World Meteorological Organization

Weather • Climate • Water

Global framework for observations and analysis of greenhouse gases in the atmosphere: Global Atmosphere Watch Programme

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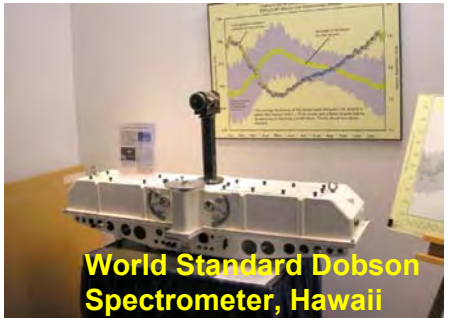
Global Atmosphere Watch Programme

- The programme of the **World Meteorological Organization** (WMO) that coordinates long-term global observations and analysis of atmospheric composition changes
- GAW is a partnership involving contributors from **100** countries
- GAW implements end-to-end approach (from observations through research to delivered products and services)
- GAW includes observational network, quality assurance system, data and metadata infrastructure, expert groups
- GAW supports different applications, including climate studies, air quality forecasting, Numerical Weather Prediction etc.
- GAW builds capacity of Members through publications, expert meetings, dedicated training and **partnerships**

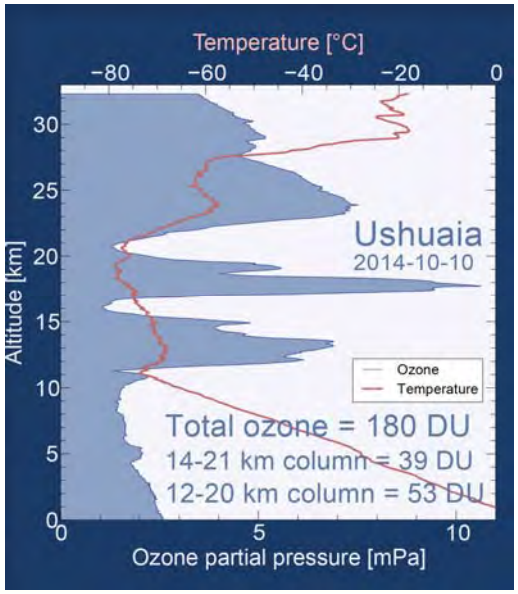

Mt. Cimone station


World Standard Dobson Spectrometer, Hawaii

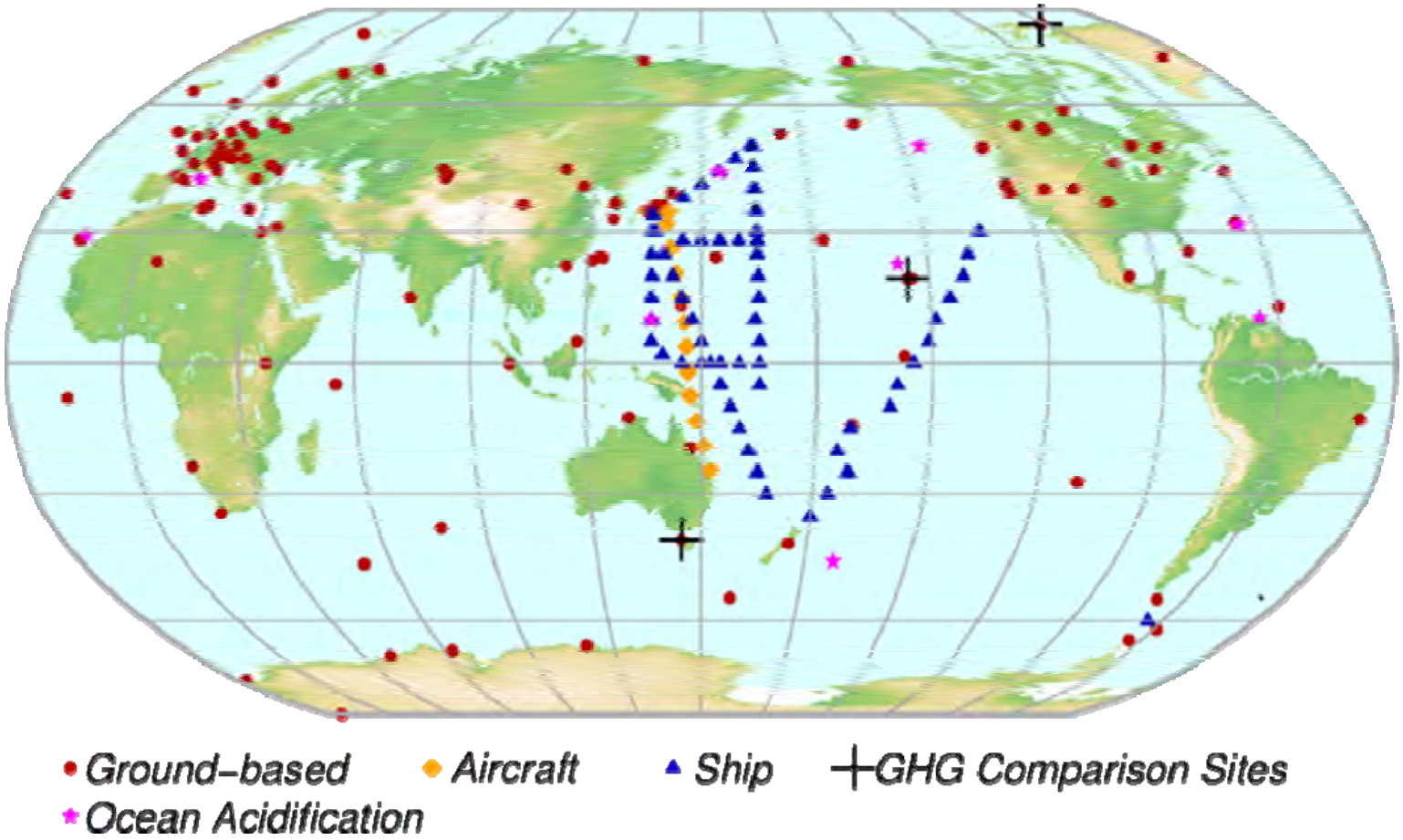

At Cabo Verde GAW Global station

Variables addressed in GAW

- Stratospheric ozone and vertical ozone distribution
- Greenhouse Gases (*CO_2 and its isotopes , CH_4 and its isotopes, N_2/O_2 ratio, N_2O, SF_6, H_2, CFCs and substitutes*)
- Reactive Gases (*O_3, CO, VOCs, NO_x, SO_2*)
- Total Atmospheric Deposition
- Aerosols (*chemical and physical properties, AOD*)
- UV Radiation



Baseline GAW GHG Network



The network consists of 141, 123 and 49 fixed stations on the ground for CO_2, CH_4 and N_2O respectively. About 13%, 13% and 18% of the stations perform both discrete air sampling in "flasks" and continuous measurements of CO_2, CH_4 and N_2O, respectively.

