Deliverable D8.2: *Final report on trans-national access to EUROCHAMP-2020 calibration facilities*

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This report is based on the final assessment of EUROCHAMP-2020 calibration services and access provision (MS8.4). It comprises the number and quality of access provided as well as the actual status of the four calibration facilities, an evaluation of user feedback, and the implementation of three of the calibration facilities in the ACTRIS central facilities. (https://www.actris.eu/facilities/central-facilities)

1. Numbers and quality of access provided

The overall objective of Work Package 8 was the provision of access to four calibration facilities complementing the existing calibration opportunities in atmospheric sciences, and employing the specific capabilities of atmospheric simulation chamber facilities for calibration purposes. The calibration facilities should be integrated in the ACTRIS-RI activities in a sustainable manner, e.g. as central facilities within the topical centers 'Cloud in situ' and 'Aerosol in situ'. Within the first three months of the EUROCHAMP-2020 project, the User Selection Panel for the transnational access proposals was established and immediately started to review the first applications. For access to calibration facilities, a specific application form and review protocol were developed. The new, unique, and cost efficient calibration and training opportunities were immediately announced on the project's website and on websites of the EUROCHAMP-2020 partners, as well as within the ACTRIS community, through social networks and during several international conferences and workshops. Information about the new calibration opportunities was also distributed during user meetings, to explain possibilities of training and participating to calibration workshops. Companies like instrument manufacturers were invited to participate in calibration workshops to increase the attractiveness for all users.
In parallel to these activities, calibration protocols were developed and traceability chains were established. Finally, the provision of access to the four calibration facilities has progressively been increasing, especially starting from the second year of the EUROCHAMP-2020 project. Table 1 provides an overview of the total foreseen usage of access units, demonstrating that the usage was achieved as planned.

Table 1: Overview of total usage

Calibration facilities	Unit	Usage	
		planned	**Final**
AIDA Calibration Centre for Cloud Physics (ACcloud)	1 DAY	20	22
Calibration Centre for Soot Measurements (CCSM)	1 DAY	20	20
World Calibration Centre for Aerosol Physics (WCCAP)	1 RWD	120	115
Organic Tracers and Aerosol Constituents Calibration Centre (OGTAC CC)	1 DAY (ILC)	75	75
	1 DAY (Training)	125	129
Sum (units)		**360**	**361**
Sum (%)		100%	100%

Table 2 shows that at midterm, less than 20% of the total expected usage had been spent. This was due to an induction period lasting for the first year, until the information about the new calibration opportunities had been spread and trans-national access activities could be planned and applied for. A more intense advertisement campaign proved to be successful and led to the expected level of usage. In year 4, significant problems due to pandemic, which strongly limited physical access, were overcome by an increased provision of remote access opportunities and by extending the project duration by 9 months.

Table 2: Overview of trans-national access activities performed

Calibration facilities	*Year 1*						*Year 2*						*Year 3*						*Year 4*						*Year 5*					
Project month	02	04	06	08	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	57	
AIDA Calibration Centre for Cloud Physics (ACcloud)														■											■					
Calibration Centre for Soot Measurements (CCSM)							■							■														■		
World Calibration Centre for Aerosol Physics (WCCAP)									■								■	■		■		■		■						
Organic Tracers and Aerosol Constituents Calibration Centre (OGTAC CC) Training							■				■			■		■		■		■			■				■	■		
Organic Tracers and Aerosol Constituents Calibration Centre (OGTAC CC) Inter-Lab-calibration								■	■	■								■	■	■						■	■			

User statistics

Of the 121 individual users of calibration facilities, half were females and 75% were from groups outside the EUROCHAMP-2020 consortium (cf. Figure 1).

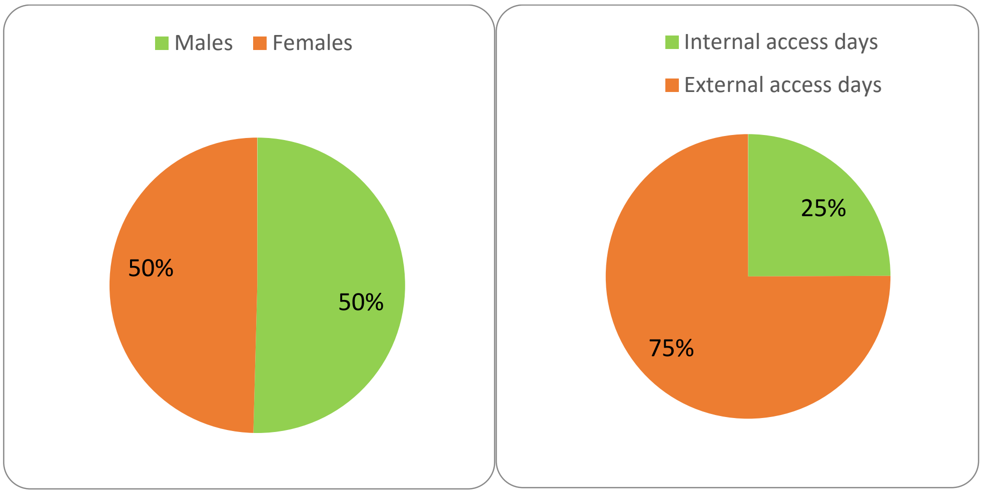

Figure 1: Gender of individual users and use of "access days" by internal partners of the consortium and by external users.

