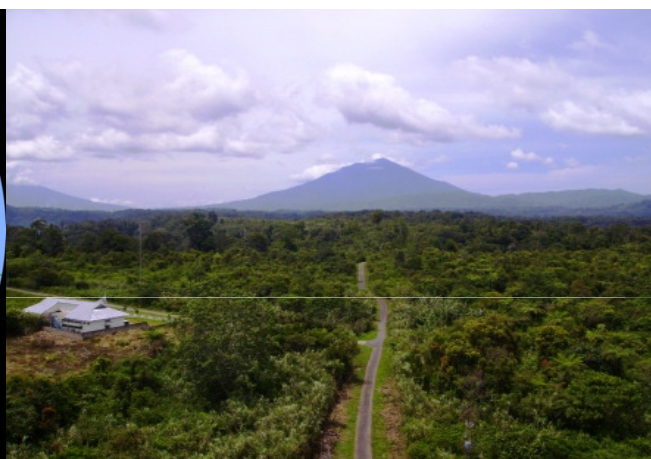




Greenhouse Gas Monitoring Activities of Global GAW Bukit Kototabang Station



SUGENG NUGROHO

Global GAW Bukit Kototabang, West Sumatra – Indonesia

sugeng.nugroho@bmkg.go.id



**The 5th Asia-Pacific GAW Workshop on Greenhouse Gases
Jeju Island, Republic of Korea, 24-25 October 2013**





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GAW Station Bukit Kototabang – Early years



Location survey



Main building



Opening road access



First personnels



Dr. G.O.P. Obasi

**Inaguration of GAW
Bukit Kototabang
by WMO Secretary-
General on 6
December 1996**

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Road Access



GAW Station Bukit Kototabang – Present

Main Building



Tower



Lobby



Laboratory



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Location

Environment : tropical rainforest on the mountainous area



0.2 S, 100.32 E, 864.5 m a.s.l



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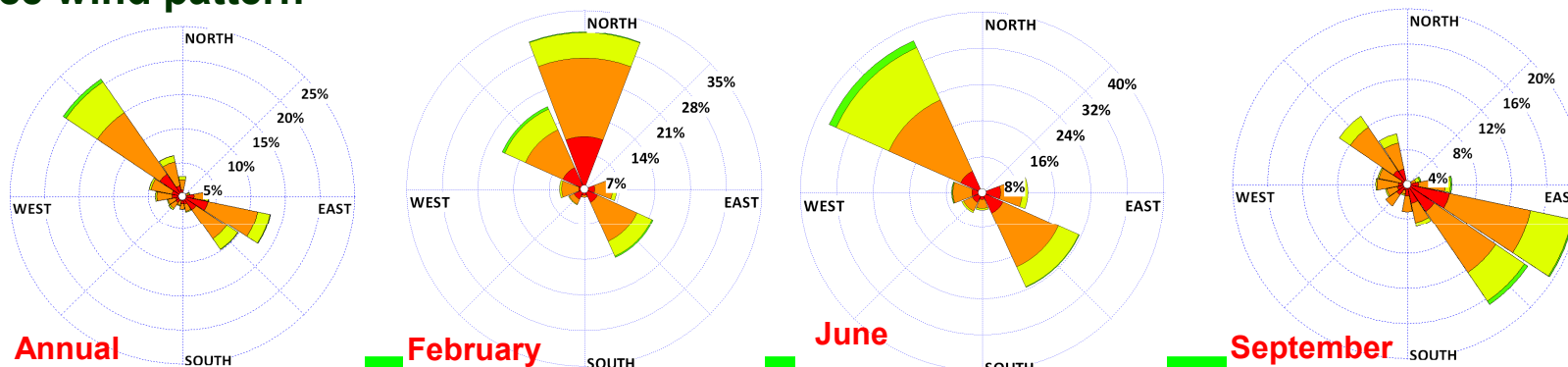


BMKG

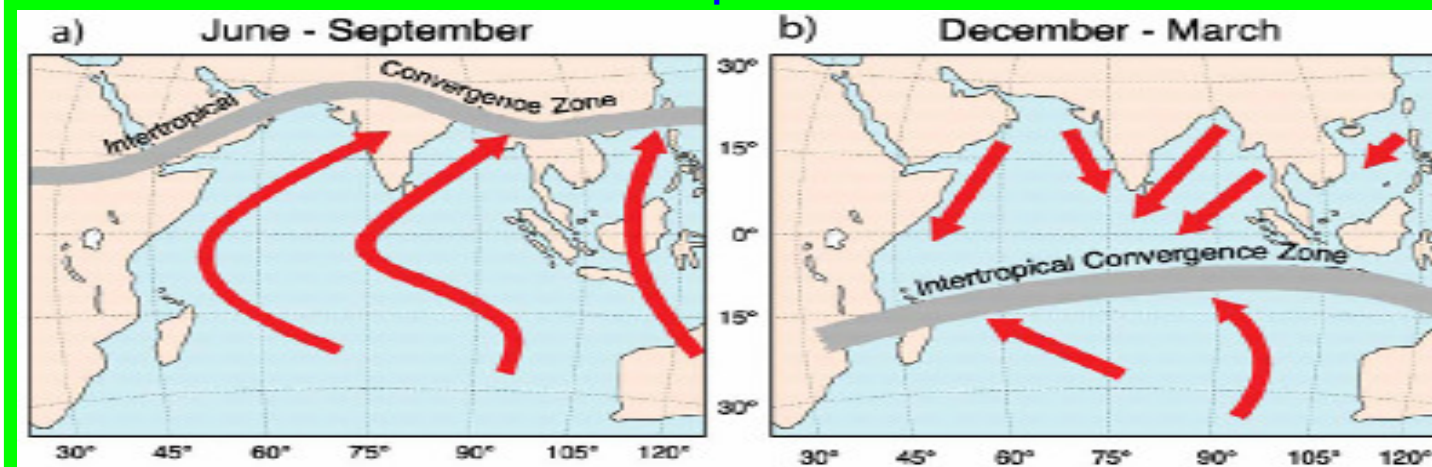
Climatology

- Annual Rainfall	: 2440 mm	- Daily Air Pressure	: 916.6 hPa
- Daily Temperature	: 21.6 °C	- Daily Sunshine	: 3.9 hour / day
- Daily Humidity	: 88 %	- Daily Global Solrad	: 193 Watt/m ²

Surface wind pattern



General atmosphere circulation

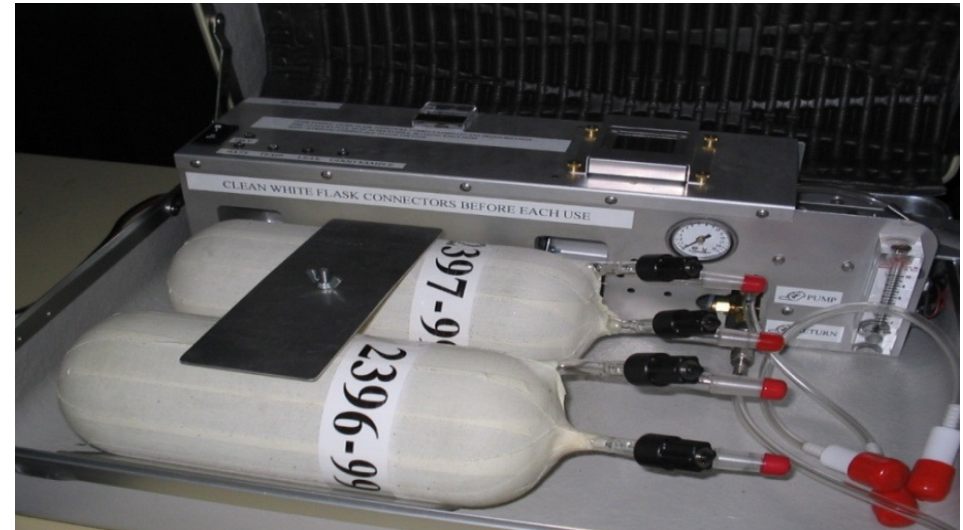




GHGs Measurement Activities

Flask Sampling (BMKG-NOAA)

- Sampled on a weekly time-base
- Air inlet at 32 meter a.g.l
- Send to NOAA CMDL for further analysis
- First operation in January 2004
- Temporary termination in February 2011
- Resume operation in February 2013
- Parameters : CO₂, CH₄, N₂O & SF₆
- Old periode data (2004-February 2011)
ftp://aftp.cmdl.noaa.gov/data/trace_gases/
- New period data (February 2013 – present), update data via
<sftp.cmdl.noaa.gov>.

