Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office of Meteorology and Climatology MeteoSwiss

WMO GAW

Empa
Materials Science and Technology

Introduction to Empa and Swiss GAW activities

Martin Steinbacher

Empa, Laboratory for Air Pollution/Environmental Technology, Dübendorf, Switzerland

Training of KMD staff, Duebendorf, 28 June till 02 July 2018

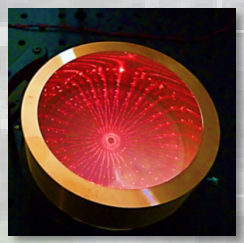
Empa in Numbers (2016)

www.empa.ch

- 3 Sites in Switzerland — Dübendorf, St. Gallen, Thun
- 5 Departments

30	Laboratories
940	Employees (860 FTE; about 29% Women)
30	Professors
200	PhD Students
42	Apprentices
> 200	Master Students & Interns

Research Focus Areas



Natural Resources & Pollutants

Health & Performance

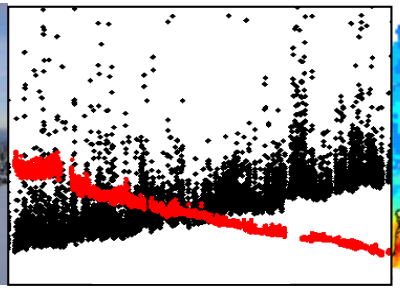
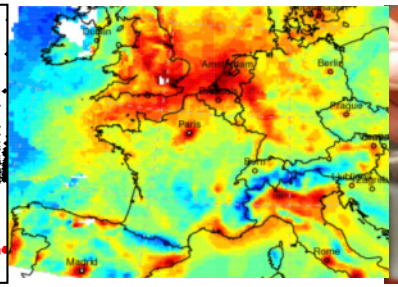
Sustainable Built Environment

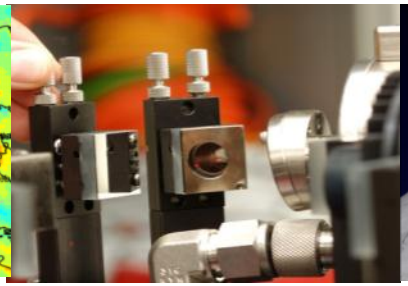
Energy

Nanostructured Materials

Empa

Air Pollution & Environmental Technology Lab



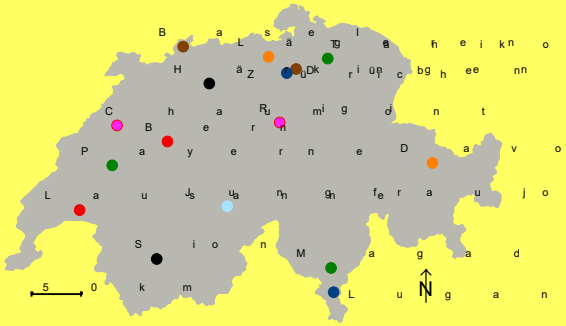

APPROACH & GOAL

- to **understand emissions** and fate of man-made pollutants and greenhouse gases
- to **provide the scientific basis** for technical solutions to reduce emissions
- to **guide decision makers** in the field of environmental politics

Research Sites & Central Facilities

- **field sites**

Swiss National Air Pollution Monitoring Network



Process studies

- **computing capacity:** Empa-Cluster: IPAZIA / CSCS Manno / C2SM

- **labs**

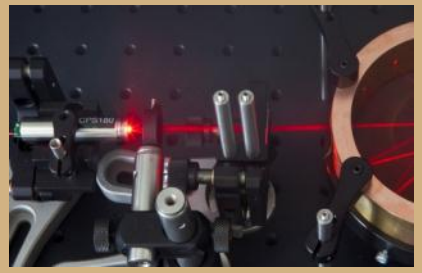
Central Calibration Lab
Swiss Air Pollution Network

Reference materials & Instrument testing

Global Atmosphere Watch

World Calibration Centre & QA /SAC Switzerland

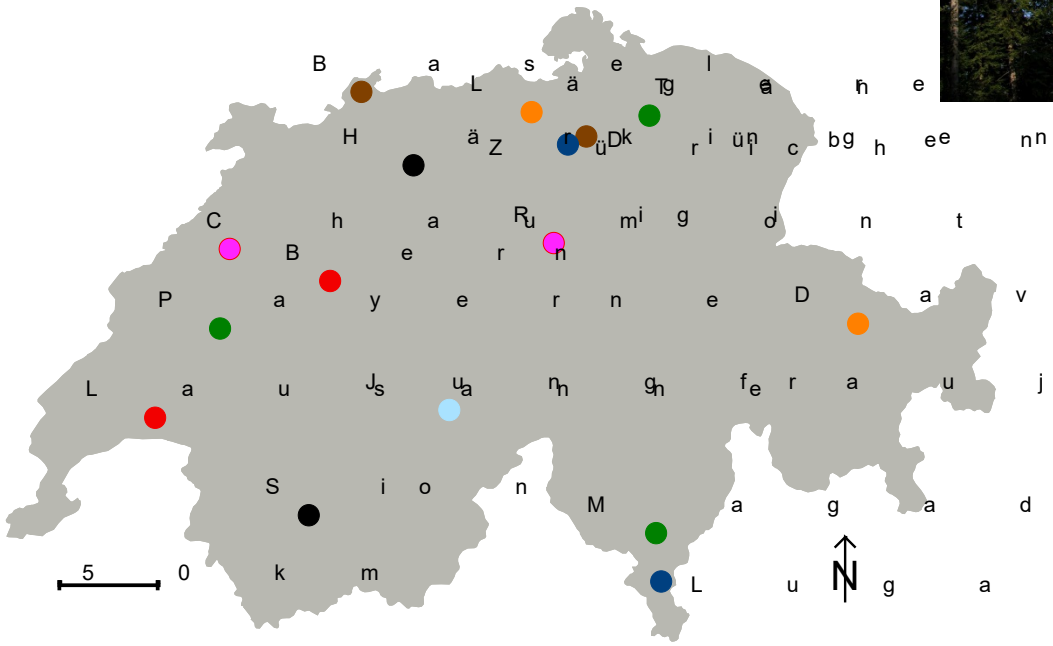
Spectroscopic Lab



optical table and electronics instrument development

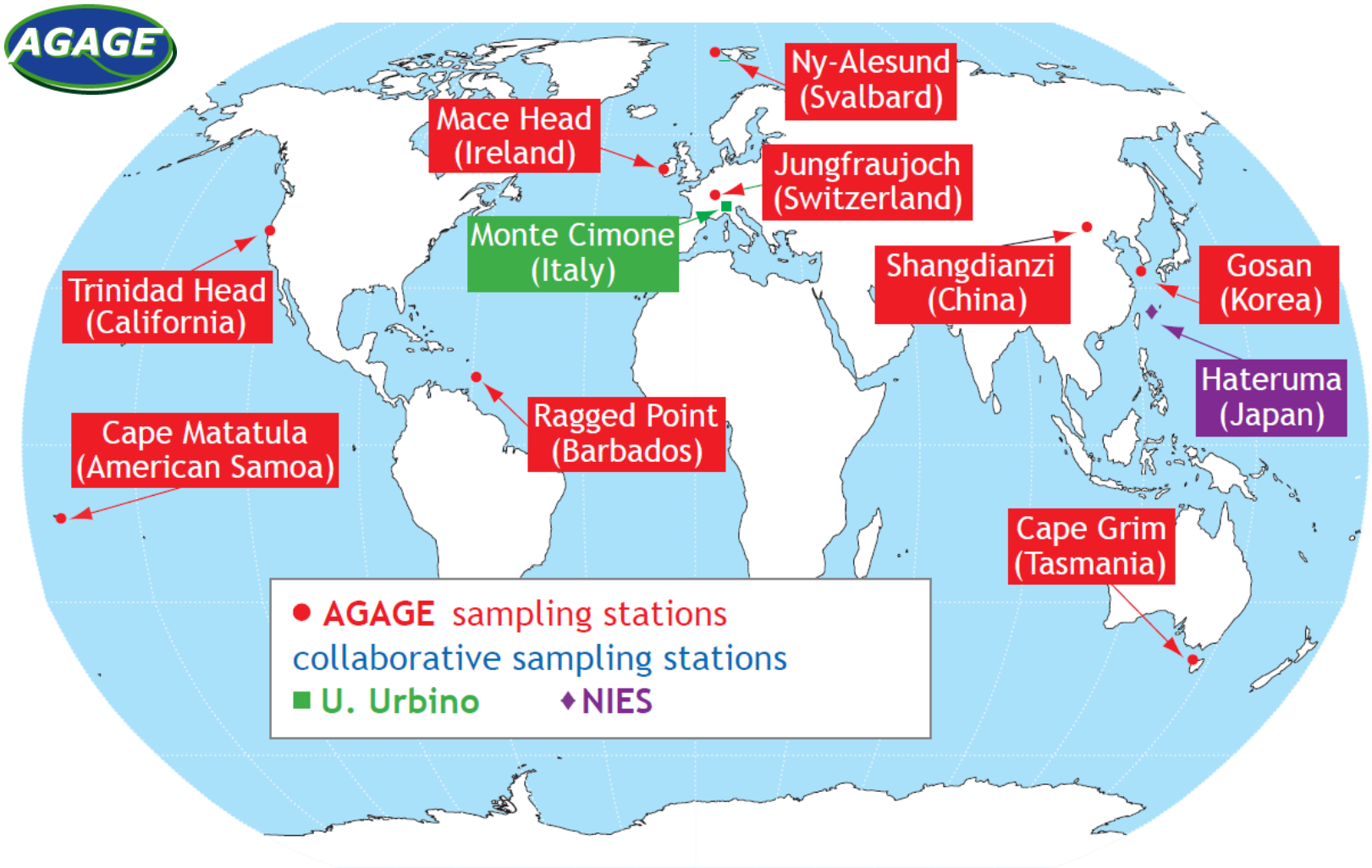
Swiss National Air Pollution Monitoring Network