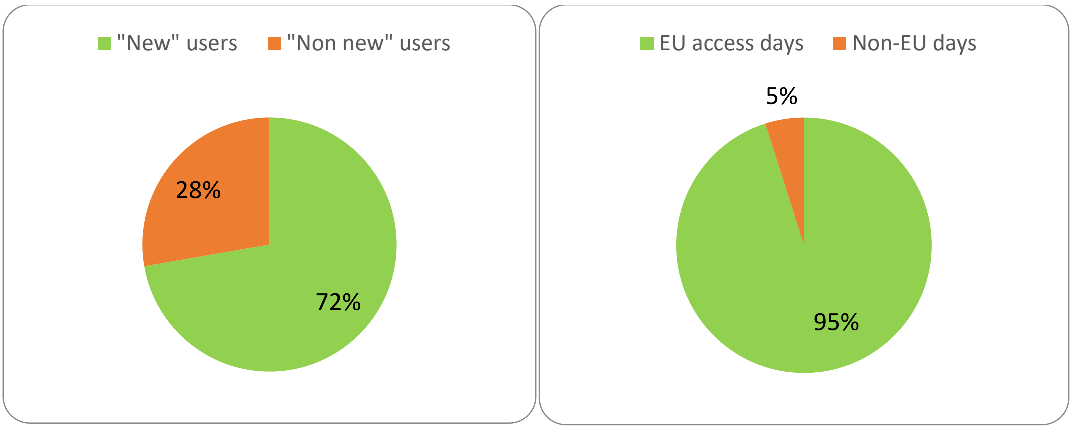

Figure 2: Access to calibration centres by new users and from outside the EU.

More than 70% of the users had never before used the EUROCHAMP-2020 calibration facilities and only 5% of the users came from outside the EU.
The progress achieved in the individual calibration facilities as well as the details of the transnational access activities are outlined in the following.

2. Activities and final status of the calibration facilities

AIDA Calibration Centre for Cloud Physics (ACcloud)

Based on a previous collaboration with the German national institute of standards, **KIT** developed dedicated protocols for the calibration of a broad range of atmospheric hygrometers like radiosondes, dew point mirrors, photoacoustic hygrometers, and various spectroscopic methods at or within the AIDA chamber. This included the validation of the traceability of the reference hygrometer to national standards and procedures for the connection or inclusion of the instruments to be calibrated to the AIDA chamber. The intrinsic AIDA reference by generating dense clouds, which provide saturated conditions (~ 100% RH) was validated by a series of new cloud experiments. As one example, Figure 3 shows the excellent agreement of the water vapour pressure measured inside dense ice clouds with the water vapour pressure calculated with the temperature dependent parameterization given by Murphy & Koop (2005). The in situ (inside the cloud) measurements by a tuneable diode laser hygrometer was, within uncertainty limits, also in agreement with a reference frost point mirror hygrometer (traceable to national standards). An international hygrometer calibration workshop, which was planned for October 2020, could not be realized

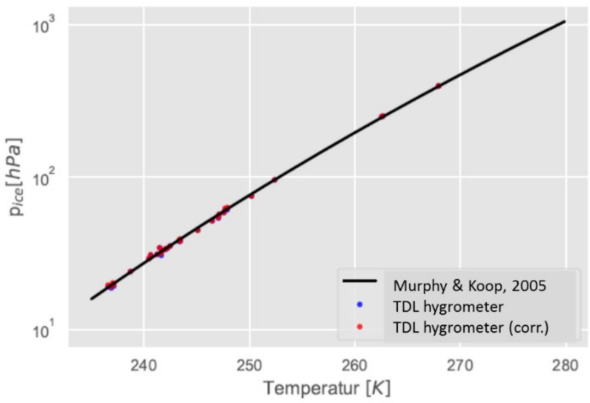

Figure 3: The water vapour pressure measured inside the AIDA simulation chamber in presence of dense ice clouds (red circles) agrees well with the water vapour pressure calculated according to the equation by Murphy & Koop (2005).

due to travel restrictions related to the COVID-19 pandemic. The workshop is now scheduled for 2022 with support hopefully by the project ATMO-ACCESS.

Basis for establishing the calibration capabilities for ice nucleating particles (INP) at KIT were the results of the Fifth International Ice Nucleation Workshop (FIN) hosted at the AIDA facility (DeMott et al., 2018). Together, with continuous discussions with the Committee on Nucleation and Atmospheric Aerosols (CNAA) this provided a basis for further developing ACcloud. KIT developed AIDA reference experiments and protocols for calibrating ice nucleating particle (INP) instruments. In May 2019 a first inter-comparison and calibration of new ice-nucleating particle counters was performed. This activity included the development of AIDA reference experiments for calibrating INP instruments and the intercomparison of INP instruments and measurement methods e.g. diffusion chambers and new expansion chambers with AIDA INP numbers. Besides experiments with pure test aerosols (e.g. Saharan dust, illite, feldspar) also first experiments with realistic mixtures of solutes and dust particles could be performed successfully.

