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THE GREENHOUSE GASES OBSERVATION AND ANALYSIS AT GAW STATIONS IN MALAYSIA

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The scope of this presentation is as follows:-

- Introduction
- Monitoring Activities
- Results and Analysis
- Future Direction

INTRODUCTION

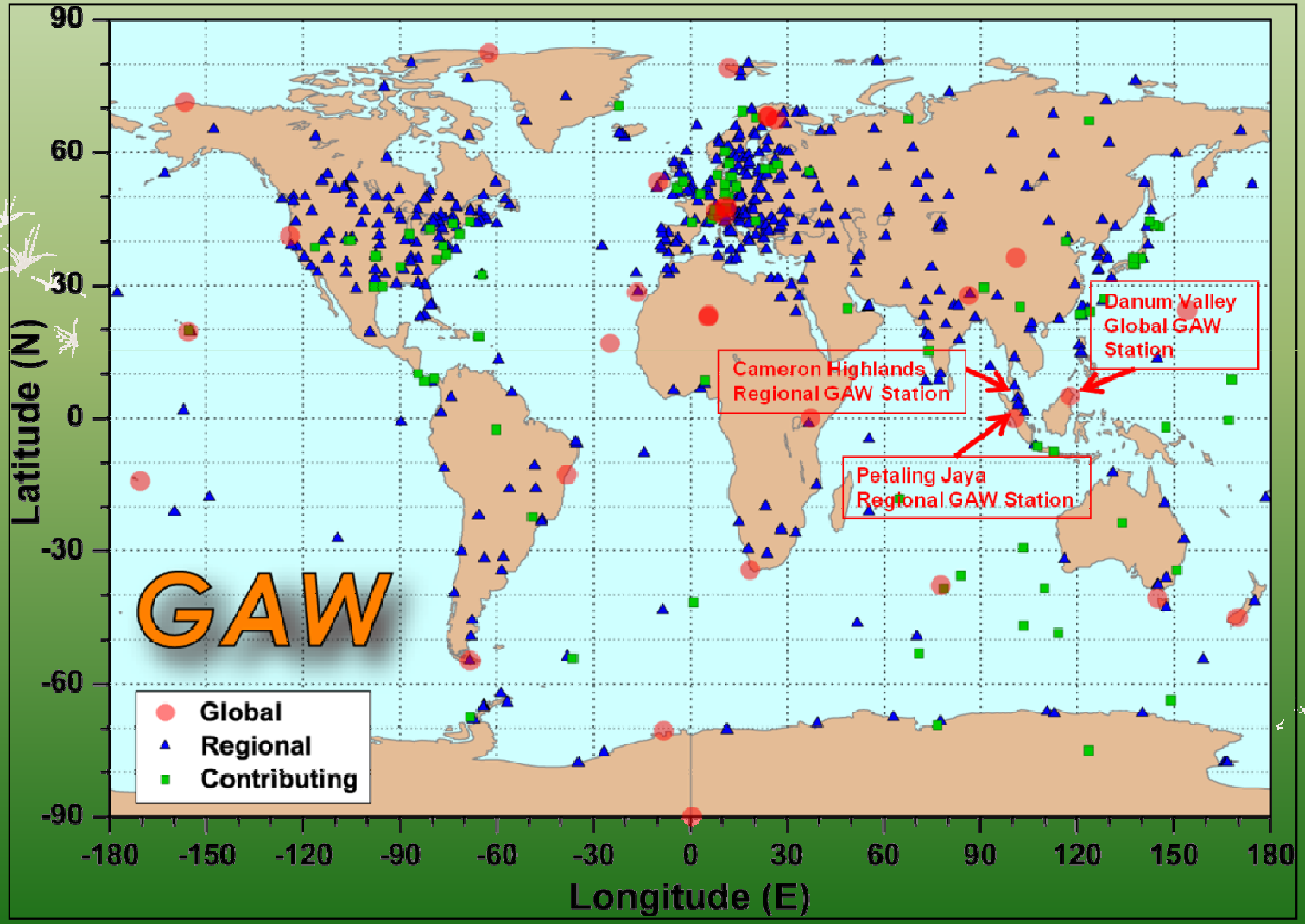
Introduction

- In order to support the Global Atmosphere Watch (GAW) Programme of World Meteorological Organization (WMO), Malaysian Meteorological Department (MetMalaysia) has since established GAW stations to carry out systematic monitoring of atmospheric constituents in response to acquire a high quality data to study and understand the regional issues on trans-boundary haze, acid deposition, climate variability, climate change and stratospheric O_3 depletion.

Introduction

- MetMalaysia has participated in the world wide network of GAW program since 1989 and will continue to play an active role in this international network for many more years.
- MetMalaysia has established a GAW Global Station in Sabah since November 2003, to fulfil as a national, as well as international obligation in addressing the environmental issues.
- At the same time, MetMalaysia is also operating two other GAW regional stations, one in Cameron Highlands and the other in Petaling Jaya.

The location of MetMalaysia's GAW stations in GAW Station Network



Danum Valley GAW Global Station

- Forest site (located within a Class 1 forest conservation area)
- Started its operation since November 2003
- Facilities: Laboratory, 15 ft high platform on the rooftop and 100 m high sampling tower
- Latitude: 4.98°N
- Longitude: 117.84°E
- Altitude: 426 m above Mean Sea Level

