Long-term Time Series, Quality Assurance and Control

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Atmospheric Composition

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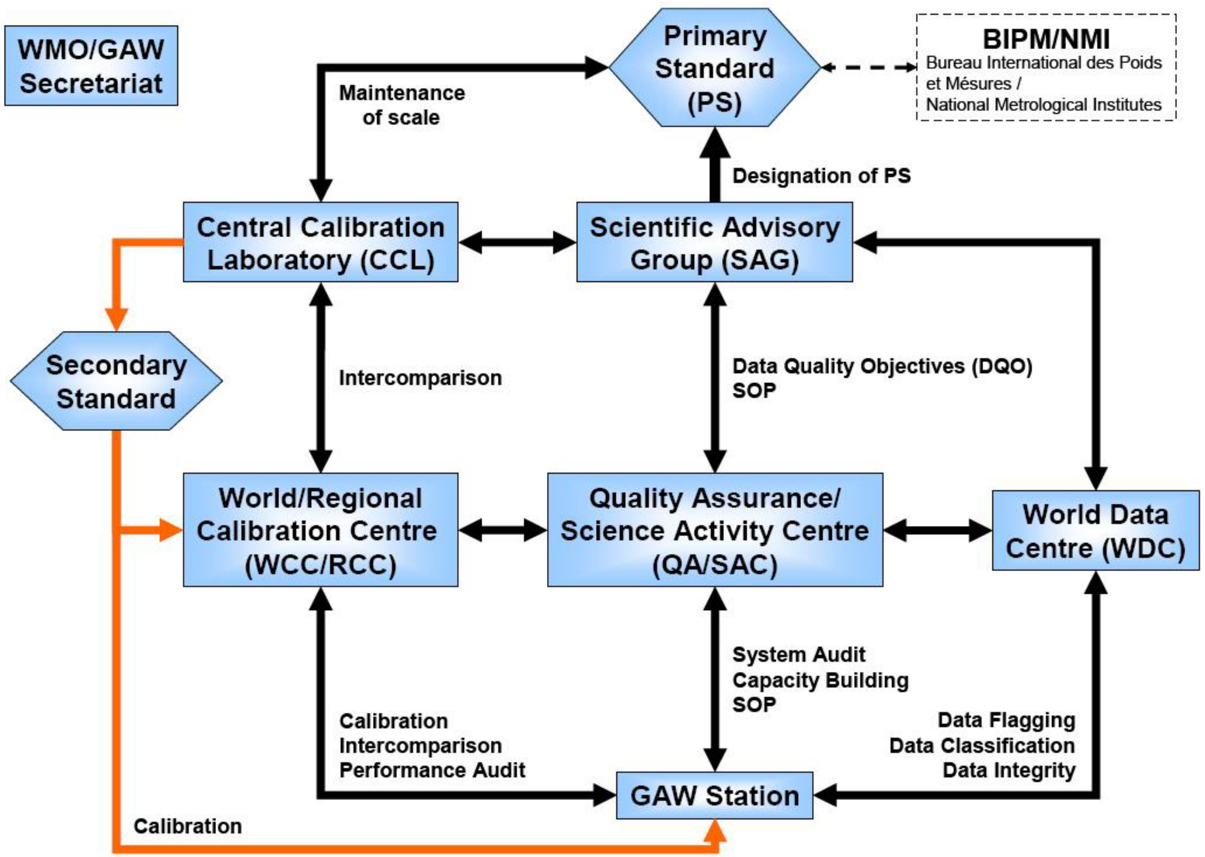
15th National GCOS Roundtable, Bern, 25 January 2018

The Global Perspective – example GAW

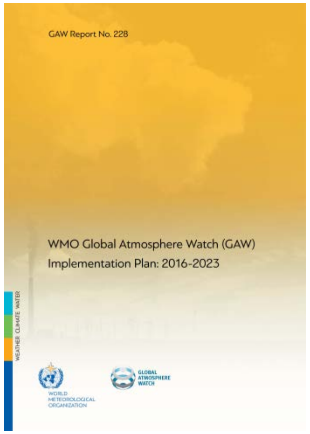
- Global Atmosphere Watch (GAW) – the atmospheric chemistry component of GCOS