In February 2021 another Intercomparison and calibration of ice nucleating particle instruments including the development of experimental procedures and reference methods was done. During this activity, previous AIDA inter-comparison experiments for INP instruments were evaluated and new strategies for the laboratory-based test, inter-comparison and calibration of INP instruments were developed. Furthermore, a protocol for certification parameters that need to be calibrated with an assured quality for field monitoring INP instruments was developed. Overall, a good agreement among the different INP instrument was observed, especially for pure aerosol systems. However, larger deviations were seen for more atmospherically relevant aerosol mixtures. Consequently, more studies to elaborate potential deviations between the different instruments are planned.

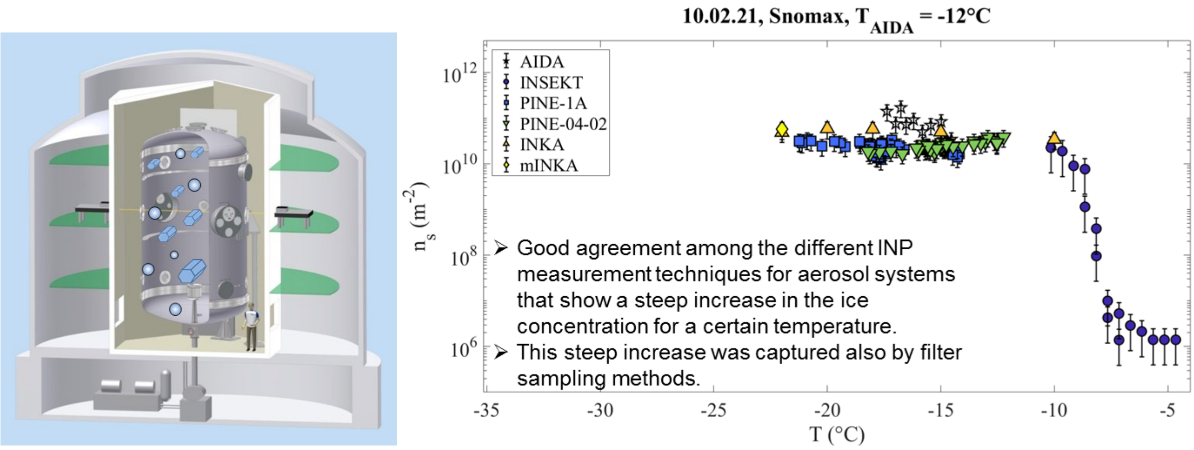

Figure 4: AIDA as reference for calibrating ice nucleating particle instruments. Comparison of various ice nuclei counters in February 2021 employing Snomax as a test aerosol.

Aerosol particles showing a stepwise increase in ice nucleating activity with decreasing temperature have proven very useful for such studies (e.g. Snomax, cf. Figure 4). Hence, more aerosol types with these properties at different temperatures are searched.

Furthermore, KIT, the University of Leeds and Bilfinger Noell GmbH developed and validated a new Portable Ice Nucleation Experiment (PINE) at ACcloud. This new instrument is the first instrument of its kind for fully automated long-term INP measurements at high sensitivity and time resolution. A commercial version of PINE was developed together with Bilfinger Noell GmbH and is available since 2019. Protocols for calibrating mobile INP instruments are currently refined accounting for ongoing instrumental developments and improved calibration methods.
All ACcloud activities are continued as leading part of the ACTRIS topical center "Cloud in situ".

Calibration Centre for Soot Measurements (CCSM)

PSI established the Calibration Centre for Soot Measurements (CCSM) and developed requirements and approaches to achieve traceability and harmonization of *refractory Black Carbon* (rBC) mass measurements. Black Carbon (BC) mass measurements are common across the whole atmospheric chemistry community. Yet each technique has its own characteristics and caveats that are often overlooked. The simulation chamber can provide a platform to characterize the different techniques. In order to better relate the different techniques, quantitatively, and traceably, there are requirements for the harmonization and traceability across the methods. The harmonization and standardization of calibrations and general measurement will go some way to reconcile the different techniques. Figure 3 shows an example time series of measurements of "black carbon mass" from 5 different instruments based on 3 commonplace methods: 1) Equivalent black carbon (eBC) mass inferred from light absorption coefficient, 2) Thermal-optical elemental carbon (EC), 3) Laser-induced incandescence (LII) resulting in refractory black carbon (rBC) mass. Whilst the qualitative agreement is good, in absolute terms the choice of instrument will determine the "measured" BC mass and thus influence subsequent scientific interpretation.

