 datasets reveal an annual drop during the boreal summer monsoon and a corresponding increase during the boreal winter monsoon. This pattern being replicated for methane, nitrous oxide and sulphur hexafluoride demonstrate the significant potential of transboundary influence upon atmospheric greenhouse gas concentrations over the region. This transboundary influence strongly correlates to the seasonal trade winds over the region.

First 4 years of greenhouse gases monitoring activities at the Pha Din GAW Regional station, Viet Nam

Nguyen Nhat Anh[1], Hoang Anh Le[2], Martin Steinbacher[3]

[1] Hydro-Meteorological Observation Center (HYMOC), Viet Nam Meteorological and Hydrological Administration (VNMHA), Ministry of Natural Resources and Environment of Viet Nam (MONRE)

[2] Faculty of Environmental Sciences, VNU University of Science, Vietnam National University

[3] Swiss Federal Laboratories for Materials Science and Technology (Empa), Switzerland

The Vietnamese Government has considered climate change to be one of national key missions in recent years. It was concretized through policy document of the Government and the Ministry of Natural Resources and Environment (MONRE).

On that basis, Pha Din Global Atmosphere Watch (GAW) Regional station was invested and constructed within the framework of the project CATCOS (Capacity Building and Twinning for Climate Observing Systems). Pha Din GAW station was launched to aim at strengthening the climate monitoring on global scale, particularly in developing countries and countries in transition. Monitoring data of Pha Din GAW Regional station will also contribute to strengthening the capacity of Vietnam in assessing the status of greenhouse gas (GHGs) emissions and air quality in a more comprehensive scale.

I. Overview and description of Pha Din GAW Regional station

Pha Din is the first GAW Regional station in Viet Nam (21.57°N 103.51°E, 1466m a.s.l.) and it was installed at the Pha Din meteorological station on the North-West high mountain belonging to Toa Tinh precinct, Tuan Giao district, Dien Bien province.

In early 2014, the instrumentation of trace gases (CO_2, CO, CH_4 and O_3) and aerosols optical properties began to be installed at Pha Din station. WMO accepted Pha Din station as a GAW Regional station at the Letter No. 5549-14/RES/AER/Viet Nam dated on 25th July 2014.

Pha Din station is located in a region where GHGs measurements are sparse. The station is located on the top of a hill, lying in a rural area and is surrounded by forest. The sample inlet is at 12m above ground, which is above the canopy, an important feature for the CO_2 measurements, which would otherwise be influenced by uptake and respiration by the nearby vegetation.

Atmospheric composition monitoring instruments at Pha Din station include:

- Picarro G2401 Cavity Ringdown Spectrometer (CRDS) measuring $CO/CO_2/CH_4/H_2O$.
- Thermo TE49i UV absorption analyzer for measuring O_3.
- Aerosols analyzers: Aurora 3000 Nephelometer and Magee Scientific Aethalometer AE31.
- Calibration equipment and six gases cylinders.
- Data acquisition computers.
- Other accessories.

After installation of monitoring equipment and testing, Swiss experts of Paul Scherrer Institute (PSI) and Swiss Federal Laboratories for Materials Science and Technology (Empa) have trained the operating staffs at Pha Din station and transferred technology to VNMHA.
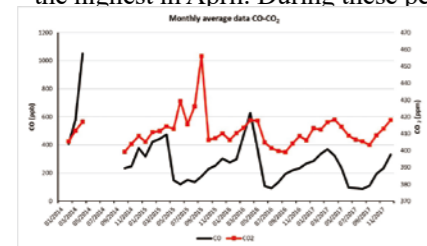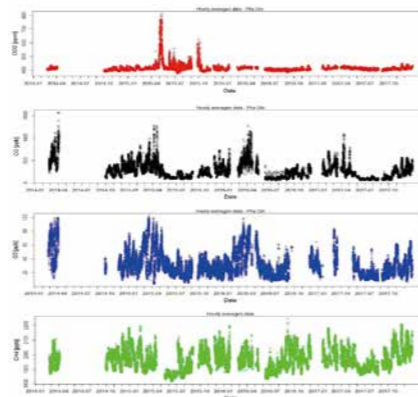
The measuring data is transferred to VNMHA via FPT servers. GHGs data is processed by R software for filtering and archiving the data while aerosols data is processed by CPX2 software. Once a year, all data is prepared for submission to the World Data Centre for Greenhouse Gases (WDCGG) and the World Data Centre for Aerosols (WDCA)

II. Major outcomes of GHGs measurement at Pha Din station and initial assessments

After 4 years (2014-2017) of implementation of measuring GHGs, first conclusions can be drawn out of the GHGs time series of Pha Din which are showed in the right figure.