NABEL



- urban, kerbside
- urban, in park
- at motorway
- suburban
- rural, below 1000 m asl
- rural, above 1000 m asl
- forest
- high-altitude

AGAGE and collaborative sites



The Swiss GAW-Programme

- under the auspices of MeteoSwiss
- operation of the global GAW station Jungfraujoch (Uni Bern, Empa, PSI, Uni Liege, BIRA Brussels, MeteoSwiss)
- vertical ozone distribution and total ozone in Payerne und Arosa (MeteoSwiss)
- radiation measurement network in Payerne, Davos, Locarno und Jungfraujoch (MeteoSwiss)
- World Optical Depth Research and Calibration Center (WORCC) (PMOD)
- World Calibration Centre (WCC) for surface ozone, methane, carbon monoxide and carbon dioxide (Empa)
- Quality Assurance / Science Activity Centre (QA/SAC) (Empa)
- support of ozone soundings in Nairobi, Kenya (MeteoSwiss)
- partnership with stations in Algeria, Indonesia and Kenya (part of QA/SAC)
- operation of the GAW-Station Information System (MeteoSwiss)

Empa's Contribution to the GAW – Observing System

Operation (Gases)

Swiss global GAW station

Swiss regional GAW stations

Collaboration & Twinning

Support for new stations

Comprehensive Measurement Programme @ JFJ

Reactive Gases and Greenhouse Gases

nearly 100 continuous time-series

Halocarbons

Montreal & Kyoto relevant, including SF_6

Greenhouse Gases

N_2O CH_4 CO_2

$^{13}C\text{-}CO_2$ & $^{18}C\text{-}CO_2$ cont.

Reactive Gases

Ozone CO SO_2

NO_2 NO NO_y

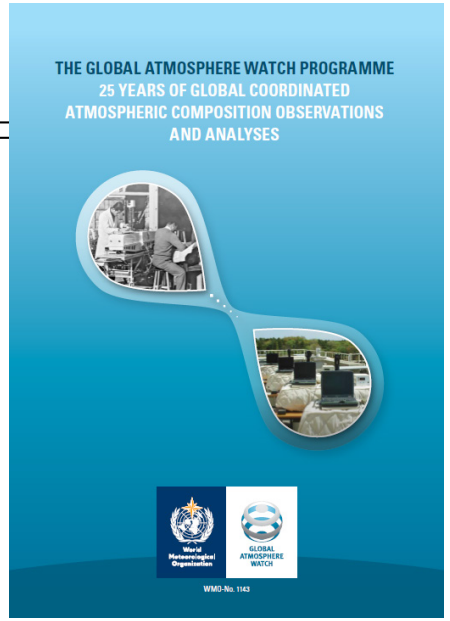
H_2 VOC

Empa

JFJ within GAW

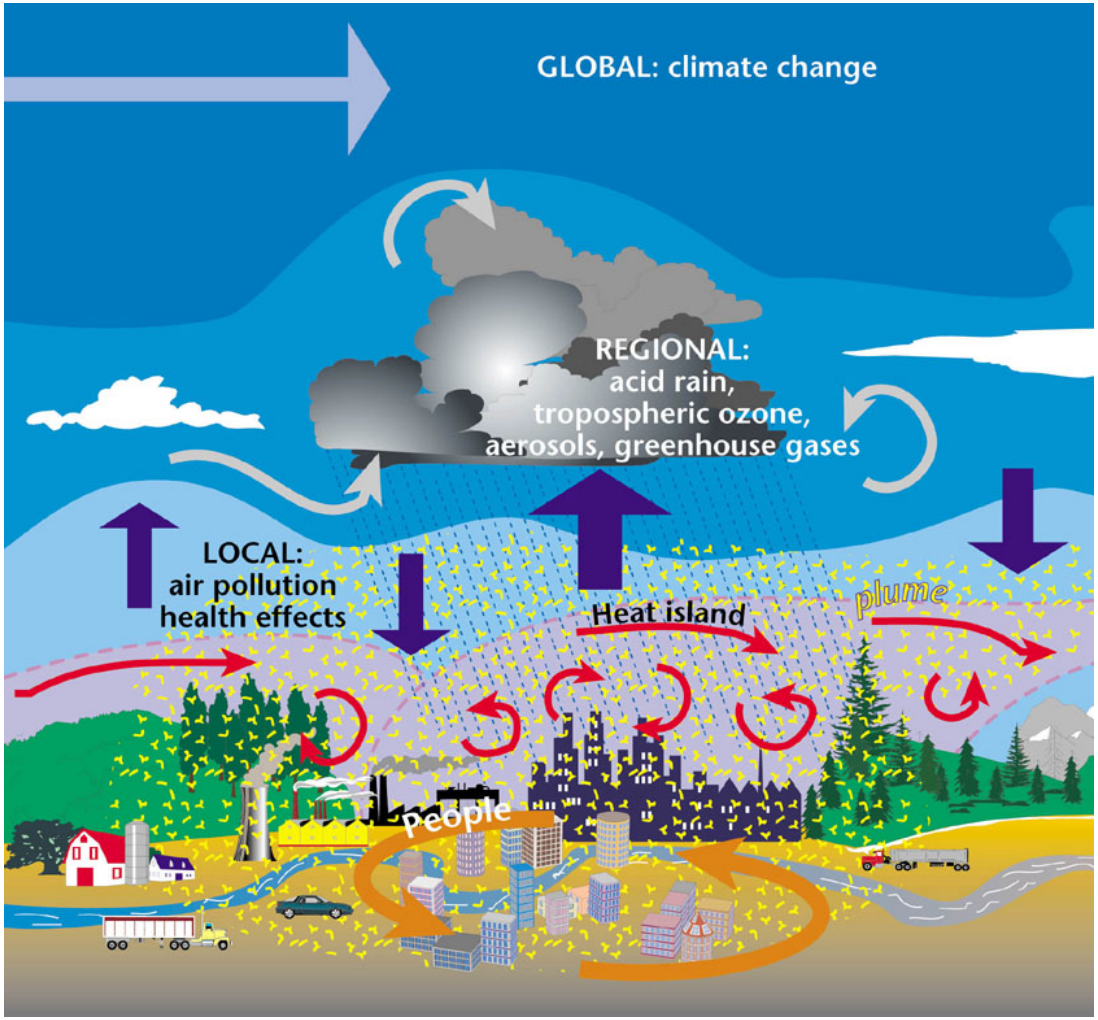
History of GAW

- 1950s: WMO launched first a programme on atmospheric chemistry and the meteorological aspects of air pollution
- 1957 (International Geophysical Year): development of first standard operation procedures, central data centres; establishment of Global Ozone Observing System (GO3OS)
- Late 1960s: Background Air Pollution Monitoring Network (BAPMoN) was established, focusing on precipitation chemistry, aerosol and carbon dioxide measurements
- In 1989: GO3OS and BAPMoN were consolidated into the Global Atmosphere Watch (GAW) programme



further reading:
Global Atmosphere Watch (GAW) Programme: 25 years of global coordinated atmospheric composition observations and analyses
https://library.wmo.int/pmb_ged/wmo_1143_en.pdf

Air Pollution and Climate – different scales



source: http://mce2.org/wmogurme/

More further reading

The Global Atmosphere Watch reactive gases measurement network

Martin G. Schultz[1*] • Hajime Akimoto[2,3] • Jan Bottenheim[4] • Brigitte Buchmann[5] • Ian E. Galbally[6] • Stefan Gilge[7] • Detlev Helmig[8] • Hiroshi Koide[9] • Alastair C. Lewis[10] • Paul C. Novelli[11] • Christian Plass-Dülmer[7] • Thomas B. Ryerson[11] • Martin Steinbacher[5] • Rainer Steinbrecher[12] • Oksana Tarasova[13] • Kjetil Tørseth[14] • Valerie Thouret[15] • Christoph Zellweger[5]