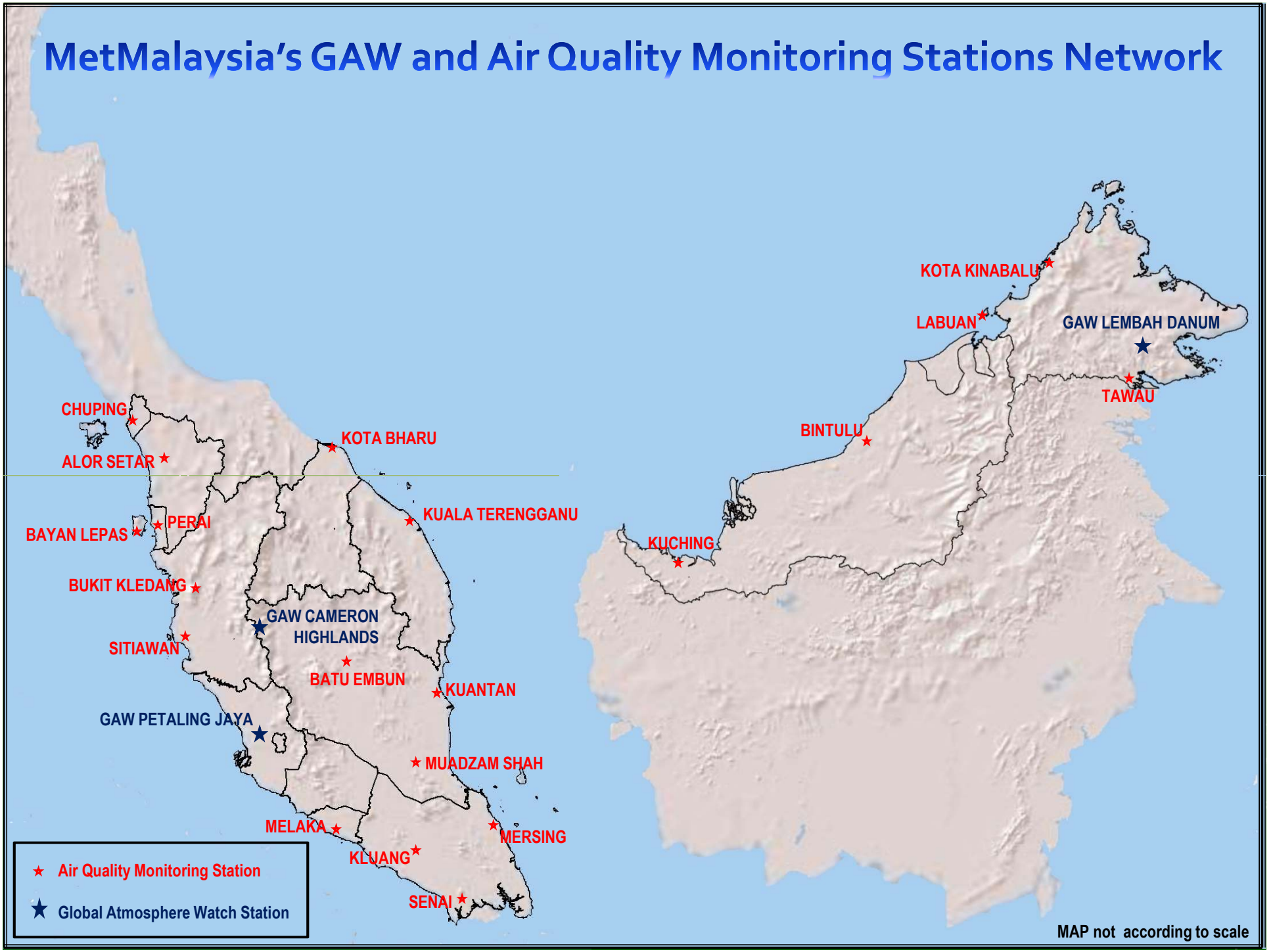
Cameron Highlands Regional GAW Station

- Developing rural site (located in the state of Pahang in the central range of highlands that run from north to south of Peninsular Malaysia)
- Cameron Highlands is a hill resort and tourism spot with a primarily agricultural domain and enjoys a distinctively cooler climate than the lowland urban sites
- Latitude: 4.47°N
- Longitude: 101.37°E
- Altitude: 1545 m above Mean Sea Level

Petaling Jaya Regional GAW Station

- Urban site (located in the urban and residential area in the state of Selangor)
- Situated in Klang Valley, Petaling Jaya is characterized by high population density, traffic volume, business and commercial centres and industries such as electronic, chemical and automotive
- Latitude: 3.10°N
- Longitude: 101.65°E
- Altitude: 46 m above Mean Sea Level

MetMalaysia's GAW and Air Quality Monitoring Stations Network



MONITORING ACTIVITIES

The monitoring activities at GAW stations in Malaysia

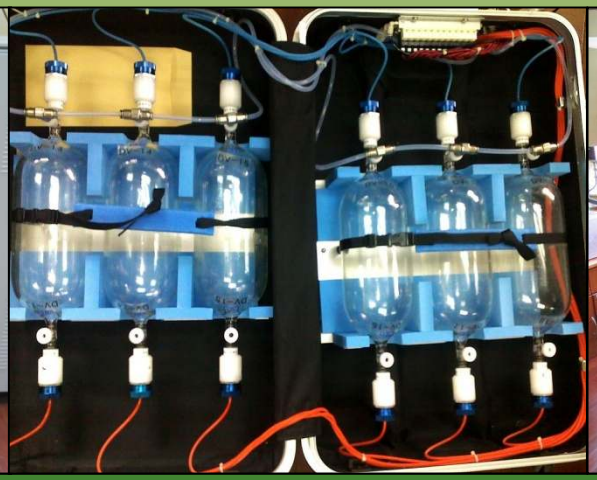
NO.	GAW FOCAL AREAS	TYPE OF INSTRUMENT	Danum Valley	Cameron Highlands	Petaling Jaya
1.	**Aerosol**				
	• Aerosol Load	• High Volume Air Sampler (TSP & PM-10) and Tapered Element Oscillating Microbalance (TEOM)	√	√	√
	• Back Scattering Coefficient	• Nephelometer	√		
	• Absorption Coefficient	• Multi Angle Absorption Photometer (MAAP)	√		
	• Aerosol Optical Depth	• Precision Filter Radiometer (PFR)	√		
2.	**Greenhouse Gases**				
	• Carbon Dioxide (CO_2)	• Lo Flo Mark II CO_2 Analyzer & Flask Sampling	√		
	• Methane (CH_4)	• Flask Sampling	√		
	• Nitrous Oxide (N_2O)	• Flask Sampling	√		
	• Sulphur Hexafluoride (SF_6)	• Flask Sampling	√		
3.	**Reactive Gases**				
	• Surface Ozone (O_3)	• O_3 Analyzer	√	√	
	• Carbon Monoxide (CO)	• CO Analyzer & Flask Sampling	√	√	
	• Nitrogen Oxides (NO_x)	• NO_x Analyzer		√	
	• Sulphur Dioxide (SO_2)	• SO_2 Analyzer		√	
	• Hydrogen (H_2)	• Flask Sampling	√		
4.	**Ozone**				
	• Total Column Ozone	• Brewer Spectrophotometer			√
5.	**UV Radiation**	• Brewer Spectrophotometer			√
6.	**Precipitation Chemistry**	• Ecotech Wet Only Rainwater Sampler	√	√	√
		• Acid Precipitation Sampler (APS)		√	√

Greenhouse Gases

- Since 2004, MetMalaysia has collaborated with Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia in installing a LoFlo Mark II CO_2 Analyzer to monitor CO_2 concentration continuously at Danum Valley GAW Station.
- In the monitoring mode, each hour comprises 10 minutes measurement on the REF cylinder (REF cylinder air through both sample and reference cells of the LI-COR), followed by 50 minutes measurement of ambient air that has been dried using the Nafion dryer (backed up by the mop-up dryer).
- The first 6 minutes of the 10 and 50 minute blocks are used to provide ample opportunity for flow and pressure stabilisation; thus 'valid data' comprises 4 minutes REF and 44 minutes of ambient air data each hour.
- Hourly averaged data is obtained from the mean of the 44 minutes values.
- In order to maintain the accuracy of the instrument and data collected is up to the international standard, the LoFlo Analyzer is calibrated every 4 to 6 weeks, while the yearly maintenance is done on a regular basis by an expert from CSIRO.