- Two ranges of very high CO_2 concentrations were observed, which can not be explained by the station's e-log book: In June 2015, and from end of September 2015 to beginning of October 2015 with maximum mixing ratios of 550 and 650ppm CO_2, respectively.

- Meanwhile, maximum hourly mean concentrations of CO reached 1500 ppb in early 2014 and again present an increase in Spring (February – April) for the years 2015 to 2017. Besides, CO mixing concentrations show a similar picture of CO_2 except the periods of very high CO_2 concentrations from June to October 2015 mentioned above. These are illustrated in the monthly average plot below.

- The maximum concentrations of both gases CO and CO_2 usually increase in the Spring annually, with the highest in April. During these periods, the air masses arriving at Pha Din have the majority coming from Southwestern area (Thailand, Myanmar, and Laos).

The FLEXTRA backward trajectory model also illustrates this trend. This evolution is perfectly in accordance with the land fire hotspot listed by ASMC because these periods are consistently characterized by no rainfall and low relative humidity. The very high mixing ratios of CO and CO_2 in these periods was identified by The FLEXTRA backward trajectory model with the air masses arriving at Pha Din have the majority coming from Southwestern area (Thailand, Myanmar, and Laos). This evolution is perfectly in accordance with the land fire hotspot listed by ASMC because these periods are consistently characterized by no rainfall and low relative humidity
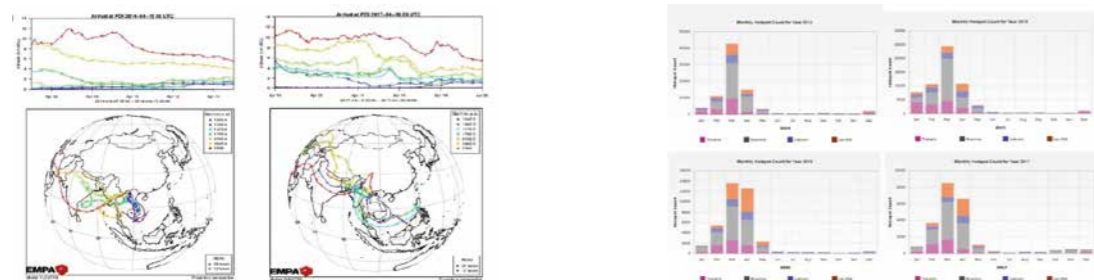
- Similar to the CO_2 and CO concentrations, the time series of O_3 have a high variation in early every years. O_3 is formed locally by advection of CO and VOCs from biomass burning and due to higher NO_x emissions.

- Finally, methane (CH_4) concentrations show a seasonal cycle with maximum concentrations in winter time. The agricultural activity in rice paddies in entire Southeast Asia leads to important bacterial emissions during the no-growth season in winter, which is reflected in the measurements
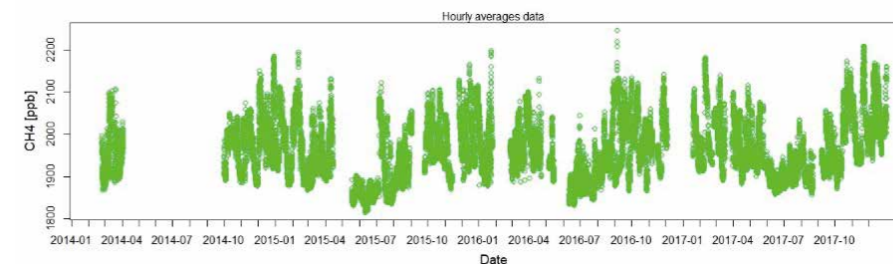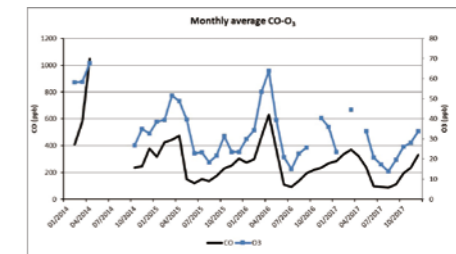
III. Difficulties in operation and maintenance of instruments at Pha Din station

- Pha Din is located in high mountainous areas, so the quality of transmission of the power supply and internet is not stable, sometimes the power supply is off causing interruption of measurement.

- During the operation of the station, sometimes the instruments have trouble or malfunction. However, it can not be fixed in time due to difficult conditions on human resources on-site.