Elementa: Science of the Anthropocene • 3: 000067 • doi: 10.12952/journal.elementa.000067
elementascience.org

Global distribution and trends of tropospheric ozone: An observation-based review

O. R. Cooper[1,2*] • D. D. Parrish[2] • J. Ziemke[3] • N. V. Balashov[4] • M. Cupeiro[5] • I. E. Galbally[6] • S. Gilge[7] • L. Horowitz[8] • N. R. Jensen[9] • J.-F. Lamarque[10] • V. Naik[8,11] • S. J. Oltmans[1,2] • J. Schwab[12] • D. T. Shindell[13] • A. M. Thompson[4,14] • V. Thouret[15] • Y. Wang[16] • R. M. Zbinden[17]

Elementa: Science of the Anthropocene • 2: 000029 • doi: 10.12952/journal.elementa.000029
elementascience.org

Atmos. Chem. Phys., 16, 1445–1457, 2016
www.atmos-chem-phys.net/16/1445/2016/
doi:10.5194/acp-16-1445-2016

How to most effectively expand the global surface ozone observing network

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[2]National Centre for Atmospheric Science, Department of Chemistry, University of York, York, YO10 5DD, UK

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Received: 15 July 2015 – Published in Atmos. Chem. Phys. Discuss.: 5 August 2015
Revised: 27 December 2015 – Accepted: 18 January 2016 – Published: 9 February 2016

Schultz, MG, et al 2017 Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations. *Elem Sci Anth*, 5: 58, DOI: https://doi.org/10.1525/elementa.244

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations

Martin G. Schultz[1,82], Sabine Schröder[1], Olga Lyapina[1], Owen R. Cooper[2,3], Ian Galbally[4], Irina Petropavlovskikh[2,3], Erika von Schneidemesser[5], Hiroshi Tanimoto[6], Yasin Elshorbany[7,8], Manish Naja[9], Rodrigo J. Seguel[10], Ute Dauert[11], Paul Eckhardt[12], Stefan Feigenspan[11], Markus Fiebig[12], Anne-Gunn Hjellbrekke[12], You-Deog Hong[13], Peter Christian Kjeld[14], Hiroshi Koide[15], Gary Lear[16], David Tarasick[17], Mikio Ueno[15], Markus Wallasch[18], Darrel Baumgardner[19], Ming-Tung Chuang[20], Robert Gillett[4], Meehye Lee[21], Suzie Molloy[4], Raeesa Moolla[22], Tao Wang[23], Katrina Sharps[24], Jose A. Adame[25], Gerard Ancellet[26], Francesco Apadula[27], Paulo Artaxo[28], Maria E. Barlasina[29], Magdalena Bogucka[30], Paolo Bonasoni[31], Limseok Chang[32], Aurelie Colomb[33], Emilio Cuevas-Agulló[34], Manuel Cupeiro[35], Anna Degorska[36], Aijun Ding[37], Marina Fröhlich[38], Marina Frolova[39], Harish Gadhavi[40], Francois Gheusi[41],

… more to come later today

GAW Rationale

- Need to understand and control the increasing human influence on the global atmosphere.
- Need to mitigate socio-economic consequences affecting
  - weather,
  - climate,
  - human and ecosystem health,
  - water supply and quality,
  - agricultural productivity.

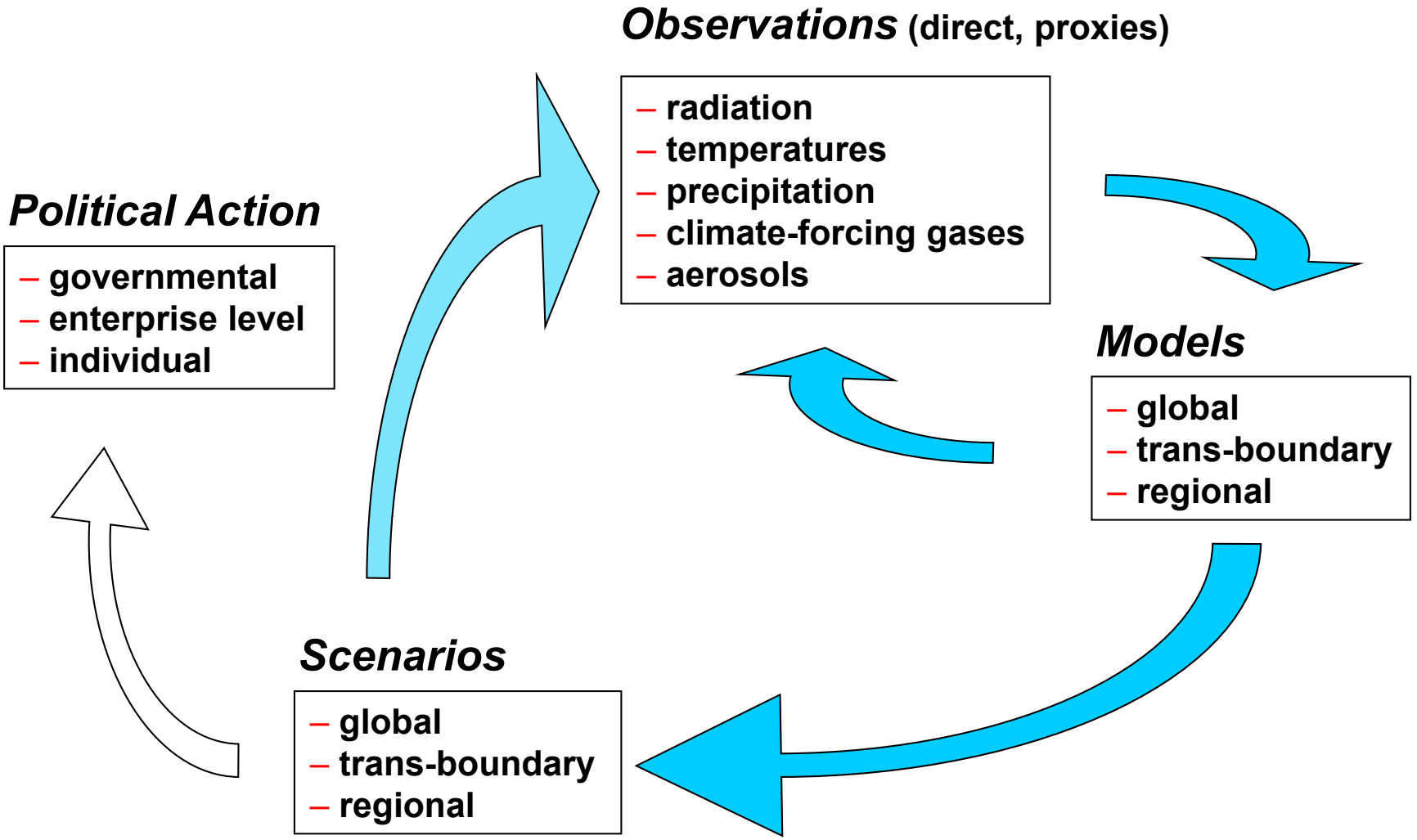
GAW Strategic Plan: 2008–2015
GAW Report # 172, 2007

Major Challenges

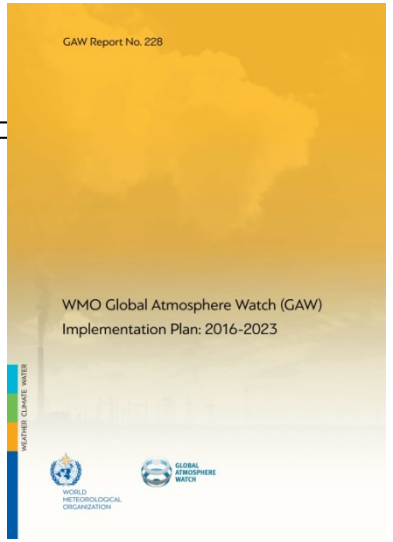
- Stratospheric ozone depletion and the increase of ultraviolet (UV) radiation.
- Changes in the weather and climate related to human influence on atmospheric composition, particularly, greenhouse gases, ozone and aerosols
- Risk reduction of air pollution on human health and issues involving long-range transport and deposition of air pollution.
- 'Chemical weather' prediction, 'high impact weather'

GAW Strategic Plan: 2008–2015
GAW Report # 172, 2007

Understanding & Mitigating Atmospheric Change



GAW Rationale, as of 2017

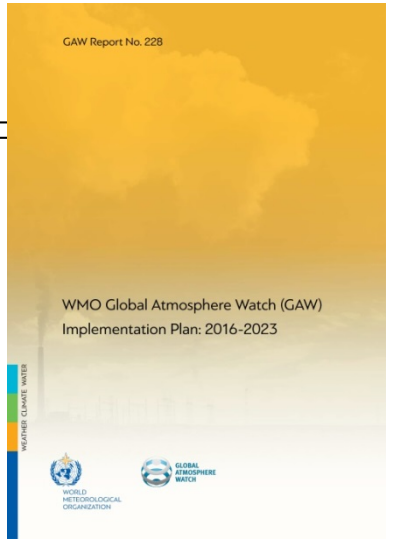


science for services

This Implementation Plan (IP) builds upon the growing importance of atmospheric composition observations and predictions, and focuses on research that enables a wide variety of **Products and Services** related to atmospheric composition. [...] GAW-lead thematic application areas [Monitoring of Atmospheric Composition, Forecasting Atmospheric Composition Change, Providing Atmospheric Composition information to support services in urban and populated areas] will help reduce societal risks from climate change, high-impact weather and events, and urban air pollution, and support conventions and treaties focused on sustainable development.