Greenhouse Gases

- On the other hand, MetMalaysia is also collaborating with National Institute of Environmental Studies, Japan (NIES) since 2010 in CO_2, CH_4, N_2O and SF_6 monitoring using Flask Sampling method in Danum Valley GAW Station.
- The flask air sample is collected automatically once a week (every Sunday at 10.00 - 10.10 pm local time) and after each sixth week, the air samples will be sent to NIES for analysis.
- The data then will be shared among the researchers from MetMalaysia and NIES.


Reactive Gases

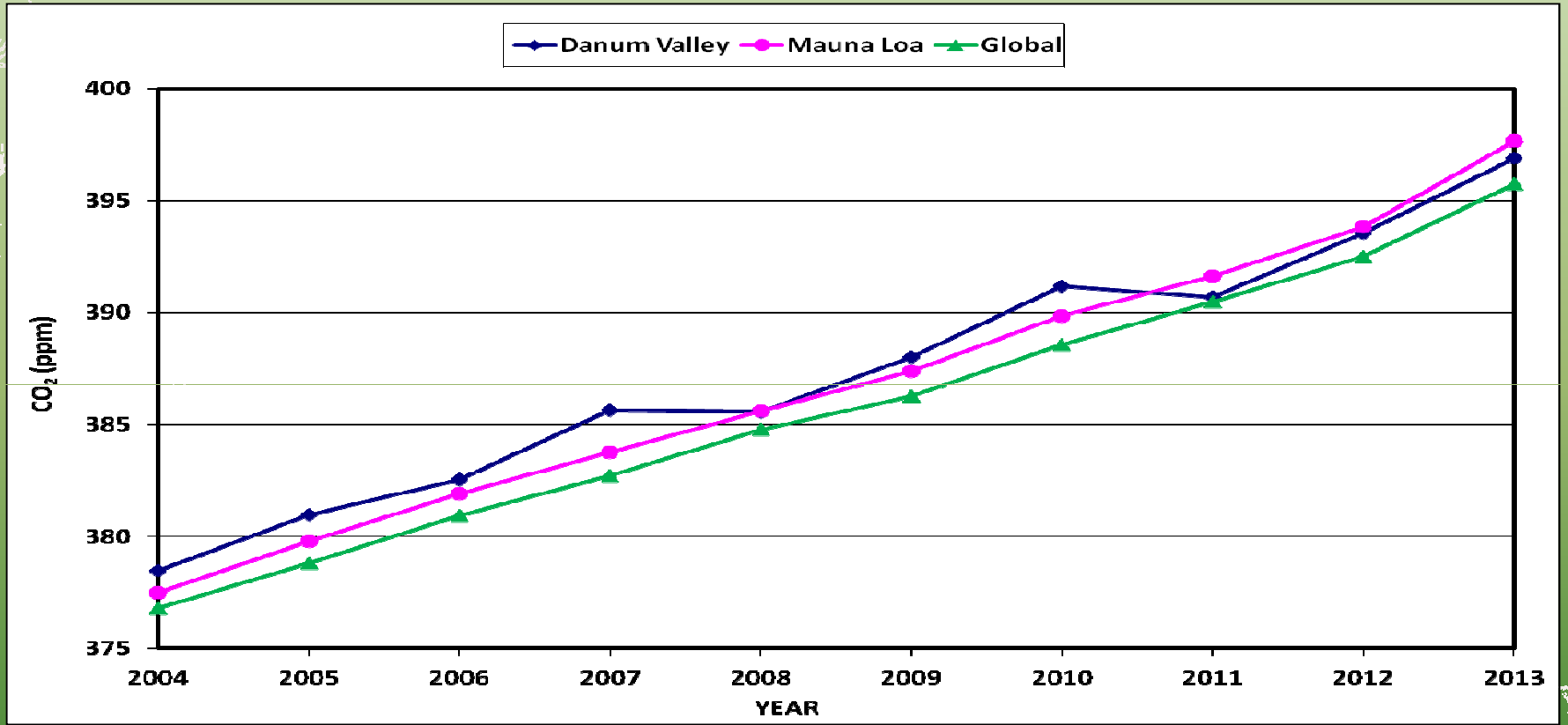
- Surface ozone (O_3) is measured continuously in Cameron Highlands GAW Station since 2003 using Thermo Model 49C UV Photometric O_3 Analyzer, while at Danum Valley GAW Station, surface ozone (O_3) is measured continuously since 2006 using Thermo Model 49*i* UV Photometric O_3 Analyzer.
- Similarly with greenhouse gases monitoring and in collaboration with NIES, reactive gases such as CO and H_2 are measured once a week using Flask Sampling since 2010.