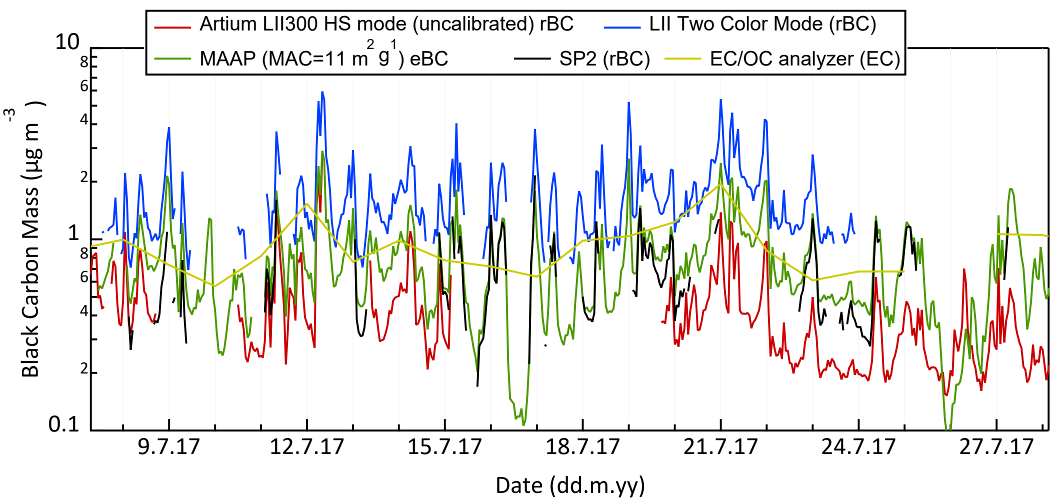

Figure 5: An example time series of "Black Carbon mass" measurement.

The strategy of the CCSM is to provide the platform for the harmonization and traceability across the methods, with a focus on rBC mass measurement. The suite of instrumentation combined with excellent scientific and technical knowledge at the CCSM is extremely useful in providing the tools required to make accurate and traceable measurements of rBC. For example, *the ideal calibration approach* for the single particle soot photometer (SP2) is to reference against a particle mass classifier (PMC) on a single particle level, specifically for the BC type under investigation (PMC mass selection to be cross-checked with traceable PSL size standards). This requires availability of the BC type of interest in pure form such that classified particle mass equates BC mass. Figure 6a shows the setup for this ideal calibration approach. It is further required to establish traceability of number concentration measurements with traceable flow rate meters and against reference number concentration measurements (either a referenced and traceable CPC, or an electrometer). *Only the combination of traceable single particle BC mass and traceable number concentration measurement provides a traceable BC mass concentration*.

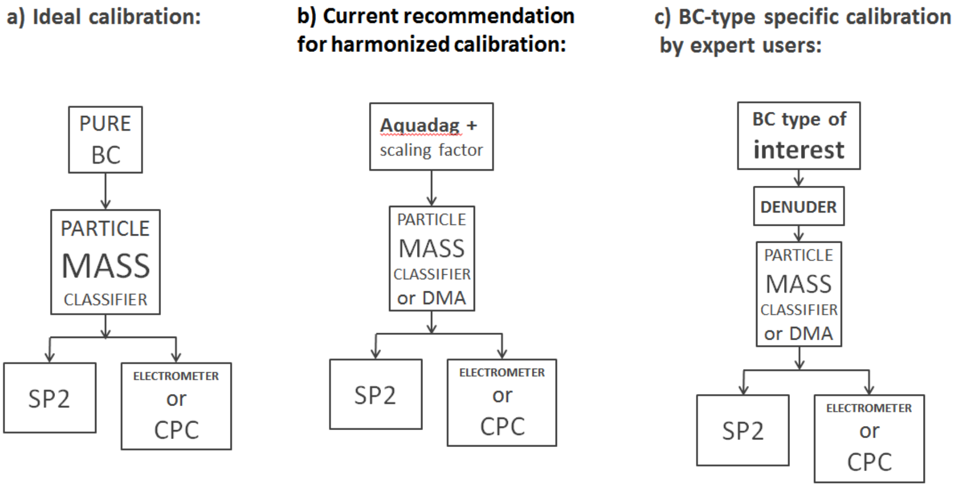

Figure 6: Example set ups for traceable rBC calibration and harmonization.

In practice, it is not always possible to perform "ideal" experiments for a number of reasons. BC properties vary between sources and combustion conditions, and the BC types of interest are not always available in pure form. Therefore, *the primary goal of the LII harmonization activities at PSI facilities is to ensure proper instrument performance and harmonization using a suitable* *reference BC aerosol* following the setup shown in Figure 6b. However, PSI and the CCSM appreciate that it may be desirable for expert users to perform *BC-type specific calibrations* independently. Figure 4c shows the proposed setup for such a calibration, whereby the BC-type aerosol of interest is thermally denuded (to remove any non-BC components), mass classified, and then measured by an SP2 (e.g. Broda et al., 2018). As shown in Figure 7, the SP2 proportionality constant (derived from raw signals) is known to depend on BC type (Moteki et al. 2010, Baumgardner et al., 2012, Laborde et al., 2012), and thus ideally all SP2 instruments would be calibrated and then back-referenced to a "standard" BC material such as Aquadag. The role of the CCSM would be to provide its expertise to the wider SP2 community such that ambient rBC measurements from SP2s around the world, in different environments and on different measurement platforms, can all be traced back and compared with far higher certainty than is currently offered from the factory. Further to continuous wave LII, the CCSM aims to include the original pulsed-shot LII technique in the general CCSM activities. Although traceability for pulsed-shot LII can in principle be independently established, *the main goal of the CCSM within the EUROCHAMP-2020 activities is to achieve harmonization (and quantification of related uncertainties) of the pulsed-shot LII approach with the SP2 measurements*.