GAW Implementation Plan: 2016-2023,
GAW Report # 228, 2017

GAW Mission



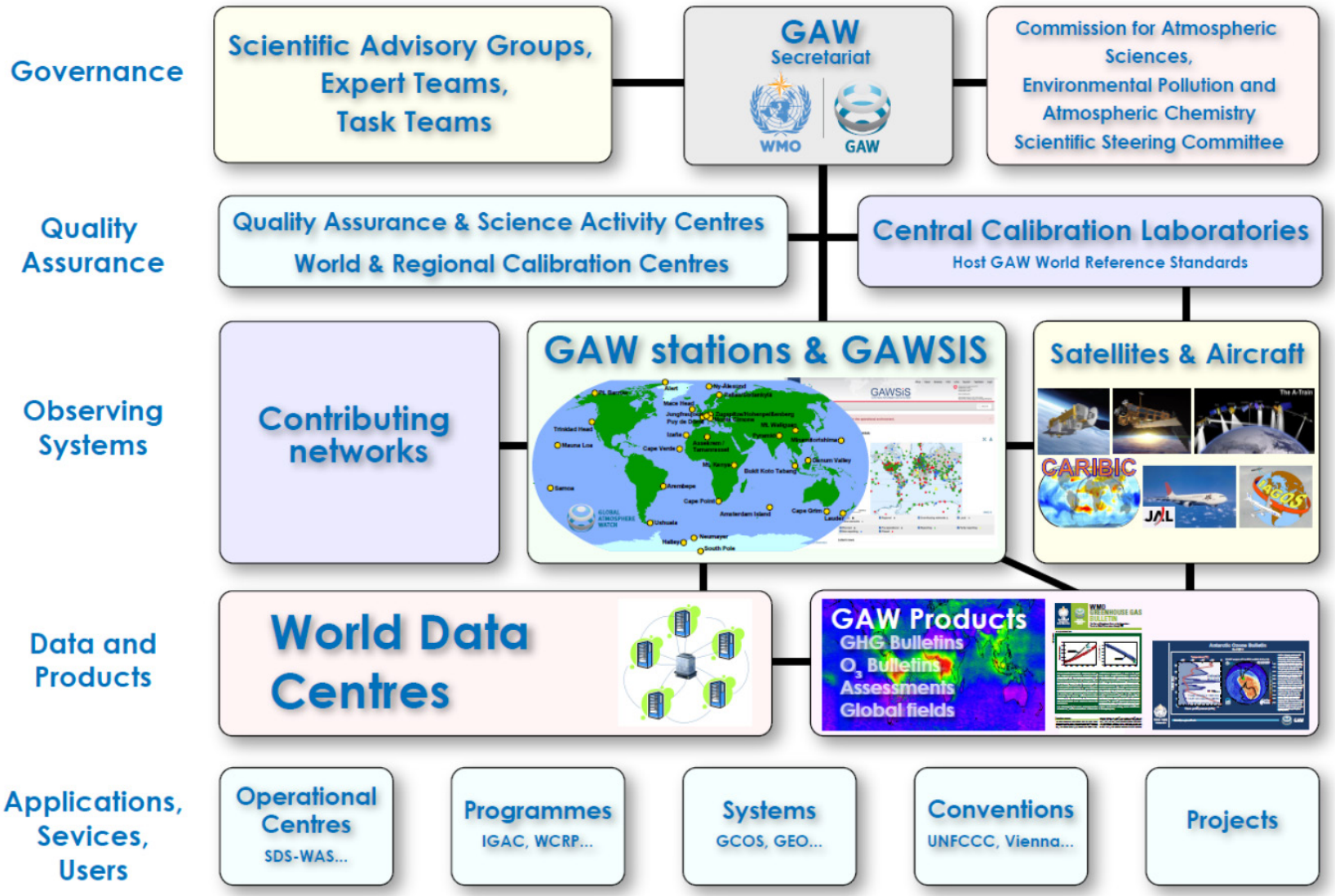
- **Reduce environmental risks** to society and meet the requirements of environmental conventions.
- Strengthen capabilities to **predict climate, weather and air quality.**
- **Contribute to scientific assessments** in support of environmental policy.

through

- Maintaining and applying global, long-term **observations** of the chemical composition and selected physical characteristics of the atmosphere.
- Emphasizing **quality assurance and quality control**.
- Delivering **integrated products and services** of relevance to users.

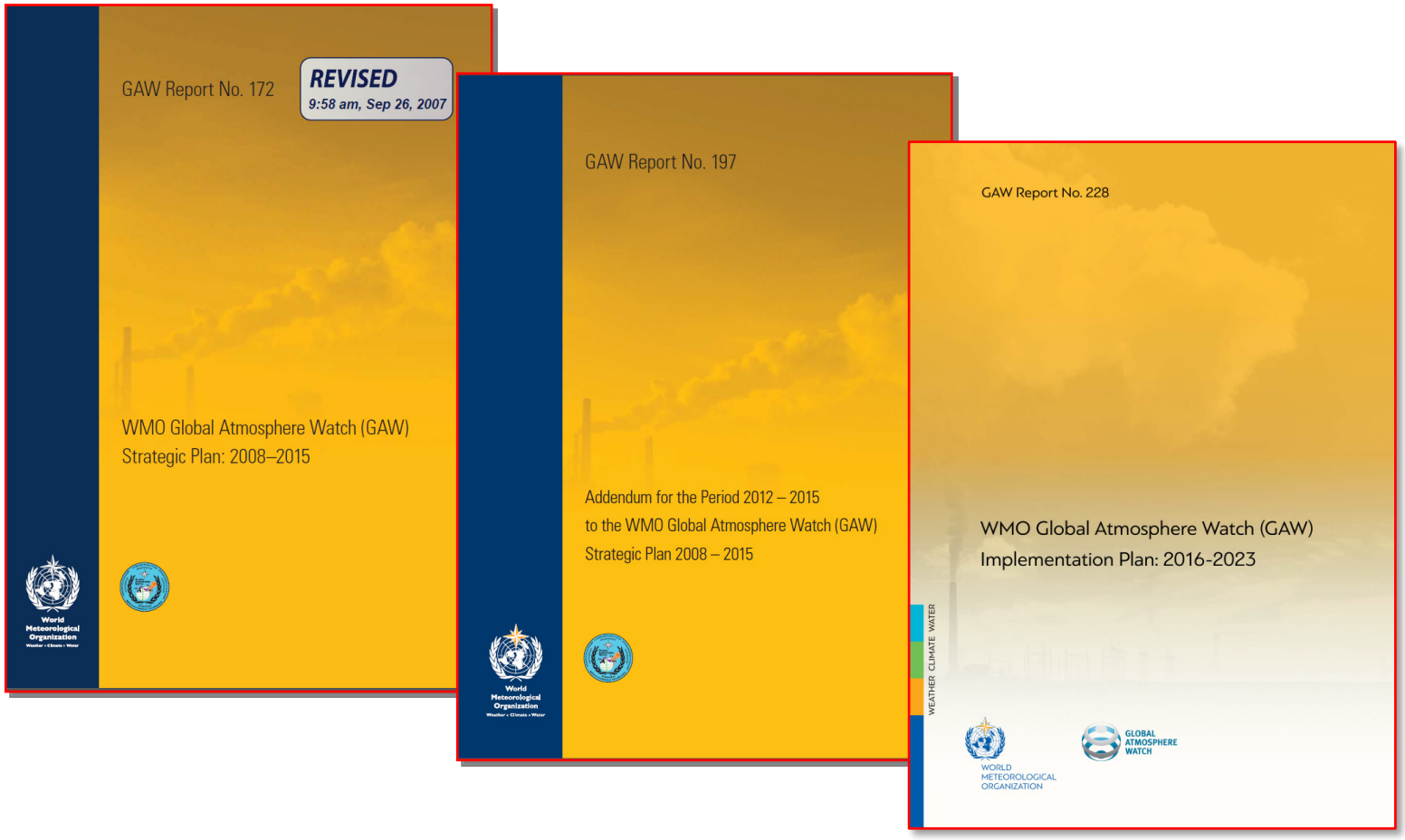
GAW Implementation Plan: 2016-2023,
GAW Report # 228, 2017

