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Annual Activity Report 2020 of 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 hundreds of registered stations contribute to the GAW programme. GAW data from all over the globe need to be consistent, traceable to common reference scales, of known and adequate quality, and require appropriate documentation. Meeting these quality objectives is essential to properly address the spatial and temporal variability of atmospheric composition in order to allow for retrieving robust averages, detecting regional gradients and long-term trends, and for verification of models and satellite retrievals.

Within GAW, an elaborate quality management framework was developed to achieve these goals. In support of the programme, central facilities responsible for quality control, scientific and technical guidance and data hosting and dissemination of the global network were established. 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. This report gives an overview of the activities of WCC-Empa for the year 2020.

1. System- and performance audits

The following GAW stations were audited in 2020:

Hohenpeissenberg (HPB)	O ₃ , CO, CH ₄ , CO ₂ and N ₂ O	4 th audit
Sonnblick (SNB)	O ₃ , CO, CH ₄ , and CO ₂	2 nd audit
Zugspitze-Schneefernerhaus	O ₃ , CO, CH ₄ , CO ₂ and N ₂ O	6 th audit

Furthermore, the following calibration and comparison activities were made in 2020 to support GAW stations and the WMO/GAW programme in general:

University of Leeds (GB Regional Stations)	GHG and CO (standard calibration)
National Physical Laboratory (GB Regional Stations)	GHG and CO (standard calibration)
Global GAW station Mace Head	GHG and CO (standard calibration)

WCC-Empa conducted the fourth system- and performance audit at the global GAW station **Hohenpeissenberg**. The audit included for the first time the measurements of the Integrated Carbon Observing System (ICOS), which recently were established at a 132 m high measurement tower near the observatory. The audit included parallel measurements for CO at the GAW observatory, and for CO, CO₂, and CH₄ at the ICOS laboratory. The results of the comparisons were mostly within the WMO/GAW network compatibility goals (CH₄, CO₂) or extended compatibility goals (CO, N₂O). Only the surface ozone measurements were slightly exceeding the WMO/GAW

Data Quality Objectives (DQOs) due to an uncorrected bias of the HPB ozone reference. The audit helped to identify this issue, and correction of the data is possible.

The **Sonnblick** observatory became recently a Global GAW station, and the measurement programme was significantly enlarged since the last WCC-Empa audit more than 20 years ago. Since then, measurements of GHGs were established, which were for the first time independently assessed during the WCC-Empa audit. The audit included parallel measurements of CO, CO₂, and CH₄ with the WCC-Empa travelling instrument. The results of the comparisons complied with the WMO/GAW compatibility goals (O₃, CH₄, and CO₂) or extended compatibility goals (CO). Nevertheless, WCC-Empa identified room for improvement concerning instrumentation (replacement of CO analyser by a different technique) and calibration strategy (more standards needed, automatisisation). The staff responsible for the operation has been trained by WCC-Empa during the audit.

The GHG and CO instrumentation was replaced after the last WCC-Empa audit in 2011 at the **Zugspitze-Schneefernerhaus** station. At that time, several instrumental and calibration issues were leading to significant exceedances of the WMO/GAW network compatibility goals. The new instrumentation was assessed for the first time, and the results showed agreement with the WMO/GAW network compatibility goals for O₃, CH₄, and CO₂, and with the extended compatibility goals for CO and N₂O. These results were also confirmed by the ambient air comparison measurements over a period of one month.

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

The audits at the GAW stations Pha Din (Vietnam) and Cape Point (South Africa), which were planned for 2020, had to be postponed due to Covid-19 related travel restrictions. WCC-Empa has been in contact with both stations, and calibration standards to be used for the upcoming audit at Pha Din were sent to Vietnam. It was further agreed with the Cape Point station manager that a comparison of standard gases will be made in 2021 preceding the audit, which is now planned for 2021.

WCC-Empa has made on average 3.6 audits per year since 1996. The impact of Covid-19 on WCC-Empa activities was therefore only minor considering the number of audits conducted in 2020. However, due to the fact that only audits in Europe could be conducted, the additionally available time was used in an intensified remote support and sound data analysis, which improved data availability e.g. at the Mt. Kenya station substantially.

