

Training, twinning, and capacity building in support of greenhouse gas observations in data sparse regions



M. Steinbacher¹, C. Zellweger¹, L. Emmenegger¹, B. Buchmann²

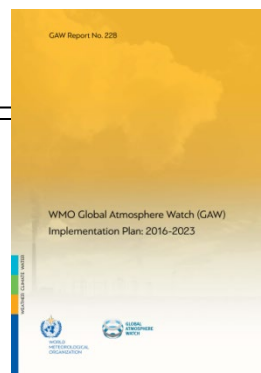
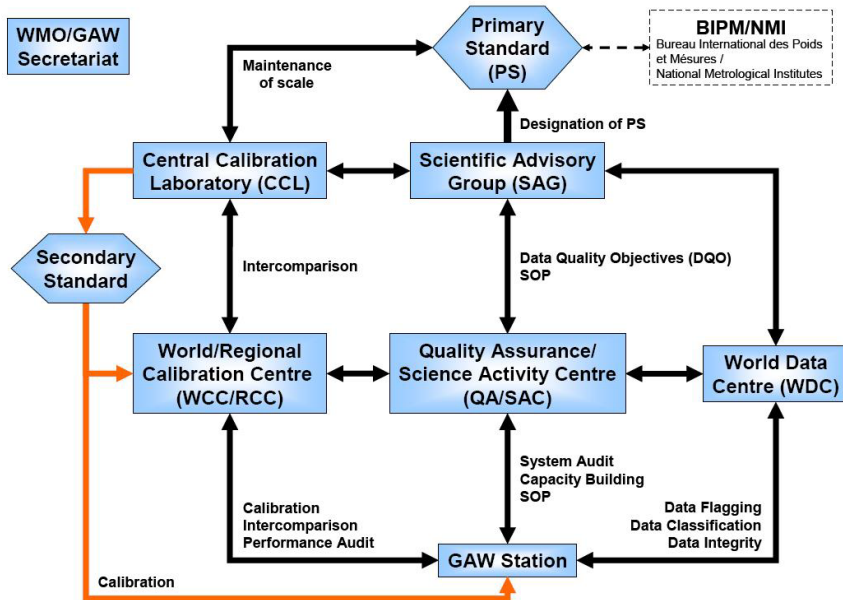
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GGMT-2019, Seogwipo, Jeju-do, South Korea, 01 – 05 September 2019

Quality Assurance / Science Activity Centre (QA/SAC)

Elements of the Quality Assurance system,
QA activities and workflow in GAW



GAW report #228

5.2.2 Quality Assurance/Science Activity Centres (QA/SACs)

Specific activities:

- QA-1. Provide an operating framework for GAW quality assurance activities and calibration facilities for a specific variable and geographical area of responsibility (world, regional, national).
- QA-2. Coordinate the activities of WCCs and RCCs in the area of their responsibility.
- QA-3. Provide advice and support for the local QA system at individual GAW sites.
- QA-4. Where appropriate, coordinate instrument calibrations and intercomparisons and other measurement activities.
- QA-5. Perform or oversee regular system audits at GAW sites.
- QA-6. Provide training, long-term technical help, and workshops for station scientists and technicians.
- QA-7. Promote the scientific use of GAW data, and encourage and participate in scientific collaboration.

Quality Assurance / Science Activity Centre Switzerland

Scope

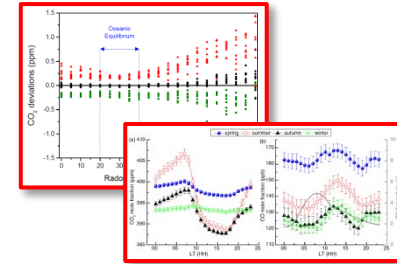
- variables mandated to WCC-Empa
- cross-cutting, system-wide

Primary Tasks

- research activities promoting technical progress and scientific data analysis,
- twinning, support, capacity building, and training
- contribution to GAW outreach,
- networking / cooperation with other programmes / projects in line with the GAW strategy