O_3 Analyzer

Flask Sampling

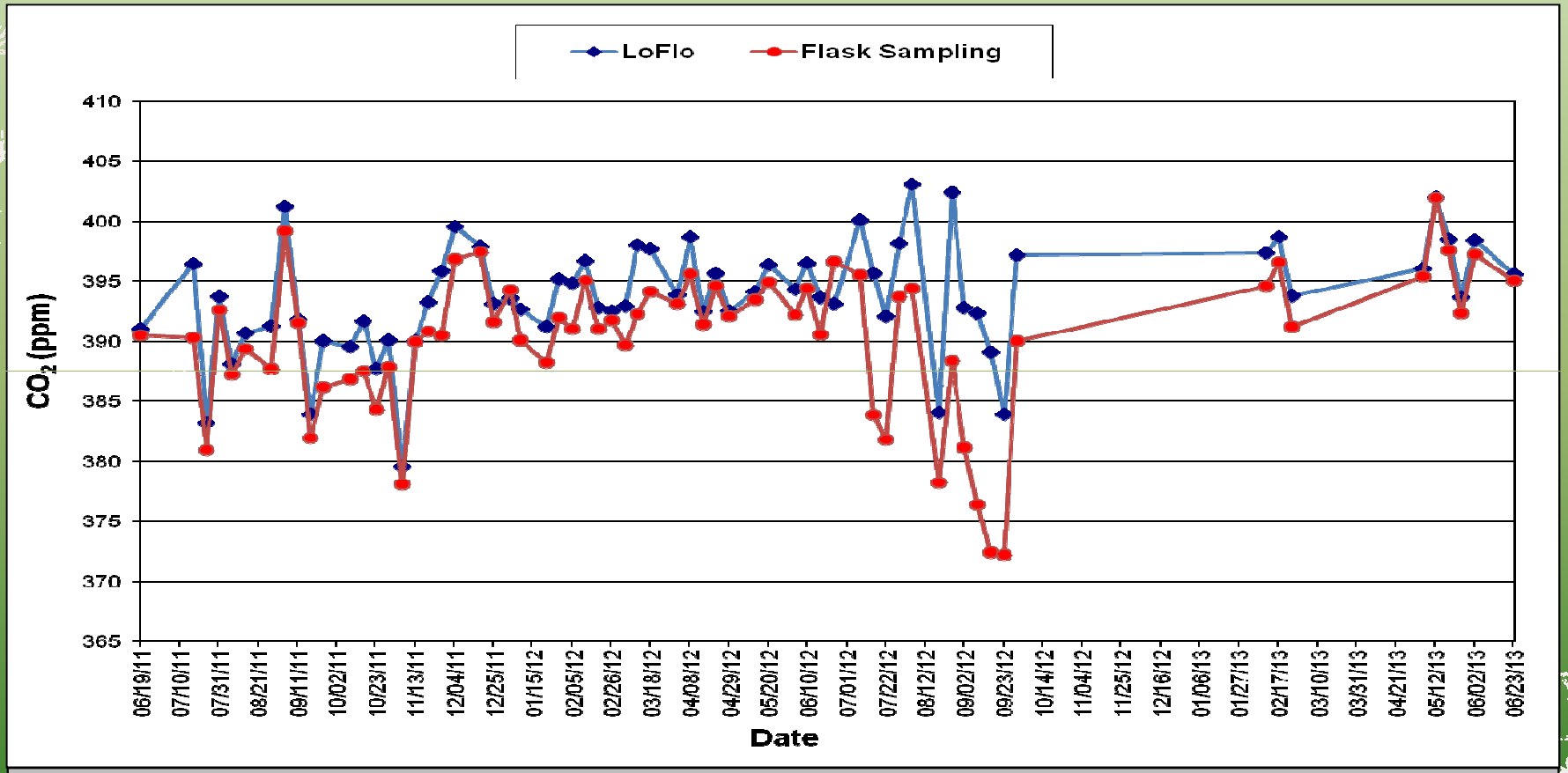
RESULTS AND ANALYSIS

The time series analysis of annual average of CO_2 concentration at Danum Valley and Mauna Loa



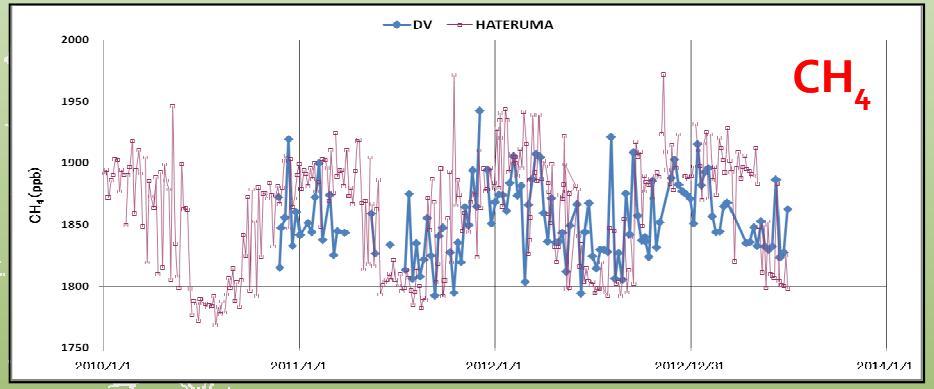
The trends of annual average CO_2 concentration for Danum Valley (using LoFlo Analyzer) and Mauna Loa GAW stations from 2004 to July 2013 are quite similar with both are showing an increasing trend of 1.90 ppm/year and 2.11 ppm/year respectively. Annual Mean Global CO_2 also showing quite similar trend with both stations with an increasing trend of 2.02 ppm/year.

The comparison of CO_2 concentration measured using LoFlo Analyzer and Flask Sampling

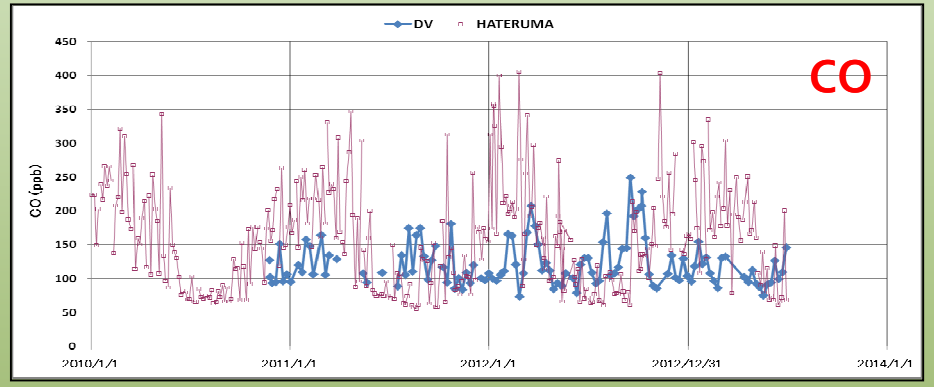


The comparison between two method of CO_2 measurement at Danum Valley GAW Station using LoFlo Analyzer and Flask Sampling from June 2011 to June 2013 are showing quite a comparable trend with only less than 5% percentage difference. The hourly mean CO_2 concentration by LoFlo Analyzer is chosen from the same hour of sampling time of Flask Sampling.