Organization of GAW



GAW Implementation Plan: 2016-2023,
GAW Report # 228, 2017

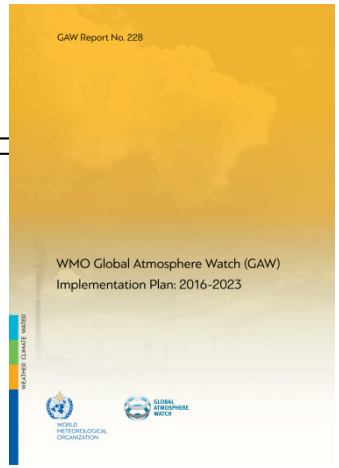
Useful documents



http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

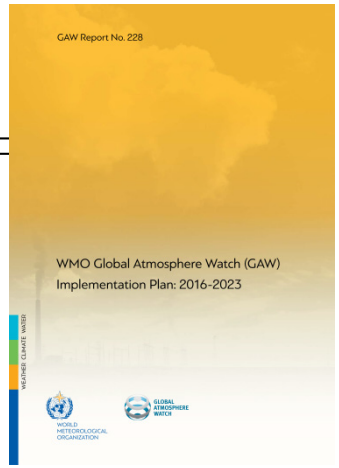
GAW – Central Facilities

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



GAW report #228

Terms of Reference – CCLs



GAW report #228

5.2.1 Central Calibration Laboratories (CCLs)

Specific activities:

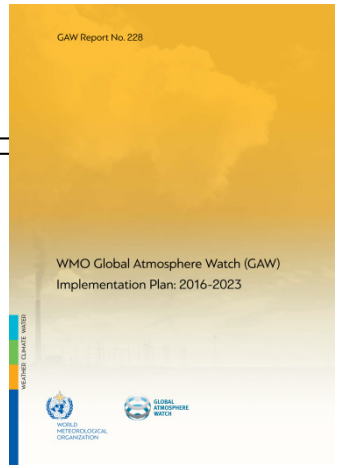
CCL-1. Host in the long term (many decades) the GAW primary standard and scale for a particular variable.

CCL-2. Serve the needs of the other quality assurance facilities and activities of GAW.

CCL-3. Prepare or commission laboratory standards required by GAW network Members for calibration purposes.

CCL-4. Supply well-calibrated reference materials in to GAW analytical laboratories as needed for conducting intercomparisons of standards (in collaboration with the World or Regional Calibration Centres) where appropriate.

Terms of Reference – WDCs



GAW report #228

5.2.4 *World Data Centres (WDCs) and Contributing Data Centres (CDCs)*

Specific activities:

WDC-1. Provide adequate archiving facilities for observational data for which GAW has global coordination responsibilities.

WDC-2. Check submitted data for necessary format elements and the availability of comprehensive metadata and reject the submission of data that do not meet these formal criteria.

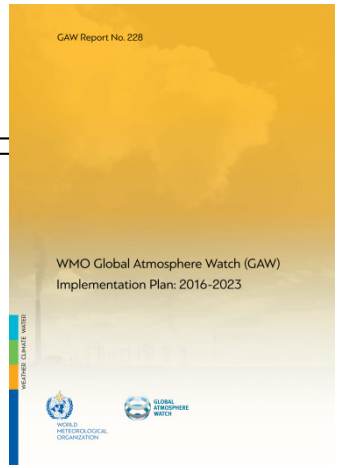
WDC-3. Perform plausibility and consistency checks on submitted data, flag data problems, and provide feedback to the data providers, when necessary.

WDC-4. Continually improve the ease of access to data of known quality by evolving WDC operations in line with the development of WIGOS and with particular attention to the increasing needs for NRT data services.

WDC-5. Contribute to the agreement of standards for interoperability of data archives through the Expert Team on GAW World Data Centres (ET-GAW WDCs). This also includes support for the establishment of harmonized guidelines and data formats for the submission and dissemination of atmospheric composition data, metadata and products.

WDC-6. Support and participate in the establishment of a distributed data management system involving all WDCs, the archives of contributing networks, and GAWSIS as the central metadata repository for discovery and access purposes.

Terms of Reference – QA/SAC



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.

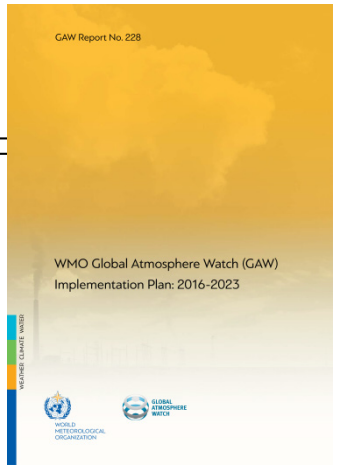
QA-4. Where appropriate, coordinate instrument calibrations and intercomparisons and other measurement activities.

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.

Terms of Reference – WCC



GAW report #228

5.2.3 World and/or Regional Calibration Centres (WCCs, RCCs)

Specific activities:

W/RCC-1. Assist Members operating GAW stations to link their observations to the GAW primary standard.

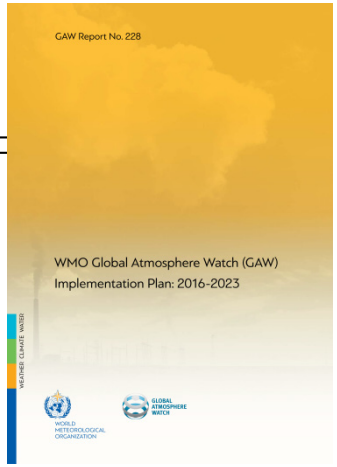
W/RCC-2. Develop quality control procedures following recommendations by the SAGs, support the QA of specific measurements and ensure the traceability of these measurements to the corresponding primary standard.

W/RCC-3. Maintain laboratory and transfer standards that are traceable to the primary standard.

W/RCC-4. Perform regular calibrations (where appropriate), organize comparison campaigns and performance audits at GAW sites using transfer standards in co-operation with the established RCCs.

W/RCC-5. Provide, in co-operation with the QA/SACs, training and long-term technical help for stations.

Terms of Reference – Station Requirements

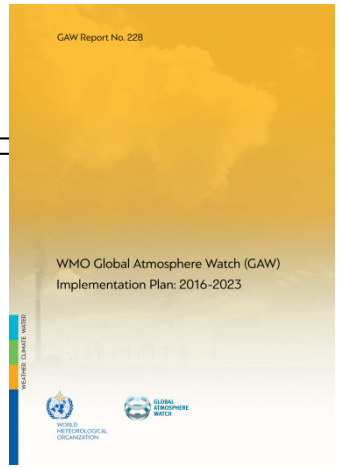


GAW report #228

Requirements for GAW Regional stations in particular include:

1. The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources or at least frequently experiences advection of pollution-free air from specific wind directions.
2. There is a commitment by the responsible agency to long-term observations of at least two variables in at least one GAW focal areas (ozone, aerosols, greenhouse gases, reactive gases, UV radiation, precipitation chemistry/total deposition). To address measurements for multiple applications in more than one focal area are recommended.
3. Adequate power, air conditioning, communication and building facilities are provided to sustain long-term observations with greater than 90% data capture[d] (i.e. <10% missing data).
4. Standard meteorological in situ observations (at least temperature, humidity, air pressure, and wind speed and direction), necessary for the accurate determination and interpretation of the GAW variables, are made of known quality.
5. Technical staff are trained to operate station equipment.
6. GAW observations are of known quality, follow GAW Quality Assurance principles and procedures, linked to the GAW Primary Standard where applicable and use the measurement methods recommended[e] by GAW.
7. A station logbook (i.e. record of observations made and activities that may affect observations) is maintained and is used in the data validation process.
8. The data and associated metadata must be submitted to one of the GAW World Data Centres at least on a yearly basis documenting Year N no later than end of Year N+1. Changes of metadata including instrumentation, traceability, observation procedures, must be reported to the responsible WDC and GAWSIS in a timely manner following the WIGOS metadata standards.
9. If feasible, data are submitted to a designated data distribution system in near-real-time.

Terms of Reference – Station Requirements



GAW report #228

Requirements for Global Stations

These stations primarily observe GAW variables under background conditions, i.e. without permanent significant influence from local pollution sources. In addition to fulfilling the requirement of GAW Regional stations, Global stations must fulfil the following:

1. Measure at least two variables in at least three of the six GAW focal areas with the full implementation of GAW's Quality Assurance system (Box 7.1 (A)).
2. Have a strong scientific supporting programme with appropriate data analysis and interpretation within the country and, if possible, the support of more than one agency.
   a. The stations should have a confirmed track record of research campaigns and/or scientific products (within last 3 years) as a Regional station.
   b. The measurements at the station have been audited or the quality of the measurements has been documented through other means of verification.
   c. The data from at least two variables in at least three focal areas have been submitted to the respective World Data Centre(s) during at least three years within the data submission period of 1 year after measurement.
3. Provide a facility at which intensive campaign research can augment the long-term routine GAW observations and where testing and development of new GAW methods can be undertaken.
4. In case the measurements of some GAW variables are occasionally influenced by local pollution, the station shall subject the data to appropriate filter methods to extract the background concentrations and submit both a filtered and an unfiltered time series to the WDC. Also the station metadata on GAWSIS should describe the conditions under which pollution influences may be found and describe the applied filter methods.