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



map of GAW stations

https://gawsis.meteoswiss.ch



GAW Implementation Plan 2016-2023,
GAW Report Nr. 228, 2017

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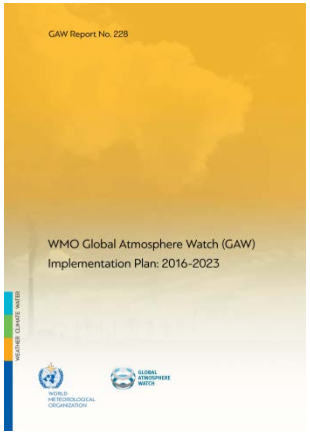
The Global Perspective – example GAW

- Global Atmosphere Watch (GAW) – the atmospheric chemistry component of GCOS

GAW Central Facilities

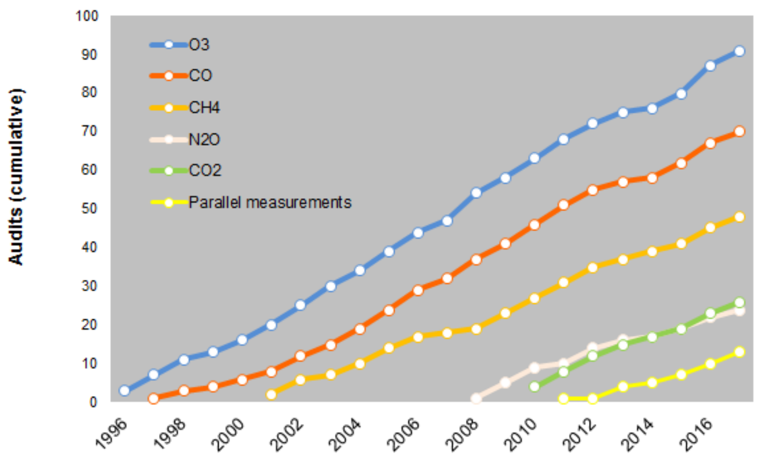
Variable	Quality Assurance / Science Activity Centre	Central Calibration Laboratory	World Calibration Centre	Regional Calibration Centres	World Data Centre
CO_2	JMA (Asia, South-West Pacific)	NOAA-ESRL	NOAA-ESRL (round robin) Empa (audits)		JMA
CO_2 Isotopes		MPI-BGC			JMA
CH_4	Empa (Americas, Europe, Africa) JMA (Asia, South-West Pacific)	NOAA-ESRL	Empa (Americas, Europe, Africa) JMA (Asia, South-West Pacific)		JMA
N_2O	UBA	NOAA-ESRL	KIT/IMK-IFU		JMA
SF_6		NOAA ESRL	KMA-KGAWC		JMA
CFCs, HCFCs, HFCs					JMA
Surface Ozone	Empa	NIST	Empa	OCBA (South America)	NILU
CO	Empa	NOAA-ESRL	Empa		JMA
VOCs	UBA	NPL (Ethane, Propane, n-butane, n-pentane, Acetylene, Toluene, Benzene, Isoprene) NIST (monoterpenes)	KIT/IMK-IFU		NILU
NO_X	UBA	NPL (NO)	FZJ (IEK-8) (NO)		NILU
SO_2					NILU