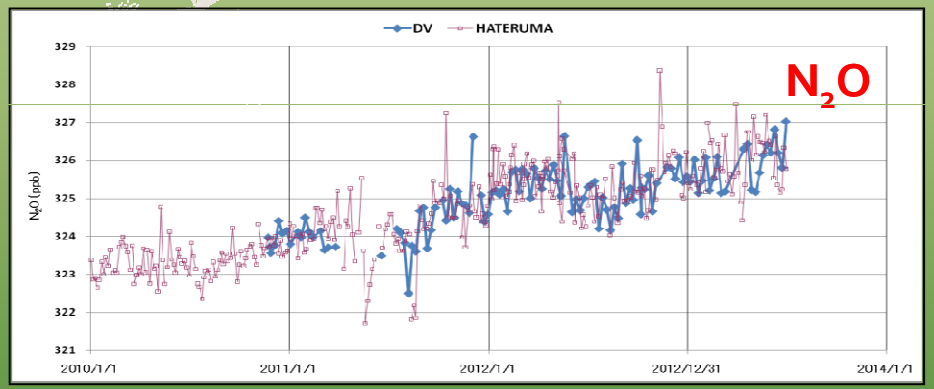
The time series analysis of CH_4, N_2O, SF_6, CO & H_2 concentrations at Danum Valley and Hateruma