Contributions to comprehensive GHG observational network

- Additional non-background sites
- In situ tall towers and aircraft vertical profiles at 17 sites operated by NOAA/ESRL
- Japan Meteorological Agency (JMA) ship and aircraft observations
- Regular commercial aircraft observations in the CONTRAIL project
- Greenhouse gas measurements (CO_2 and CH_4) are part of the IAGOS-ERI project.

The Total Carbon Column Observing Network (TCCON) is a contributing network to GAW

Attributes of the GAW observations

- Multi-national and multi-agency
- Global in nature
- Diverse in measurement approach (flask sampling, continuous, remote sensing techniques)

BUT:

-Have to be comparable between countries

-Have to be compared with and assimilated into the global models

-Have to be compared with the satellite observations (one instrument per globe)

Quality Management principles

✓Network-wide use of only one reference standard or scale (***primary standard***). In consequence, there is only one institution that is responsible for this standard.

✓ Full traceability to the ***primary standard*** of all measurements made by Global, Regional and Contributing GAW stations.

✓ The definition of data quality objectives (DQOs).

✓ Establishment of guidelines on how to meet these quality targets, i.e., harmonized measurement techniques based on Measurement Guidelines (MGs) and Standard Operating Procedures (SOPs).

✓ Establishment of MGs or SOPs for these measurements.

✓ Use of detailed log books for each parameter containing comprehensive meta information related to the measurements, maintenance, and 'internal' calibrations.

✓ Regular independent assessments (system and performance audits).

✓ Timely submission of data and associated metadata to the responsible World Data Centre as a means of permitting independent review of data by a wider community.