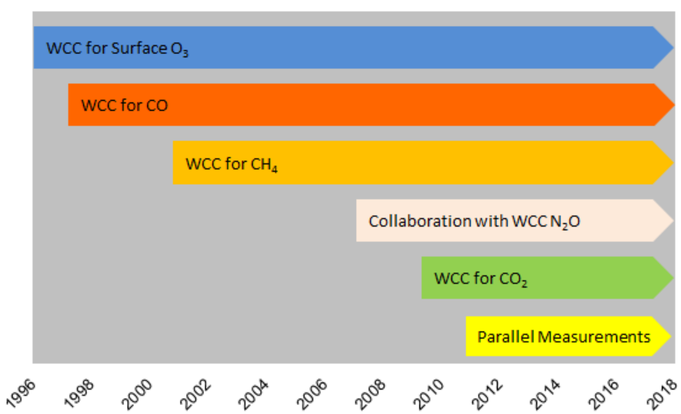


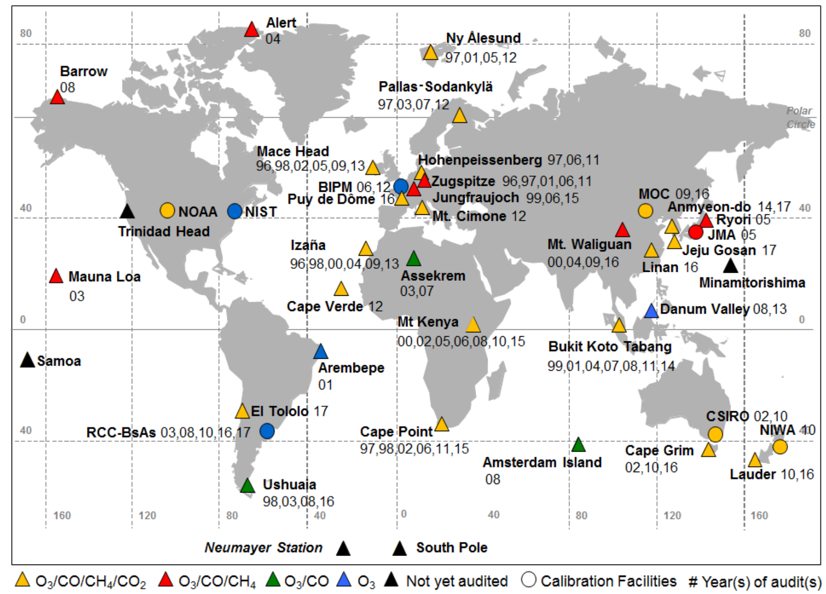
GAW Implementation Plan 2016-2023,
GAW Report Nr. 228, 2017

The Global Perspective – example WCC-Empa

- World Calibration Centre for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide (WCC-Empa)







- established in 1996, more than 90 audits since then
- ensures traceability to the GAW reference and determines compatibility
- assists stations with regards to instruments and measurement issues (WCC-Empa & QA/SAC-CH)
- improves technical know-how at stations through on-site training (WCC-Empa & QA/SAC-CH)

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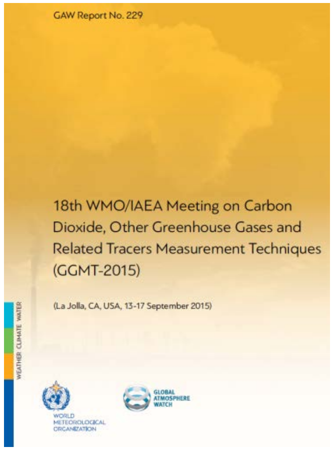
The Global Perspective – example greenhouse gases

Recommended compatibility of greenhouse gas measurements

Component	*Compatibility goal 1-sigma*	*Extended compatibility goal*[1]	*Range in unpolluted troposphere (approx. range for 2015)*	*Range covered by the WMO scale*
CO_2	± 0.1 ppm (North.Hem.) ± 0.05 ppm (So.Hemisph)	± 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
$\delta^{13}C$-CO_2	± 0.01‰	± 0.1‰	-9.5 to -7.5‰ (VPDB)	
$\delta^{18}O$-CO_2	± 0.05‰	± 0.1‰	-2 to +2‰ (VPDB-CO_2)	
$\Delta^{14}C$-CO_2	± 0.5‰	± 3‰	-50 to 50‰	
$\Delta^{14}C$-CH_4	± 0.5‰		50-350‰	
$\Delta^{14}C$-CO	± 2 molecules cm^{-3}		0-25 molecules cm^{-3}	
$\delta^{13}C$-CH_4	± 0.02‰	± 0.2‰		
δ D-CH_4	± 1‰	± 5‰		
O_2/N_2	± 2 per meg	± 10 per meg	-900 to -400 per meg (vs. SIO scale)	