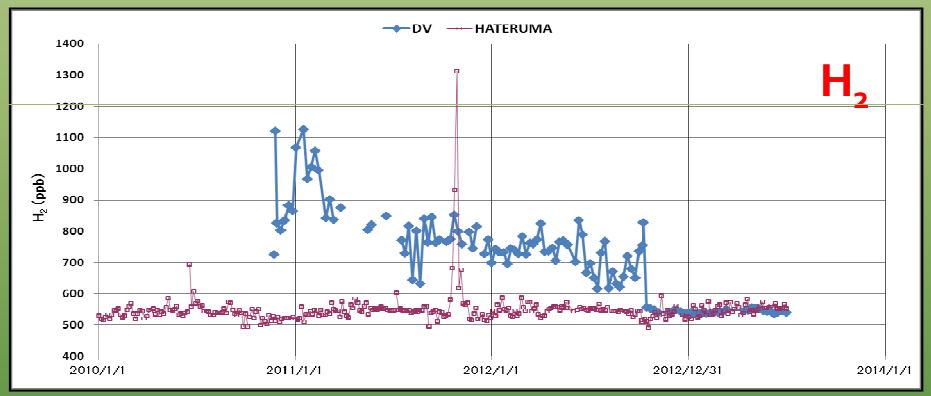
CH_4



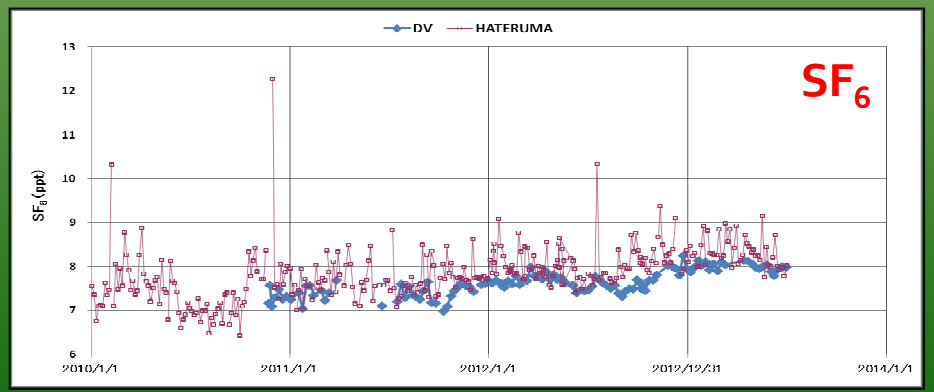
CO



N_2O



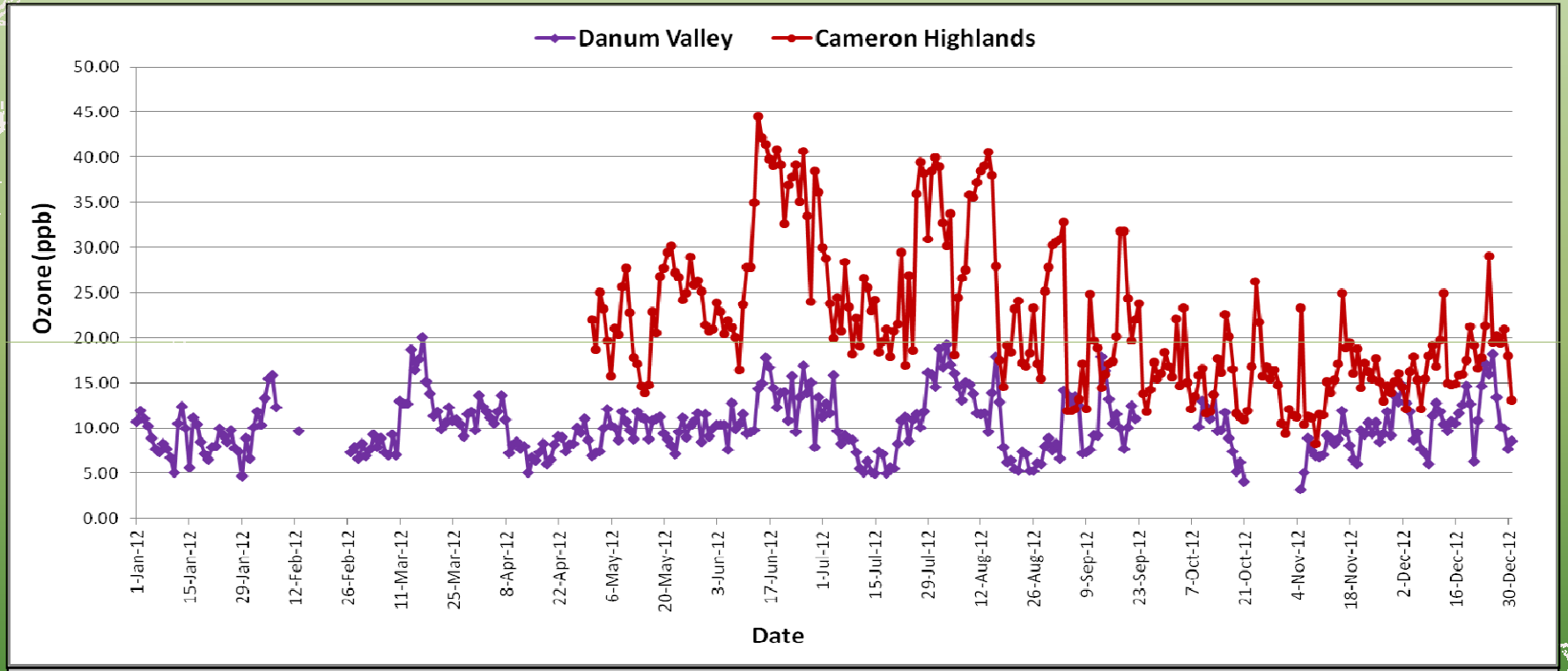
H_2



SF_6

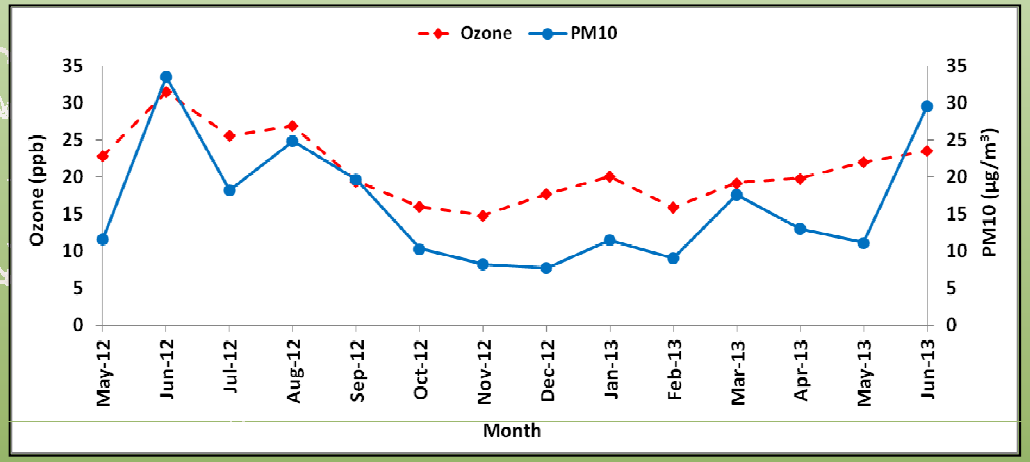
Try to explain the trend and time series of some greenhouse gases (CH_4, N_2O & SF_6) and reactive gases (CO & H_2) concentrations using Flask Sampling at rainforest in the tropics (Danum Valley GAW Station) and coastal area in temperate zone (Hateruma, Japan contributing station) from January 2010 to June 2013. The flask air sample is collected automatically once a week at Danum Valley, while at Hateruma is once in 4 days.

The time series analysis of daily average of O_3 concentration at Cameron Highlands and Danum Valley GAW Stations

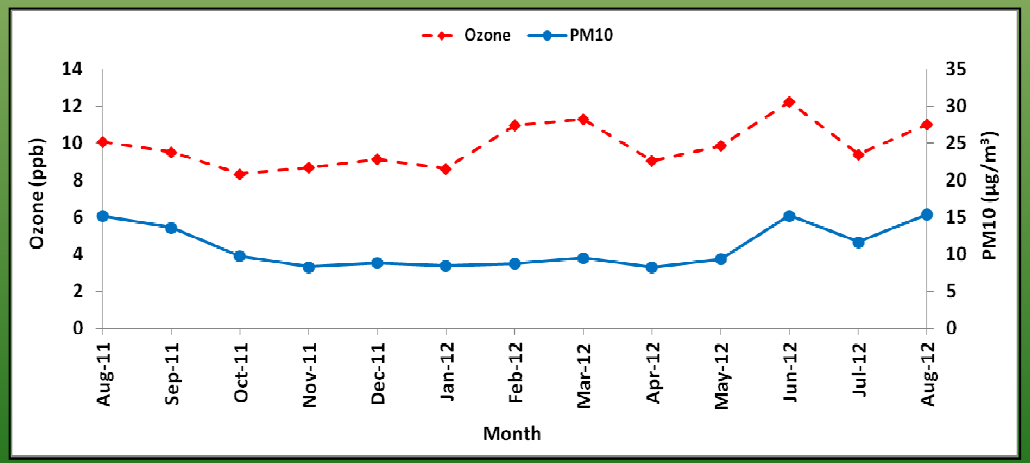


The concentration of O_3 in Danum Valley GAW Station is generally less than the concentration of O_3 in Cameron Highlands GAW Station during period from January to December 2012. For Danum Valley, the concentration fluctuated between 3.18 - 20.06 ppb with average value of 10.26 ppb. While for Cameron Highlands, the concentration recorded are higher with values fluctuated between 8.31 - 44.48 ppb with average value of 21.86 ppb.

The comparison of mean monthly values between O_3 and PM10 at Cameron Highlands and Danum Valley GAW Stations