Apply network wide

Central Facilities

Five types of central facilities:

- Central Calibration Laboratories (CCLs)
- Quality Assurance/Science Activity Centres (QA/SACs)
- World Calibration Centres (WCCs)
- Regional Calibration Centres (RCCs)
- World Data Centres (WDCs)

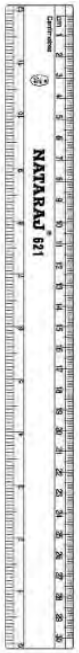
Data Quality Objectives for GHG

Component	Compatibility goal	Extended compatibility goal	Range in unpolluted troposphere	Range covered by the WMO scale
CO_2	± 0.1 ppm (Northern hemisphere) ± 0.05 ppm (South. hemisphere)	± 0.2 ppm	380 - 450 ppm	250 – 520 ppm
CH_4	± 2 ppb	± 5 ppb	1750 – 2100 ppb	300 – 5900 ppb
CO	± 2 ppb	± 5 ppb	30 – 300 ppb	30 - 500 ppb
N_2O	± 0.1 ppb	± 0.3 ppb	325 – 335 ppb	260 – 370 ppb
SF_6	± 0.02 ppt	± 0.05 ppt	8 – 10 ppt	2.0 – 20 ppt
H_2	± 2 ppb	± 5 ppb	400 – 600 ppb	140 −1200 ppb
$\delta^{13}C\text{-}CO_2$	± 0.01‰	± 0.1‰	-7.5 to -9.5‰ vs. VPDB-CO2	
$\delta^{18}O\text{-}CO_2$	± 0.05‰	± 0.1‰	-2 to +2‰ vs. VPDB-CO2	
$\Delta^{14}C\text{-}CO_2$	± 0.5‰	± 3‰	-50 - 50‰	
$\Delta^{14}C\text{-}CH_4$	± 0.5‰		50 - 350‰	
$\Delta^{14}C\text{-}CO$ $\delta^{13}C\text{-}CH_4$	± 2 molecules cm^{-3} ± 0.03‰	± 0.2‰	0-25 molecules cm^{-3}	
$\delta D\text{-}CH_4$	± 1‰	± 5‰		
O_2/N_2	± 2 per meg	± 10 per meg	-400 to -900 per meg (vs. SIO scale)	

Reviewed at GGMT-2015

Current WMO Scales for GHG

- WMO CO_2 X2007
- WMO CH_4 X2004A
- WMO CO X2014
- WMO N_2O X2006A
- WMO SF_6 X2014
- WMO H_2 X2009
- JRAS-06



Central Calibration Laboratories

Host of WMO World Reference Standards for long-lived GHG

- **CO_2, CH_4, N_2O, CO, SF_6 - NOAA ESRL, USA**
- **H_2, CO_2 isotopes – MPI –BG, Jena**

Collaboration with International Bureau of Weights and Measures (BIPM) under the formal Mutual Recognition Arrangements allows NOAA to represent WMO in key comparisons (coordinated by CCQM)

K-68:	N_2O (2008)
K-82:	CH_4 (2013)
K-84:	CO (2012)
K-120:	CO_2 (planned 2016)
K-xxx:	N_2O (planned 2018)

World Calibration Centres

Linking Observations to World Reference Standards and
Ensuring Network Comparability through comparison campaigns
and regular audit