capacity building



science



networking

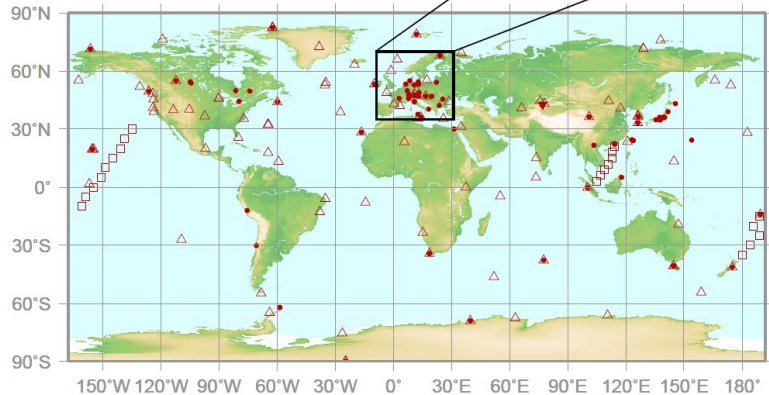
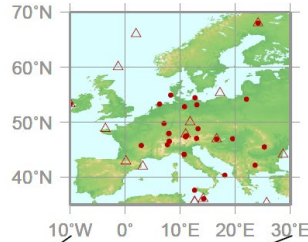


outreach

Rationale for training and capacity building

Stations reporting CO₂ data

- : CONTINUOUS STATION
- △ : FLASK STATION
- : FLASK MOBILE (SHIP)
- ▼ : REMOTE SENSING STATION



WDCGG Data Summary, No. 42, 2018

" ... Building expertise in developing countries including the establishment of high-quality measurement capabilities remains a critical issue for achieving adequate spatial coverage of the globe in the coming decade. WMO and IAEA can make large contributions here through training courses, and stimulating partnerships between laboratories. ..."

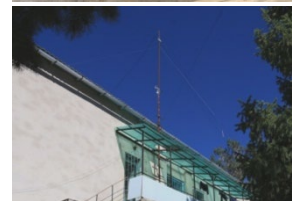


The long process of capacity building

A-priori: basic equipment / infrastructure available, willingness to perform high-precision air quality observations in a pristine environment

- advice for instrument selection
- technical support / advice to set up measurement capabilities
- regular on-site training
- remote support / trouble shooting
- facilitating the provision of spare parts
- support for data processing / data submission
- support for (research) proposal writing
- support for scientific data analysis and publication

A-posteriori: fully autonomous monitoring station, high-quality data, good visibility in the GAW and the scientific community



Infrastructure Requirements

Measurement site infrastructure

- shelter
- mast for free exposure of the inlet
- reliable power supply
- air conditioning
- internet access
- access to the station (365 days a year)
- local support
- ...

Instrument(s) and periphery

- adequate GHG analyzer
- periphery for automatic calibration
- reference gases (cals, targets)
- pressure reducers
- plumbing (additional pumps, tubing, connectors, inlet hat, drying unit, ...)

- consumables, spare parts, backup instruments, ...

Traceability to common scales



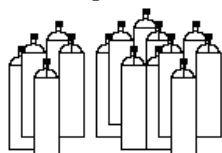
15 PRIMARY STANDARDS
246 TO 520 PPMV CO₂.



10 SECONDARY STANDARDS
290 TO 420 PPMV CO₂.



CMDL/CCG
IN-SITU
STANDARDS



CMDL/CCG LAB
AIRCRAFT FLASKS
NETWORK FLASKS
TOWERS
EXPERIMENTAL GAS



OUTSIDE CCG
RESEARCHERS

station operators



primary
laboratory
standards



working
standards
(in-situ)

recalibration every x years!

For CO₂:

CALIBRATION PRECISION; 0.014 $\mu\text{mol/mol}$ [1 sd of calibrations < 6 months apart].

precision for < 325 approx. 0.1

precision for > 425 approx. 0.25

Absolute Uncertainty; 0.1 $\mu\text{mol/mol}$

Internal consistency [325-425 $\mu\text{mol/mol}$]; 0.04 $\mu\text{mol/mol}$ [2 sigma] [< 2 years]

<https://www.esrl.noaa.gov/gmd/ccl/airstandard.html>

Operation and maintenance

Measurements and beyond

- documentation, log books
- metadata management

The screenshot displays a web-based interface for managing log entries. The main window shows a list of entries with the following columns: ID, Date, Author, Type, Category, Subject, and Event Date. The entries are sorted by date, with the most recent at the top. A detailed view of a specific entry is shown on the right, including fields for Entry time, Author, Type, Category, Subject, and Event Date. The application also includes a search bar and various navigation buttons.