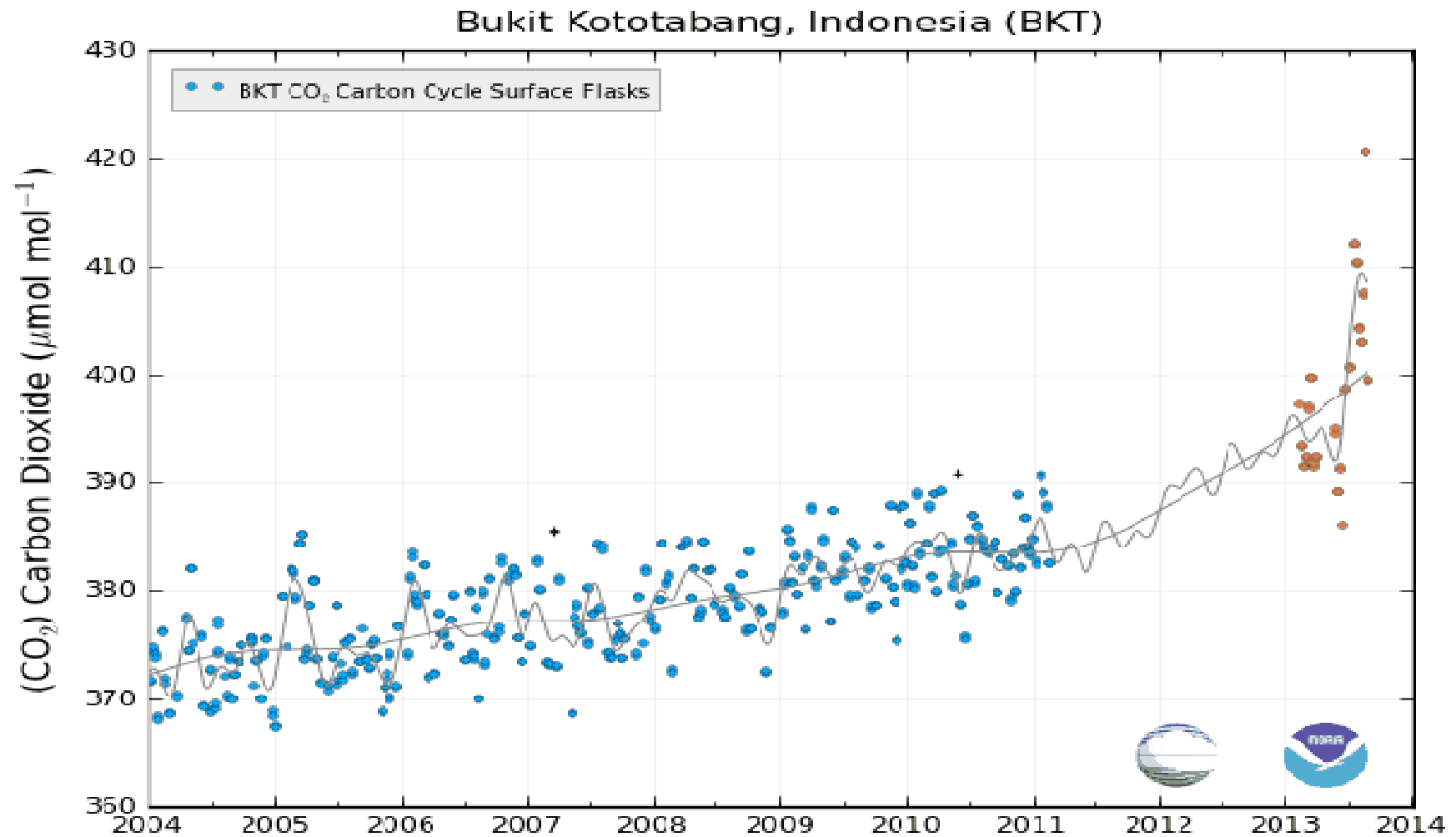




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GHGs Measurement Activities

Result – CO₂ Mixing Ratio



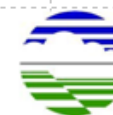
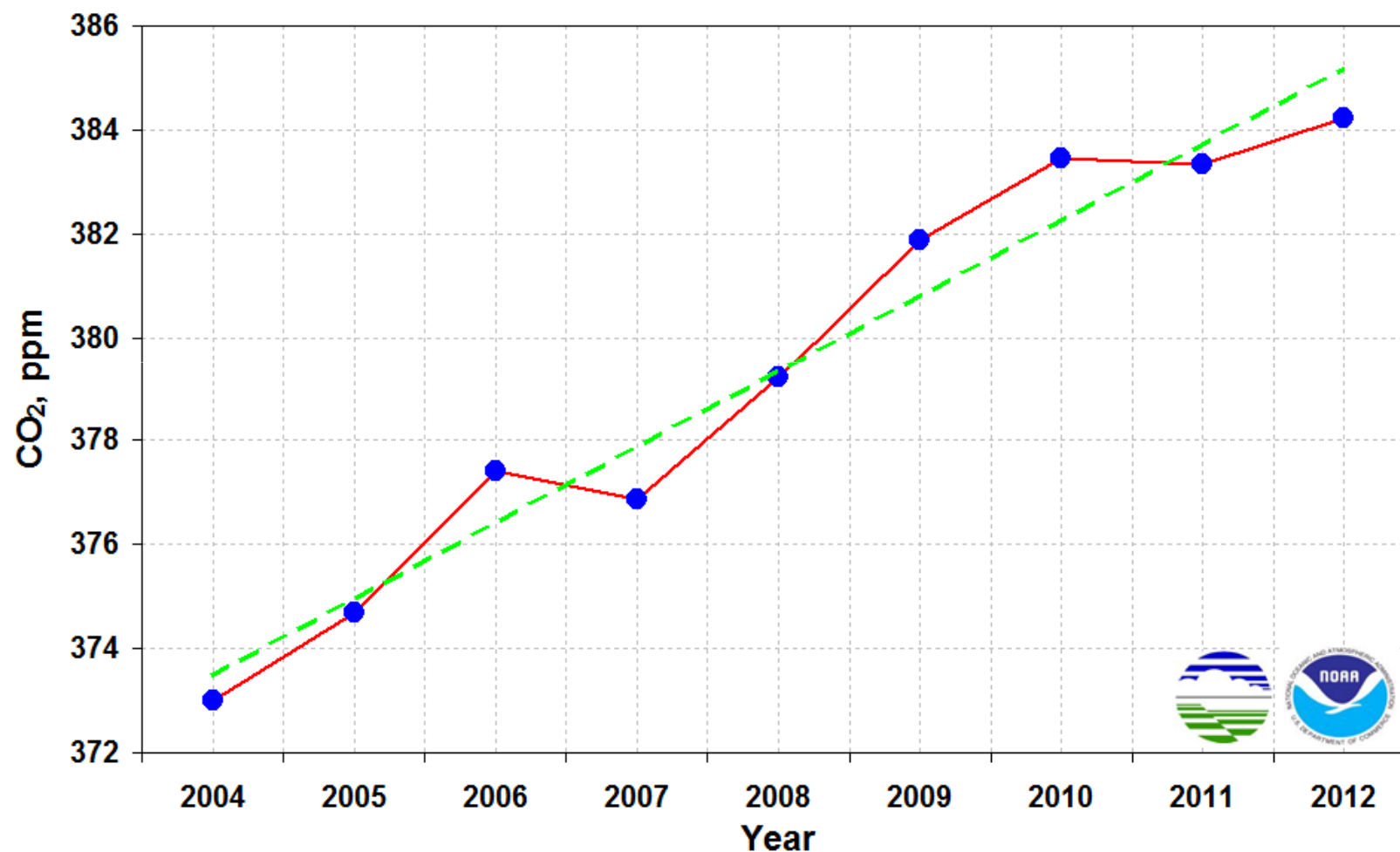
Graph created ESPL/GMD - 2013-October-19 04:08 am