GAW's Quality Assurance System

ELEMENTA
Science of the Anthropocene

The Global Atmosphere Watch reactive gases measurement network

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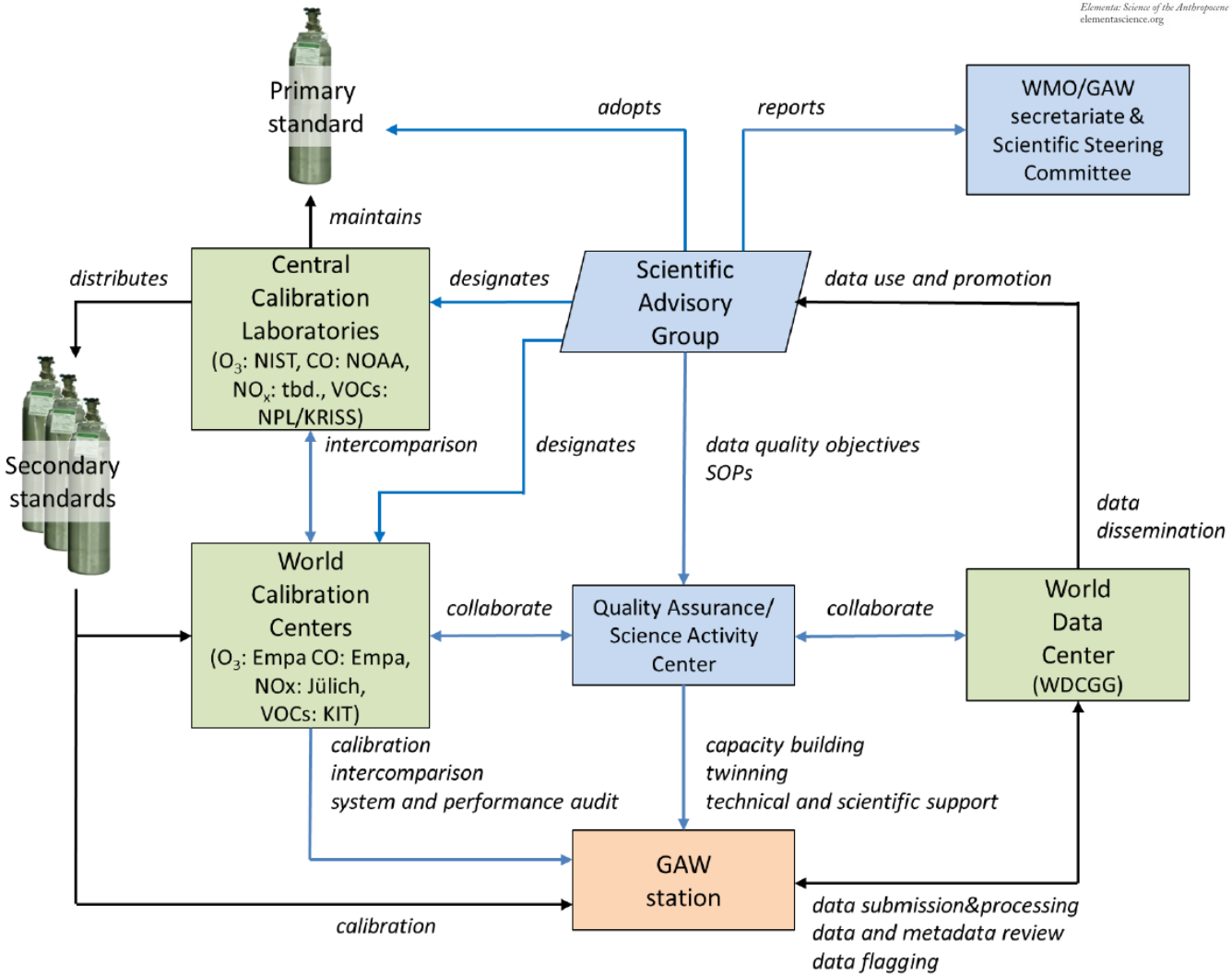


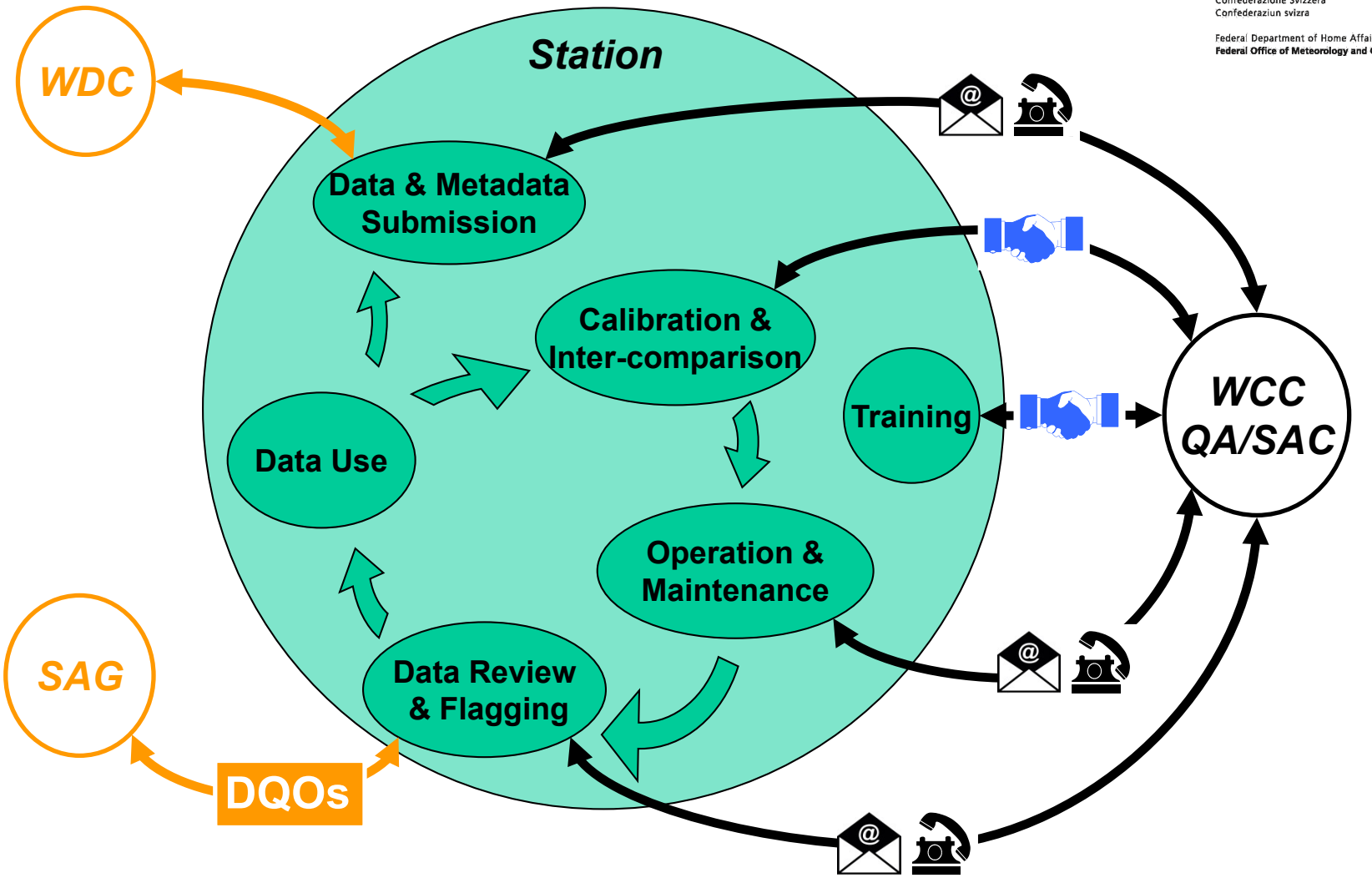
GAW QA System - Objectives and Principles

- Primary responsibility for data quality rests with the data originator.
- Primary objectives of GAW QA System
  - To ensure consistency of data residing at WDCs
  - To ensure known and adequate data quality
  - To ensure availability of comprehensive metadata

through

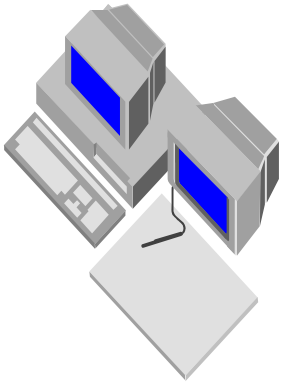
- Full support of GCOS monitoring principles
- Network-wide use of only one reference standard and full traceability of all observations
- Definition of data quality objectives (DQOs) and establishment of guidelines for implementation (Measurement Guidelines, Standard Operating Procedures)
- Independent assessments (system and performance audits)
- Timely submission of observations and metadata to WDCs