WCC-Empa audit reports are now published as WMO/GAW reports under the WMO Research Infrastructure Quality Assurance framework, and are made available online in the WMO library, which increases the visibility of WCC-Empa. The audit reports are further published on the WCC-Empa website, and also linked in GAWSIS.

2. Capacity building and technical / scientific meetings

- Following the WMO reform, new expert teams were established in 2020. Christoph Zellweger was nominated to be a core member of the Expert Team on Atmospheric Composition Measurement Quality (ET-ACMQ). A first virtual meeting with representation from all WMO/GAW central facilities was held in September 2020. WCC-Empa contributed actively to the meeting, and a presentation on "World Calibration Centres for GHGs (CH₄, CO₂, N₂O) and reactive gases (CO, O₃)" was given during the introduction session.

- Christoph Zellweger was nominated to be a member of the Expert Team on Measurement Uncertainty (ET-MU) of the WMO Infrastructure Commission/Standing Committee on Measurements, Instrumentation and Traceability (INFCOM/SC-MINT). The expert team was established, and two virtual meetings were held so far.
- WCC-Empa trained operators of the GAW stations Hohenpeissenberg, Sonnblick and Zugspitze-Schneefernerhaus in ozone and greenhouse gas measurement techniques during the audits. At all stations, new principal researchers commenced, and the knowledge transfer between the new station staff and WCC-Empa will strengthen the quality of the measurements made at these station.
- WCC-Empa remotely supported the operators of the GAW stations Bukit Kototabang (issues with the GHG measurements could be solved), El Tololo (GHG standard exchange with remote instructions), and Mt. Kenya (remote instructions to modify ozone analyser to external pump after failure of the internal pump of the instrument). Furthermore, monthly feedback was provided to the MKN operators regarding the GHG and CO measurements. These measurements have been successfully running since the installation in 2019, and data availability reached approximately 80% in 2020.
- WCC-Empa continued to provide input for both the GAW and GCOS Rolling Review of Requirements (RRR) processes coordinated by a joint WMO GAW/GCOS Task Team on Atmospheric Composition Observational Requirements.
- Due to the Covid-19 pandemic, all physical conferences and meetings were cancelled in 2020. WCC-Empa participated at the following scientific online meetings:
 - International Workshop on Metrology Needs for Climate and Ocean Observations (Online, NPL, 12 February 2020).
 - Virtual Global Monitoring Annual Conference (eGMAC).
 - ICOS Science Conference 2020 (online).
 - Joint Reactive Gases, Total Atmospheric Deposition, and Aerosols SAGs meeting (online, September 2020).
 - Meeting of the Scientific Advisory Group for Reactive Gases (online, 15. October 2020).
 - BIPM Virtual Workshop on Accurate Monitoring of Surface Ozone (no participation due to scheduling conflict, but WCC-Empa contribution on the GAW surface ozone monitoring network to a presentation given by Owen Cooper et al.).

3. Technical and theoretical work / publications

Surface Ozone: Inter-comparisons between Standard Reference Photometers SRP#15 and #23 were made to ensure the stability of the WCC-Empa ozone reference over time.

The ISO 17025 accredited calibration for ozone measuring instruments (WCC-Empa) was audited by the Swiss Accreditation Service (SAS) in June 2020. Only minor nonconformities were found, which were timely addressed by WCC-Empa.

The electronic, hardware and software upgrade of the SRP systems announced by NIST has not yet been released due to a delay in the software development. A virtual meeting was held between WCC-Empa and NIST to discuss progress. NIST confirmed that the release of the upgrade is planned for 2021.

Greenhouse Gases and Carbon Monoxide: WCC-Empa participated in an ongoing round robin between NOAA, the ICOS flask and calibration laboratory, and the ICOS mobile lab. The results confirmed the traceability of all laboratories to the WMO/GAW reference provided by NOAA, despite small differences. The WMO round robin experiment, which will be organised by the

Central Calibration Laboratory (CCL) and was scheduled to start already in 2019, has been further delayed, and the revision of the CO₂ calibration scale has also not been released but is now published by NOAA (Hall et al., 2020). The scale revision will reduce small inconsistencies in the current CO₂ calibration scale, and it will be implemented by WCC-Empa as soon as it is released.