- Due to hard natural conditions in Vietnam (hot-wet and rainfall climate) and continuous operation 24/24h, the equipment at the station are susceptible to be broken suddenly. While the funds allocated for the task of checking and troubleshooting at station is quite limited. Therefore, it is very difficult to ensure stable and continuous operation.

- Price of GHGs observing equipment is very high, so spare parts for it are relatively expensive. This is a great difficulty for Viet Nam in the current economic context.

- Moreover, the experience of the management and operation team of the station is lacking so the results are still limited.

IV. Proposal and suggestion

- Strengthen the coordination between GAW stations in the Asia - Pacific region in particular and globally in general to exchange and share experiences in operation and maintenance of instruments at station.

- Provide additional support in capacity building for managing and operating staffs of the station by giving workshops and training courses related to GHGs monitoring programs similar to this one.

- VNMHA is now considering to submit to the MONRE for funding to maintain the annual operation of Pha Din GAW station.

- There should be an effective coordinative mechanism to assist countries that are facing difficulties in technology such us training as well as financing in order to maintain stable operation of GAW stations in these countries, including Pha Din GAW station.

ABSTRACT

Greenhouse Gas Monitoring Activities in Bukit Kototabang

Tanti Tritama Okaem

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Global Atmosphere Watch (GAW) station of Bukit Kototabang, Agam Regency, West Sumatra is the only global atmospheric monitoring station in Indonesia and represents the atmospheric condition of equator area. The composition of atmosphere is truly sensitive and can be easily altered by either naturally or human activity. GAW Bukit Kototabang is one of stations as sampling site which ships Air Kit Flask bottle to NOAA ESRL for being analyzed. CO_2 annual average concentration in Bukit Kototabang has been increasing from 373.1 ppm in 2004 to 398.5 ppm in 2017. CO_2 concentration in Bukit Kototabang GAW station still under global and Mauna Loa. SF_6 concentration increased from 5.43 ppt in 2004 to 9.27 ppt in 2017. The concentration increased 3.84 ppt or almost 70% higher than its initial value. The Average Annual Growth Rate (AAGR) of N_2O concentration is 0.87 ppb/year. The highest CH_4 concentration was 2021.3 ppb in 2015 because Indonesia experienced severe fire forest in October 2015.

ABSTRACT

CH_4 and N_2O flux measurements from local sources in Fiji Island

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The researchers from the University of the South Pacific developed the in-house capacity to measure CH_4 and N_2O using GC-FID and GC-ECD respectively. A series of clean air samples were collected from a coastal site near Suva, Fiji (18°08'S, 178°26'E). The precision for CH_4 measurements is 4 ppbv and for N_2O measurements is approximately 2 ppbv. Some long term trends in the background observation of CH_4 will be discussed. The measurement capacity development enabled static chamber flux measurements of CH_4 from Naboro landfill and rice farms and N_2O flux from N-synthetic fertilizer application in sugar cane farms. The CH_4 flux measurements ranged from 0.55 g/m^2day^{-1} – 489.5 g/m^2day^{-1} with low values observed during the rainy seasons. The CH_4 fluxes from two common rice varieties (Star and Totoka) observed for two different ecosystems such as rainfed and irrigated were investigated and the results obtained verified the IPCC emission factor. The experimental CH_4 emission factors (EF) calculated for rainfed and continuously flooded systems were 67 ± 19 mg CH_4 $m^{-2}day^{-1}$ and 200 ± 49 mg CH4 $m^{-2}day^{-1}$ respectively. These values overlap with the default IPCC EF of 80 – 220 mg CH_4 $m^{-2}day^{-1}$ and 21 – 59 mg CH_4 $m^{-2}day^{-1}$ respectively for continuously flooded and rainfed system. The N_2O flux measurements from sugarcane fields resulted in an EF of 4.7% of N applied. The experimentally derived EF is significantly higher than the default IPCC emission factor of 1% of N applied, which is used to estimate N_2O emission from direct N fertilizer application in the national greenhouse gas inventory. The greenhouse gas measurement undertaken at USP assists in estimating annual flux measurements which in turns verifies the national greenhouse gas inventory making it more robust and reliable and highlights the opportunities for emission reductions as part of our Nationally Determined Contributions (NDCs).