Our Role – WCC & QA/SAC



QA/SAC Switzerland

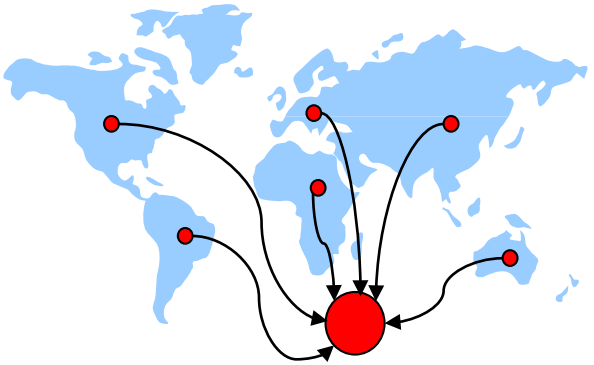
- Scope
  - Variables mandated to WCC-Empa
  - Cross-cutting, system-wide
- Primary Tasks
  - Support and audit the quality control system at Global GAW stations
  - Provide support regarding data quality issues, data submission
  - Contribution to GAW outreach
  - Support of Scientific Advisory Groups
  - Promote use of GAW data
  - Capacity building & twinning
  - Organisation of workshops



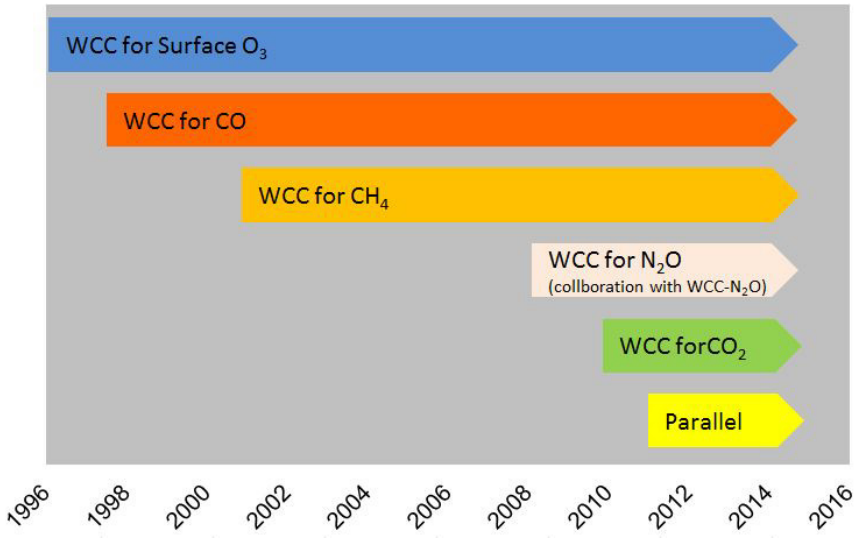
WCC-Empa

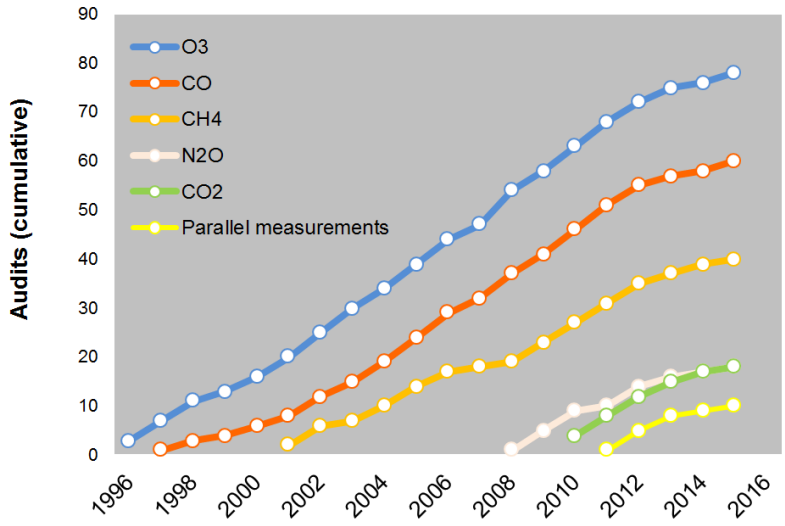
- Scope
  - Methane, (nitrous oxide), carbon dioxide
  - Surface ozone, carbon monoxide

- Primary Tasks
  - Ensure traceability of measurements at Global GAW stations to designated GAW Reference Standard
  - Support stations with regards to instrument and/or measurement problems
  - Capacity Building, "1:1"-Training