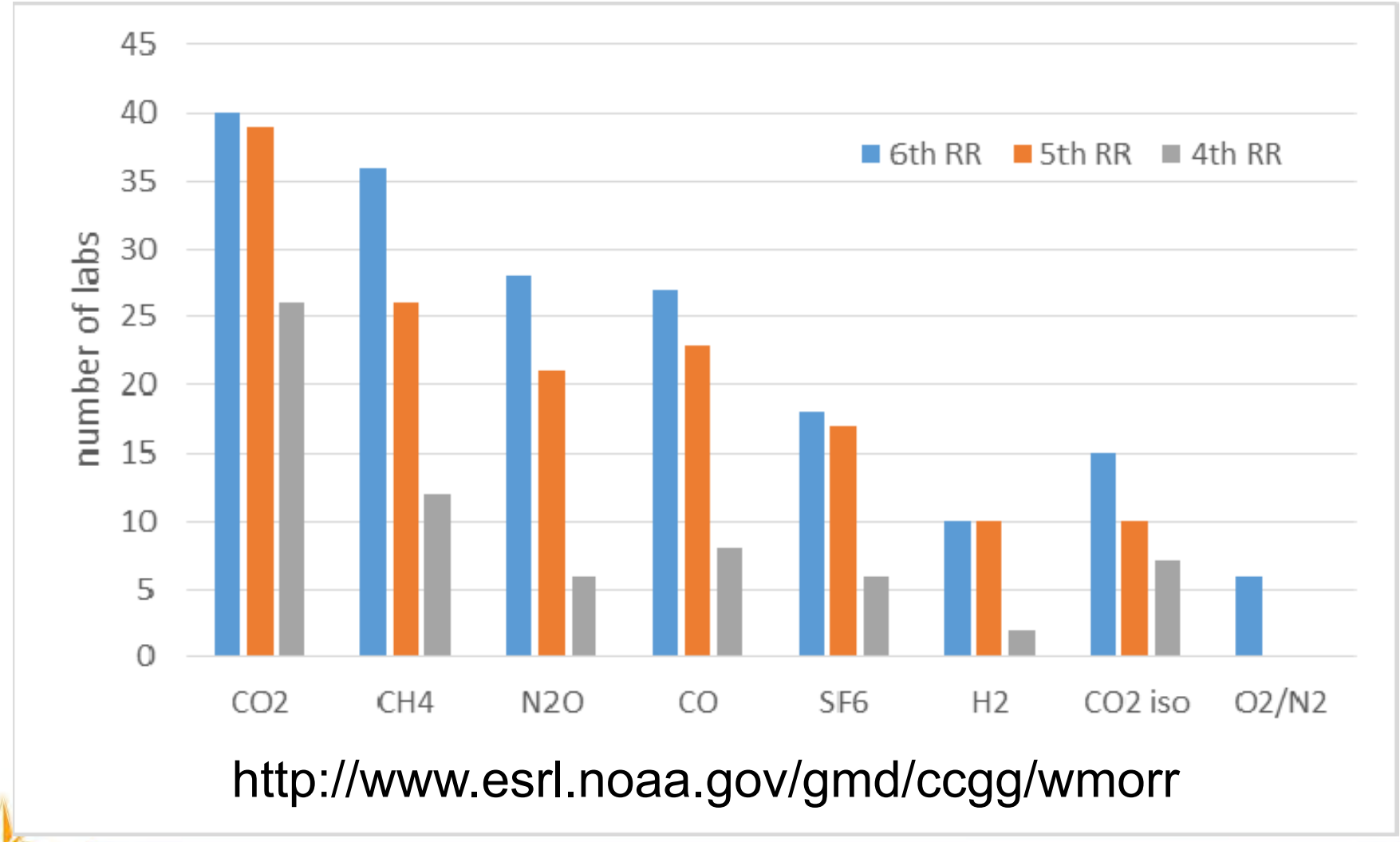
CO_2	- NOAA ESRL USA - EMPA, Switzerland (audits)
CH_4	- EMPA, Switzerland (Am,E/A) - JMA, Japan (A/O)
N_2O	Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate Research, IMK-IFU, Garmisch-Partenkirchen, Germany
SF_6	Korea Meteorological Administration

WMO Round-Robin comparisons

- In reference to WMO goals for compatibility, the purpose of the WMO Round-Robin (RR) reference gas intercomparison would be NOT to distribute calibration scales, but to verify how well the WMO scale is propagated to each of the participating lab, and to the relevant field measurements if they routinely uses WMO standards directly.

- The 6th Round Robin started in January 2014 and officially closed on 7 September 2015.
- Laboratories in each of the 5 circuits (Circuit 1: 13 labs, Circuit 2: 8 labs, Circuit 3: 10 labs, Circuit 4: 11 labs, Circuit 5: 6 labs) received a set of two RR cylinders.
- As in previous RR, air in each cylinder is near ambient range of CO_2, CH_4, CO, H_2, N_2O, SF_6, O_2/N_2, and $\delta^{13}C$ and $\delta^{18}O$ of CO_2.

