Dr. Christoph Zellweger
Empa
Überlandstrasse 129
CH-Dübendorf, Switzerland

phone: +41-58-765 4328 / 1111
fax: +41-58-765 1122
mailto: christoph.zellweger@empa.ch

Activity Report 2023
WCC-Empa

The Global Atmosphere Watch (GAW) programme, coordinated by the World Meteorological Organization (WMO), is a truly international endeavour driven by the need to understand and control the increasing influence of human activity on the global atmosphere. Several hundred registered stations contribute to the GAW programme. GAW data from all over the globe must be appropriately documented, consistent, traceable to common reference scales, and of known and adequate quality. This is essential to address the spatial and temporal variability of atmospheric composition.

Within GAW, an elaborate quality management framework was developed to achieve these goals. Central facilities supporting the quality assurance and control (World- and Regional Calibration Centres, Central Calibration Laboratories), providing scientific and technical guidance (Quality Assurance/Science Activity Centres), and allowing access to data of the global network (World Data Centres) were implemented.

Empa, in collaboration with MeteoSwiss, is running the World Calibration Centre for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide (WCC-Empa) as a contribution to the GAW programme since 1996. The main task of WCC-Empa is to perform system- and performance audits at GAW stations to ensure traceability within the network, but also to provide technical and scientific support in general. This is done in close collaboration with the Quality Assurance/Science Activity Centre Switzerland (QA/SAC-CH), also hosted by Empa. Both WCC-Empa and QA/SAC-CH are well embedded in the activities of the Empa Laboratory for Air Pollution / Environmental Technology. They have strong synergies with the Swiss National Air Pollution Monitoring Network, the group for Climate Gases, the group for Emissions and Isotopes, the Laser Spectroscopy group, and the group for Atmospheric Modelling and Remote Sensing at Empa. This report gives an overview of the activities of WCC-Empa for the year 2023.

1. System- and performance audits

The following GAW stations were audited in 2023:

Izaña (IZO)	O_3, CO, CH_4, CO_2 and N_2O	8th audit
Cholpon-Ata (CPO)	O_3, CO, CH_4, and CO_2	1st audit
Mt. Cimone (CMN)	O_3, CO, CH_4, and CO_2	3rd audit
Baring Head (BHD)	O_3, CO, CH_4, and CO_2	1st audit
Kennaook / Cape Grim (CGO)	O_3, CO, CH_4, CO_2 and N_2O	3rd audit

The audit at Baring Head, New Zealand, was carried out instead of the originally proposed audit at Lauder. Baring Head, despite being a regional GAW station, is considered as the most important GAW station in New Zealand and has the second longest CO_2 time series in the Southern Hemisphere. In addition, the GHG and CO working standards used at all New Zealand GAW stations are calibrated at BHD.

In addition, the following calibration and comparison activities were carried out in 2023 in support of the GAW stations and the WMO/GAW programme in general:

University of Bristol (GB stations and Mace Head) GHG and CO (standard calibration)

WCC-Empa conducted the eights system- and performance audit at the global GAW station **Izaña**. Excellent results meeting the WMO/GAW network compatibility goals were found for all parameters. These results were also confirmed by the parallel measurements of CO, CH_4, and CO_2 over a period of one month. However, a small leak in the IZO inlet system was detected, resulting in slightly elevated CO_2 levels when people were present in the laboratory. This shows the added value of parallel measurements.

The first audit at the **Cholpon-Ata** regional GAW station focused on operator training. The GHG, CO and ozone measurements were established in 2016 as part of the Capacity Building and Twinning for Climate Observing Systems (CATCOS) project, supported by the Swiss Agency for Development and Cooperation (SDC), with MeteoSwiss as the coordinating partner. The audit confirmed that the measurements are still operational, and results within the WMO/GAW network compatibility goals (O_3, CH_4 and CO_2) and extended goal (CO) were found.

An issue with a faulty ozone scrubber of the ozone instrument could be fixed during the audit. It was noted that the issue also affected data that had already been submitted to the World Data Centre. It was possible to re-evaluate and re-submit the data after applying a correction. This was done by QA/SAC Switzerland after the audit. In addition, calibration standards were provided by WCC-Empa for the continuation of the GHG and CO measurements. However, the instrumentation is reaching the end of its expected lifetime, and replacement needs to be considered especially for the GHG analyser.

The audit at the GAW global station **Mt. Cimone** (CMN) showed results within the WMO/GAW compatibility goal (O_3, CH_4, CO_2, N_2O) and the extended goal (CO). The WCC-Empa audit overlapped with an audit by the ICOS mobile laboratory, and cross-comparisons of calibration and travelling standards were made.