ID	Date	Author	Type	Category	Subject	Event Date	Text
20	3/26/2013 12:46:21 PM	mt134	Multipoint	Tests	overflow checks	3/26/2013 12:46:15 PM	Flows measured with ADM3000 membrane flowmeter after measurements stopped; ports selected by activating the port with the hardware
19	1/9/2013 8:22:52 AM	mt134	NZO/CO-23d	General	Passwords	1/9/2013 10:21:20 AM	New passwords set under the Unix Environment for: robsoc
18	1/9/	El-Tobols	Plan Dist	TGR_NZO_CO_23	password in		for: L0240240240240
17	12/15/						
16	12/15/						
15	12/15/						
14	12/7/						
13	12/7/						
12	12/7/						
11	12/4/						
10	10/5/						
9	8/16/						
8	8/8/						

Operation and maintenance

Measurements and beyond

- documentation, log books
- metadata management
- preparation of checklists

Maintenance and Quality Control
Ata, Kyrgyzstan
Version: v160808
CO₂, CH₄ & CO Analyzer, Picarro G2401

Make notes in the electronic logbook

Regular checks should be done

- Every weekly
 - visually inspect current
 - check cylinder pressures
- every month
 - backup data
- every 6 months
 - Change filter at the back
 - Change inlet filter at the front

See details below

Every week:

- Turn on screen, select Picarro window (at the bottom; see screenshot)
- Go to External Valve Sequencer (Valve Sequencer isn't shown)
- Select Data Acquisition configuration: press 'Show', all values at Cholpon Ata are: 1000 ppb, H₂O: 0 to 4 vol%
- Check inlet flow at the front; if not adjust the flow and mix

Add a new comment in the e-log (e.g. Type 'Checked')

Every month:

- Backup all data from the Picarro analyzer
 - Data acquisition computer
 - C:\Data\log
 - on an USB stick
 - Picarro computer: copy C:\UserData\Data on an USB stick

Add a new comment in the e-log (e.g. Type 'Done')

Every 6 months:

- Change filter at the back of the Picarro calibration unit (January and July)
 - Remove filter holder, open large screw, replace filter, put filter holder back in place

Add a new comment in the e-log (e.g. Type 'Maintenance', Category 'Picarro G2401', Subject 'Filter (back of calibration unit) replaced')

- Change (black) inlet filter at the top of the roof (April and October)
 - Open black filter holder, put new black filter inside, close filter holder properly, make sure that the hole is pointing downwards

Add a new comment in the e-log (e.g. Type 'Maintenance', Category 'Picarro G2401', Subject 'Rooftop filter replaced')

Operation and maintenance

Measurements and beyond

- documentation, log books
- metadata management
- preparation of checklists
- regular station updates in GAWSIS

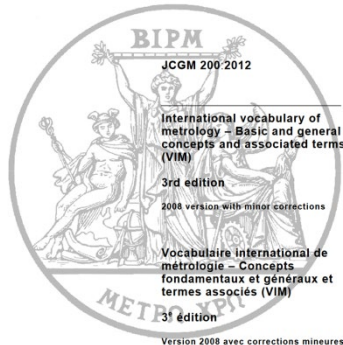
The screenshot shows the GAWSIS web interface for the Pha Din station. The header includes the logo of the National Center for Hydro-Meteorological Information and the text 'GAWSIS STATION INFORMATION SYSTEM'. The main content area displays the station name 'Pha Din (Viet Nam)' and its location 'GAW Regional station in WMO Region II - Asia'. A map shows the station's location in a mountainous region. The interface is divided into several sections: 'Station characteristics' (Name, Station area, Date established, Date closed, Defined status, Current recorded status, Station code, Station codes, GAW ID, WMO ID), 'WMO region' (WMO region, Country / Territory, Coordinates, Time zone, Supervising organization, Station type, Other IDs), 'Site description' (Detailed text about the station's location and history), 'Climate zone' (Precipitation surface cover, Surface roughness, Topography or bathymetry, Population in 10km / 50km or thousands, Station - person event logbook), 'Photo gallery' (No photos available), 'Programs / network affiliations' (Table with columns for Program / network affiliation, Program search ID, Status, Current recorded status, Defined status, From, To), 'Observations / measurements' (List of observation types like Airspeed, Cloud cover, etc.), 'Station contacts' (List of contact persons like Dr. Jürgen Arndt, etc.), and 'Biogeographic references' (List of references).

Operation and maintenance

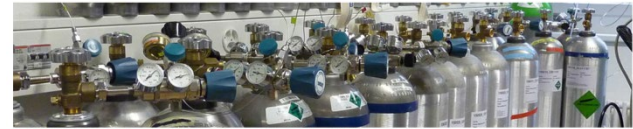
Measurements and beyond

- documentation, log books
- metadata management
- preparation of checklists
- regular station updates in GAWSIS

- use of common terminology



Version 2008 avec corrections mineures



WMO/GAW Glossary of QA/QC-Related Terminology

Version 1.0 2010-09-14 (last update: 2016-05-26 (minor changes, see [Version history](#) for details))

Editors: J. Klausen, H.-E. Scheel and M. Steinbacher

Table of Contents

Introduction
Glossary
-Alphabetical list of terms
-SECTION 1 - Quantities and Units
-SECTION 2 - Measurement
-SECTION 3 - Devices for Measurement