GGMT-2015 Report,
GAW Report Nr. 229, 2016

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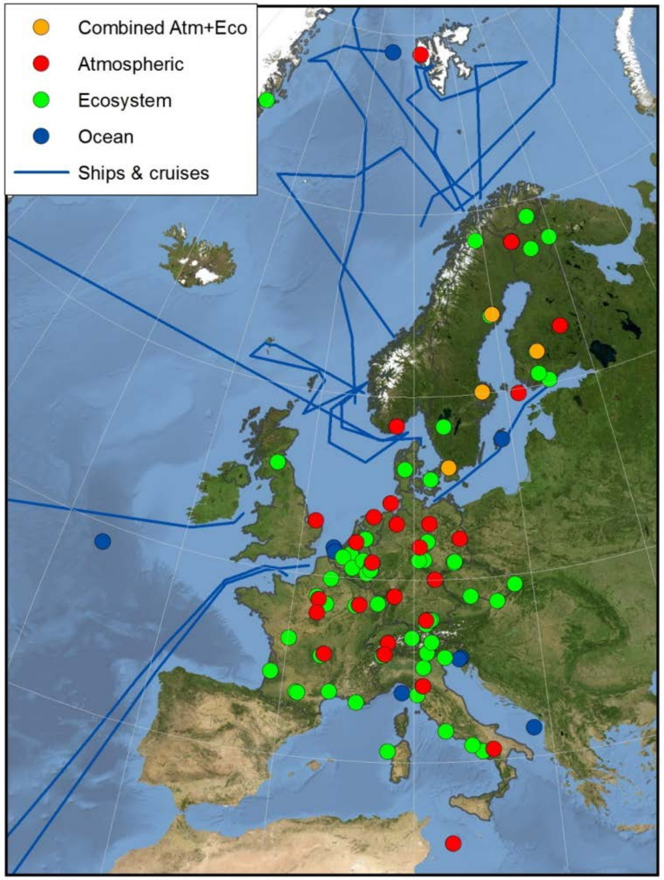
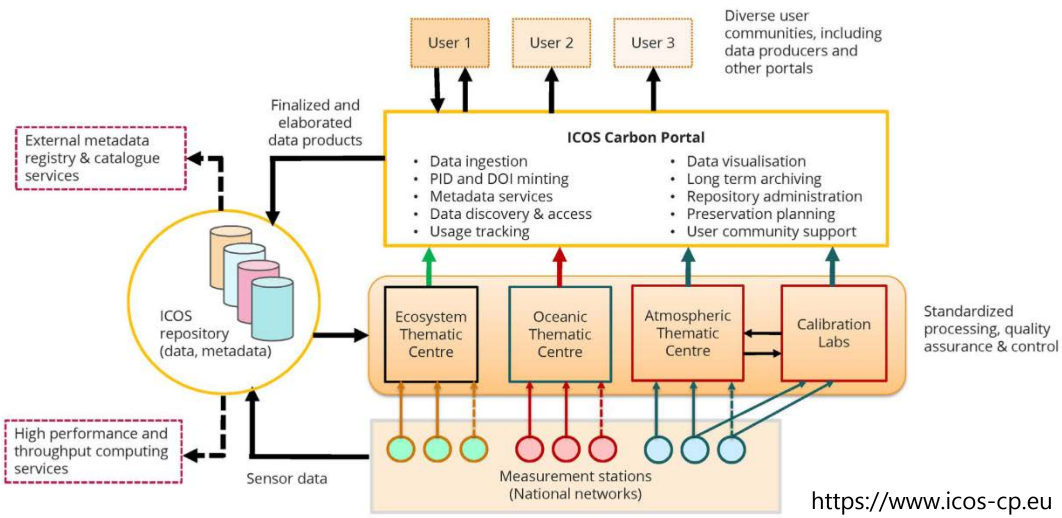
The European Perspective – example ICOS

- Integrated Carbon Observation System (ICOS) – a pan-European research infrastructure which provides harmonized and high precision scientific data on carbon cycle and greenhouse gas budget and perturbations