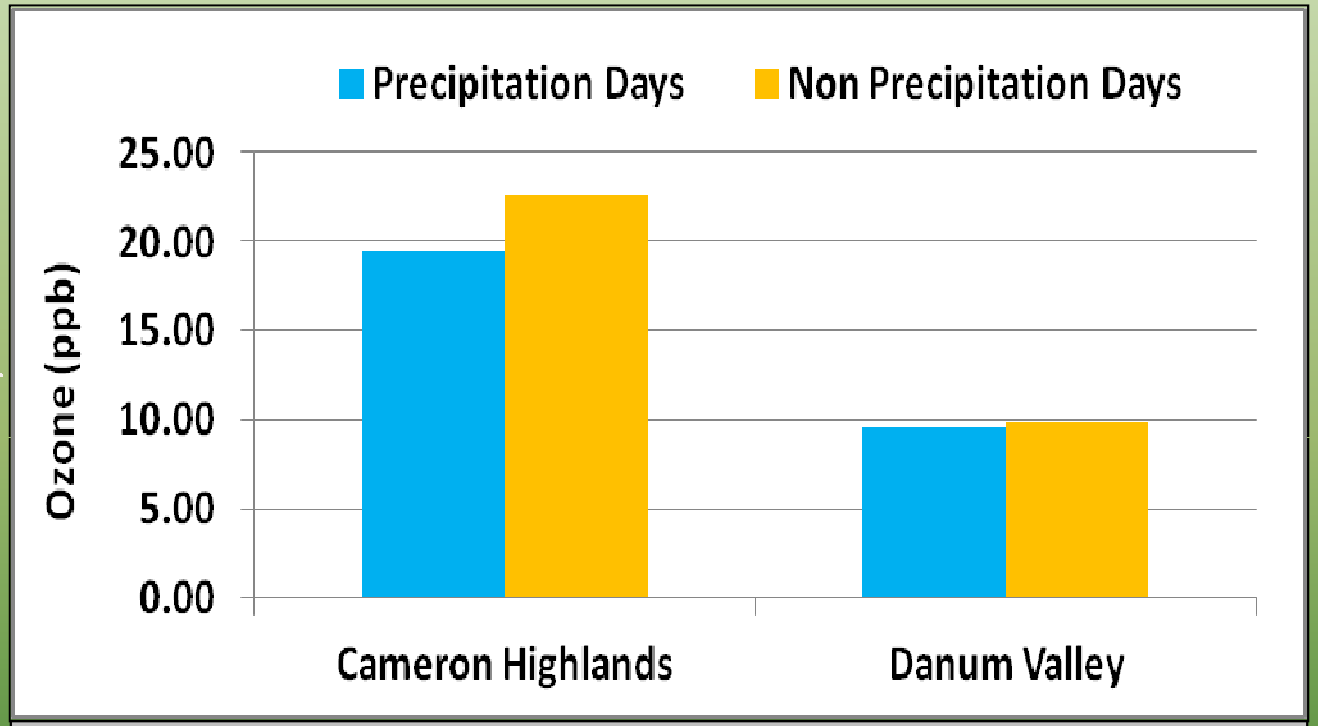
Cameron Highlands



Danum Valley

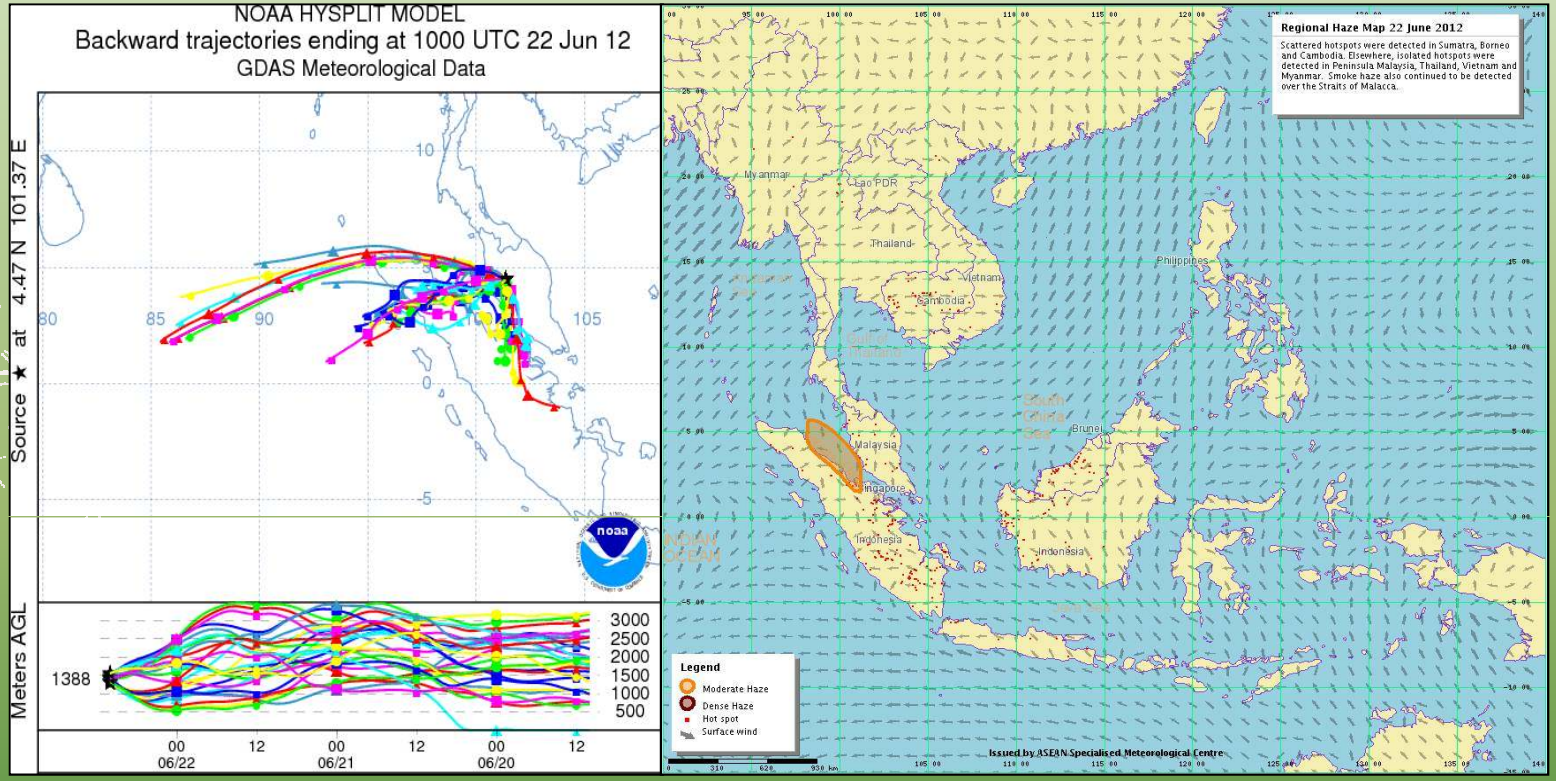
The comparison of mean monthly values between O_3 and PM10 at Cameron Highlands (May 2012 - June 2013) and Danum Valley (August 2011 - August 2012) GAW stations shows that PM10 exhibits a similar trend as O_3 with maximum concentration for both O_3 and PM10 are observed during Southwest monsoon (also known as summer monsoon; usually from June to September) which coincides with the regional biomass burning period. Hence the O_3 precursors most likely originated from the same source as the PM10 precursors.

The comparison of mean O_3 values between precipitation days and non-precipitation days



The average O_3 concentration at Cameron Highlands (May 2012 - June 2013) and Danum Valley (August 2011 - August 2012) GAW stations is lower during precipitation days compared to non-precipitation days. This is likely due to the removal of O_3 precursors NO_x and VOCs but possibly also due to different meteorological conditions on days with rain.