Glossary

Alphabetical list of terms

accuracy | adjustment of a measuring system | audit | calibration | calibration curve | calibration hierarchy | Central Calibration Laboratory (CCL) | certified reference material | combined standard measurement uncertainty | concentration | conventional quantity value | correction | coverage factor | coverage interval | coverage probability | data quality objectives (DQOs) | definitional uncertainty | expanded measurement uncertainty | indication | input quantity in a measurement model | International system of units | laboratory standard | measurand | measured quantity value | measurement | measurement accuracy | measurement bias | measurement error | measurement guideline (MG) | measuring instrument | measurement precision | measurement procedure | measurement repeatability | measurement reproducibility | measurement result | measurement trueness | measurement standard | measuring system | measurement uncertainty | metrological comparability of measurement results | metrological compatibility of measurement results | metrological traceability | metrological traceability chain | (mass) mixing ratio | (volume) mixing ratio | mole fraction | nominal quantity value | ordinal quantity | output quantity in a measurement model | precision | primary measurement standard | quality assurance | quality control | quantity | quantity value | random measurement error | reference material | reference measurement standard | reference quantity value | reference scale | repeatability condition of measurement | reproducibility condition of measurement | resolution | secondary measurement standard | sensitivity of a measuring system | selectivity of a measuring system | (measurement) standard | standard measurement uncertainty | standard operating procedure (SOP) | standard scale | surveillance cylinder | systematic measurement error | target cylinder (target gas) | tertiary standard | transfer measurement device | travelling measurement standard | true quantity value | Type A evaluation of measurement uncertainty | Type B evaluation of measurement uncertainty | World Calibration Centre (WCC) | working measurement standard | zero adjustment of a measuring system

https://www.empa.ch/web/s503/gaw_glossary

Data handling and analysis

Data processing

- automated procedures are encouraged
- facilitates diagnostics and quality control
- allows for re-processing of the data (e.g. in case of scale changes)



source codes w/o graphical user interface

Data handling and analysis

Data processing

- automated procedures are encouraged
- facilitates diagnostics and quality control
- allows for re-processing of the data (e.g. in case of scale changes)
- estimation of measurement uncertainty

Bureau International des Poids et Mesures – the intergovernmental organization through which Member States act together on matters related to measurement science and measurement standards.

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> You are here: publications > guides > Guide to the Expression of Uncertainty in Measurement (GUM)

GUM: Guide to the Expression of Uncertainty in Measurement

In order to benefit fully from the hyperlinking between the documents, the reader is advised to download all JCGM documents presently available in one ZIP file.

→ The fundamental reference document is the *Guide to the Expression of Uncertainty in Measurement* (GUM):

↓ Evaluation of measurement data – Guide to the expression of uncertainty in measurement (GUM 1995 with minor corrections) JCGM 100:2008	📄
Note: JCGM 100:2008 is also available in HTML form from the JCGM portal on ISO's website.	

→ The JCGM Working Group 1 (JCGM-WG1) is producing a series of documents to accompany the GUM. The first four of these documents have been approved and are available for download as PDF files. Printed copies are available for purchase from ISO.

↓ Evaluation of measurement data – An introduction to the "Guide to the expression of uncertainty in measurement" and related documents JCGM 104:2009	📄
↓ Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method JCGM 101:2008	📄
↓ Evaluation of measurement data – Supplement 2 to the "Guide to the expression of uncertainty in measurement" – Extension to any number of output quantities JCGM 102:2011	📄
↓ Evaluation of measurement data – The role of measurement uncertainty in conformity assessment JCGM 106:2012	📄
↓ Evaluation of measurement data – Concepts and basic principles	📄

The following documents are at an early stage of preparation:

↓ Evaluation of measurement data – Supplement 3 to the "Guide to the expression of uncertainty in measurement" – Modelling	
↓ Evaluation of measurement data – Applications of the least-squares method	

Related articles

GUM:

- BIPM Workshop on Measurement Uncertainty
- Software related to the GUM and the GUM supplements 1 and 2
- Tutorial for metrologists on the probabilistic and statistical apparatus underlying the GUM and related documents
- Bibliography on Uncertainty
- News from JCGM-WG1
- JCGM Working Group 1

VIM:

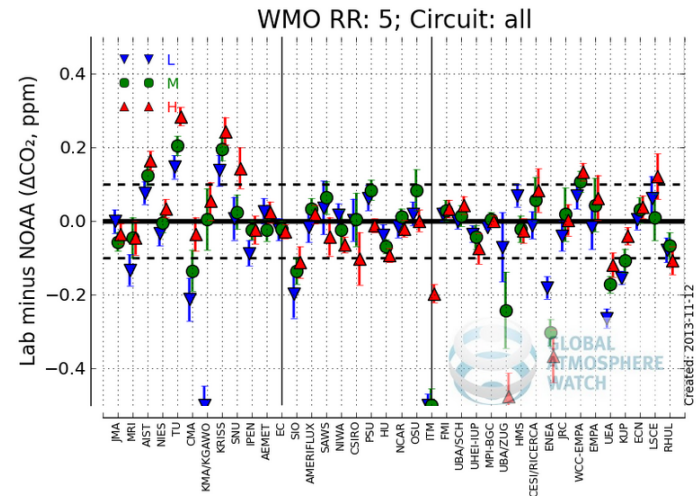
- "Annotated VIM3"
- The rationale for VIM3
- FAQs on the VIM3
- News from JCGM-WG2
- JCGM Working Group 2

<https://www.bipm.org/en/publications/guides/gum.html>

Data handling and analysis

Additional quality control

- participation in comparison (e.g. round robin) exercises

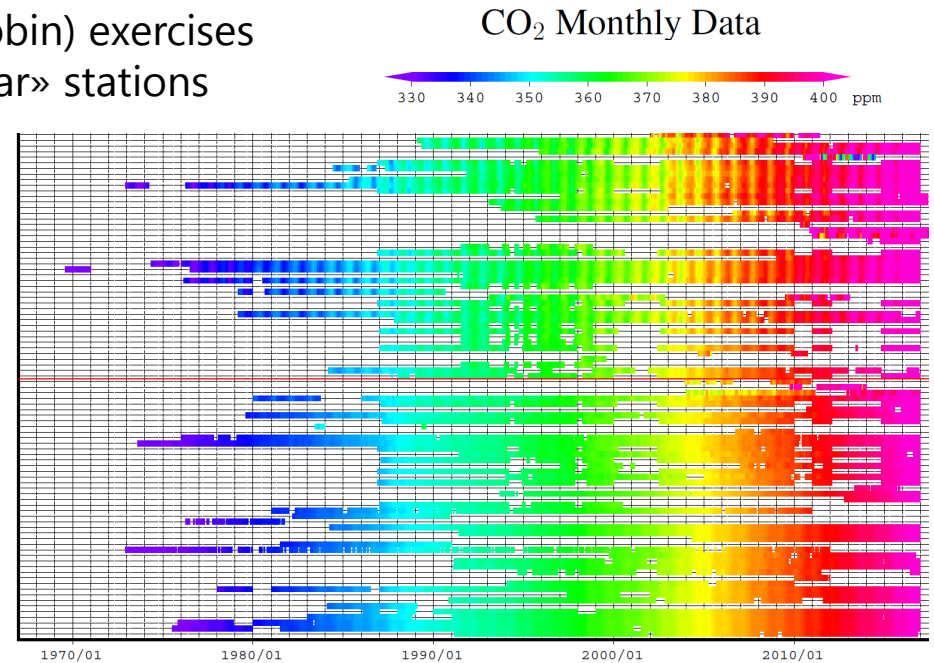


<https://www.esrl.noaa.gov/gmd/ccgg/wmorr/>

Data handling and analysis

Additional quality control

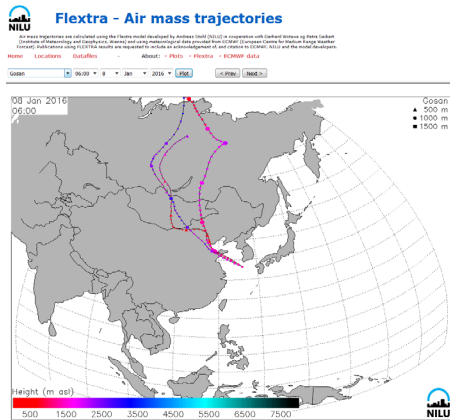
- participation in comparison (e.g. round robin) exercises
- comparison of data with data from «similar» stations