WCC-Empa carried out a first audit at **Baring Head** (BHD), New Zealand. The station is classified as a regional station but is strategically very important. It is considered to be the main station for in-situ measurements of greenhouse gases within New Zealand's GAW activities. The station also has the second longest CO_2 series in the Southern Hemisphere. In addition, calibrations of the GHG/CO working standards that are used to calibrate New Zealand's GAW stations (Lauder, Arrival Heights) are carried out at BHD. The audit identified a problem with the ozone measurement. The ozone results did not meet the data quality objectives of the GAW programme and corrective action has been initiated by BHD. Preliminary results for CH_4, CO_2 and CO showed compliance with the (extended) WMO/GAW compatibility goals. The audit at BHD also included parallel measurements of CH_4, CO_2 and CO, but the WCC-Empa travelling instrument failed after a few days of operation. Through a joint effort of BHD staff, WCC-Empa and Picarro, measurements were resumed in mid-January 2024 and are currently ongoing.

Preliminary results of the third audit at the global GAW station **Kennaook / Cape Grim** show excellent agreement within the WMOGAW network compatibility goals for O_3, CH_4, CO_2 and N_2O. The results for CO differ between the different measurement techniques and will be further evaluated. The parallel measurements of CH_4, CO_2 and CO are currently ongoing.

The above audits included a review of data series available from the corresponding World Data Centres. In addition, WCC-Empa requested an update of the information available in GAWSIS.

2. Contribution to expert teams

Scientific Advisory Group for Reactive Gases (SAG-RG): WCC-Empa participated in the online meetings of the SAG-RG. The SAG-RG was continuously updated by WCC-Empa on the progress regarding the of the ozone cross section change.

Expert Team on Atmospheric Composition Measurement Quality (ET-ACMQ): WCC-Empa actively participated in the three online meetings in 2023 and attended the in-person meeting online. WCC-Empa provided input to a report giving an overview of the activities of the central facilities, and informed the Expert Team on the progress regarding the ozone cross section change.

Expert Team on Measurement Uncertainty (ET-MU): Three virtual meetings were held in 2023, two of which were attended by WCC-Empa.

CCQM-GAWG Task Group on Ozone Cross-Section Change Management: WCC-Empa actively participated in two online meetings in 2023, and contributed to the guidelines document "How to implement the new absorption cross-section for ozone concentration measurements", which will be published as a BIPM report in 2024. Due to the need to revise a number of standard documents such as ISO guides, the implementation date of the cross-section change has been postponed to January 2025.

3. Capacity building and technical / scientific meetings

- WCC-Empa gave an oral presentation "*Sensoren zur Messung von Luftschadstoffen: Eigene Erfahrungen und Empfehlungen der WMO*" at the NABEL Tagung 2023.
- WCC-Empa contributed to the GAW-DACH meeting, Munich, January 2023, and gave an oral presentation on "*World Calibration Center for Surface Ozone, Carbon Monoxide, Methane, and Carbon Dioxide (WCC-Empa)*".
- WCC-Empa participated in the WMO International Greenhouse Gas Monitoring Symposium, Geneva, January 2023, and presented a poster on "*Accurate Greenhouse Gas Measurements Supporting Global Research and Policies*".
- WCC-Empa attended the WMO meeting Observations within the Global Greenhouse Gas Watch (GGGW), Geneva, October 2023, and gave an oral presentation about "*Challenges in the Quality Assurance of Greenhouse Gas Measurements*".
- WCC-Empa remotely contributed to the SDS-WAS Training School on Sunphotometer and Brewer Calibration (training of North African station operators) with a lecture on the "*Measurements of Tropospheric Ozone*".
- WCC-Empa trained the operators of the GAW stations Izaña, Cholpon-Ata, Mt. Cimone, Baring Head and Kennaook / Cape Grim in ozone and greenhouse gas measurement techniques during the audits.
- WCC-Empa remotely supported the operators of the Mt. Kenya GAW station with monthly feedback on the GHG and CO measurements. Remote support was also provided to Ushuaia (ozone instrument troubleshooting, advice on setting up and calibrating the new N_2O/CO analyser), GAW stations in India (dryer selection), Hohenpeissenberg (advice on the selection of ozone transfer standards), and Pha Din (CRDS measurements troubleshooting).

4. Technical work

Surface ozone: Comparisons between SRP#15 and #23 were carried throughout the year to ensure the stability of the WCC-Empa ozone reference over time.

SRP#15 participated in the international comparisons of ozone standards organised by the International Bureau of Weights and Measures (BIPM). Agreement within the uncertainties of the SRPs was found, confirming the conformity of the WCC-Empa ozone reference.

WCC-Empa was successfully reaccredited by the Swiss Accreditation Service as a calibration laboratory for ozone measuring instruments for the period 2024 to 2029.