The GHG measurement system of the NABEL / GAW calibration laboratory has been extended by the addition of a Los Gatos Off-Axis Integrated Cavity Output Spectroscopy analyser (owned by the National Air Pollution Monitoring Network (NABEL)). The instrument has formerly been used at the Jungfraujoch station, and serves now as a backup system for the calibration of N₂O and CO standards. It has been tested and integrated in the calibration scheme of WCC-Empa.

WCC-Empa continued with the support of the Carbosense project (low cost CO₂ sensors) mainly through calibrations of reference standards.

Publications: WCC-Empa contributions and expertise lead to co-authorship in a scientific publication (Yu et al., 2020). Significant contributions were also made to another publication (Gas reference materials for underpinning atmospheric measurements of stable isotopes of nitrous oxide, Pearce et al). Submission to Analytical Chemistry is planned for early 2021.

WCC-Empa also provided input for the update of the low-cost sensor recommendations report, which is currently under review by the writing team. A new version of the report is planned to be released soon (An update on low-cost sensors for the measurement of atmospheric composition).

Data of the surface ozone audits and the stability of the WCC-Empa ozone reference instruments from the last 25 years was analysed. This data set will be used for a publication (in preparation).

4. Storehouse

The support of the Global Environment Facility (GEF) stations with remaining funds of the GAW GEF project continued. Additional funds of USD 25'000.- (CHF 24'505) were provided by WMO in 2020. In 2020, no support of the GEF stations has been made. It was planned to exchange the ozone analyser at the GAW station Assekrem, but shipping of the equipment was too difficult (expensive) due to Covid-19 related suspension of all domestic flights within Algeria. With the additional funds provided by WMO in 2020, continued support for the next one or two years depending on the needs of the stations is secured. An overview of the activities and the budget of the Storehouse project are available from WCC-Empa on request.

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References

Hall, B. D., Crotwell, A. M., Kitzis, D. R., Mefford, T., Miller, B. R., Schibig, M. F., and Tans, P. P.: Revision of the WMO/GAW CO₂ Calibration Scale, Atmos. Meas. Tech. Discuss., 2020, 1-33, 2020.

Yu, L., Harris, E., Henne, S., Eggleston, S., Steinbacher, M., Emmenegger, L., Zellweger, C., and Mohn, J.: The isotopic composition of atmospheric nitrous oxide observed at the high-altitude research station Jungfraujoch, Switzerland, Atmos. Chem. Phys., 20, 6495-6519, 2020..

Workflow 2020

1st quarter 2020

- Remote support of GAW stations (mainly MKN, BKT, TLL, and USH) throughout the year.
- Comparisons between Standard Reference Photometers SRP#15 and #23.
- Input for the GAW and GCOS Rolling Review of Requirements (RRR) processes.

2nd quarter 2020

- Surveillance audit by the Swiss Accreditation Service (16. - 17. June).
- System and performance audits at the global GAW station Hohenpeissenberg (O₃, CO, CH₄, N₂O, CO₂, parallel measurements) (29. June – 3. July).

3rd quarter 2020

- System and performance audits at the global GAW station Sonnblick (O₃, CO, CH₄, CO₂, parallel measurements) (13. – 17. July).
- GHG and CO standard calibration, University of Leeds (GB Regional Stations).
- System and performance audits at the global GAW station Zugspitze-Schneefernerhaus (O₃, CO, CH₄, N₂O, CO₂, parallel measurements) (7. – 10. September).
- ET-ACMQ and Joint Reactive Gases, Total Atmospheric Deposition, and Aerosols SAGs virtual meetings

4th quarter 2020

- Input for publications (Pearce et al.).
- GHG and CO standard calibration, Mace Head and NPL.
- Testing of the Los Gatos Off-Axis Integrated Cavity Output Spectroscopy analyser, integration into the analytical system of the GAW laboratory.

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