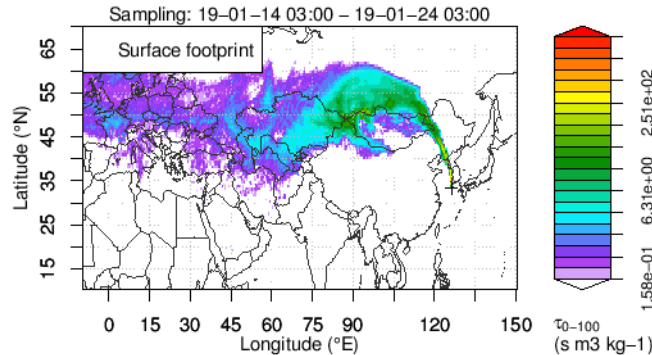
Data handling and analysis

Additional quality control

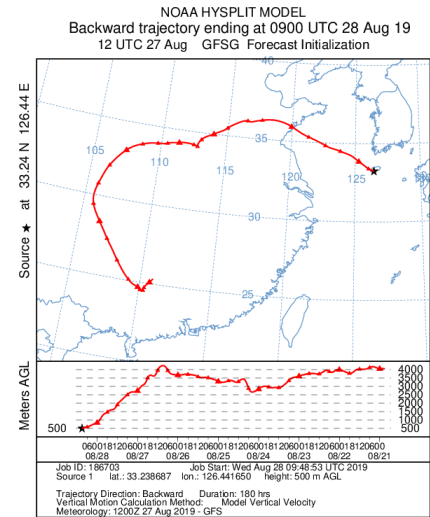
- participation in comparison (e.g. round robin) exercises
- comparison of data with data from «similar» stations
- use available online tools for trajectory calculations, e.g.



