The importance of training for long-term operation of atmospheric greenhouse gas observations

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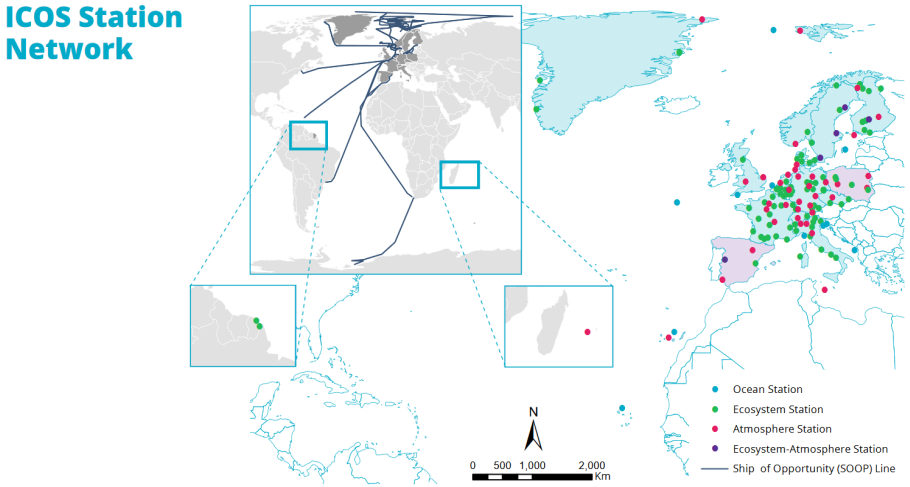
Materials Science and Technology

Rationale

- the atmospheric abundance of greenhouse gases is one of the prime drivers of climate change
- atmospheric observations need to be of known quality, of high precision and global consistency
- coordinating networks such ICOS facilitate highly compatible data over a large area



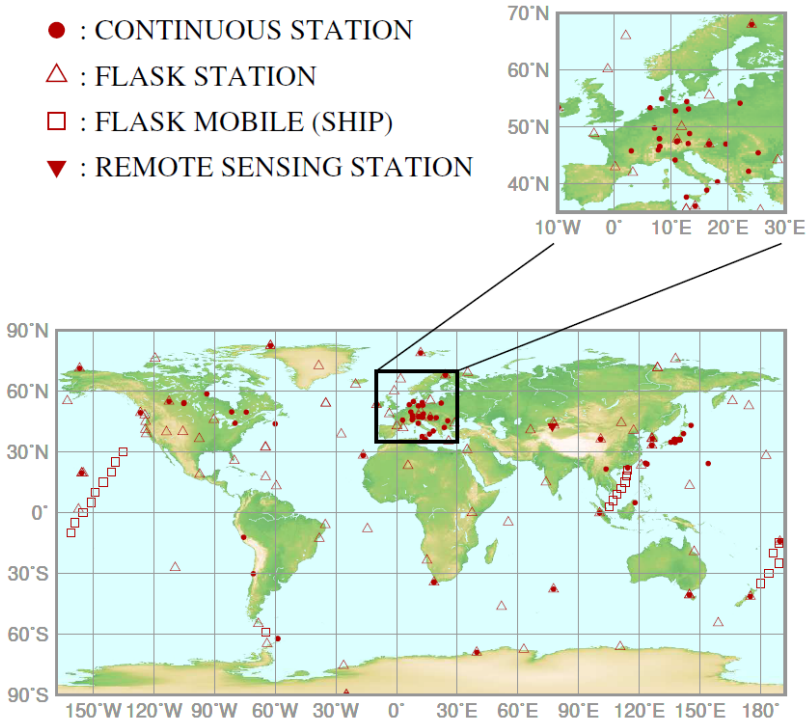
ICOS handbook, 2020

Rationale

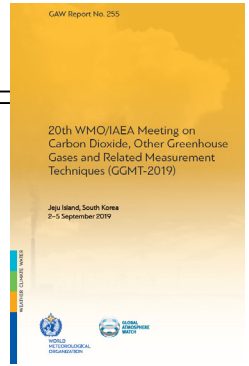
- the atmospheric abundance of greenhouse gases is one of the prime drivers of climate change
- atmospheric observations need to be of known quality, of high precision and global consistency
- coordinating networks such ICOS facilitate highly compatible data over a large area
- the availability of long-term, consistent, and publicly accessible greenhouse gases observations of adequate quality is still sparse in other regions of the world, like in the tropics and developing countries