BMKG

GHGs Measurement Activities

Result – Annual CO₂

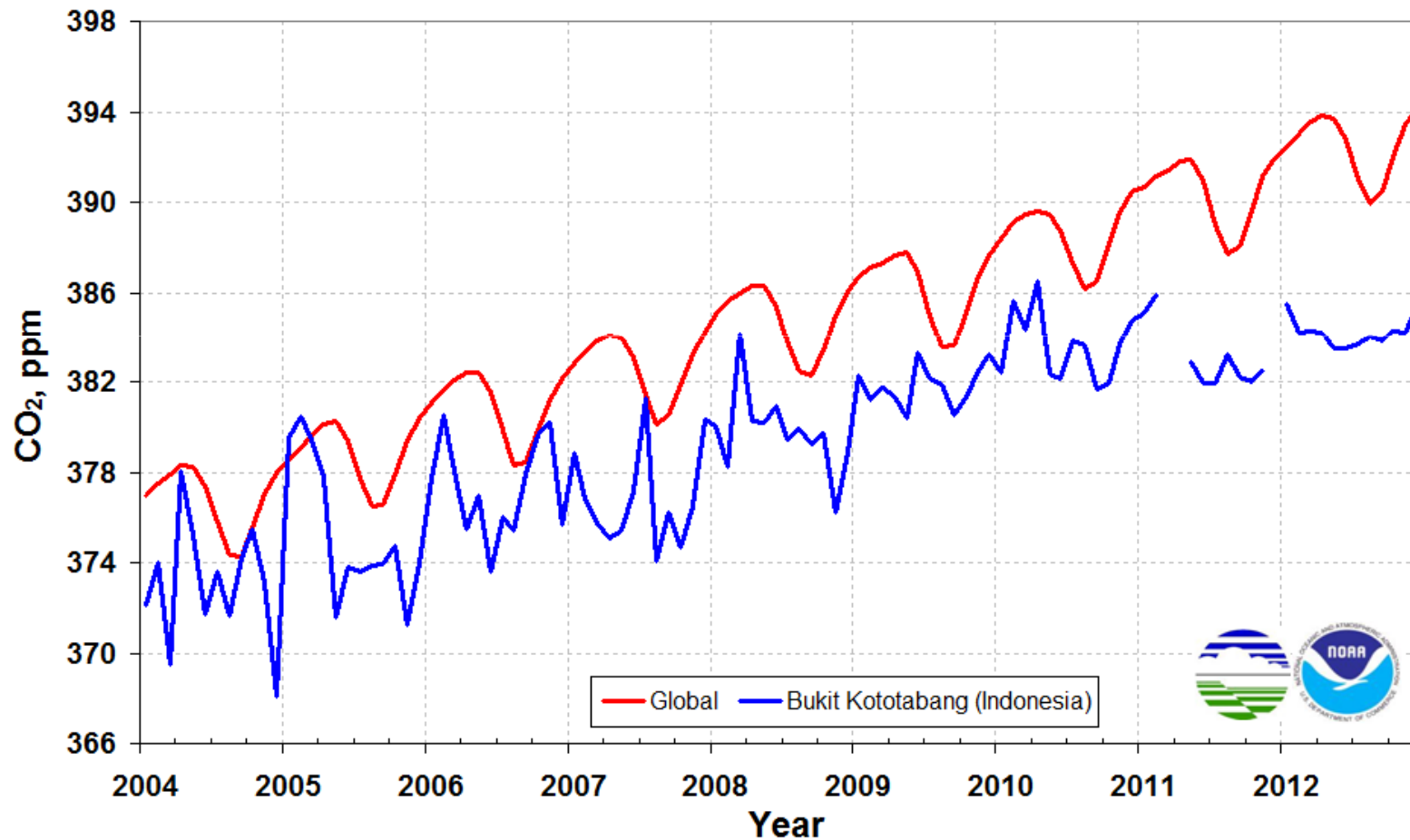




BMKG

GHGs Measurement Activities

Result – Comparing CO₂

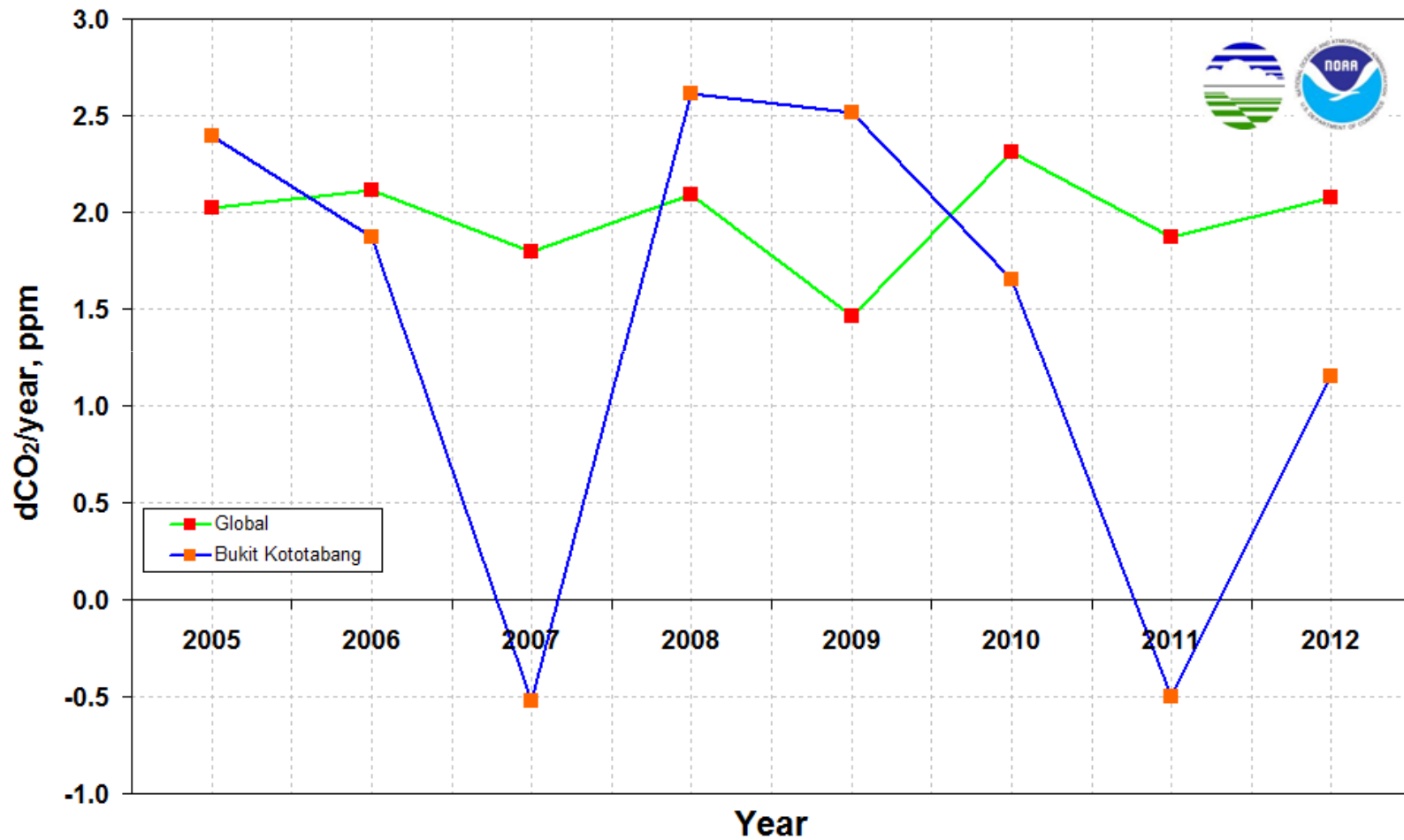




BMKG

GHGs Measurement Activities

Result – CO₂ Growth Rate

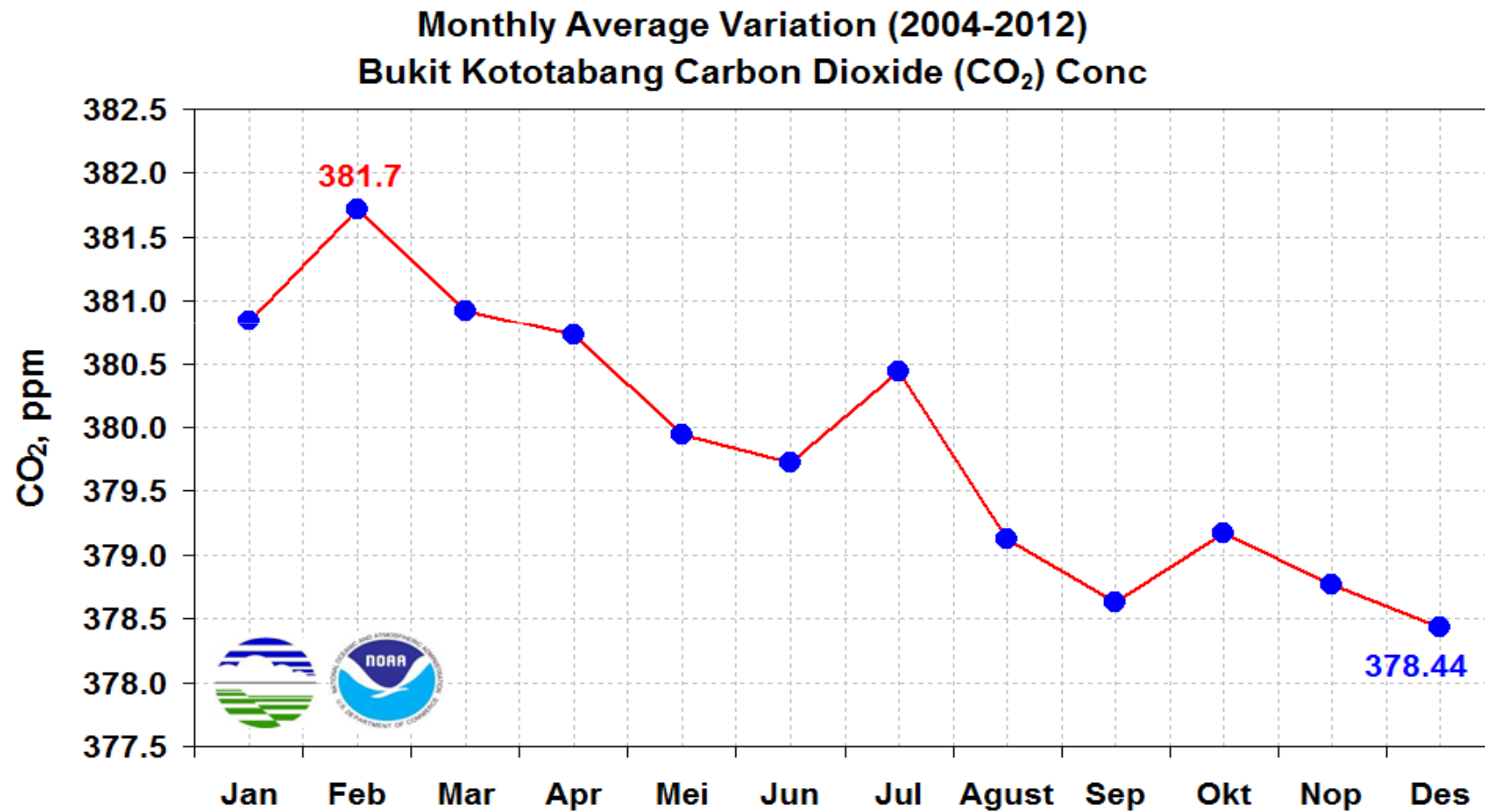




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GHGs Measurement Activities

Result – Monthly Average CO₂ (2004-2012)