<https://projects.nilu.no//ccc/>

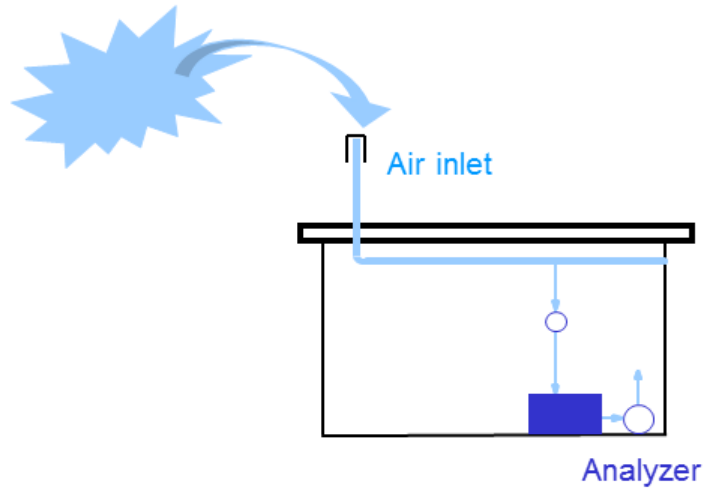


<http://lagrange.empa.ch/>

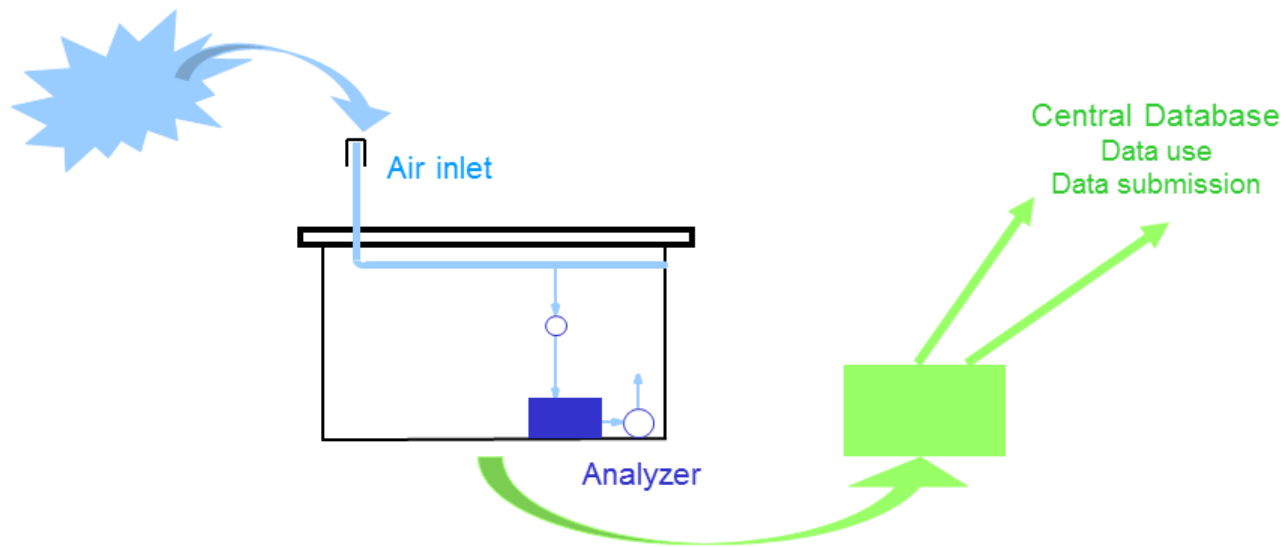


<https://ready.arl.noaa.gov/hypub-bin/trajtype.pl>

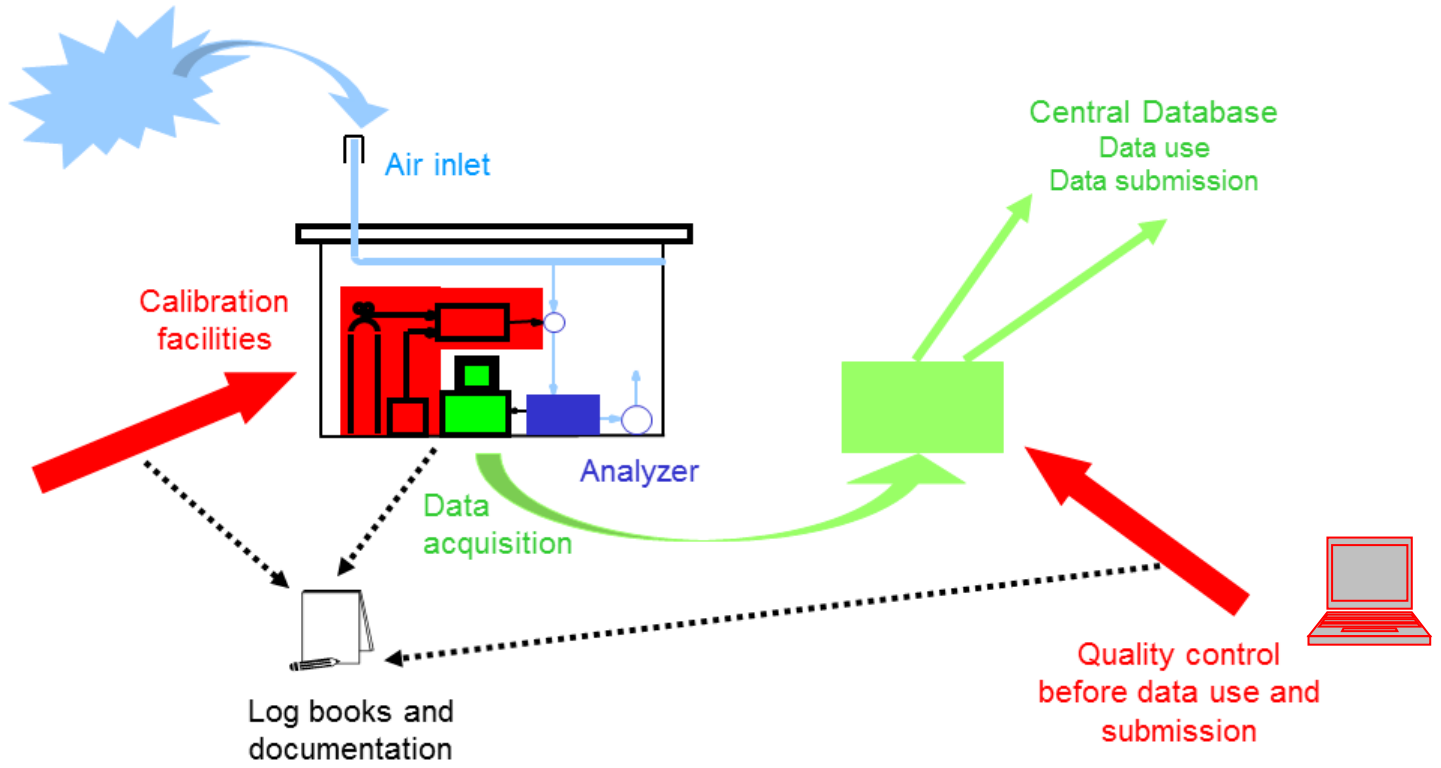
What do we need for in-situ GHG observations?



