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ANNUAL ACTIVITY REPORT 2018 OF QA/SAC SWITZERLAND

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.

An elaborate quality management framework was developed to achieve these goals. In support of the programme, Central Facilities responsible for quality control, scientific guidance and data hosting and dissemination of the global network were implemented. Among others, four Quality Assurance/Science Activity Centres (QA/SACs) exist to perform network-wide data quality and science-related functions. The Quality Assurance/Science Activity Centre Switzerland (QA/SAC-CH) was established at Empa in collaboration with MeteoSwiss in 2000. Being closely linked to the World Calibration Centre also hosted by Empa (WCC-Empa), QA/SAC-CH mainly focuses on surface ozone, carbon monoxide, methane and carbon dioxide measurements but is also broader in scope and provides technical and scientific support in general.

For 2018, QA/SAC-CH's program proposed activities in four main areas:

- Science Activities including QA/QC (Quality Assurance / Quality Control)
- Training, Twinning, and Capacity Building
- Contribution to GAW Outreach
- Cross-cutting Activities

A detailed account on progress in each of these activities is given below.

Science Activities including QA/QC

Tropospheric Ozone Assessment Report

The mission of the TOAR activity ("Tropospheric Ozone Assessment Report: Global metrics for climate change, human health and crop/ecosystem research") is to provide an up-to-date scientific assessment of tropospheric ozone's global distribution and trends from the surface to the tropopause. Martin Steinbacher is part of the team of scientific experts. The assessment is published as a special feature in Elementa. Since 2017, 7 peer-reviewed publications were released. Martin Steinbacher co-authored the publications on the TOAR surface ozone database

(in 2017) and the global-scale impact of ozone on climate (Gaudel et al., 2018). More publications are in preparation.

Exchange with SAG Aerosol

QA/SAC-CH was invited to join the cross-cutting day of the 2018 Meeting of the Science Advisory Group for Aerosols in Geneva in July. The dedicated session with invited participants from other focal areas aimed at stimulating the cross-domain collaboration. Martin Steinbacher gave a presentation on "Quality assurance and quality control for trace gas observations within GAW". Input from other domains and the following discussions were well appreciated by the participants.

Scientific collaboration within GAW and with other projects

QA/SAC-CH (Martin Steinbacher) contributed to the paper by Hervé Petetin from the Université de Toulouse in France. Its main focus was on measurements from IAGOS (In-service Aircraft for a Global Observing System) in the lower troposphere above the airports during take-off and landing. Data from air quality stations and stations of the GAW network were used to assess the impact of emissions related to airport activities and/or other aircrafts on the observations (Petetin et al., 2018).

QA/SAC-CH was involved in the preparation of a newly quality controlled dataset of high-precision methane observations from 18 stations across Europe. They were used as input data for 7 different inverse models to estimate updated European methane emissions (Bergamaschi et al., 2018).

QA/SAC-CH (Martin Steinbacher) provided measurements from the GAW network to assess the potential of satellite-borne methane and nitrous oxide observations by comparison to aircraft-borne in-situ observations, ground-based remote sensing and ground-based in-situ observations. The study – led by Omaira Garcia from the Meteorological State Agency of Spain – revealed promising results for methane while shortcomings were identified for nitrous oxide (Garcia et al., 2018).

Observations of the GAW station Jungfraujoch contributed to the assessment of an international team of scientists led by Arlene Fiore from Columbia University in the United States. The team of authors (including Martin Steinbacher) demonstrated the value of long-term mountaintop peroxy acetyl nitrate (PAN) measurements for the evaluation of multiple chemistry-transport models and their performances (Fiore et al., 2018).

ICOS Science Conference

Martin Steinbacher participated in the ICOS (Integrated Carbon Observation System) Science Conference in Prague (Czech Republic) which was attended by more than 300 participants from 30 different countries. He gave an oral presentation on "Continuous atmospheric greenhouse gas measurements in a semi-remote area in the Kyrgyz Republic – first scientific findings towards policy making".

Evaluation of new measurement techniques

The evaluation of (new) measurement techniques was only a minor QA/SAC-CH task in 2018. The international low-cost sensor activities were coordinated by WCC-Empa, the testing of a novel laser spectrometer and the design of the respective calibration strategy had to be postponed to 2019.