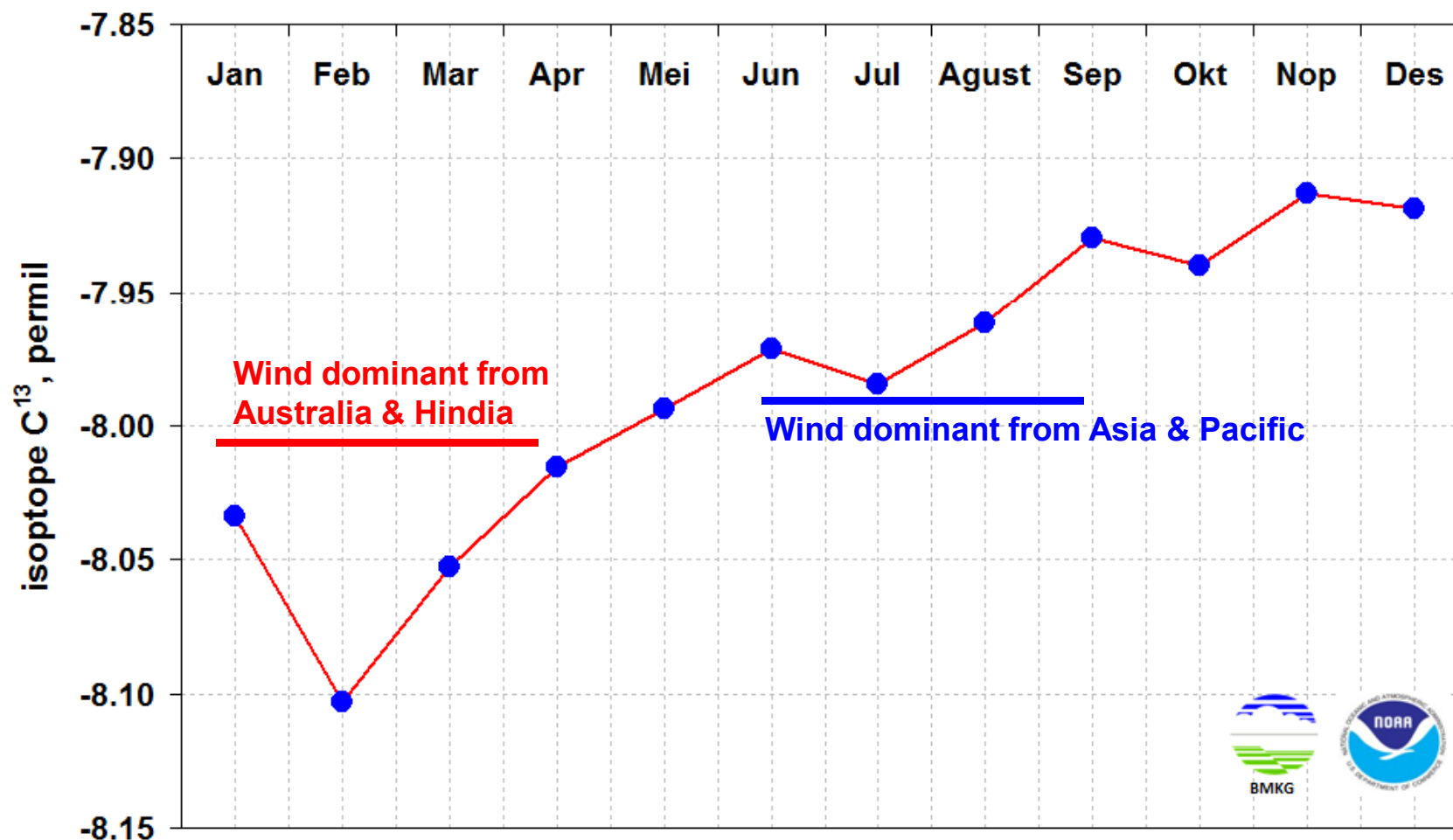




BMKG

GHGs Measurement Activities

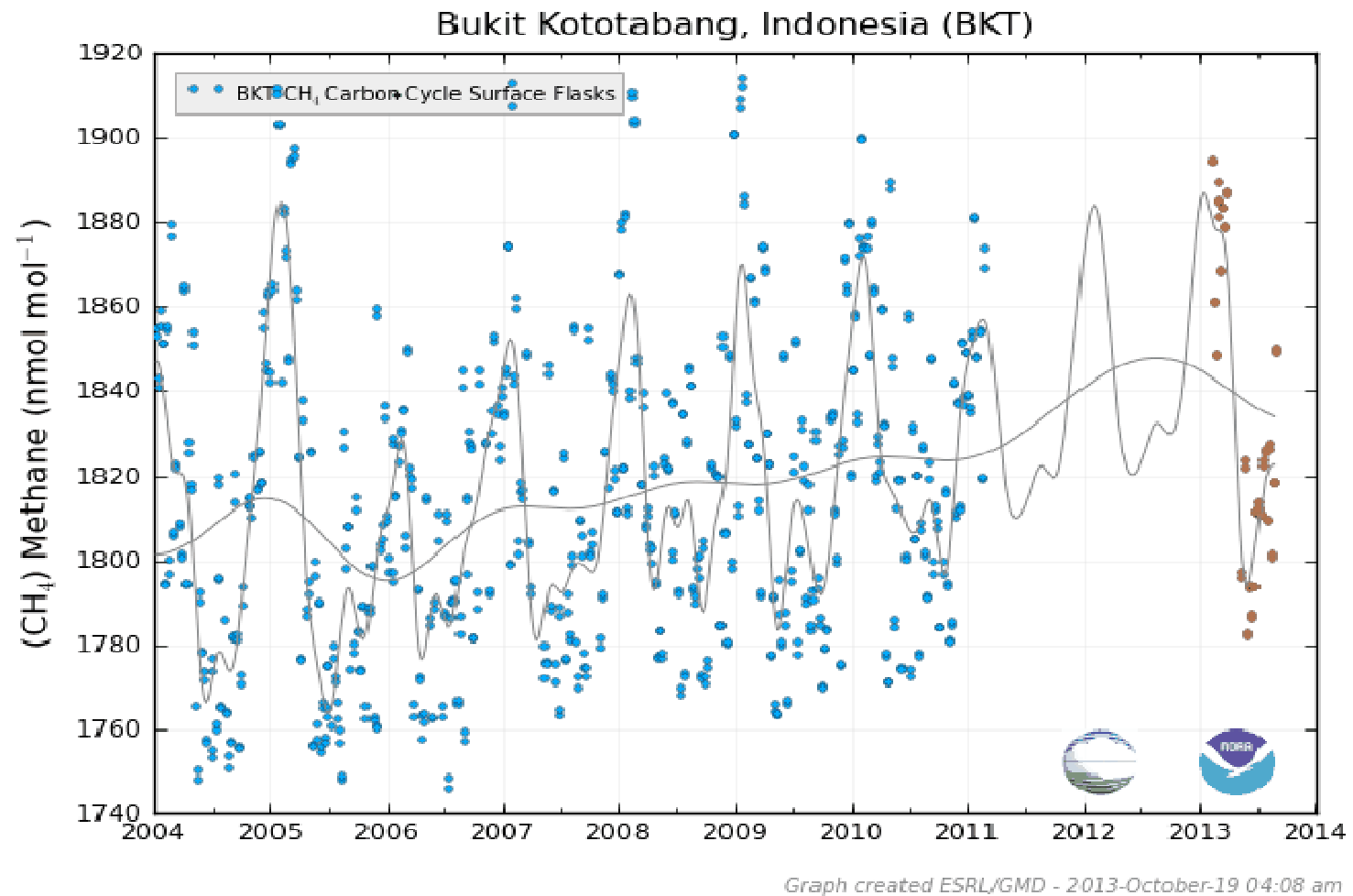
Result – $\delta^{13}\text{C}$ from CO_2