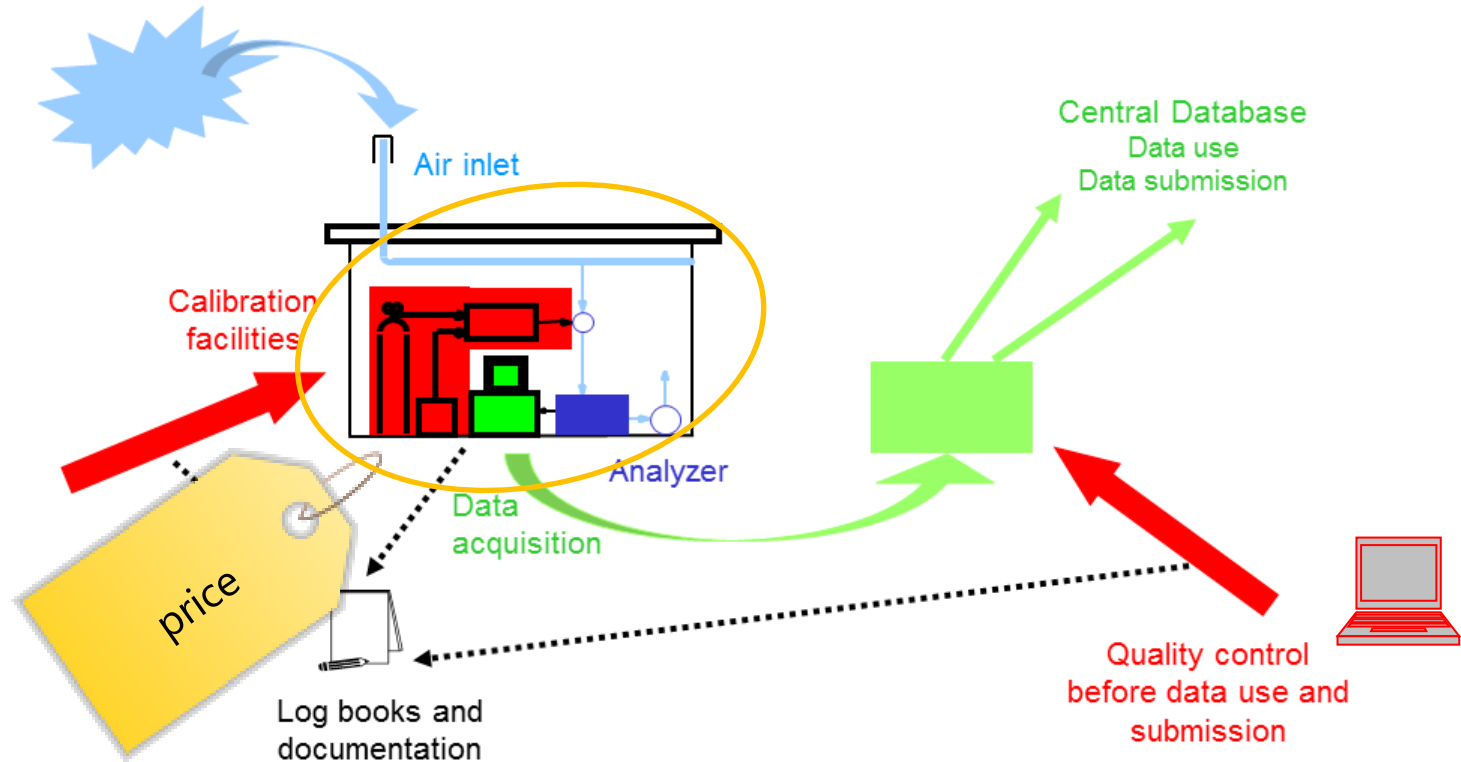
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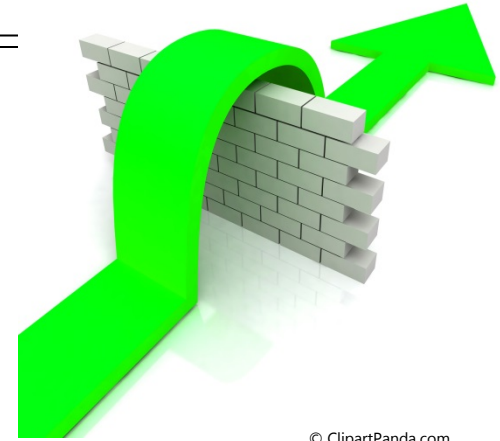


What do we need for in-situ GHG observations?



Obstacles

- lack of consumables
- lack of spare parts
- lack of budget, lack of financial authority
- hierarchy issues within the organisation
- (long-term) commitment of the partner
- insufficient know-how
- distance to the headquarters
- unclear responsibilities within an institution and among the partners
- fluctuation in staff
- language barriers
- ...



© ClipartPanda.com

Conclusions & suggestions

- capacity building is a lengthy process
- coordinated efforts (e.g. opening training during twinning activities to others) may result in more frequent training options
- an exchange of lessons-learnt may improve the impact of capacity building
- provision of more catchy information (like tick lists) would be helpful

You need:

- | | |
|------------|--------------|
| ✓ shelter | ✓ instrument |
| ✓ power | ✓ cal gases |
| ✓ A/C | ✓ calibrator |
| ✓ internet | ✓ plumbing |
| ✓ ... | ✓ ... |