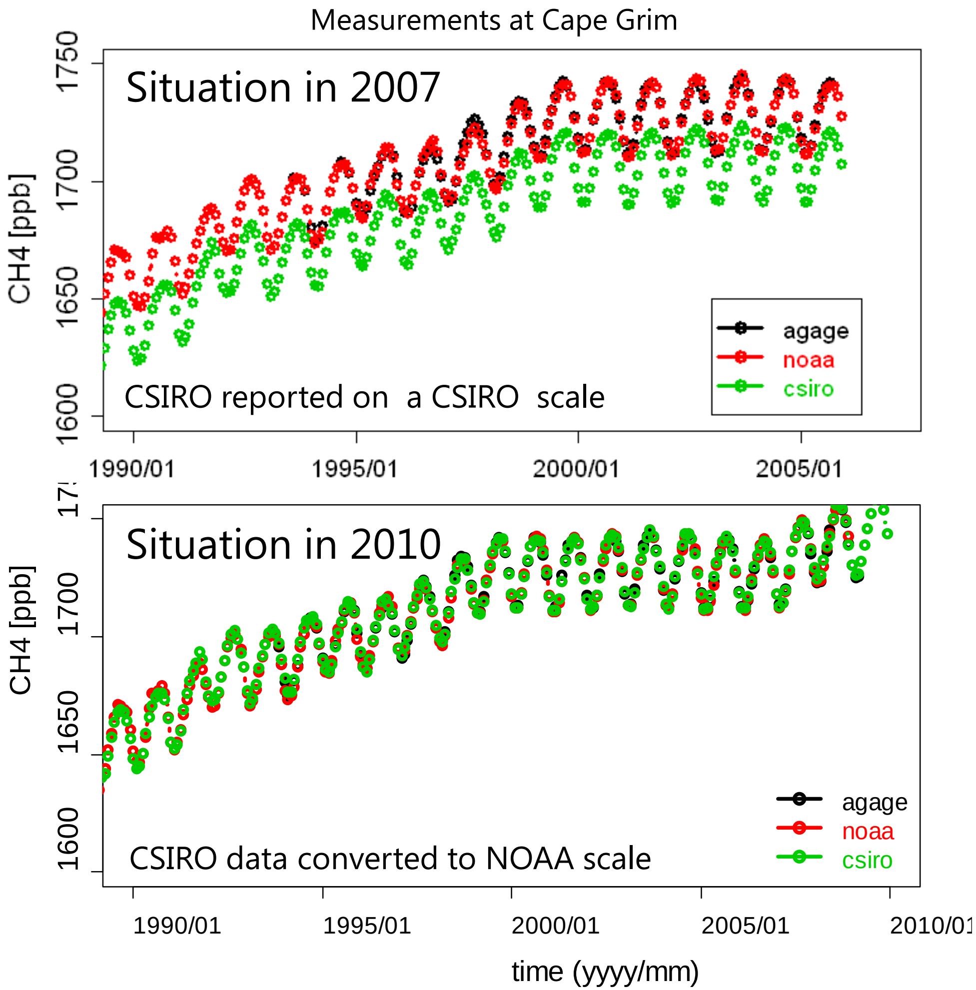




https://www.icos-cp.eu

- standardized instruments and procedures
- central provision of reference gases
- central data processing and data dissemination

Measurement networks – homogeneity vs. diversity



NOAA04 CH_4 scale = GAW reference, scale revision published in 2005

AGAGE CH_4 scale: Tohoku University (TU)

Conversions between scales

NOAA04/TU = 1.0003

NOAA04/CSIRO = 1.0122

(see Dlugokencky et al., JGR, 2005)

A diversity of independent quality-controlled, transparent and traceable measurement and calibration methods in encouraged. This diversity assures that the measurements remain robust and less vulnerable to systematic or method-specific error. Rigorous and frequent comparison of independent methods and standards is key.

GGMT-2015 Report, GAW Report Nr. 229, 2016

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Measurement uncertainty

Table 1 - Example of an uncertainty budget of an ozone analyser

Component (*y*)	Source	Distribution	Contribution to *u(x)*
Imperfect calibration / linearity	Comparison between TS and OA	Rectangular	0.0017·*x*[*]
Repeatability	Instrument stability	Rectangular	0.0016·*x*
Span drift	Instrument stability	Rectangular	0.0040·*x*
Zero drift	Instrument stability	Rectangular	0.17
Pressure *P*	Pressure measurement	Rectangular	0.0002·*x*
Temperature *T*	Temp. measurement	Rectangular	0.0005·*x*
H_2O interference	Interference in the UV		0.0060·*x*
Other interferences	Interference in the UV		0.6
Sampling loss (Inlet)	Inlet material, dirt	Rectangular	0.0014·*x*