Greenhouse gases and carbon monoxide: WCC-Empa participated in the WMO/IAEA round robin experiment. Results will be available as soon as the experiment is completed (expected 2024).

Together with QA/SAC Switzerland, WCC-Empa has tested an Aeris Ultra CO_2/N_2O analyser. Based on the promising results, WCC-Empa purchased an Aeris Ultra CO/N_2O analyser to be used as a travelling CO/N_2O instrument for on-site comparisons during performance audits. The instrument was tested on arrival, but performance in terms of CO/N_2O noise and drift did not meet the manufacturer's specifications. Further testing revealed a leak in the instrument within the temperature controlled enclosure. The instrument was returned to the manufacturer for repair.

5. Publications

WCC-Empa contributed to a publication on carbon monoxide data at Mt. Kenya and Nairobi (Kirago et al., 2023).

Work on the proposed first author publication on ozone measurements is ongoing and is expected to be completed in 2024.

6. WMO-GEF Storehouse

Support of the Global Environment Facility (GEF) stations continued with remaining funds from the GAW GEF project. In 2023, the GAW station Mt. Kenya was supported by the provision of an ozone calibrator (used instrument, in-kind contribution by Empa, only shipping costs) and a fan replacement kit for the GHG/CO instrument.

An overview of the activities and the budget of the Storehouse project is available on request from WCC-Empa.

7. Storehouse for Twinning Stations

A new pump for the ozone analyser was installed at the GAW / CATCOS station Cholpon-Ata. In addition, a Nafion drying system was installed at CPA to protect the GHG instrument and to improve CO measurements, and five additional calibration standards (GHG and CO) were provided to CPA.

The GAW / CATCOS station Pha Din was supported with the supply of a spare part for the Picarro GHG analyser (fan replacement kit).

Acknowledgements
WCC-Empa is financially supported by MeteoSwiss and Empa.

References

Kirago, L., Gustafsson, Ö., Gaita, S. M., Haslett, S. L., Gatari, M. J., Popa, M. E., Röckmann, T., Zellweger, C., Steinbacher, M., Klausen, J., Félix, C., Njiru, D., and Andersson, A.: Sources and Long-term Variability of Carbon Monoxide at Mount Kenya and in Nairobi, EGUsphere, 2023, 1-17, 2023.

Proposed WCC-Empa tasks 2023 and progress overview

The table below gives an overview of the tasks proposed by WCC-Empa for the year 2023, and the status as of 31 December 2023.

Task #	Short description	Status	Remarks
W23-1	Audit Mt. Cimone	Done	September 2023
W23-2	Audit Izaña	Done	June 2023
W23-3	Audit Cholpon-Ata	Done	June 2023
W23-4	Audit Kennaook / Cape Grim	Done	December 2023
W23-5	Audit Lauder	Done	BHD instead LAU, November 2023
W23-6	SAG-RG	Done	Ongoing
W23-7	ET-ACMQ	Done	Ongoing
W23-8	ET-MU	Done	Ongoing
W23-9	CCQM-GAWG Task Group	Done	Ongoing
W23-10	Operator training	Done	CPA and other stations, training course
W23-11	Video tutorials	Done	Videos available and online
W23-12	NABEL Tagung	Done	Oral presentation
W23-13	GAW DACH Meeting	Done	Oral presentation
W23-14	WMO GHG Symposium	Done	Poster presentation; in addition, oral presentation at WMO GGGW meeting
W23-15	Internal SRP-SRP comparisons	Done	Several comparison in 2023
W23-16	BIPM O_3 key comparison	Done	June 2023
W23-17	Re-accreditation (SAS audit)	Done	Passed, only one minor nonconformity
W23-18	WMO round robin	Done	November 2023
W23-19	Parallel measurements	Done	Passed, only minor nonconformities
W23-20	N_2O audits	Done	IZO, CGO
W23-21	Empa as WCC-N_2O?	In progress	UBA Germany has to resign
W23-22	N_2O parallel measurements	Postponed	Aeris instrument was not yet fit for purpose
W23-23	O_3 Publication by WCC-Empa	In progress	Planned for 2024
W23-24	GAW GEF Storehouse	Done	Continued support of GEF stations
W23-25	Twinning Storehouse	Done	Continued support of twinning stations

Dübendorf, March 2024,

Laboratory Air Pollution / Environmental Technology

Head of the Laboratory

Digital unterschrieben von Lukas Emmenegger
Datum: 2024.03.19 16:22:56 +01'00'

Dr. L. Emmenegger

Project manager

Digitally signed by Christoph Zellweger
Date: 2024.03.19 16:02:56 +01'00'

Dr. C. Zellweger