Rationale

Stations reporting CO_2 data



WDCGG Data Summary no. 43, 2020

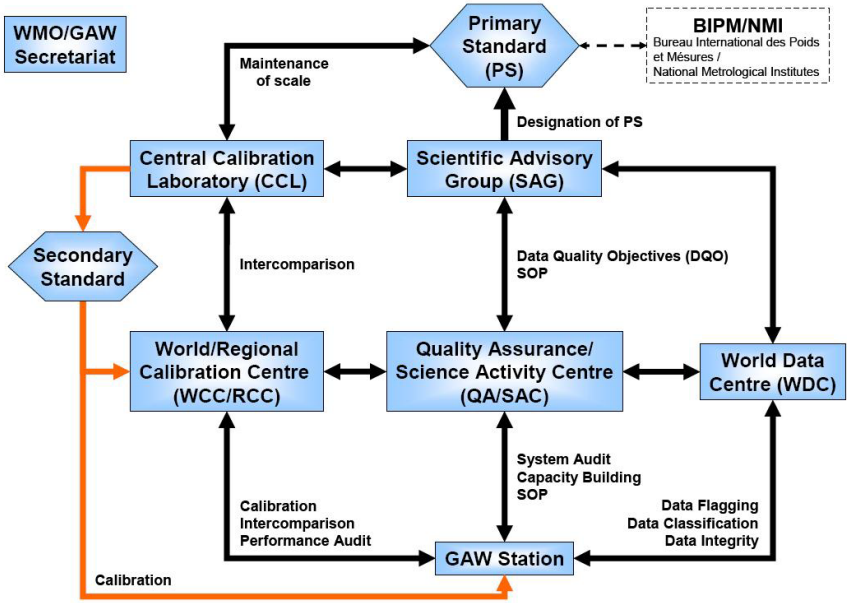


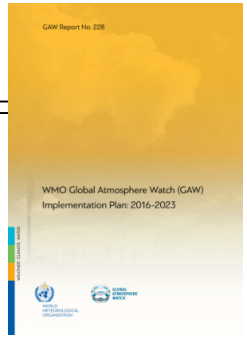
GAW report #255, 2020

" … 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. …"

Quality Management within WMO's GAW programme

Elements of the Quality Assurance system, QA activities and workflow in the Global Atmosphere Watch (GAW) program of the World Meteorological Organization (WMO)





GAW Implementation Plan 2016 – 2023, GAW report #228, 2017

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.

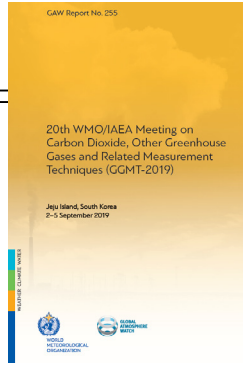
QA-6. Provide training, long-term technical help, and workshops for station scientists and technicians.

QA-7. Promote the scientific use of GAW data, and encourage and participate in scientific collaboration.

Data Quality Objectives for GHG Observations

Table 1. Recommended network compatibility of measurements within the scope of WMO/GAW

Component	*Network compatibility goal[1]*	*Extended network compatibility goal[2]*	*Range in unpolluted troposphere (approx. range for 2019)*	*Range covered by the WMO scale*
CO_2	0.1 ppm (NH) 0.05 ppm (SH)	0.2 ppm	380 - 450 ppm	250 – 520[3] 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	9 – 11 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‰	-9.5 to -7.5‰ (VPDB)	
$\delta\,^{18}O\text{-}CO_2$	0.05‰	0.1‰	-2 to +2‰ (VPDB-CO_2)	
$\delta\,^{13}C\text{-}CH_4$	0.02‰	0.2‰	-51 to -46‰ (VPDB)	
$\delta\,^{2}H\text{-}CH_4$	1‰	5‰	-120 to -63‰ (VSMOW)	
$\Delta^{14}C\text{-}CO_2$	0.5‰	3‰	-80 to 20‰	
$\Delta\,^{14}C\text{-}CH_4$	0.5‰		50-350‰	
$\Delta\,^{14}C\text{-}CO$	2 molecules cm^{-3}		0-25 molecules cm^{-3}	
O_2/N_2	2 per meg	10 per meg	-900 to -400 per meg (vs. SIO scale)	