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Result – CH₄ Mixing Ratio

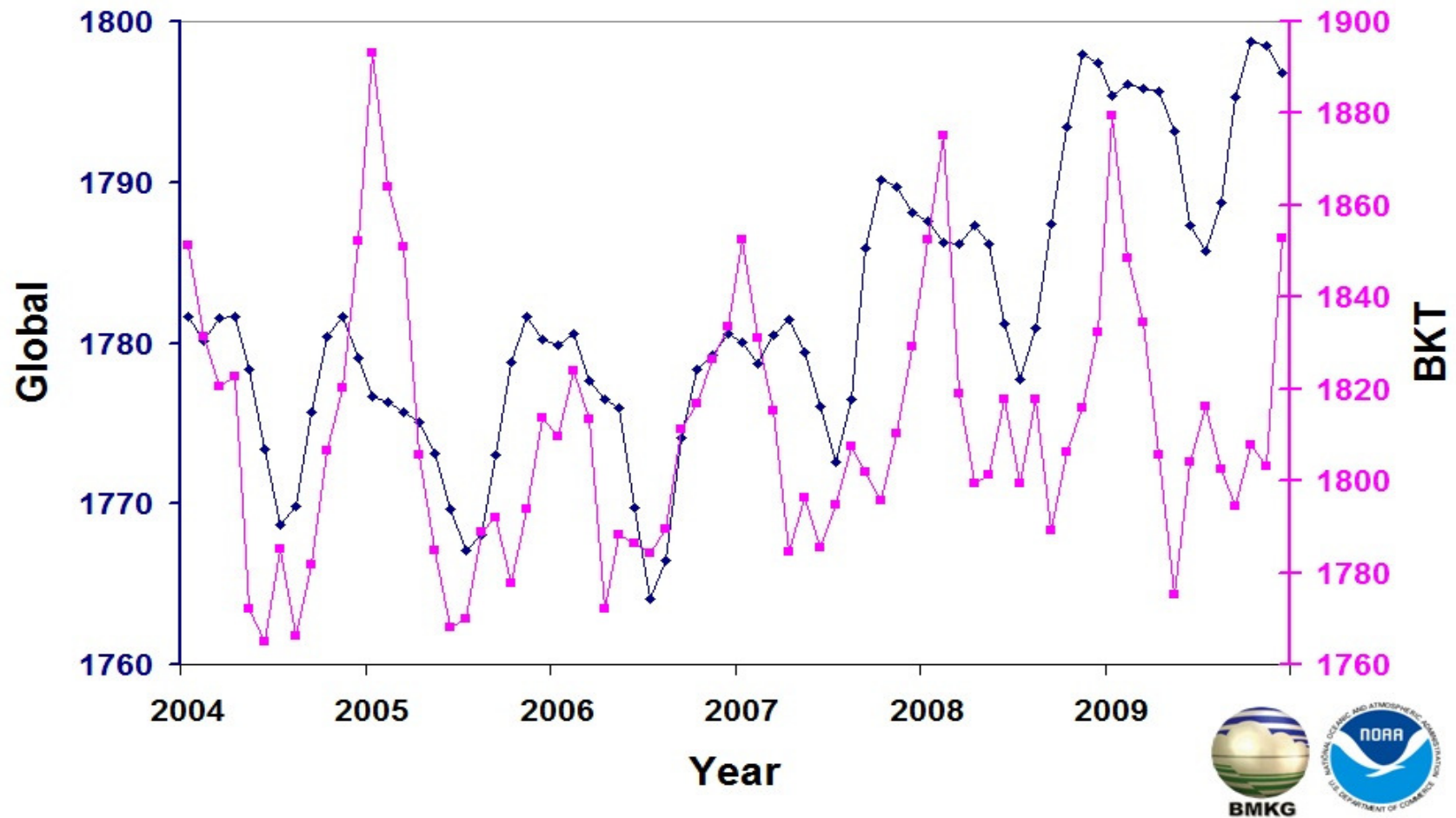




BMKG

GHGs Measurement Activities

Result – Comparing CH₄

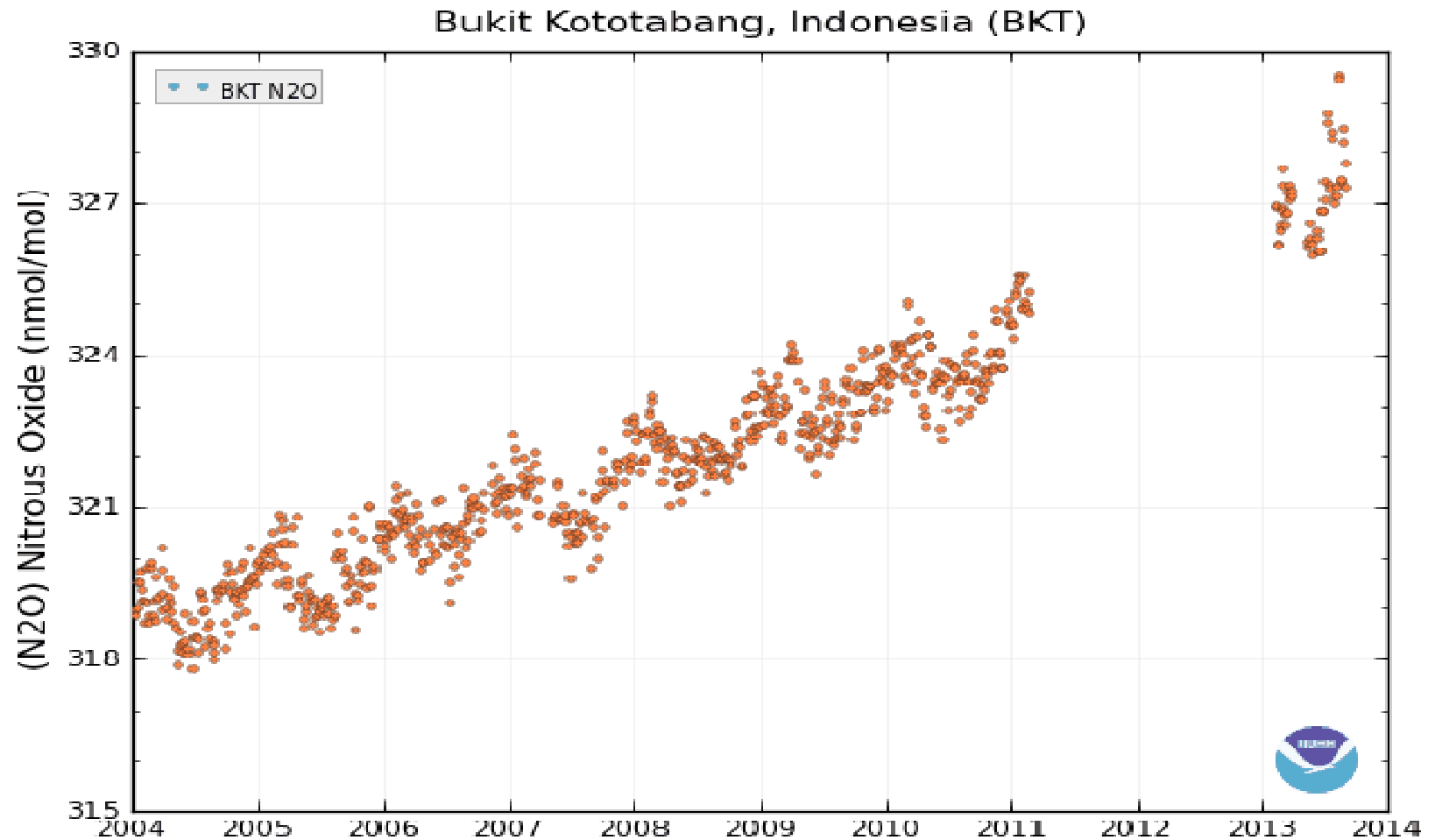




BMKG

GHGs Measurement Activities

Result – N₂O Mixing Ratio



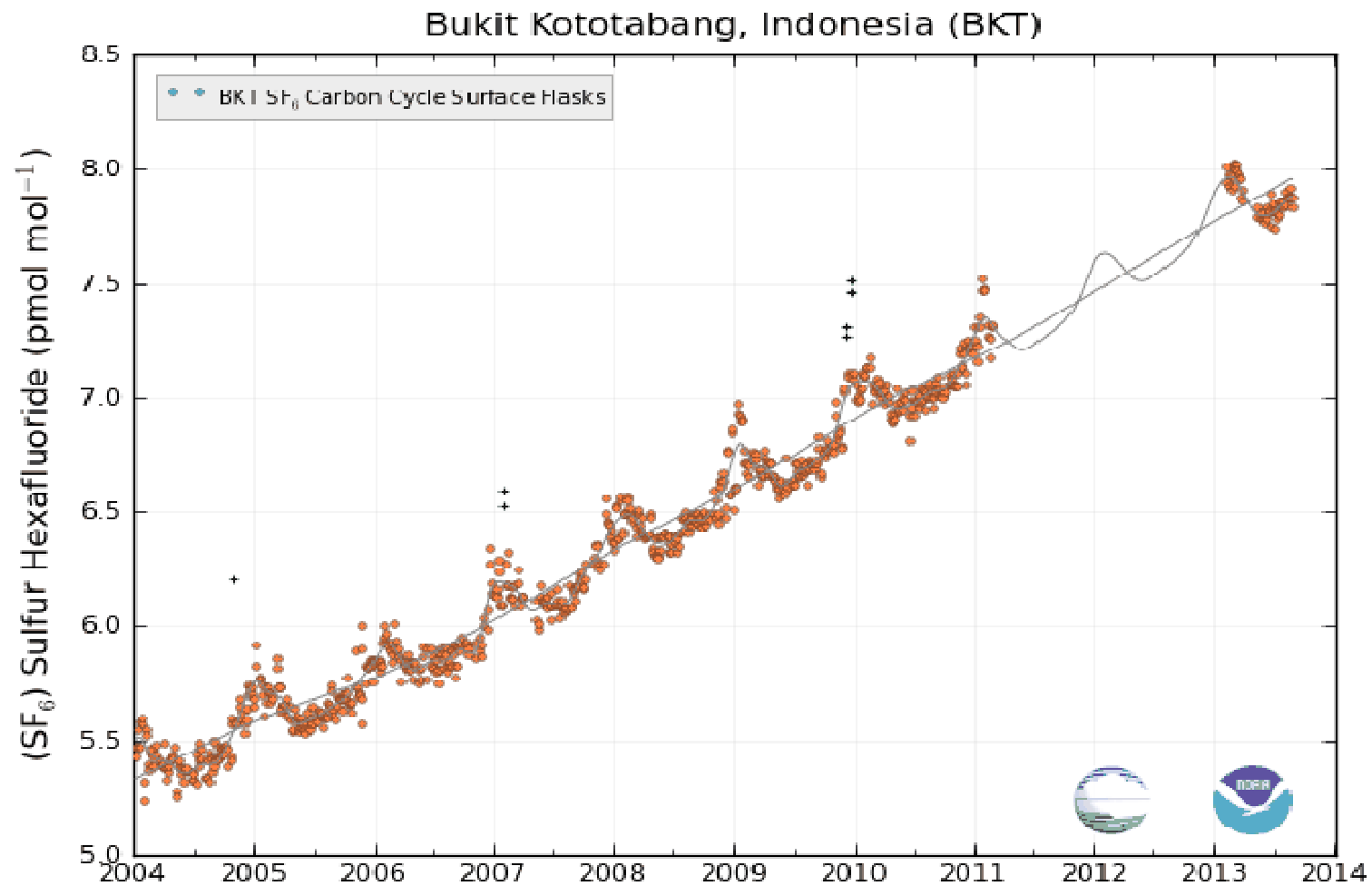
Graph created ESRI/GMD - 2013-October-19 21:02 pm



BMKG

GHGs Measurement Activities

Result – SF₆ Mixing Ratio



Graph created ESRI/GMD - 2013-October-19 04:09 am



BMKG

GHGs Measurement Activities

NRT Monitoring (BMKG-EMPA)

- Using Picarro G1301 Analyzer (2011 – present)
- Collaboration between BMKG (instrument), Empa and MeteoSwiss (standard gases and calibration unit), with an extensive guidance directly from Picarro, Inc.
- Continues monitoring, data frequency ÷ 5 sec
- Inlet at : 10, 20 and 32 meter a.g.l.
- Parameters : CO₂ and CH₄

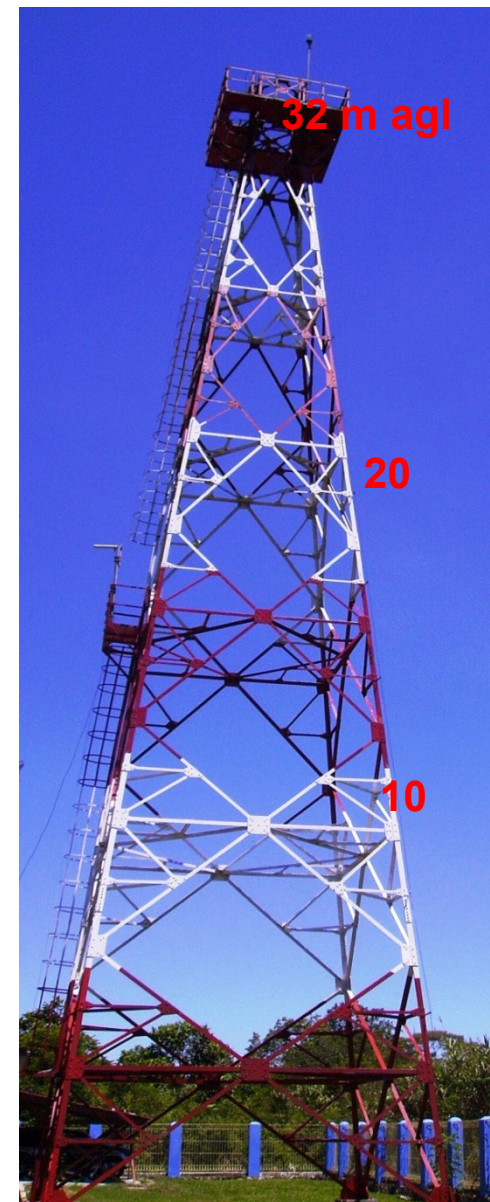
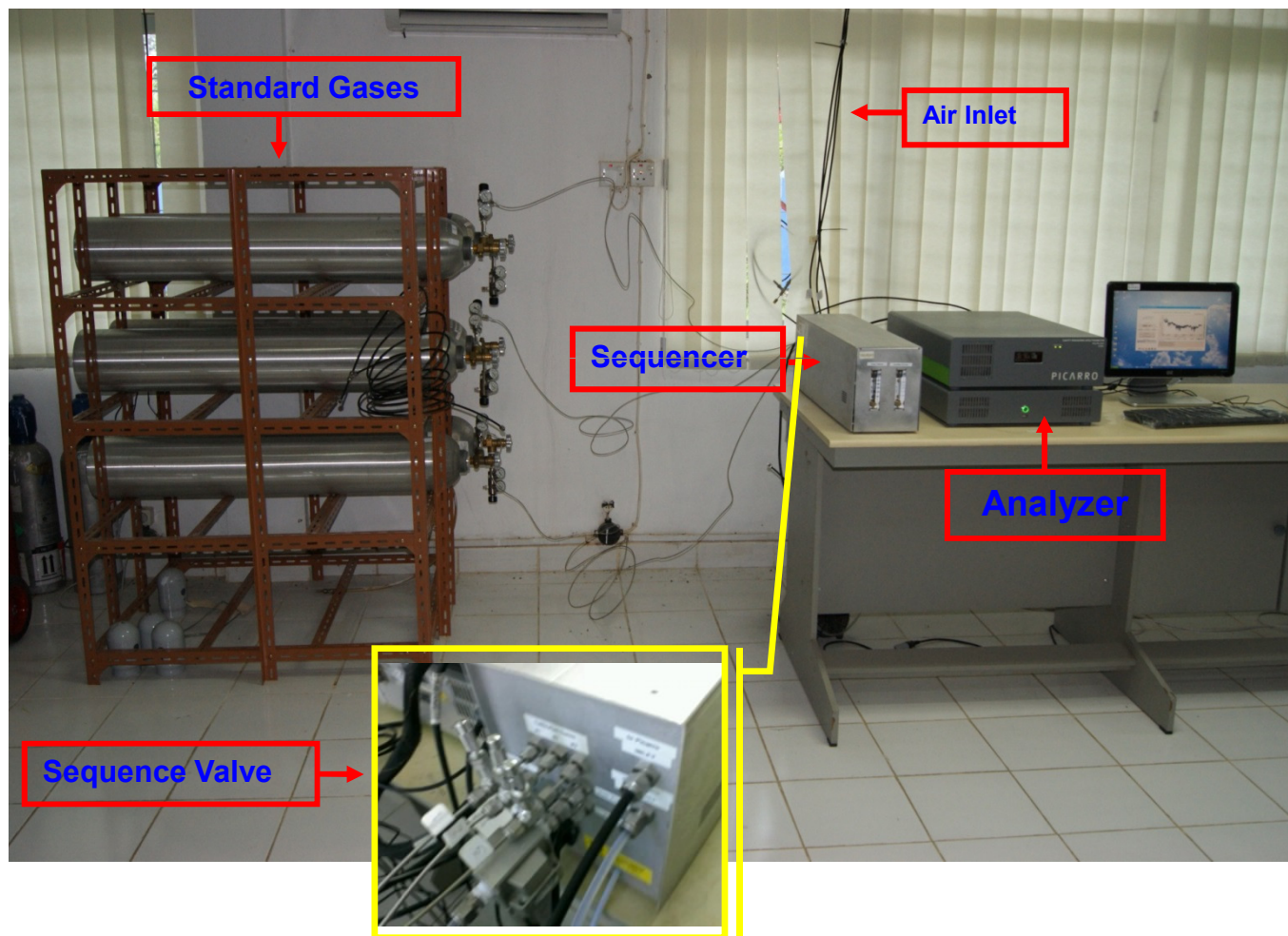