[*] *where x refers to ozone mole fraction*

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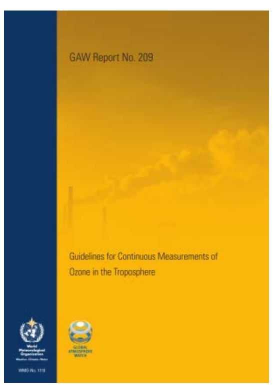
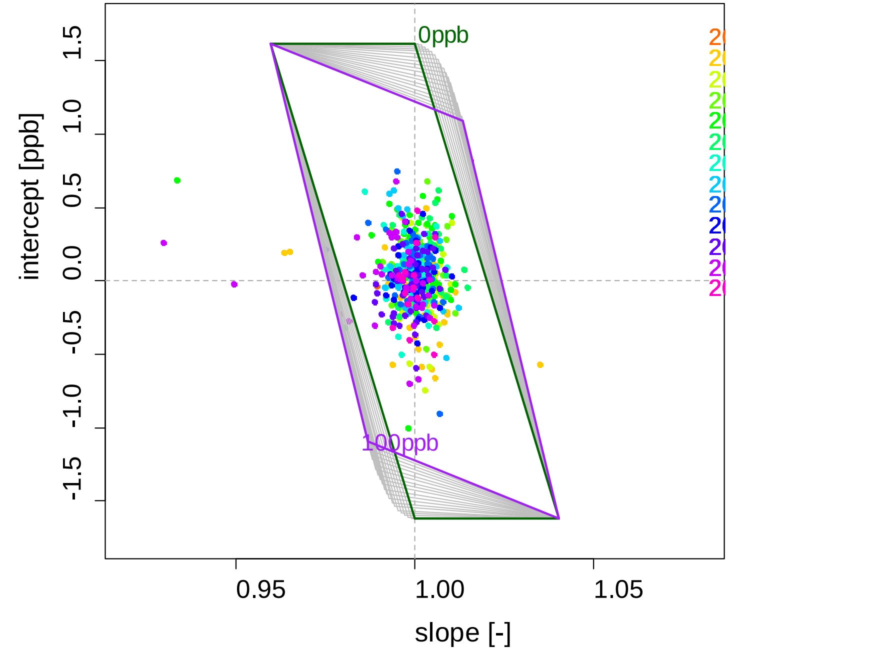
A conservative estimate of the total uncertainty can now be obtained by combing the uncertainties of the ozone analyser (13), the transfer standard (12) and the primary reference (11).

$$u(O_3) = \sqrt{(0.81)^2 + (0.0089 \times O_3)^2} \text{ nmol mol}^{-1} \quad (14)$$



O3 measurement guidelines,
GAW Report Nr. 209, 2013

Intercept vs. slope plot for 559 calibrations of various ozone analysers with transfer standards within the Swiss National Air Pollution Monitoring Network between November 2005 and April 2017



Tarasick et al., in prep.