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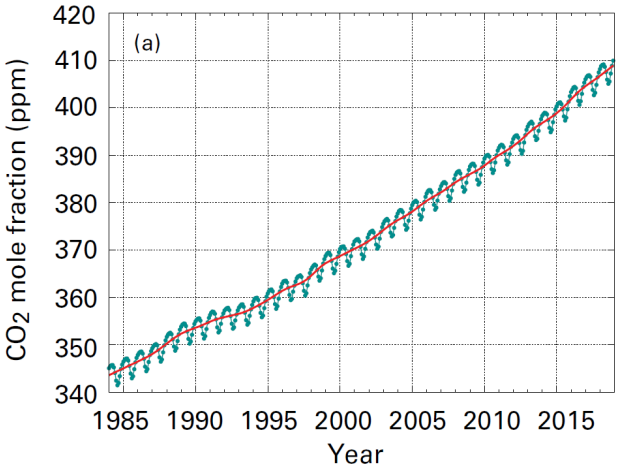
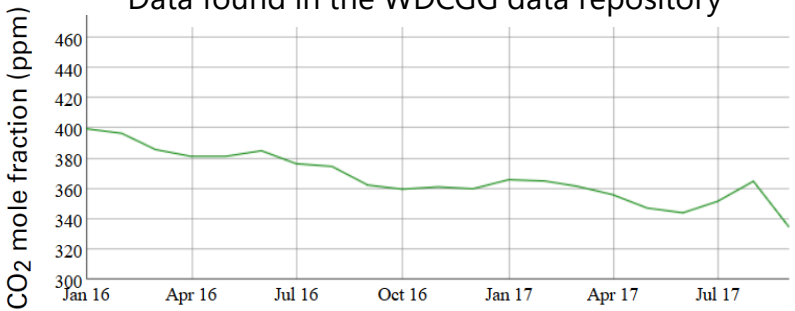
		0.1‰		

Globally averaged CO2 mole fraction



WMO Greenhouse Gas Bulletin, 2019

Data found in the WDCGG data repository



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

> 10 years

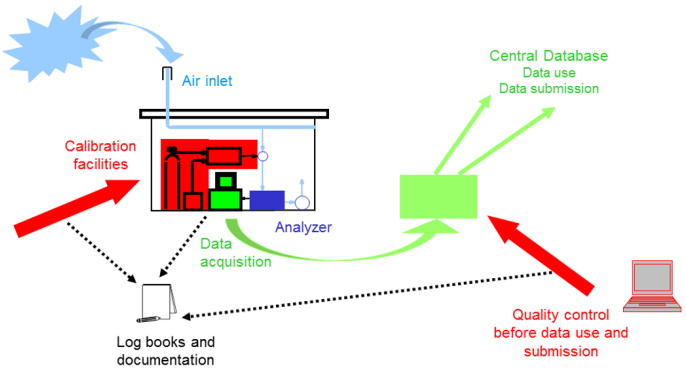




Infrastructure Requirements

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, …)
- documentation tools
- data logger / data visualization

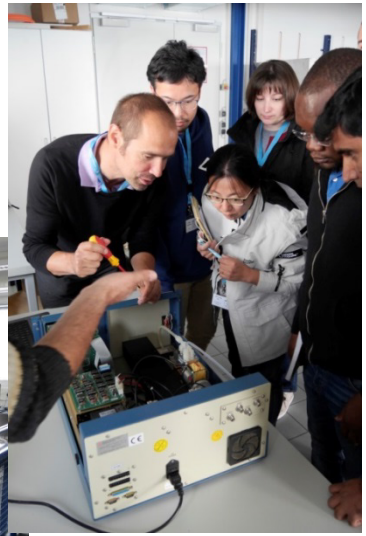
- consumables, spare parts, backup instruments, …

Hands-on training – operation and maintenance

GAWTEC – GAW Training and Education Centre, https://www.gawtec.de/

two courses per year, at Zugspitze mountain in Germany

organised by QA/SAC Germany, funded by WMO, German Environment Agency and the Bavarian State