BMKG

GHGs Measurement Activities

NRT Monitoring – System Measurement



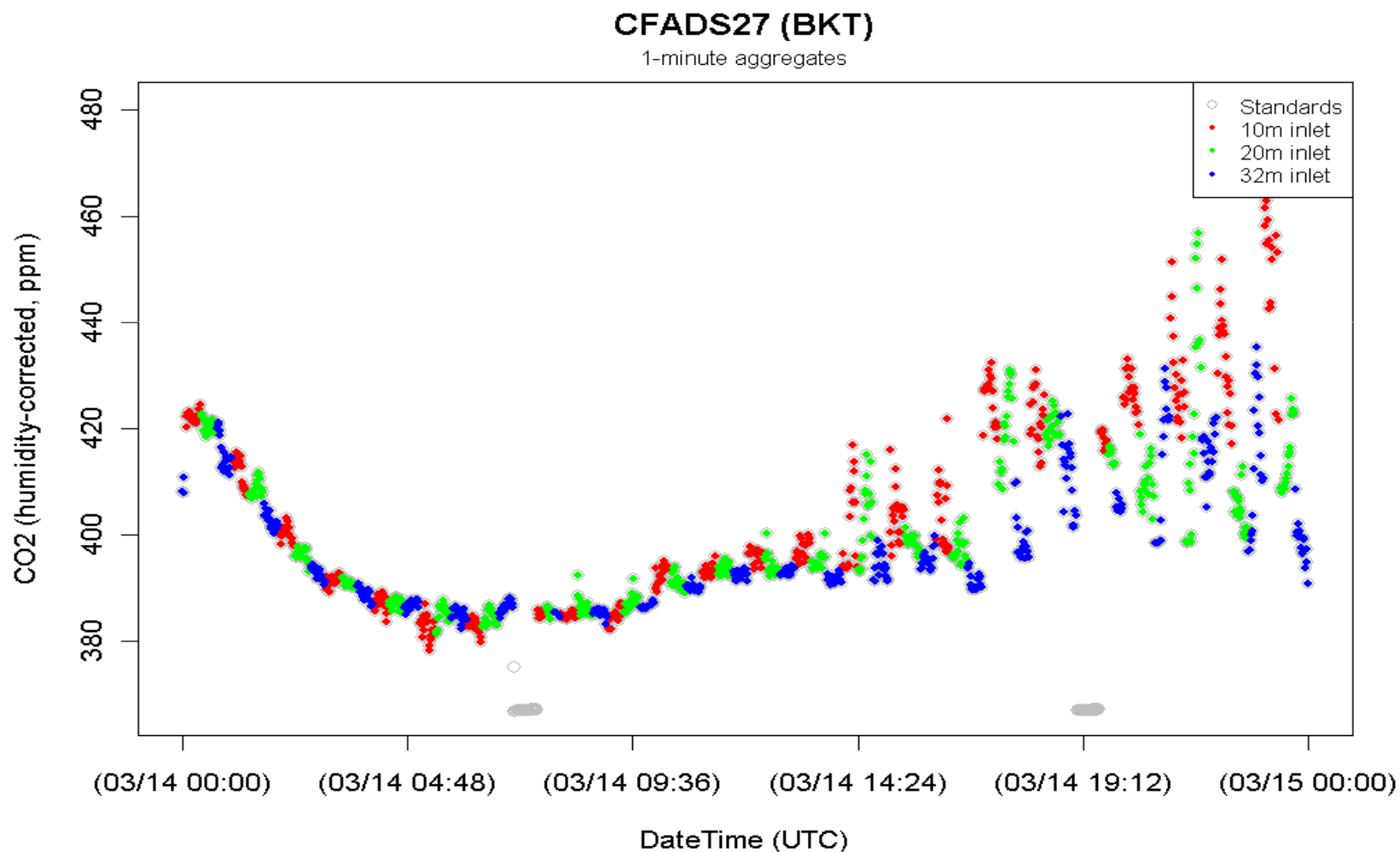
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GHGs Measurement Activities

Result : Output NRT Monitoring CO₂ – CH₄ – H₂O



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GHGs Measurement Activities

NRT Monitoring – Data Handling – R Program

R source code Step #1

```
RGui (32-bit) - [D:\KorSel\picarro_BKT_UserLogFiles_v2.R - R Editor]
R File Edit Packages Windows Help
##### analyse picarro data from BKT #####
#
# data (UserLog Data) directly downloaded from Picarro computer
#
# purpose:
#           analysing the data locally
#           generating new parameters
#           applying humidity correction
#           analysing calibrations
#           applying calibration
#
# input:
#           path and filename
#
# quicklooks:
#           all data
#           all ambient air data
#           mean target gas data
#
# output:
#           various quicklooks of ambient air and calgas data
#           file with 1min averages (uncalibrated, -> ProcStep1)
#           files with calgas data (1min averages)
#           file with calibration results
#           files with
#           STRUCTURE
#
# 1 - INPUT SECTION
# 2 - IMPORT SECTION
# 3 - identify invalid data
# 4 - NEW PARAMETER SECTION
# 4 - DATA FLAGGING SECTION
# 5 - CALCULATING MEAN VALUES FOR CAL/TARGET MEASUREMENTS SECTION
# 6 - APPLY CALIBRATION, GENERATE SEPARATE PARAMETER (air, target)
# 7 - EXPORT DATA
# 8 - CALCULATE 1-MIN AVERAGES
#
# TO BE DONE:
#
# version history
#
# version1: based on processing code for JUN, adapted to BKT data, humidity cc
#
# see 'readme DataProcessing.txt' in folder 'C:\Users\mar134\Documents\GAW\data\BKT'
```



analysing the data locally
generating new parameters
applying humidity correction
analysing calibrations
applying calibration



NRT Monitoring – Data Handling – R Program

R source code Step #2

```
RGui (32-bit) - [D:\KorSel\picarro_BKT_readProcStep2_v1.R - R Editor]
R R File Edit Packages Windows Help
#####
##### analyse picarro data from BKT #####
#
# read processed BKT Picarro data, processed with xpicarro_BKT_UserLogFiles_v2.R'
#
# purpose:      reads monthly 1min files
#               plots data for a whole year
#               generates data file for a whole year
#               calculates higher aggregates
#
# input:        path and filename pattern
#
# quicklooks:   plot of all ambient air data
#
# output:       one file with 1min averages
#               one file with 1min calgas data (if full data set is read)
#               file with calibration results (if full data set is read)
#               files with 10min and 1h data
#
# STRUCTURE
# 1 - INPUT SECTION
# 2 - IMPORT SECTION (1min data)
# 3 - NEW PARAMETER SECTION
# 4 - PLOT DATA
# 5 - EXPORT 1min DATA
# 6 - CALCULATE 10min and 1h DATA
# 7 - EXPORT 10min and 1h DATA
#
# TO BE DONE:
#
# version history
#
# version1:     based on processing code for JUN
#
# see 'readme_DataProcessing.txt' in folder 'C:\Users\mst134\Documents\GAW\data\BKT_i
#
# last update 25.10.2012, mst
#
#####
```

reads monthly 1min files
plots data for a whole year
generates data file for a whole year
calculates higher aggregates



NRT Monitoring – Data Handling – R Program

R source code Step #3

```
RGui (32-bit) - [D:\KorSel\picarro_BKT_readProcStep3_v1.R - R Editor]
File Edit Packages Windows Help

##### analyse picarro data from BKT #####
#
# read processed and 1h-averaged BKT Picarro data, processed with picarro BKT I
#
# purpose:      reads yearly 1h files
#               plots data for multiple years
#               #calculates higher aggregates
#
# input:        path and filename pattern
#
# quicklooks:   plot of all ambient air data
#
# output:       one file with 1min averages
#               one file with 1min calgas data (if full data set is read)
#               file with calibration results (if full data set is read)
#               files with 10min and 1h data
#
#
# STRUCTURE
# 1 - INPUT SECTION
# 2 - IMPORT SECTION (1min data)
# 3 - NEW PARAMETER SECTION
# 4 - PLOT DATA
# 5 - EXPORT 1min DATA
# 6 - CALCULATE 10min and 1h DATA
# 7 - EXPORT 10min and 1h DATA
#
# TO BE DONE:
#
# version history
#
# version1:     based on processing code for JUN
#
# see 'readme_DataProcessing.txt' in folder 'C:\Users\mst134\Documents\GAW\data'
#
# last update 25.10.2012, mst
#
#####
```

Thanks to Dr. Martin Steinbacher-EMPA
for develop R code NRT CO₂-CH₄ data handling

reads yearly 1h files
plots data for multiple years
#calculates higher aggregates



BMKG

GHGs Measurement Activities

NRT Monitoring – Data Handling – File Data Output

2012	3	2	2	20	45.9	10	390.38	1842.92
2012	3	2	2	20	47.3	10	390.38	1842.16
2012	3	2	2	20	50.2	10	390.65	1842.13
2012	3	2	2	20	51.7	10	390.65	1844.13
2012	3	2	2	20	54.7	10	391.32	1844.14
2012	3	2	2	20	56.1	10	391.32	1849.64
2012	3	2	2	20	59.1	10	391.89	1849.63
2012	3	2	2	21	0.5	10	391.89	1853.78
2012	3	2	2	21	3.3	10	391.98	1853.79
2012	3	2	2	21	4.8	10	391.98	1856.43
2012	3	2	2	21	7.8	10	390.85	1856.43
2012	3	2	2	21	9.2	10	390.85	1841.95
2012	3	2	2	21	12.2	10	390.82	1841.94
2012	3	2	2	21	13.5	10	390.82	1845.78
2012	3	2	2	21	16.5	10	391.14	1845.80
2012	3	2	2	21	18.0	10	391.14	1852.91
2012	3	2	2	21	20.9	10	391.31	1852.89
2012	3	2	2	21	22.2	10	391.31	1850.93
2012	3	2	2	21	25.1	10	390.92	1850.94
2012	3	2	2	21	26.5	10	390.92	1851.62
2012	3	2	2	21	29.5	10	390.98	1851.63
2012	3	2	2	21	30.9	10	390.98	1852.55
2012	3	2	2	21	33.8	10	391.09	1852.53
2012	3	2	2	21	35.3	10	391.09	1854.56
2012	3	2	2	21	38.3	10	391.06	1854.58
2012	3	2	2	21	39.6	10	391.06	1854.77

Height 10 m

2012	3	2	2	35	30.2	20	390.50	1858.84
2012	3	2	2	35	31.5	20	390.50	1858.32
2012	3	2	2	35	34.5	20	390.97	1858.32
2012	3	2	2	35	35.9	20	390.97	1863.73
2012	3	2	2	35	38.9	20	390.85	1863.68
2012	3	2	2	35	40.3	20	390.85	1864.24
2012	3	2	2	35	43.3	20	390.30	1864.18
2012	3	2	2	35	44.7	20	390.30	1852.39
2012	3	2	2	35	47.8	20	390.68	1852.38
2012	3	2	2	35	49.1	20	390.68	1858.31
2012	3	2	2	35	52.0	20	390.57	1858.29
2012	3	2	2	35	53.4	20	390.57	1860.00
2012	3	2	2	35	56.3	20	391.30	1860.03
2012	3	2	2	35	57.7	20	391.30	1858.00
2012	3	2	2	36	0.6	20	391.68	1858.00
2012	3	2	2	36	2.0	20	391.68	1855.35
2012	3	2	2	36	5.1	20	391.58	1855.38
2012	3	2	2	36	6.5	20	391.58	1850.66
2012	3	2	2	36	9.5	20	391.79	1850.62
2012	3	2	2	36	10.8	20	391.79	1854.95
2012	3	2	2	36	13.8	20	391.59	1854.95
2012	3	2	2	36	15.2	20	391.59	1855.36
2012	3	2	2	36	18.3	20	391.78	1855.37
2012	3	2	2	36	19.6	20	391.78	1858.11
2012	3	2	2	36	22.6	20	391.64	1858.11
2012	3	2	2	36	24.0	20	391.64	1856.65