Training, Twinning, and Capacity Building

Requests for support

QA/SAC-CH responds to various requests from GAW stations for support regarding measurements and data management. In particular, programmatic advice was given to the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) in support of its upgrade and extension of air pollutants and greenhouse gas monitoring activities in Indonesia. Remote support was provided to facilitate the proper resumption of the trace gas observations at the global GAW station Bukit Koto Tabang after a major renovation of the monitoring site. The procurement process of a new carbon dioxide, methane and carbon monoxide analyser for Bukit Koto Tabang was assisted.

Limited ongoing support was given to the stations implemented during the CATCOS (Capacity Building and Twinning for Climate Observing Systems) project. The measurements at Pha Din (Vietnam), El Tololo (Chile), and Cholpon Ata (Kyrgyz Republic) are still ongoing. Several issues required remote advice for trouble shooting, support in data processing and submission to the international data repositories.

In response to other requests for support, assistance was e.g. provided to (a) the Servicio Meteorológico Nacional in Argentina (review of carbon monoxide data prior to submission to the GAW data centre), (b) to the Meteorologische Dienst in Suriname (identification of instrumental issues of the surface ozone analyzer in Paramaribo), (c) the Universidad Mayor de San Andrés (Bolivia) (inlet design, operation and calibration of SO_2 measurements), and (d) the Hungarian National Research, Development and Innovation Office (evaluation of research proposals).

Teaching

The Indonesian Agency for Meteorology, Climatology and Geophysics organised the International Workshop on Global Atmosphere Watch Activities in Jakarta (Indonesia) in August 2018. The event specifically focused on strengthening the greenhouse gas monitoring and analysis, on developing potential regional activities in monitoring greenhouse gases and on escalating research and new improvements in greenhouse gas monitoring. Martin Steinbacher gave a plenary talk about "Quality Control of Greenhouse Gas Measurements" and held a dedicated half-day training on "Quality Assurance and Quality Control of Trace Gas Measurements" jointly with Ed Dlugokencky from NOAA.

In October 2018, QA/SAC-CH taught again at the GAW Training and Education Centre (GAWTEC). Topic of the one-day course was "Carbon Monoxide in the Atmosphere". The teaching included lectures and practical exercises. The overall topic of GAWTEC 35 was "Reactive Gases".

The Training School of Atmospheric Measurements in Latin America and the Caribbean (SAMLAC) took place in Puerto Rico in November 2018. Martin Steinbacher was invited as a lecturer and gave a talk (via remote connection) on "Quality Control of Trace Gases Observations". The training course was attended by more than 60 participants, mainly from Latin America and the Caribbean.

A 3-day training at Empa was given by QA/SAC-CH and WCC-Empa to 4 technicians of the Kenyan Meteorological Department. This was part of a two-week training at several institutions in Europe supported through the General Trust Fund for Financing Activities on Research and Systematic Observations Relevant to the Vienna Convention. The main topic covered at Empa was training on in-situ surface ozone and greenhouse gas observations.

Collaboration with Chinese Researcher

QA/SAC-CH collaborated with Ye Yuan, a Chinese colleague who currently holds a scholarship from the Chinese government at the Technical University in Munich. The study aimed at developping a statistical data selection strategy to identify atmospheric CO_2 baseline levels at mountain stations. QA/SAC-CH's contribution to the paper included the provision of observations, methodological input and commenting on and writing of parts of early drafts of the article. (Yuan et al., 2018).

Provision of backward trajectories for GAW stations

The operational calculation of atmospheric trajectories (every four hours) for a large set of GAW monitoring stations along with the provision of freely available and easily accessible trajectory images on the internet (see http://lagrange.empa.ch/FLEXTRA_browser/) is ongoing and provides a valuable input for many station operators for data evaluation and interpretation.