ABSTRACT

BACKGROUND AND NON-BACKGROUND OZONE VARIATION IN THE 21ST CENTURY AT CAPE POINT GLOBAL ATMOSPHERE WATCH (GAW) STATION

T. Mkololo, W. Joubert, C. Labuschagne, L. Martin, E. Mbambalala and D. VanderSpuy

This study presents an investigation of surface ozone (O_3) at Cape Point (2001 to 2017). The Cape Point data was statistically separated to background (marine) and non-background (anthropogenic) data. The main aim of the study was to investigate diurnal cycles, seasonal cycles, 'weekend effect' and long term trends in surface O_3.

The observed O_3 concentrations were higher during the day than at night, with non-background data showing more pronounced peak-to-peak variations relative to background data. No 'weekend effect' was evident at Cape Point for both non-background and background data. This behavior in absence of 'weekend effect' at Cape Point could be related to the geographic location of the station and dominant wind regimes. The Cape Point background (CPT_BG) O_3 maxima were observed in winter (June to August) with minima in summer (January to February), while, Cape Point non-background (CPT_NBG) O_3 maxima was observed in September with minima in summer (January). The seasonal cycle for CPT_BG is inversely proportional to solar radiation, with maxima in winter when solar radiation is at its minima and vice versa. On the other hand, CPT_NBG is driven by Nitrogen oxide (NO_x) chemistry. An increasing O_3 trend was observed at Cape Point in both CPT_BG and CPT_NBG data since 1990 until present.

Abstract

Recent Greenhouse Gas studies in Korea:

Chair Dr. Yogesh Tiwari

ABSTRACT

Understanding carbon cycle from urban to the entire globe by integrating data and model

In this presentation, we introduce our current three research projects related to GHGs with specific focusing on carbon cycle. Firstly, we are evaluating urban enhancement of atmospheric CO_2 through comparing carbon inventory and XCO_2 measurements from satellite remote sensing (OCO-2, NASA). Secondly, we are evaluating the role of terrestrial ecosystem in atmospheric CO_2 variations of Korea by analyzing atmospheric CO_2 measurements from Anmyeondo, satellite and models. Finally, we try to understand the global-scale long-term variations in atmospheric CO_2 by analyzing atmospheric CO_2 measurements, satellite remote sensing and models. Three research projects will help us to understand the carbon cycle from town to the entire globe.

Measurements of atmospheric CO_2 columns using ground-based FTS spectra

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Global climate change is one of the most urgent challenges facing mankind, however it is induced by humans themselves. The latter one is continuously boosted by increasing greenhouse gas (GHG) concentrations. Due to its increase from 315 ppm in 1958 to 407ppm in 2017, carbon dioxide (CO_2) is the major contributor to the anthropogenic greenhouse effect. In order to understand global climate change and to estimate future effects, the investigation of CO_2 sources and sinks within the carbon cycle is strongly required. For this reason, several measurement programs were initialized being mainly in situ measurements, satellite measurements and ground-based Fourier Transform Spectrometer (FTS) measurement. In contrast to in situ measurements, ground-based FTS spectrometers and satellites detect total column abundances of CO_2. The Total Carbon Column Observing Network (TCCON) is a worldwide network of high-resolution ground-based FTS spectrometers measuring solar absorption spectra in the near-infrared (NIR) region. The main goal is to provide accurate total column amounts of atmospheric trace gases for the validation of satellites and the investigation of the carbon cycle. In this main part the theoretical basis of this work, including an overview about relevant processes in the Earth's atmosphere, an outline about important aspects of remote sensing in the NIR region, an introduction to the subject FTS and analysis of ground-based IR spectra. With an error source of special relevance for FTS NIR measurements, namely sampling errors in the recorded interferograms, leading to erroneous total column abundances. In order to improve the accuracy, the quantification of this error and is correction is presented.

Kay Words: CO_2, FTS, TCCON, NIR, Column, Error, Accuracy

Multipoint Normalization of $\delta^{18}O$ of Water Against the VSMOW2-SLAP2 Scale with Uncertainty Assessment