Height 20 m

2012	3	2	2	55	30.0	32	388.41	1858.21
2012	3	2	2	55	31.4	32	388.41	1861.11
2012	3	2	2	55	34.4	32	388.63	1861.09
2012	3	2	2	55	35.8	32	388.63	1858.97
2012	3	2	2	55	38.8	32	389.01	1858.96
2012	3	2	2	55	40.2	32	389.01	1855.46
2012	3	2	2	55	43.0	32	388.86	1855.40
2012	3	2	2	55	44.5	32	388.86	1851.53
2012	3	2	2	55	47.5	32	390.83	1851.54
2012	3	2	2	55	48.9	32	390.83	1845.99
2012	3	2	2	55	51.8	32	391.54	1845.99
2012	3	2	2	55	53.0	32	391.54	1846.93
2012	3	2	2	55	56.1	32	391.56	1846.91
2012	3	2	2	55	57.3	32	391.56	1851.64
2012	3	2	2	56	0.3	32	391.72	1851.65
2012	3	2	2	56	1.7	32	391.72	1859.10
2012	3	2	2	56	4.6	32	391.80	1859.09
2012	3	2	2	56	6.1	32	391.80	1853.83
2012	3	2	2	56	9.1	32	391.84	1853.82
2012	3	2	2	56	10.4	32	391.84	1851.58
2012	3	2	2	56	13.5	32	391.98	1851.58
2012	3	2	2	56	14.9	32	391.98	1853.05
2012	3	2	2	56	17.9	32	391.81	1853.04
2012	3	2	2	56	19.2	32	391.81	1853.19
2012	3	2	2	56	22.3	32	392.05	1853.20
2012	3	2	2	56	23.8	32	392.05	1850.47

Height 32 m



BMKG

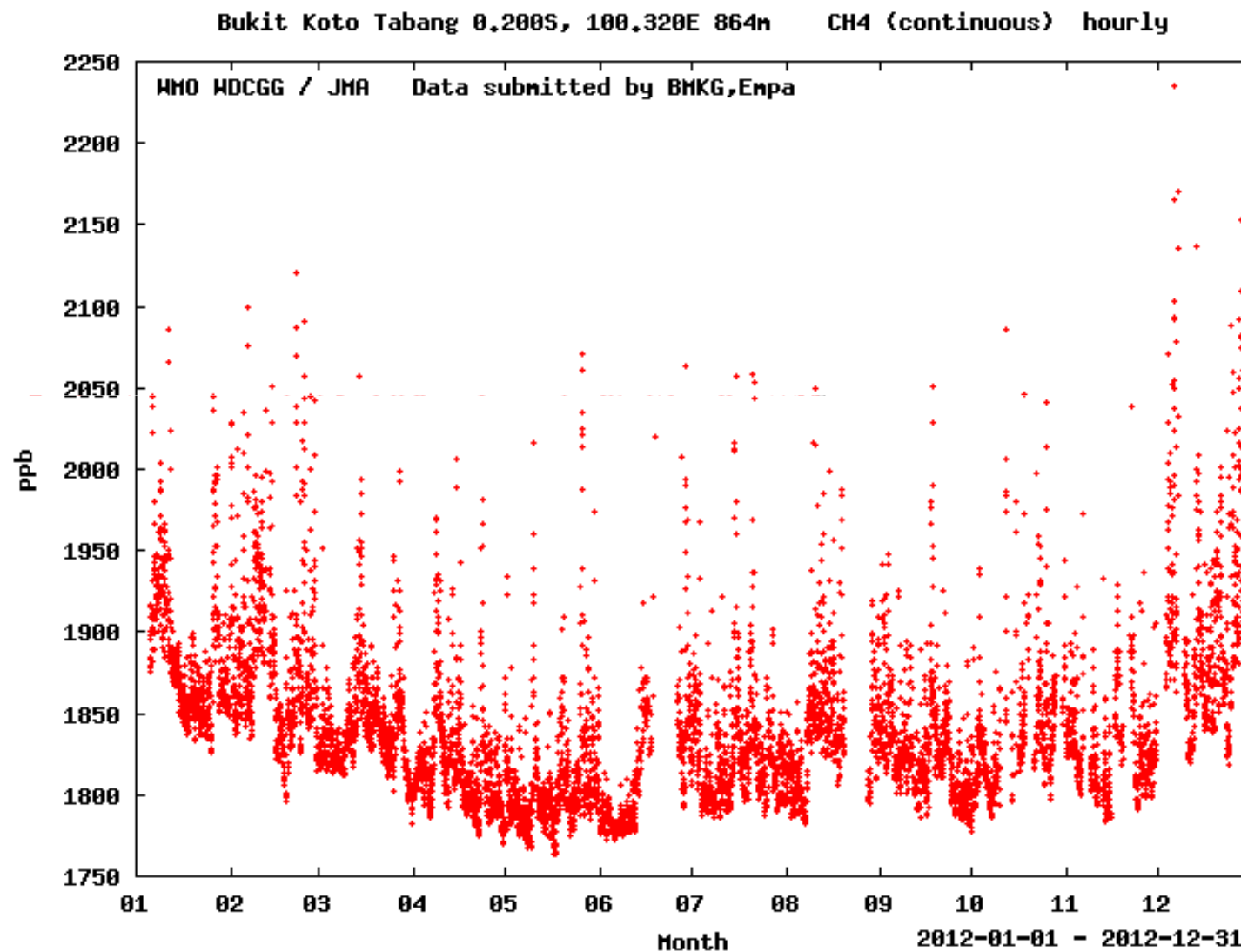
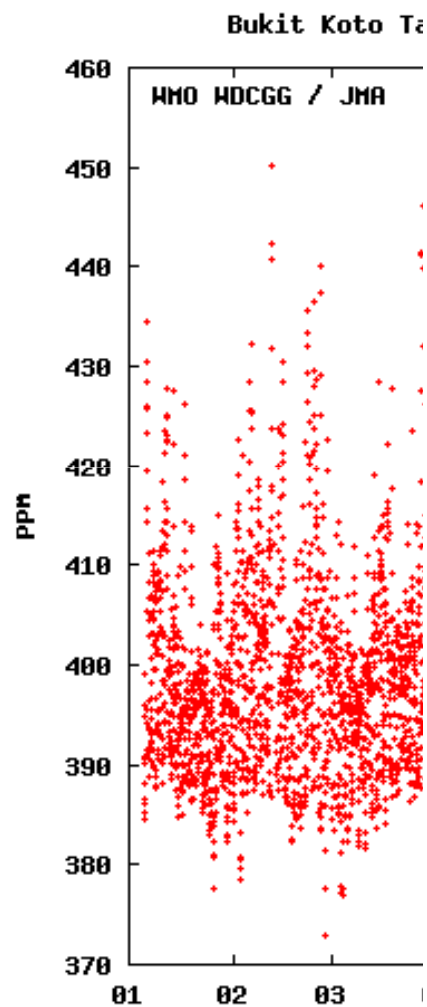
GHGs Measurement Activities

Data Handling – Submit to WDCGG

```
bkt500s00.bmkg_empa.as.cn.co2.nl.hr2011.dat x
1 C01 TITLE: CO2 hourly mean data
2 C02 FILE NAME: bkt500s00.bmkg_empa.as.cn.co2.nl.hr2013.dat
3 C03 DATA FORMAT: Version 1.0
4 C04 TOTAL LINES: 4376
5 C05 HEADER LINES: 32
6 C06 DATA VERSION: 201307
7 C07 STATION NAME: Bukit Kototabang
8 C08 STATION CATEGORY: Global
9 C09 OBSERVATION CATEGORY: Air sampling observation at a stationary platform
10 C10 COUNTRY/TERRITORY: Indonesia
11 C11 CONTRIBUTOR: BMKG, EMPA
12 C12 LATITUDE: -0.2
13 C13 LONGITUDE: 100.32
14 C14 ALTITUDE: 864.5
15 C15 NUMBER OF SAMPLING HEIGHTS: 1
16 C16 SAMPLING HEIGHTS: 32
17 C17 CONTACT POINT: sugeng.nugroho@bmkg.go.id martin.steinbacher@empa.ch
18 C18 PARAMETER: CO2
19 C19 COVERING PERIOD: 2013-01-01 2013-01-30
20 C20 TIME INTERVAL: hourly
21 C21 MEASUREMENT UNIT: ppm
22 C22 MEASUREMENT METHOD: Cavity Ringdown Spectroscopy (CRDS)
23 C23 SAMPLING TYPE: continuous
24 C24 TIME ZONE: Other UTC+7
25 C25 MEASUREMENT SCALE: NOAA04
26 C26 CREDIT FOR USE: This is a formal notification for data users. "For scientific purposes, access to these data is unlimited
27 and provided without charge. By their use you accept that an offer of co-authorship will be made through personal contact
28 with the data providers or owners whenever substantial use is made of their data. In all cases, an acknowledgement
29 must be made to the data providers or owners and the data centre when these data are used within a publication."
30 C30 COMMENT:
31 C31
32 C32 DATE TIME DATE TIME CO2 ND SD F CS REM
33 2013-01-01 00:00 9999-99-99 99:99 413.23 15 6.11 -9999 0 -99999999
34 2013-01-01 01:00 9999-99-99 99:99 411.72 60 7.03 -9999 0 -99999999
```