Contribution to GAW Outreach

Review of Global Environmental Outlook-6

The United Nations Environment Programmme (UN Environment) currently prepares its next flagship integrated environmental assessment, called Global Environmental Outlook-6 (GEO-6). Martin Steinbacher was assigned as one of the reviewers of the assessment. Following reviews of earlier drafts in 2017, 3rd order drafts and 5th order drafts were again reviewed in April and August 2018, respectively. The comprehensive and repeated technical (3rd order drafts) and technical and intergovernmental (5th order drafts) reviews aimed at ensuring that the final assessment report will be of the highest possible quality based on the most accurate scientific evidence to inform the intended policy. Release of the assessment in planned for the next UN Environment Assembly in May 2019.

Report of the GGMT-2017 conference

Martin Steinbacher (QA/SAC-CH) and Andrew Crotwell (NOAA) were assigned as editors of the report of the GGMT-2017 conference. The report – being considered as the key reference for technical information on greenhouse gas measurements within the GAW programme – was published as a GAW report (Crotwell and Steinbacher, 2018) in November 2018.

Update of the CIMO guidelines

QA/SAC-CH reviewed and contributed to the 2018 edition of the Guide to Meteorological Instruments and methods of Observation (WMO-NO. 8). Main input was given to the chapter on "Measurements of Atmospheric Composition".

Contribution to GAW's Reactive Gases Bulletin

As an affiliate member of the Scientific Advisory Group on Reactive Gases, Martin Steinbacher was part of the author team of the 2018 edition of the GAW Reactive Gases Bulletin. The main topic was tropospheric ozone; the surface ozone time series from Jungfraujoch was shown on the front page.

Contribution to the IG^{3}IS Science Implementation Plan

WMO promotes the establishment of an Integrated Global Greenhouse Gas Information System (IG^{3}IS). An international team of scientists with QA/SAC-CH representation wrote the IG^{3}IS Science Implementation Plan for the attention of and approval by the WMO Executive Council.

The implementation plan presents the main principles of the IG^{3}IS implementation and outlines the four main objectives as well as specific technical solutions of IG^{3}IS.

Media attention of Jungfraujoch activities

The greenhouse gas observations as Jungfraujoch are in integral part of the atmospheric monitoring network of the European Integrated Carbon Observation System (ICOS) for many years. ICOS became fully operational in November 2015 with the formal establishment of the Integrated Carbon Observation System European Research Infrastructure Consortium (ICOS ERIC). In May 2018 – following a three-year evaluation period – Jungfraujoch was awarded the status of an ICOS class 1 station. Class 1 stations are committed to the most ambitious set of parameters. A press release was issued when the labelling was approved which received a good media attention in several Swiss newspapers. A Finnish photographer visited Jungfraujoch for the ICOS photo campaign, and a short video (available on youtube) was produced about the importance of greenhouse gas observations at Jungfraujoch.

In December, 7 Swiss newspapers (La Liberté, Le Nouvelliste, La Côte, Jounral du Jura, Le Quotidien Jurassien, ArcInfo, Le Courrier Genève) published an article about the greenhouse gas measurements at Jungfraujoch, particularly featuring the Empa activities.

Cross-cutting activities

Active role in ICOS

The Integrated Carbon Observation System (ICOS) Research Infrastructure aims at harmonizing high precision long-term observations of greenhouse gas concentrations in the atmosphere and their fluxes from ecosystems and the oceans. Close links do exist with the GAW network but the development of the infrastructure, such as the definition of standard operation procedures, needs to be proactively shaped to ensure consistency with the GAW guidelines. Martin Steinbacher is elected deputy chair of the atmospheric ICOS Monitoring Assembly and is also member of the ICOS Research Infrastructure Committee which is consulted by the ICOS Director General for scientific matters.

The first level 2 (i.e. final, quality-controlled) data from 11 atmospheric stations including Jungfraujoch were released by the ICOS Carbon Portal in August 2018 providing hourly averaged mole fractions of CO_2, CH_4 and CO, meteorological observations, and two weekly integrated samples of $^{14}CO_2$ (Colomb et al., 2018). These data will also be sent to the World Data Centre for Greenhouse Gases.