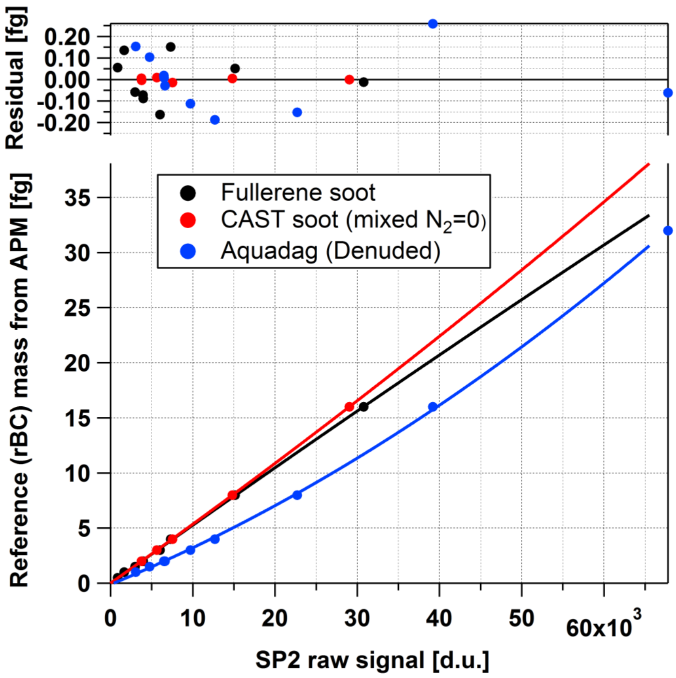

Figure 7: Calibration curves of the SP2 differ with BC type. High EC mass fraction CAST soot is an additional artificial BC type used at the CCSM as the sensitivity of the SP2 to CAST soot is comparable to its sensitivity to typical ambient BC.

PSI has organized three **TNA activities** at the CCSM:

1. **CCSM-002-2017**: The Institute of Atmospheric Sciences and Climate (CNR-ISAC) participated in a calibration and training activity for single particle soot photometer related to deploying SP2 instruments during the ACTRIS-JRA1 campaign at Mt. Cimone and Bologna in 2017 and a field experiment in Bolivia at the Chacaltaya GAW station (TNA PI: A. Marinoni).

2. **CCSM-003-2019:** Was a SP2 calibration workshop at PSI facilities focusing on instrument best practices for a consistent and harmonized SP2 calibration. A specific goal was to prepare a series of instruments for deployment during Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAIC) in 2019/2020. The pre-deployment calibration campaign prepared and trained users how to consistently process the raw data. Beyond the campaign preparation there are two intercomparison manuscripts nearing submission (TNA PI: M. Zanatta).

3. **CCSM-004-2021**: This campaign was continually delayed due to the corona virus situation in Europe. A smaller version of the campaign was performed with two SMEs (Schnaitec and Haze Instruments) and two research institutes (KIT and UNG). The pared down version featured an intercomparison between the latest filter-based and in situ techniques for measuring aerosol light absorption coefficients, including traditional absorption photometers, extinction-minus-scattering measurements, two novel photo-thermal interferometers, and photo-acoustic spectrometers. To measure BC mass absorption cross sections for a range of different mixtures of BC, BrC (Brown Carbon) and non-absorbing aerosols. Beyond BC measurements chamber studies will also focus on changes in optical properties with aerosol aging using detailed chemical measurements to determine the types of coatings generated (clear vs. BrC) (TNA: G. Mocnik).

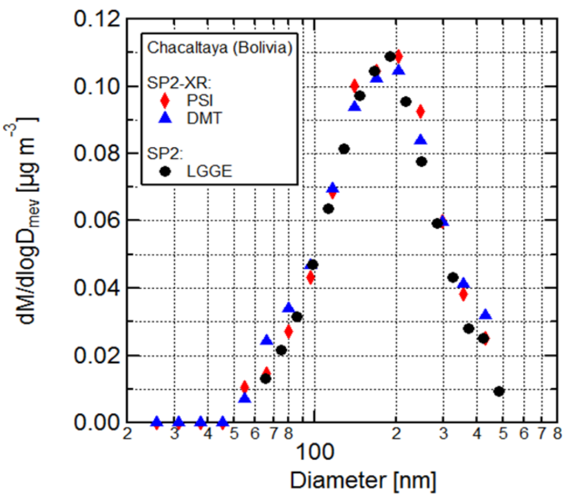

Figure 8: Example of excellent agreement of independent refractory black carbon (rBC) measurements achieved in a field study in Bolivia at the Chacaltaya GAW station following calibration at CCSM-001-2017.

Organic Tracers and Aerosol Constituents - Calibration Centre (OGTAC CC)

TROPOS established within the framework of EUROCHAMP-2020 a calibration centre for the analysis for organic tracers and aerosol constituents (OGTAC CC). This new calibration center is focused on the most up-to-date techniques for the analysis of the main secondary organic aerosol (SOA) constituents of biogenic and anthropogenic origin, which are extremely useful for both sources and processes apportionment. For this reason, its service is extremely valuable to harmonize the practices among the chamber community with respect to organic analytical chemistry and to provide references for the field and observation community. OGTAC-CC provides training of users with advanced analytical techniques and inter-laboratory comparisons (ILCs).