Case Studies - Cameron Highlands

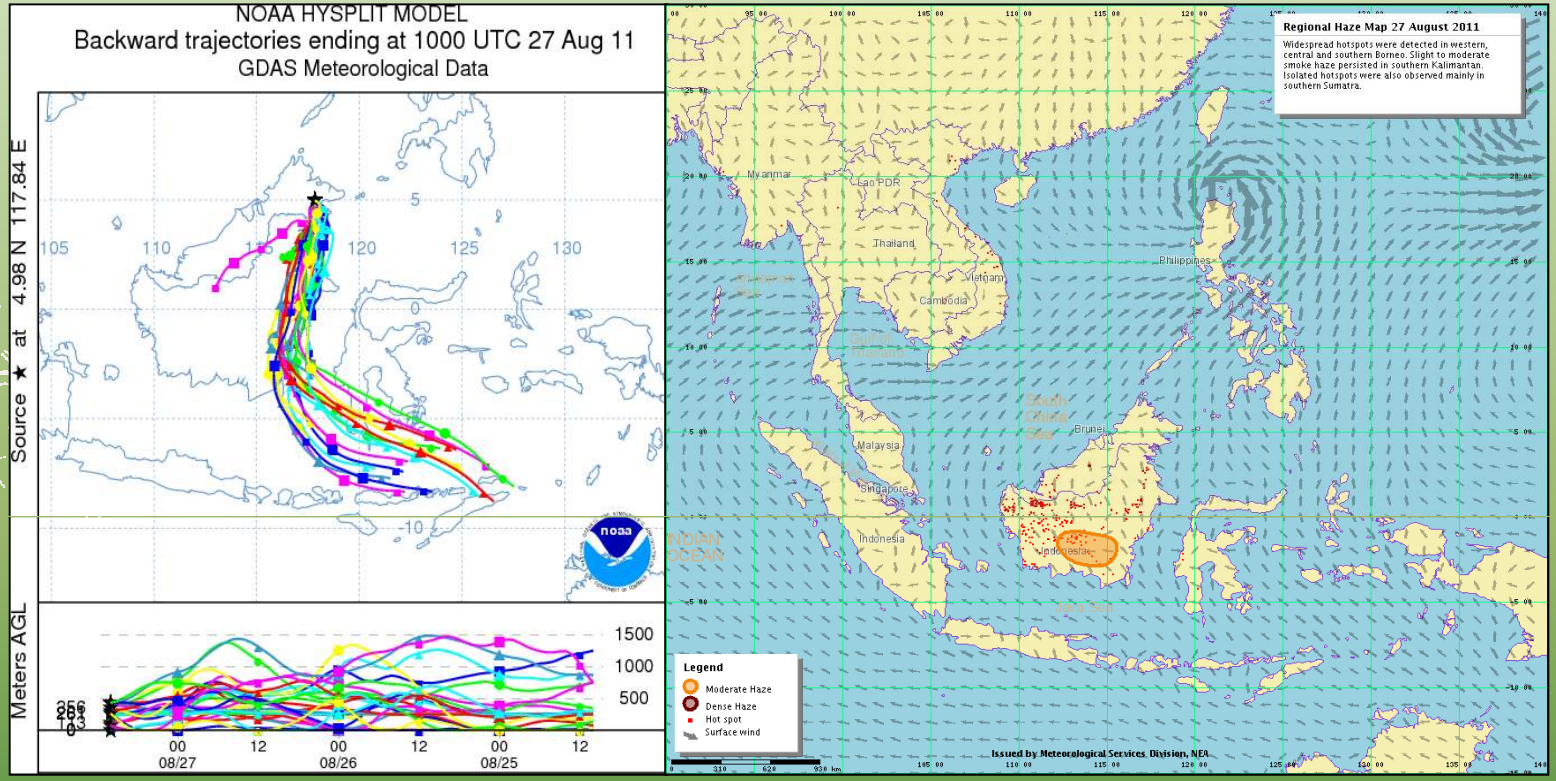


- The highest hourly mean O_3 mixing ratio recorded was 70.12 ppb at 22 June 2012, 18:00 local time.
- The 72 hours backward trajectories ending at 22 June 2012, 1000 UTC (22 June 2012, 18:00 local time) was computed using the HYSPLIT model showing that the air mass originates from Sumatra.

Case Studies - Cameron Highlands

- On 22 June 2012, O_3 started to increase at 13:00 local time and remained above 40 ppb from 15:00 to 22:00 local time.
- The enhanced concentration during the night time indicates the contribution from regional transport of O_3.
- During the drier period of the year, the biomass burning over Indonesia will normally start around May (SW monsoon) and last until September or October. Fire hotspot count was used in order to investigate the role of biomass burning on measured O_3 concentrations.
- The fire hotspot count at Sumatra derived from the NOAA-18 satellite is 119 on 22 June 2012, 226 on 21 June 2012, and 341 on 20 June 2012 which is higher than the monthly mean of 109.
- This suggests the transport of air pollutants from biomass burning in Sumatra releases large amounts of precursors and leads to an increase in O_3.
- This is also supported by regional haze map dated 22 June 2012 (Source: ASEAN Specialised Meteorological Centre) which displays scattered hotspots with smoke haze were detected in Sumatra.

Case Studies - Danum Valley



- The highest hourly mean O_3 mixing ration recorded was 28.32 ppb at 27 August 2011, 18:00 local time.
- The 72 hours backward trajectories ending at 27 August 2011, 1000 UTC (27 August 2011, 18:00 local time) was computed using the HYSPLIT model showing that the air mass originates from Kalimantan and Sulawesi, Indonesia.

Case Studies - Danum Valley

- On 27 August 2011, O_3 started to increase at 15:00 local time and remained above 20 ppb from 16:00 to 02:00 (28 August 2011) local time.
- The enhanced concentration during the night time indicates the contribution from regional transport of O_3.
- The fire hotspot count at Kalimantan derived from the NOAA-18 satellite is 248 on 27 August 2011, 539 on 26 August 2011, and 684 on 25 August 2011 which is higher than the monthly mean of 170.
- This suggests the transport of air pollutants from biomass burning in Kalimantan which releases large amounts of precursors and leads to an increase in O_3.
- This is also supported by regional haze map dated 27 August 2011 (Source: ASEAN Specialised Meteorological Centre) which displays widespread hotspots with smoke haze were detected in Kalimantan.

Conclusion

- It is known that the global abundance of key greenhouse gases namely CO_2, CH_4 and N_2O where these greenhouse gases are the major contributors to an increase of radiative forcing in the atmosphere.
- From the overall analysis, what is quite evident is that most of the greenhouse gases are showing slight increasing trend except for CH_4 and is quite comparable with the global trend.
- Most of the greenhouse gases and reactive gases measured by Flask Sampling at Danum Valley GAW Station are showing similar trend with Hateruma, Japan contributing station (as a reference site).
- Overall the O_3 mixing ratio at Danum Valley and Cameron Highlands GAW stations are very low and does not exceed the recommended Malaysia Air Quality Guidelines for 1 hour average (100 ppb).
- Since greenhouse gases are closely linked to anthropogenic activities and have strong interactions with the biosphere and the oceans, therefore the greenhouse gases measurement program in Malaysia especially in Danum Valley GAW Station is an important program for background measurement in the tropics and for understanding the critical tropical processes that impact global atmospheric greenhouse gases distribution especially in the Southeast Asia region.

FUTURE DIRECTION

Future Direction

- In the near future, MetMalaysia is planning to expand its greenhouse gases monitoring programme to include other greenhouse gases analyzer namely methane (CH_4) and nitrous oxide (N_2O) at Danum Valley GAW Station as well as to install another CO_2 analyzer in Cameron Highlands GAW Station and Langkawi Station.

- In addition to address the urban environmental issues in Klang Valley, Malaysia, MetMalaysia is proposing to the Malaysian Government to participate in the WMO GAW Urban Research Meteorology and Environment (GURME) in 2014.

Terima Kasih…

Thank You…

Kamsahamnida…