Participation in RINGO project

Martin Steinbacher attended the annual meeting of the H2020 RINGO (Readiness of ICOS for Necessities of Integrated Global Observations) project in Antwerp (Belgium) in March 2018. RINGO aims at cutting-edge science beyond the current ICOS activities and its transition into operationally run monitoring networks. RINGO also strives for the re-evaluation of historic CO_2 data. To do so, common procedures for uncertainty estimates are developed for earlier years of CO_2 observations when calibration strategies were still less standardized as they are now.

Attendance of the first IG3IS Symposium

Martin Steinbacher attended the first IG^{3}IS Symposium in Geneva in November. A poster presentation was given highlighting the "Importance of high-quality long-term atmospheric trace gas observations within IG^{3}IS".

Review of QA4ECV project

Quality Assurance for Essential Climate Variables (QA4ECV) was a project funded by the European Union Framework Program 7 which terminated in 2018. Main goals are the definition of good practice guidance, training, tools for satellite retrieval of essential climate variables and the provision of services. Martin Steinbacher was invited to act as a reviewer of the project and attended the final project meeting in De Bilt (NL) in April 2018. Significant strategic overlap between the GAW quality management framework and QA4ECV activities were identified.

Copernicus In Situ Component Survey

The Copernicus In Situ Component (https://insitu.copernicus.eu/) has initiated a survey on the sustainability of the existing meteorological, atmospheric composition and ocean observation networks in Europe. The survey aimed at developing a realistic picture of the sustainability of the existing observation network. Martin Steinbacher provided the relevant information for the network of atmospheric composition observations in Switzerland.

Contribution to ACTRIS

The Aerosols, Clouds and Trace gases Research InfraStructure network (ACTRIS) is currently designing the technical concepts and requirements for ACTRIS Observational Platforms. QA/SAC-CH contributed its expertise in terms of trace-gas in-situ observations, in particular for sound observations of nitrogen oxides.

Contribution to GCOS Switzerland

Martin Steinbacher contributed with a talk on "Long time series, quality assurance and control - air pollutants" to the GCOS Switzerland Round Table (January 2018, Bern) . QA/SAC-CH is also presented in the updated report "National Climate Observing System, Global Climate Observing System – GCOS Switzerland".

Contribution to GEO/GEOSS

The Group on Earth Observations (GEO) and GEO's ambitions to build a Global Earth Observation System of Systems (GEOSS) are important players in the international environmental arena. Coordination of GEO activities (such as the Geo Carbon and GHG Initiative) and GAW activities is crucial to avoid duplications and inconsistencies. Thus, a thorough monitoring of GEO operations is desirable. Martin Steinbacher attended the „Nationales Koordinationstreffen GEO/GEOSS" on invitation by the Swiss Federal Office for the Environment, and gave a talk on "Empa's contribution to GEO / GEOSS", and attended the GEO Symposium 2018 in Geneva.

Various publications

Next to the publications mentioned above, various other publications were also co-authored by Martin Steinbacher that mainly made use of data of the GAW site Jungfraujoch. Trace gas observations were mainly used to complement aerosol observations and their interpretation. Lead authors were affiliated with the University of Basel (Conen et al., 2018) and ETH Zurich (Lacher et al., 2018a, 2018b).

Acknowledgements

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Contributions to scientific conferences, workshops and meetings

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Workflow 2018

1st quarter 2018

- publication on European CH_4 emission estimates
- attendance of RINGO meeting, Antwerp, Belgium
- publication of statistical data selection strategy
- publication on IAGOS and GAW data

2nd quarter 2018

- publication of TOAR-Climate manuscript
- review of QA4ECV project, De Bilt, the Netherlands
- review of GEO-6 drafts
- training of KMD staff at Empa
- attendance of GEO symposium

3rd quarter 2018

- review of GEO-6 drafts
- attendance of ICOS science conference, Prague, Czech Republic
- publication on satellite-borne CH4 and N2O observations
- teaching at workshop in Indonesia

4th quarter 2018

- teaching at GAWTEC
- publication of GGMT-2017 report
- publication on mountaintop PAN measurements
- lecture at workshop in Puerto Rico
- attendance of IG3IS symposium

continuous activity

- support of GAW stations
- cooperation with other projects such as ICOS, InGOS, ACTRIS, CATCOS, DACH, QA4ECV

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