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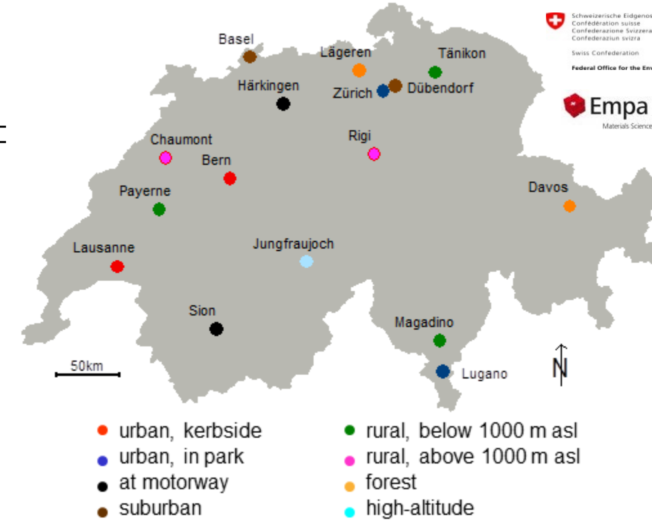
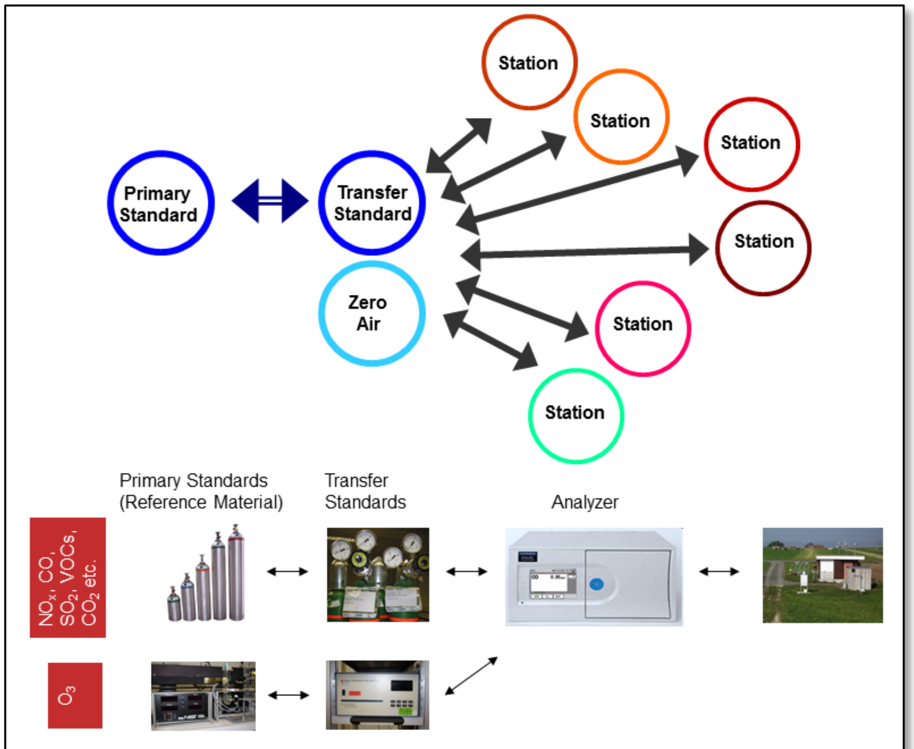
The Swiss Perspective – NABEL

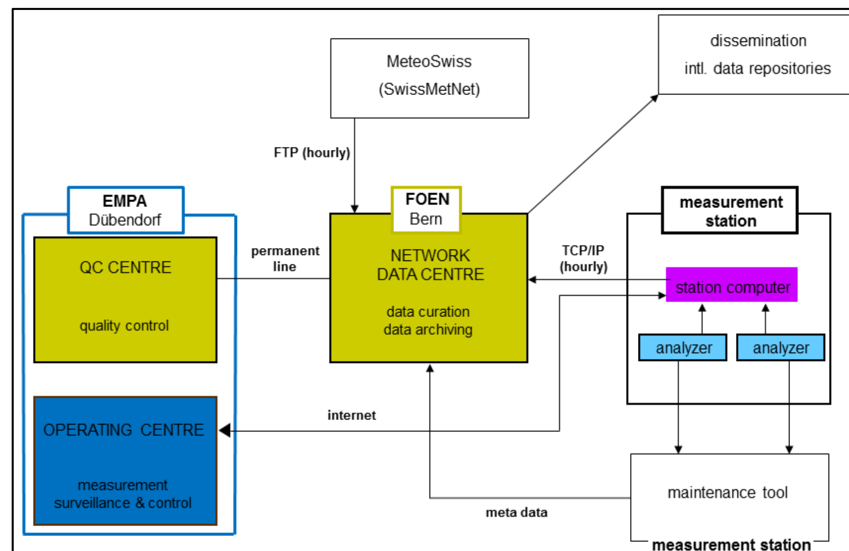
Swiss National Air Pollution Monitoring Network



traceability



data flow



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Requirements, Achievements & Shortcomings

Requirements
- full adherence to the GCOS Monitoring Principles
  - long-term data, consistent, of adequate quality, and available world-wide

Achievements
- through GAW, quality management framework, central facilities, measurement guidelines, data repositories, etc. are in place

Shortcomings
- truly global coverage of high-quality observations is lacking
- main deficits are:
  - long-term, high-level (financial) commitment
  - skilled personnel and adequate infrastructure
  - data dissemination
  - documentation (metadata)
  - uncertainty assessments