WMO Round-Robin comparisons

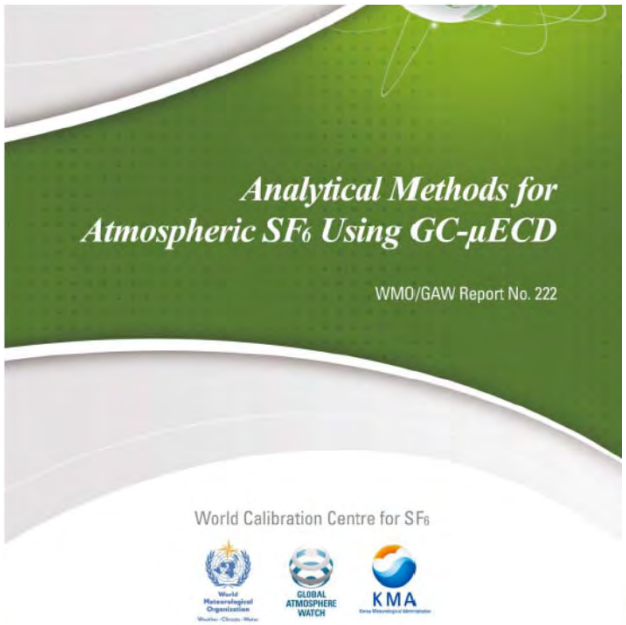


http://www.esrl.noaa.gov/gmd/ccgg/wmorr

Measurement Guidelines

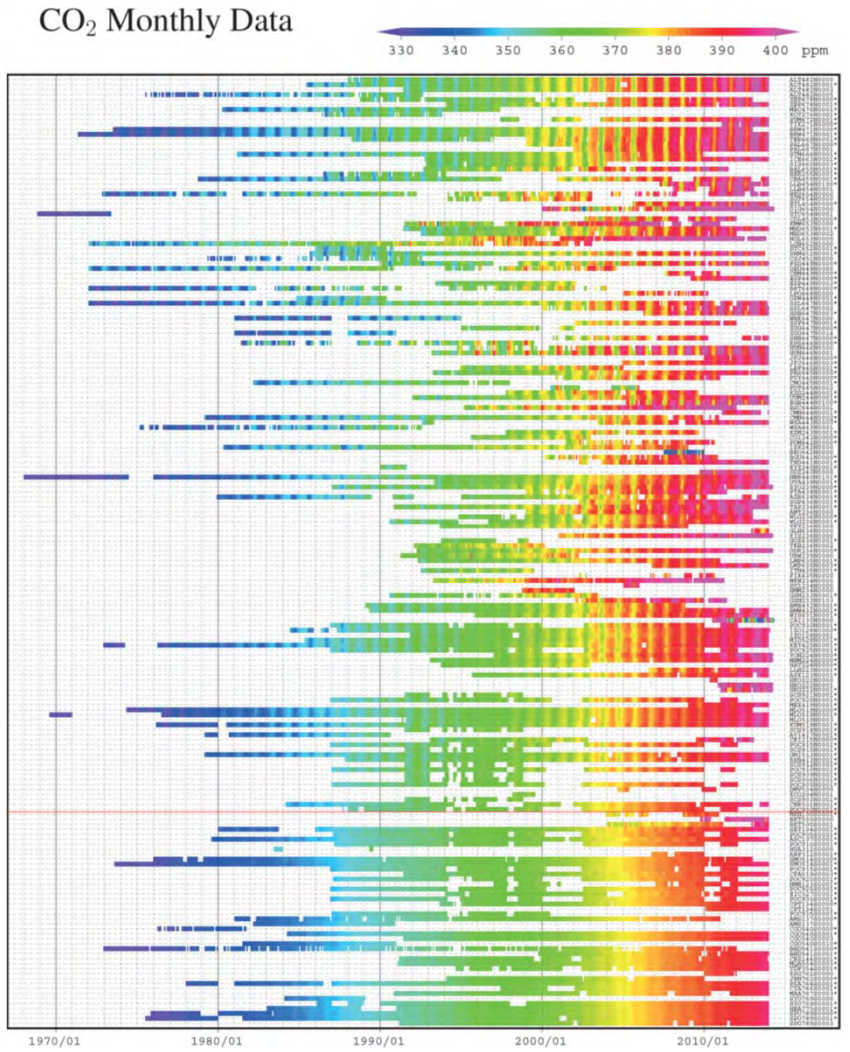
- CO_2 measurement guidelines to be finalized in 2016
- GAW Report 188 - Revision of the World Data Centre for Greenhouse Gases Data Submission and Dissemination Guide, November 2009.
- GAW Report 185 - Guidelines for the Measurement of Methane and Nitrous Oxide and their Quality Assurance, September 2009
- GAW Report 192 - Guidelines for the Measurement of Atmospheric Carbon Monoxide, July 2010.

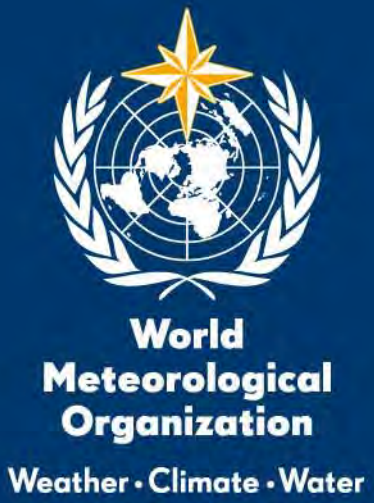
  - *No measurement guidelines for H_2, SF_6, O_2/N_2, or isotopic measurements*
  - *General recommendations related to quality assurance are summarized in GGMT meeting recommendations*
  - *Most of measurement guidelines are 5+ years old*



Availability of the observational data

- GHG data from the GAW stations are archived at the World Data Centre for Greenhouse Gases (WDCGG) operated by Japan Meteorological Agency
- WDCGG performs global analysis (results are reported in the Annual Greenhouse Gas Bulletin)
- WDCGG publishes annual Data Summary





Thank you for your attention!