1. Training

In total, OGTAC-CC conducted 14 training sessions within the Eurochamp-2020 project with 53 participants (35% of users from EUROCHAMP partners). Training of single persons, research groups and courses have been provided.
For the latter OGTAC-CC activity (**OGTAC CC-Training-001-2017, 002-2017, OGTAC CC-Training-005-2019, OGTAC CC-Training-006-2019, OGTAC CC-Training-009-2019 and OGTAC CC-Training-010-2010**) courses covered:

- hands-on training sessions at state of the art instruments;
- lectures in atmospheric particle related chemical analysis;
- practical training for filter collection, extraction, analysis and quantification of target compounds
- derivatisation and enrichment procedures

As an example, the topic of Liquid Chromatography coupled with Mass Spectrometry (LC/MS) was selected for the first two training courses, as this is the most dominating technique for the target analysis of atmospheric relevant tracer compounds. The analytical training course focused on the target analysis of atmospheric relevant particle-phase constituents. The training offered the possibility to all applicants to get practical training at state of the art instruments, discussions with experts, and to strengthen their network.
Within two weeks (10 Access days) 11 international users from France, Spain, Poland, Ireland, Romania and Denmark and seven national users from Germany (showing the attractiveness of the calibration facility, led to intensified knowledge exchange, and networking during the users) were trained. The training conducted focused on the application of LC/MS for the analysis of atmospherically relevant particulate products. In particular High-Performance Liquid Chromatography Electrospray Ionization coupled to Time-of-Flight Mass Spectrometry (HPLC/(-)ESI-TOFMS), Ultra-Performance Liquid Chromatography Electrospray Ionization coupled to Ion-Mobility Mass Spectrometer with a Time-of-Flight Mass Spectrometer (UPLC/ESI-IMS-QTOFMS). Thus, within the training the participants learned each step from sample collection to quantitative data analysis, with special emphasis for a high level of QA/QC during each phase of sample treatment. Partners from industry joined the training courses as well (ThermoFisher and Waters) to introduce new perspectives in chemical analysis. .
In addition to the courses, eight trainings of research groups and/or single persons have been performed (**OGTAC CC-Training-003-2018, OGTAC CC-Training-004-2019, OGTAC CC-Training-007-2019, OGTAC CC-Training-008-2019, OGTAC CC-Training-011-2019, OGTAC CC-Training-012-2019, OGTAC CC-Training-013-2020, and OGTAC CC-Training-014-2020).** As one example, the third training focused on detailed molecular characterization of organic aerosols from

Domestic Solid Fuel burning (DSF). The user group (University of Cork) aimed to identify and quantify well-known combustion markers in ambient and fuel-burning samples of PM, but also new combustion markers for different fuel types to support apportioning potential contributions of coal, peat and wood burning to ambient levels of PM. The training focused on HPLC/ESI-TOFMS, HPAEC-PAD, and CPP-GC/MS.

All training activities resulted in well-trained users regarding the analysis of organic tracers and aerosol constituents, but all performed TNAs also fostered international collaboration and strengthen scientific outcome worldwide. Examples of the training activities have been presented on the annual conference of the European Geophysical Union (Gomez Alvarez et al., 2019).

2. Interlaboratory comparisons (ILCs)

Seven of the users of the analytical training course participated afterwards also in the 1st inter-laboratory comparison (**OGTAC CC-ILC-001-2018**) organized by the OGTAC-CC. The 1st ILC was focused on biogenic secondary organic aerosol (BSOA) marker compounds. The main goal was to obtain an overview about groups working on BSOA characterization and a comprehensive overview about existing method to extract, detect and quantify BSOA marker compounds. In total 13 laboratories from Europe (France, Spain, Germany, Poland, Denmark, Switzerland, Slovenia and UK) and the US participated. The ILC comprises the distribution of filter samples collected in the TROPOS ACD aerosol chamber (ACD-C) and at the TROPOS research station Melpitz (Germany) with subsequent chemical analysis at the participating laboratories. This activity was finished at the end of August 2018 and first results were presented at the annual conference of the European Geophysical Union (Mutzel et al., 2019).

The 2nd inter-laboratory comparison (**OGTAC CC-ILC-002-2019**) focused again on BSOA marker compounds, as the follow up on the 1st ILC. After evaluation of this 1st ILC, a standard operation procedure was developed for the determination of BSOA marker compounds. The standard operation procedure (SOP) was provided to all users and the aim of the 2nd ILC was to test and evaluate the applicability and general performance of the SOP with respect to quantitative characterization of BSOA marker compounds from chamber and real field aerosol samples. In detail, each participant received a set of 3 filter samples composed of 1 filter collected at the TROPOS research station Melpitz and 2 filters from the aerosol chamber experiments in ACD-C. Analogous to the 1st ILC, the participants were asked to quantify five different target compounds, namely terebic acid, terpenylic acid, pinic acid, pinonic acid and 3-Methyl-1,2,3-tricarboxylic acid (MBTCA). Each analysis had to be done as triplicate. However, in this 2nd ILC each participant was asked to follow the SOP provided by OGTAC-CC. The results of this 2nd ILC demonstrated the applicability of the tested SOP to measure BSOA marker compounds from filter samples. The comparison with the results from the 1st ILC showed the improvement of the data validity when the participants follow a SOP and apply the same measurement techniques (LC-MS). This was confirmed by in summary less stragglers and outliers, smaller percentage deviations from an assigned value and smaller z-scores. However, it should be emphasized that the overall process of this 2nd ILC was highly impacted by the pandemic situation resulting in only the small number of participants and the respective data availability.