Hands-on training – operation and maintenance

Other regional training opportunities

Curso de formación sobre Monitoreo de la calidad del aire urbano en Bolivia

Data processing and analysis

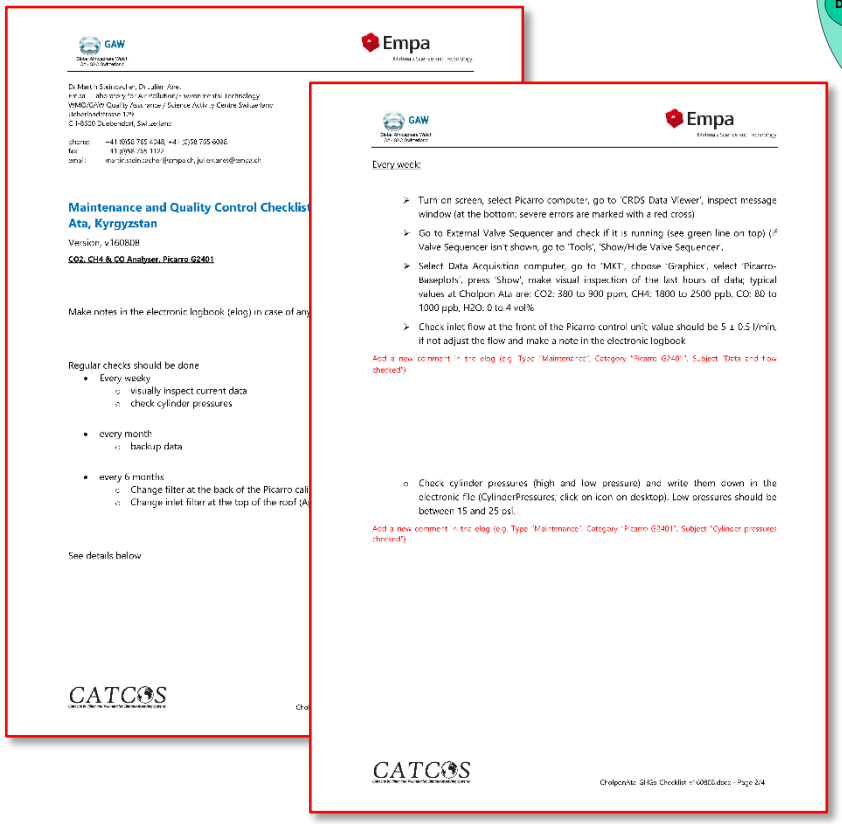
- automated procedures are encouraged
- facilitates diagnostics and quality control
- allows for re-processing of the data (e.g. in case of scale changes)

- teaching of data processing often needs to be more specific than teaching of operation and maintenance

source codes w/o graphical user interface

Remote support

- joint trouble shooting
- preparation of checklists



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Maintenance and Quality Control Checklist
Ata, Kyrgyzstan

Version: v 160808

CO2, CH4 & CO Analyser, Picarro G2401

Make notes in the electronic logbook (elog) in case of any

Regular checks should be done

- Every weeky
  - visually inspect current data
  - check cylinder pressures
- every month
  - backup data
- every 6 months
  - Change filter at the back of the Picarro cali
  - Change inlet filter at the top of the roof (A

See details below

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Every week:

- Turn on screen, select Picarro computer, go to 'CRDS Data Viewer', inspect message window (at the bottom: severe errors are marked with a red cross)
- Go to External Valve Sequencer and check if it is running (see green line on top) (if Valve Sequencer isn't shown, go to 'Tools', 'Show/Hide Valve Sequencer.
- Select Data Acquisition computer, go to 'MKT', choose 'Graphics', select 'Picarro-Baseplots', press 'Show', make visual inspection of the last hours of data; typical values at Cholpon Ata are: CO2: 380 to 900 ppm, CH4: 1800 to 2500 ppb, CO: 80 to 1000 ppb, H2O: 0 to 4 vol%
- Check inlet flow at the front of the Picarro control unit, value should be 5 ± 0.5 l/min, if not adjust the flow and make a note in the electronic logbook

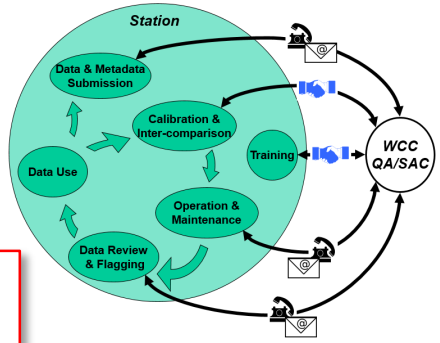
Add a new comment in the elog (eg. Type 'Maintenance', Category 'Picarro G2401', Subject 'Data and flow checked')

- Check cylinder pressures (high and low pressure) and write them down in the electronic file (CylinderPressures; click on icon on desktop). Low pressures should be between 15 and 25 psi.

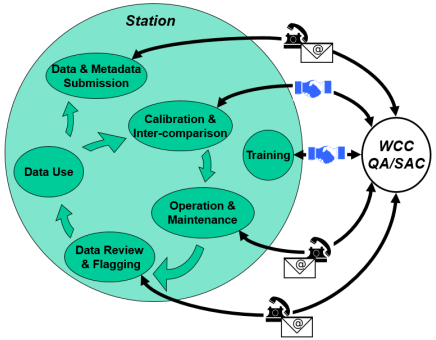
Add a new comment in the elog (eg. Type 'Maintenance', Category 'Picarro G2401', Subject 'Cylinder pressures checked')

CATCOS

Cholpon/Ata GHGs Checklist v160808.docx - Page 2/4



Remote support



- joint trouble shooting
- preparation of checklists
- release of CO_2 measurement guidelines (in preparation)
- planned: video tutorials and recordings of online seminars

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
- …

Conclusions

- capacity building is a lengthy process
- coordinated efforts (e.g. opening training during twinning activities to others) and increased use of web conferencing can 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
✓ …	✓ …

Acknowledgements:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

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Thank you for your attention.