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In this study, we measured the oxygen stable isotope ratio of drinking water using gas chromatography isotope ratio mass spectrometry. The $\delta^{18}O$ value of drinking water was normalized based on the VSMOW2, SLAP2, and GSIP scale by carbonate equilibria for 24 h. The isotope ratio responses of a dummy sample drifted as much as 0.145‰ due to a significant decrease in the amount of injected sample during the injection. The autodilution technique improved measurement precision of the $\delta^{18}O$ of dummy sample two fold compared to that without autodilution to give 0.025‰. The autodilution of an injected concentration of equilibrated CO_2 also helped improve measurement precision of the isotope ratio response. The linearity of the ratio responses was tested with linear model regression to validate linearity within the sample concentration and isotope ratio ranges. Measurement reliability was assessed using various statistical approaches. One-way ANOVA analysis verified non-reproducible results of individual measurements. Normalization uncertainties were then assessed by various normalization schemes including two-pointed and three-pointed standard values of the VSMOW2, SLAP2, and GSIP standards. Equivalent results among various normalization methods were came out with slightly better accuracy and precision for 3 point normalization. The uncertainty of certified $\delta^{18}O$ of GSIP was 0.09‰, three times worse than the reported values for both certified $\delta^{18}O$ of VSMOW2 and SLAP2, which were 0.02‰. Uncertainty of the GSIP contributed one-third to the total normalization uncertainty, implying that uncertainties in the normalization scheme improved. The measured $\delta^{18}O$ values of drinking water samples and the reported values of online isotope samples in the precipitation calculator were in agreement. Together with $\delta^{13}C(VPDB)$, $\delta^{18}O$ of CO_2 gas was also assigned for users to use.

In-situ Observation of Atmospheric CO_2 Isotopologues at the Korean Antarctic Station, Jang Bogo, in Terra Nova Bay, Antarctica

Tae Siek Rhee

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It is well recognized that the current global climate change is dominantly driven by human activities since the Industrial Revolution. Fossil fuel combustion is the main driver as one of its byproducts, CO_2, accumulates in the atmosphere and warms up the surface by trapping the radiative heat. Large efforts were put forth to predict future climate with various scenarios of the atmospheric CO_2 increase on the basis of the long-term observations of atmospheric concentrations worldwide. Besides the growth of atmospheric CO_2 concentration, we need to monitor the source and sink strengths of atmospheric CO_2 budget to validate model predictions. CO_2 isotopic signatures may give us opportunities to tackle with this goal. The second Korean Antarctic base was established in Terra Nova Bay, Antarctica, in 2014 to contribute to the advancement of the Antarctic sciences. We installed a set of instruments to monitor the variation of atmospheric composition in situ, including major long-lived greenhouse gases, CO_2, CH_4, and N_2O, and reactive trace gases, O_3, NO_x, SO_2, and CO. To investigate the source and sink signatures of CO_2 in the high latitudes of the Southern Hemisphere, its main isotopologues, $^{12}C^{16}O_2$, $^{12}C^{18}O^{16}O$, $^{13}C^{16}O_2$, have been analyzed in situ using a quantum cascade laser spectroscope (CW-QC-TILDAS-CS) installed at the station since December in 2016. The Antarctic ambient air was withdrawn from the top of the laboratory roof and analyzed at 1 Hz for CO_2 isotopologues. In the talk, I will present the preliminary results from the last ~2-year observations.

Understanding on atmospheric oxidation capacity changes in latest few decades

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Oxidation capacity of the troposphere determines the lifetime of atmospheric pollutants related with not only for air quality issues but also for climate change. Especially for greenhouse gases, their life spans in the air, mainly depends on the strength of OH oxidation. This oxidation strength can be determined by the abundance of OH radical as well as meteorological parameters such as temperature and pressure. The global burden of OH is a net balance of chemical production via O_3 photolysis and its chemical loss processes related with pollutants removals on the top of the physical loss procedures. To diagnose the contemporary OH abundances in global scale as well as its changes with time are truly challenging mainly because of that the direct evaluations are not possible due to its high reactive chemical characteristics; the direct measurement of OH concentration, no matter what working principle is applied, only reveals the features of air masses in local scope than global scale. So far the in-direct estimation methods have been developed in support of state-of-the-art modeling techniques with the observational constraints of pollutants from global network by tracking down changes in loss processes of long lived greenhouse gases. In this presentation, we will introduce a simple method to extract the trend in OH concentration caused by anthropogenic activities from the growth and emission rates of CH_4. As a part of an effort to understand this trend, the production rate of O_3 changes with time will be also discussed by contrasting and comparing those parameters among 2 South Korean GAW stations and 44 routine air quality monitoring stations in Seoul Metropolitan Area. Our approach to understand the O_3 forming sensitivities with respect to the abundances of precursors, NOx, will provide significant insights of the tight links between climate issues and air quality degradation. The necessity of characterizing the air quality issue in urban area to understand its impact on global scale climate changes will be emphasized via the influences on oxidation capacity changes and which should be also included in climate model for better accuracy in prediction, as well as the ready known links of direct and indirect effect of aerosol in climate change and short lived climate pollutant.

The 9th Asia-Pacific
GAW Workshop on Greenhouse Gases

and the 4th WCC-SF$_6$
Training and Education Course

ABSTRACT BOOK