As a next and final step within EUROCHAMP-2020, OGTAC-CC performed a 3rd ILC (**OGTAC CC-ILC-003-2021**) on anthropogenic SOA marker compounds. In combination with the results of the former ILCs on BSOA marker compounds, it aimed to improve further the harmonization of the respective analytical procedures and strengthen the QA/QC for these methods. Within the 3rd ILC (procedure similar to the 1st ILC), each participating laboratory extracted and analyzed the filter following their own procedure. With this, a first overview was obtained on all applied techniques and the quality of these techniques. The results will be used later on within OGTAC-CC as ACTRIS central facility unit to develop a SOP for ASOA marker compounds. In this way, the analysis of biogenic and anthropogenic SOA marker compounds can be harmonized ensuring the highest level of QA/QC for future work.

The Organic Tracers and Aerosol Constituents - Calibration Centre (OGTAC-CC) is integrated in the ACTRIS in the topical center 'Aerosol in situ' and will continue providing its valuable services.

World Calibration Centre for Aerosol Physics (WCCAP)

TROPOS established the WCCAP in 2002 to serve as a competence center for in-situ physical and optical aerosol measurements as part of the worldwide GAW-program of the WMO. WCCAP is worldwide unique for the quality assurance of physical and optical in-situ aerosol measurements and station audits to improve infrastructures. As part of the European Centre for Aerosol Calibration (ECAC, www.actris-ecac.eu), WCCAP provides Calibration and Intercomparison Workshops especially for the ACTRIS community with focus on the following instruments:

- Condensation Particle Counter - CPC
- Mobility Particle Size Spectrometer - MPSS
- Aerodynamic Particle Size Spectrometer - APSS
- Optical Particle Size Spectrometer - OPSS
- Integrating Nephelometer - IN
- Absorption Photometer - AP
- Extinction Monitor - EM
- Cloud Condensation Nuclei Counter - CCNC
- On-Site Intercomparisons & Audit - OSIA (only for MPSS)

In EUROCHAMP-2020, the WCCAP had two main objectives: increasing the quality of aerosol measurements within EUROCHAMP-2020, and providing external users with more access to the WCCAP. A EUROCHAMP-2020 internal survey evaluated in 2018 the amount and diversity of physical aerosol instrumentation suitable for WCCAP services.

A first calibration workshop especially for the EUROCHAMP community with focus on Condensation Particle Counter and Mobility Particle Size Spectrometer had been organized in June 2018 (TNA projects of **WCCAP-001-2018** and **002-2018**). The success of this activity initiated to several additional calibration activities throughout the EUROCHAMP2020 project.
In total 110 research working days (RWD) were spent from 2018 to 2021. Overall, 18 calibration workshops were done for condensation particle counters (2 postponed), 7 for mobility particle size spectrometers (1 postponed), 7 for absorption photometers (AP), 7 for integrating nephelometers (1 postponed), and one for cloud condensation nuclei counters (postponed). Several activities needed to be postponed due to COVID-19 restrictions, but will most likely be performed in the framework of ACTRIS.

The WCCAP is leading part of the ACTRIS topical center "Aerosol in situ". The WCCAP is part of the European Center for Aerosol calibration & Characterization (ECAC). The ECAC consortium will be officially established in ACTRIS-ERIC in 2022. WCCAP will have the lead of the ECAC for the ACTRIS implementation period. The ECAC will provide specific preliminary recommendations for the chamber studies until end of 2021. ACTRIS national facilities, which start with the labelling process, will get the full support and service from ECAC.
Since 2018, 35 instruments have been calibrated.

3. Evaluation of user feedback

The AIDA Calibration Centre for Cloud Physics (**ACcloud**) received several positive comments on intercomparison and calibration activities at the facility as well as expressions of interest to participate in future intercomparison and calibration activities.

User feedback on the first calibration activity at the Calibration Centre for Soot Measurements (**CCSM**) in February 2018 was very positive for both training and calibration activities (CCSM-001-2017).
"The facility was very useful both in providing training for evaluating previous measurements (including calibrations) and in optimizing and calibrating the SP2 instrument for the following field campaign in Bolivia. PSI laboratories were very well equipped for our purpose and people extremely available to help to collaborate to reach the goal of the SouMount Project."

The second calibration activity at CCSM (CCSM-002-2019) created for example impact in terms of harmonization of black carbon mass measurements on global scale. This is reflected in the following excerpt taken from a manuscript on long-term and multi-site black carbon measurements in the Arctic (Ohata et al., 2021).
"[…] In the previous study by Sharma et al. (2017), the constant value of ρ_{eff} (= 0.7 g cm^{-3}) for Aquadag was assumed to derive MBC (SP2) at Alert. However, we have found that MBC (SP2) at Alert highly depended on the assumed ρ_{eff} values of Aquadag used for the on-site calibration with a DMA. Because of this, we used the calibration curve obtained by fullerene

soot with an APM at the Paul Scherrer Institute after the observation period for this study. […] MBC (COSMOS) and MBC (SP2) agree to within 10% at Alert, consistent with previous studies that reported the stability of the relationship between MBC (COSMOS) and MBC (SP2) at various sites (Kondo et al., 2011; Ohata et. al., 2019). […]"

User feedback on the calibration activities at the World Calibration Centre for Aerosol Physics **(WCCAP)** were very positive especially with respect to the high quality of service provided compared to the relatively moderate costs.
"It is extremely useful to have the opportunity to get aerosol instruments like CPCs calibrated at the WCCAP. It is not only much cheaper than calibrations e.g. by the major manufacturers but the WCCAP gives also very useful advices for instrument operation and applies adjustments to the instruments. The complete calibration procedure is done in a very professional manner."