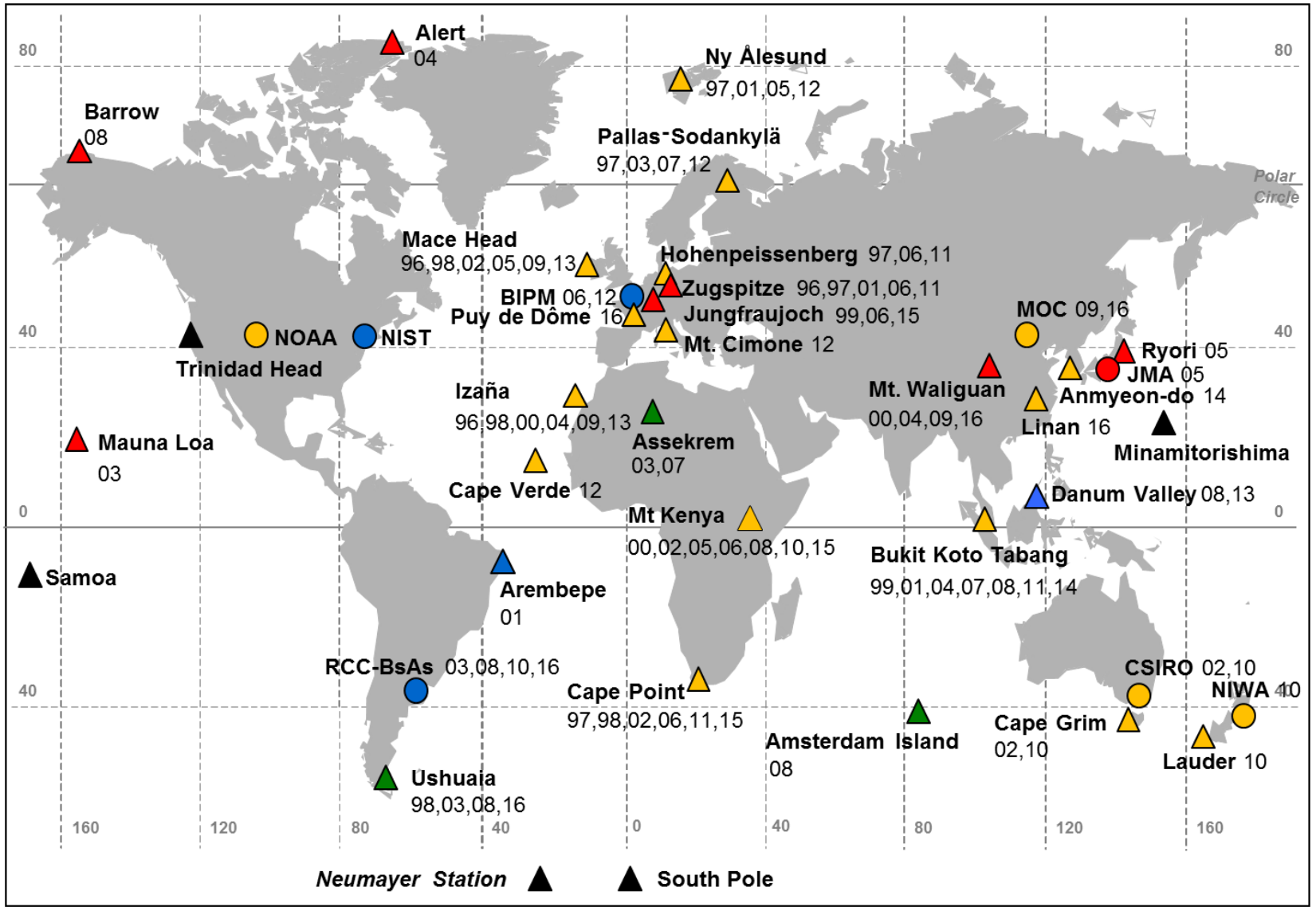
History of WCC-Empa



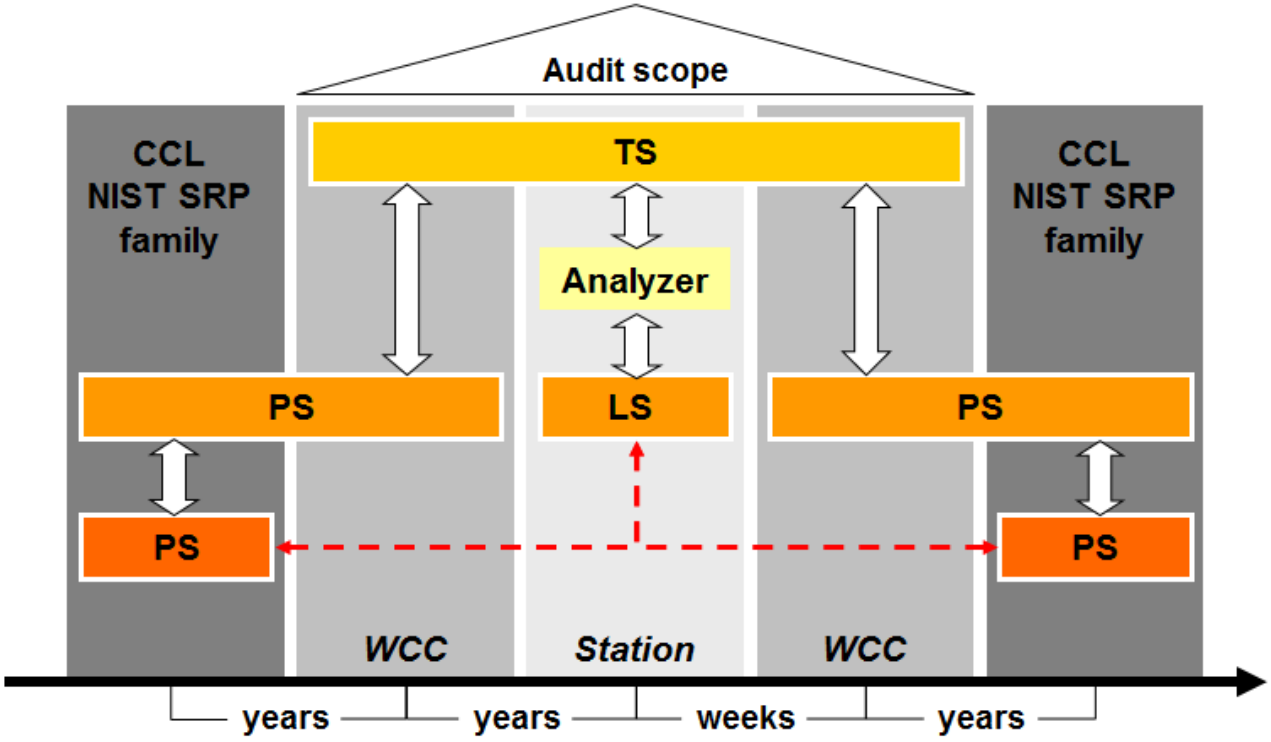


- 1996 Start with surface ozone audits
- 1997 carbon monoxide
- 2000 QA/SAC Switzerland at Empa
- 2001 methane
- 2008 collaboration with WCC-N_2O
- 2010 carbon dioxide
- 2010 MoU BIPM/WMO, Empa designated by WMO as ozone calibration laboratory
- 2011 Parallel measurements with a travelling instrument (CO, CH_4, CO_2)

WCC-Empa Audit Overview, 1996 – 2016



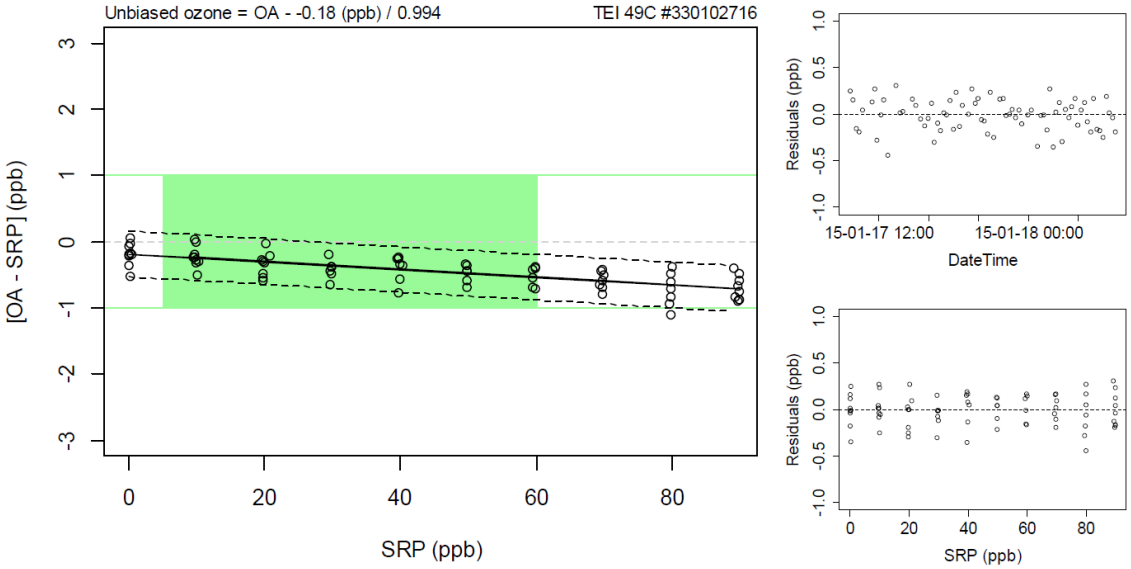
WCC-Empa audits at GAW sites - Traceability



Ozone Measurement Guidelines,
GAW Report # 209, 2013

Exemplary Audit Results

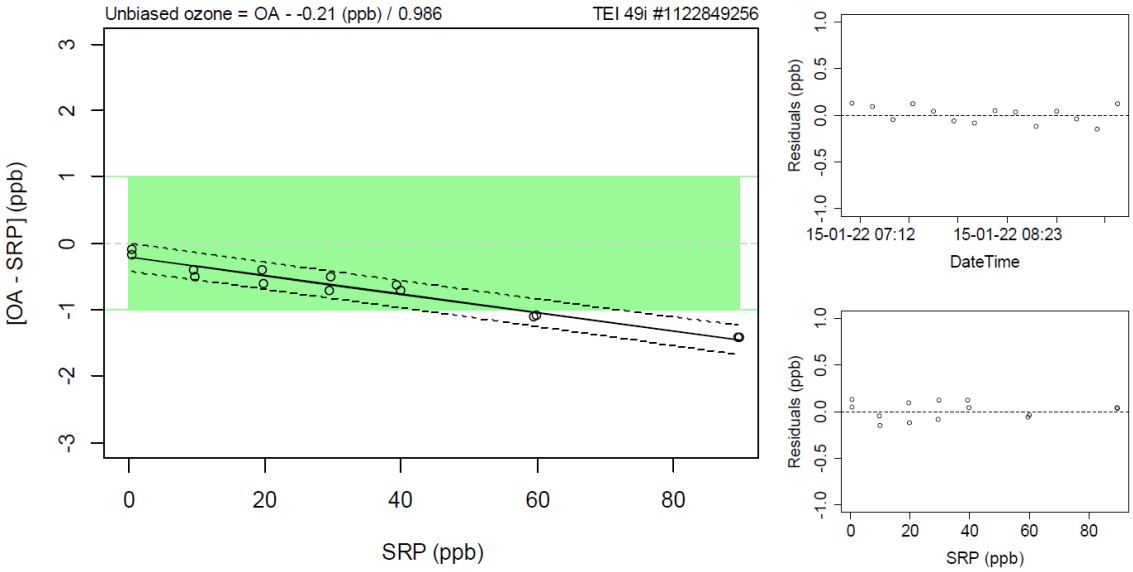
- Mount Kenya, January 2015



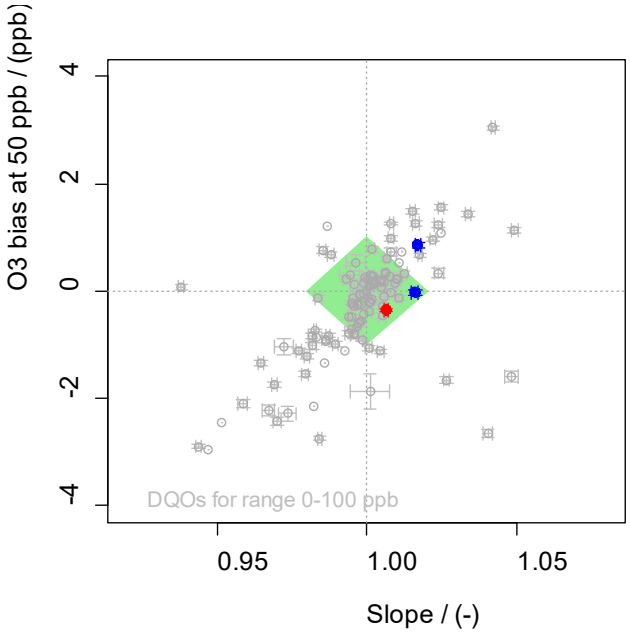
Audit reports publicly available at www.empa.ch/gaw

Exemplary Audit Results

- KMD Nairobi, January 2015



- Mount Waliguan, September 2016



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Federal Office of Meteorology and Climatology MeteoSwiss

WMO

GAW

Empa
Materials Science and Technology

Questions ?