GHGs Measurement Activities



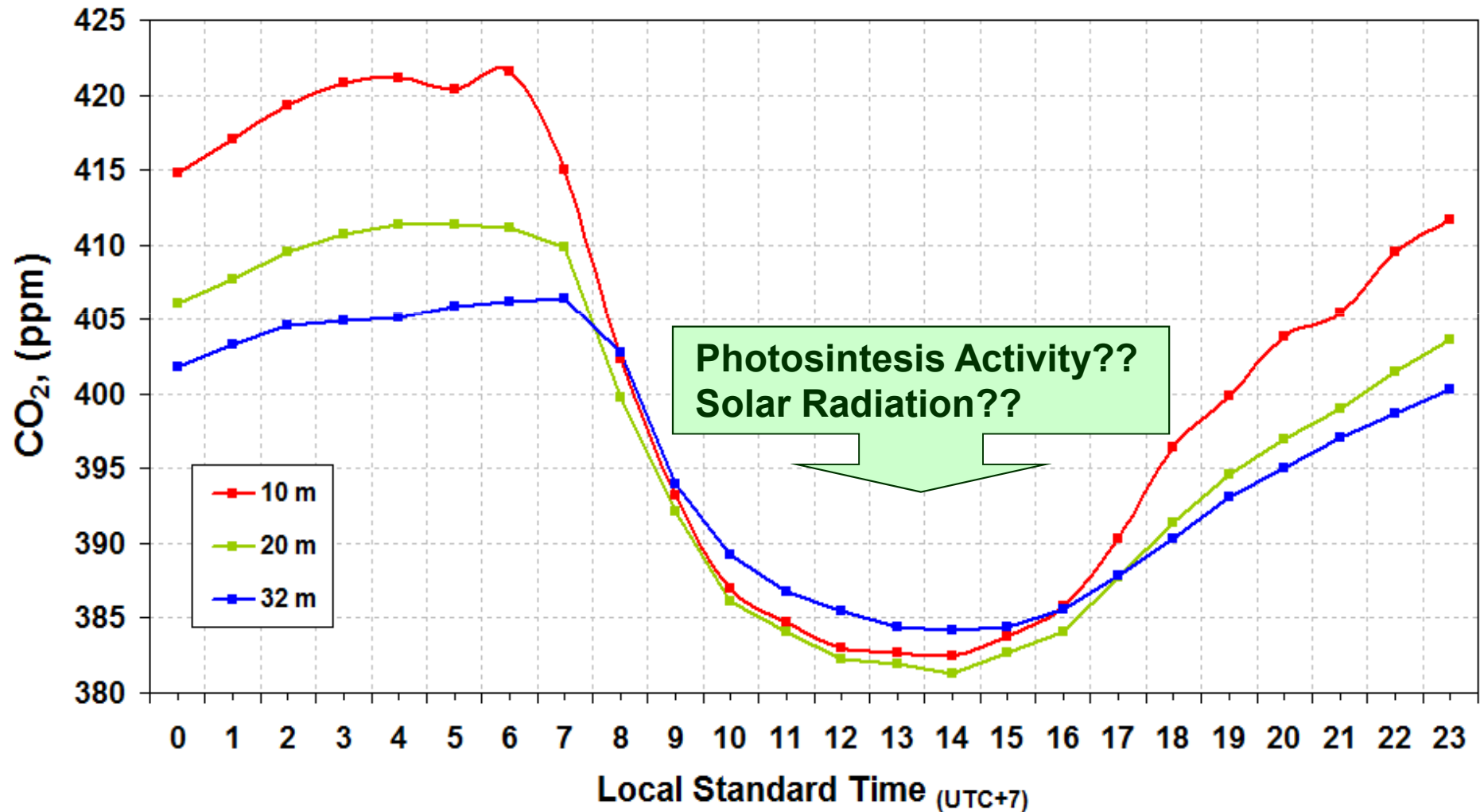
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GHGs Measurement Activities

Simple Analysis – CO₂ diurnal variation 2012

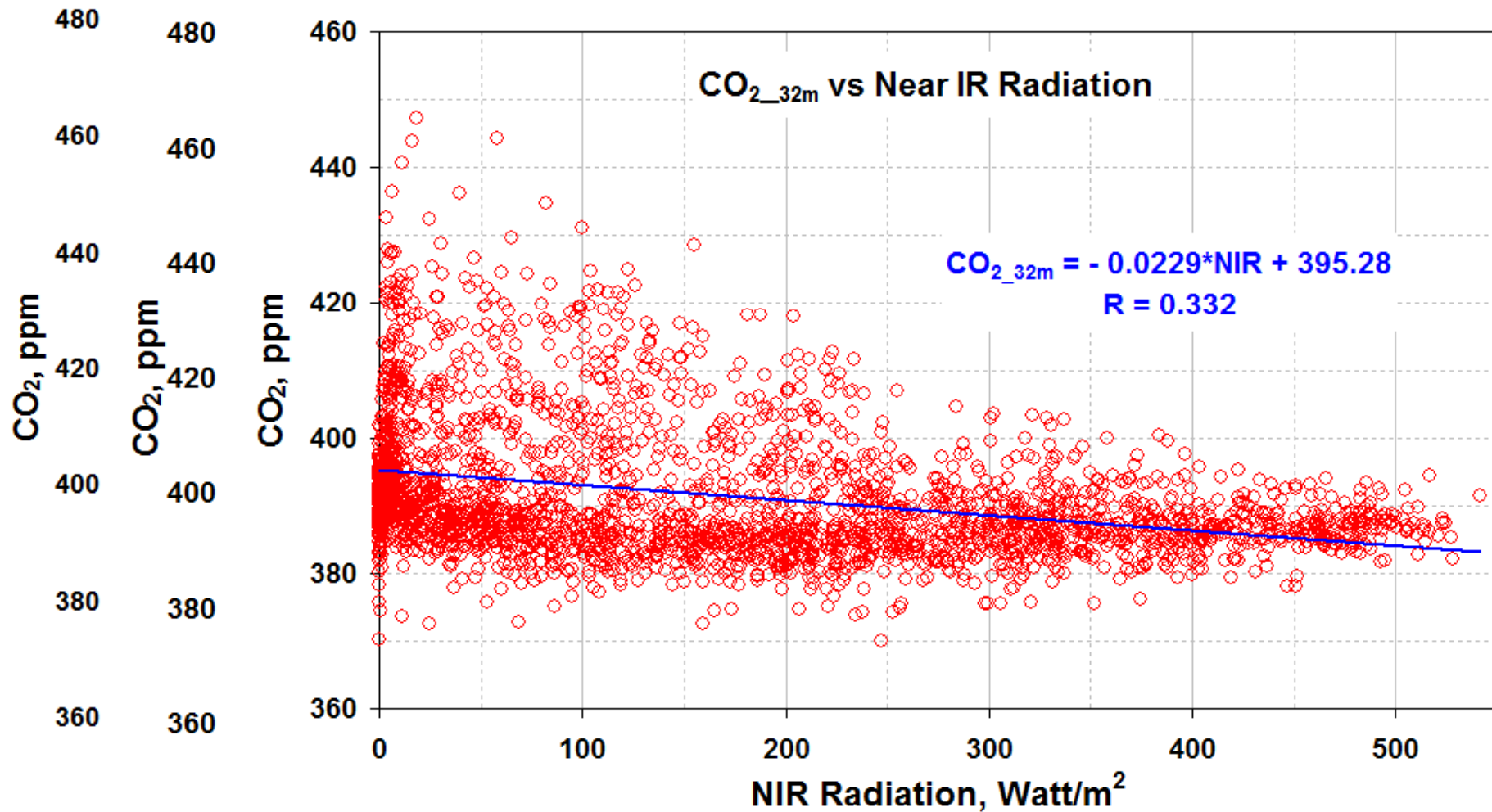




BMKG

GHGs Measurement Activities

Simple Analysis – CO₂ vs Near IR Radiation

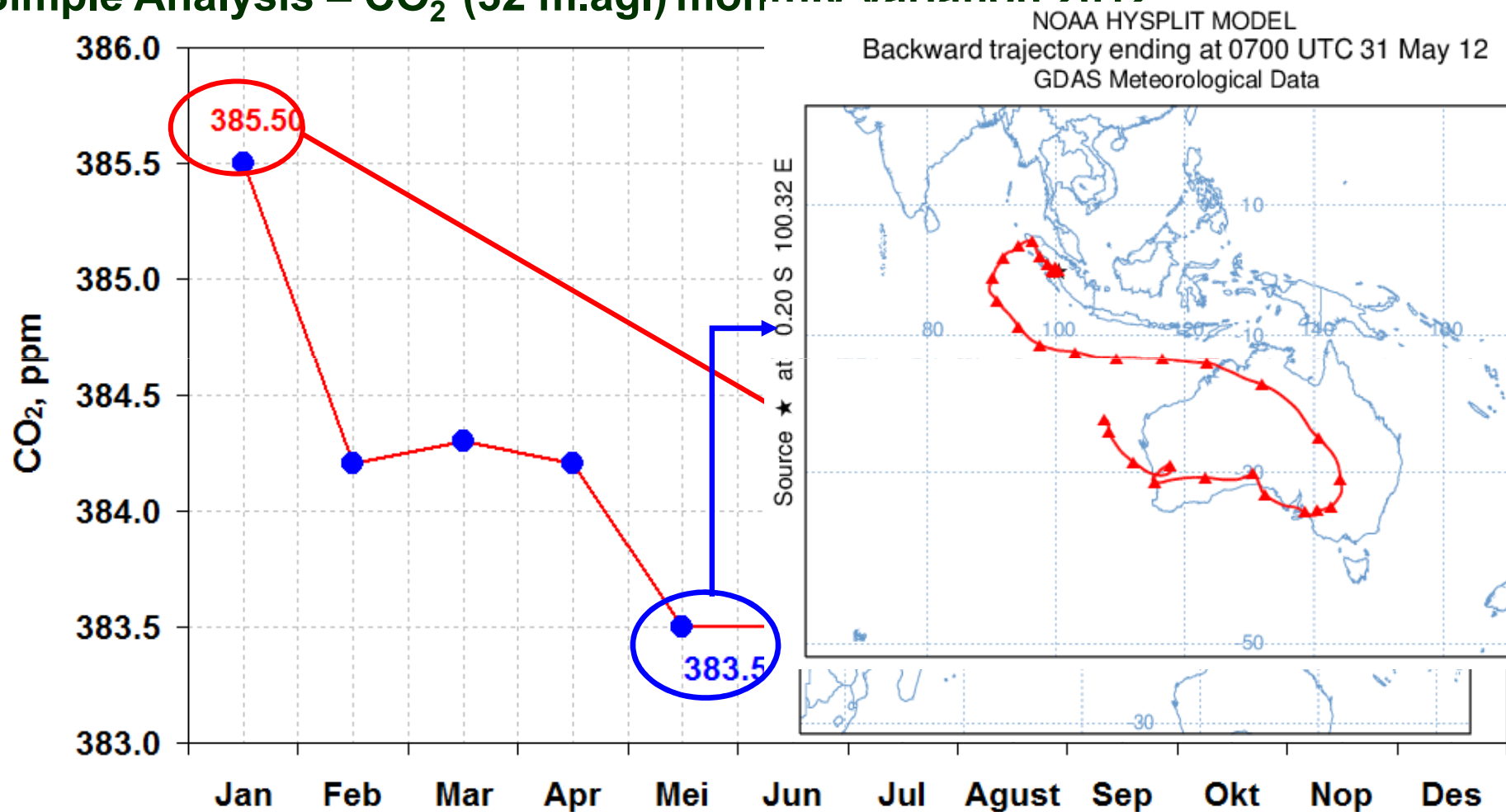




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GHGs Measurement Activities

Simple Analysis – CO₂ (32 m.agl) monthly variation 2012



Challenges on conducting GHGs Measurement

- Maintaining in land use,
- NRT measu standard ga
- Need more

inst changes

strument,

New NRT Intrument for
 N_2O Measurement.
Thermo Scientific IRIS 4600
Start on Sep 2013





BMKG

THANK YOU

TERIMA KASIH

Acknowledgements

BMKG KMA KGAWC WMO/GAW NOAA EMPA GAWTEC