The Organic Tracers and Aerosol Constituents - Calibration Centre **(OGTAC-CC)** conducted six training sessions with participants from all over Europe (e.g., France, Spain, Poland, Ireland, Romania, Denmark and Germany). All users were asked to answer a feedback questionnaire including the following points: overall impression, organisation, balance between theory and practical work, structure of the course, content, oral presentations, and practical part. Everybody could rate between 1 (excellent), 2 (very good), 3 (good), 4 (fair) and 5 (poor). All participants filled the questionnaire. Analysis of these questionnaires resulted in an average rating of 1.7, which can be counted as very good. Finally, the participants were asked if they would recommend this course. In this case a unanimously result was obtained as all participants recommended the course.
The majority of the users highlighted the importance of the possibility to learn and train all necessary basics. All of them joined the discussion during the lectures and during the hands-on sessions. Few users also made suggestions for improvements and these will be taken into account for up-coming sessions. They include an extension of the practical part and a dedicated session on method development.
In addition, the users from the single person and research group TNAs within OGTAC-CC always highlighted the great chance to learn how to properly work with state of the art analytical techniques and the great opportunity to work together with experts in that field of research, exchange knowledge and to foster future collaborations.

4. Final assessment summary

It was the aim to provide access to four EUROCHAMP-2020 calibration facilities to achieve special benefit for users of atmospheric simulation chambers, ACTRIS-2 facilities, airborne platforms for atmospheric studies, and SMEs improving and validating existing or new instruments. These facilities should complement existing calibration opportunities in atmospheric sciences and demonstrate the specific usefulness of atmospheric simulation chamber facilities for calibration purposes. Finally, the calibration facilities should be integrated in the ACTRIS-ERIC activities in a sustainable manner (e.g. as topical centers). The milestones and deliverables were achieved as scheduled (cf. Table 4).

All calibration centers of EUROCHAMP-2020: for Cloud Physics (ACcloud), for Soot Measurements (CCSM), for Aerosol Physics (WCCAP), and for Organic Tracers and Aerosol Constituents (OGTAC-CC), developed dedicated calibration and training protocols and established suitable traceability chains. In intensive interactions with users, relevant SMEs, international advisory boards, and national institutes of standards, the corresponding protocols were refined and adapted to ensure highest usefulness and applicability. These activities lead to the following results:

- Protocols for calibrating ice nucleating particle (INP) instruments and for the calibration of a broad range of atmospheric hygrometers.
- Protocols for calibrations with black carbon (BC) standards (fullerene soot, Aquadag) and real-world BC aerosols (diesel soot coated with secondary organic aerosol, BC mixed with magnetite dust).
- Protocols on training quantitative sampling and chemical analysis of major secondary organic aerosol constituents of biogenic and anthropogenic origin.
- Standard operation procedures (SOPs) for inter laboratory comparisons for the chemical analysis of marker compounds of secondary organic aerosol of biogenic and anthropogenic origin.
- Protocols for the calibration of instruments to measure aerosol particle number, size, light scattering, extinction, and cloud nuclei concentrations as well as recommendations for quantitative aerosol sampling.

All user feedback was generally very positive with special emphasis on the personal engagement of the people at the calibration facilities and some of the feedback was used to improve the services offered. Throughout the project the new, unique, and cost efficient calibration and training opportunities became more and more popular so that 360 calibration units (days) were used including 125 training days. The majority of users are females from groups outside the EUROCHAMP-2020 consortium which have not been at the calibration facilities before. Finally, the EUROCHAMP-2020 calibration facilities are integrated in ACTRIS-ERIC as central facilities having a leading role in the topical centers ‘Cloud in situ’ and ‘Aerosol in situ’, except for the CCSM given that LII-based refractory black carbon mass measurements evolved towards an ACTRIS auxiliary variable. Thus, the calibration facilities integrated in ACTRIS will continue to provide recommendations not only for chamber studies but will support all national facilities in ACTRIS in consequently ensuring highest data quality.

Table 4: Milestones and deliverables of WP8

WP8 milestones and deliverables		*Year 1*						*Year 2*						*Year 3*						*Year 4*						*Year 5*					
	Project month	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	57	
M8.1	**Definition of application and selection procedure for access to the calibration facilities**	✓																													
M8.2	**Advertisement of TNA opportunities and launch of continuous call for TNA**		✓																												
M8.3	**Intermediate assessment of EUROCHAMP-2020 calibration service and access provision**											✓																			
D8.1	**Intermediate report on trans-national access to the calibration facilities**												✓																		
M8.4	**Final assessment of EUROCHAMP-2020 calibration service and access provision**																												✓		
D8.2	**Final report on trans-national access to EUROCHAMP-2020 calibration facilities**																													✓	

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