TNA User Report

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Project title	AP-2019-3
Name of the accessed calibration center	WCCAP (World Calibration Center for Aerosol Physics)
Number of users in the project	1
Project objectives (max 100 words)	The object of the intercomparison and calibration workshop was to see if the absorption photometers meet the requirements for data quality within accepted uncertainty limit. The instruments were also cleaned and calibrated.
Description of work (max 100 words):	This project was an intercomparison and calibration workshop for absorption photometers. The measurement cells of the photometers were cleaned and the flows were calibrated. After the cleaning and calibration procedures, the noise of the instruments were determined and they were compared against the WCCAP reference instruments. Institute for Atmospheric and Earth System Research attended the workshop with two absorption photometers: MAAP and CLAP. The MAAP and CLAP met the requirements. However, the absorption measured by CLAP deviated from the reference absorption depending on the filter transmission.

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[1] Physics; Chemistry, Earth Sciences & Environment; Engineering & Technology; Mathematics; Information & Communication Technologies; Material Sciences; Energy; Social sciences; Humanities.
[2] UNI= University and Other Higher Education Organisation;
RES= Public Research Organisation (including international research organisations and private research organisations controlled by public authority);
SME= Small and Medium Enterprise;
PRV= Other Industrial and/or Profit Private Organisation;
OTH= Other type of organization.
[3] UND= Undergraduate; PGR= Post graduate; PDOC= Post-doctoral researcher; RES= Researcher EXP= Engineer; ACA= Academic; TEC= Technician.
[4] Reproduce the table for each user who accessed the infrastructure

Trans-National Access (TNA) Scientific Report

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Instructions

Please limit the report to max 5 pages, you can include tables and figures. Please make sure to address any comments made by the reviewers at the moment of the project evaluation (if applicable, in this case you were informed beforehand). Please do not alter the layout of the document and keep it in Word version. The report will be made available on the eurochamp.org website. Should any information be confidential or not be made public, please inform us accordingly (in this case it will only be accessible by the European Commission, the EUROCHAMP-2020 project partners, and the reviewers). Please include:

- Introduction and motivation
- Scientific objectives
- Reason for choosing the calibration facility
- Method and experimental set-up
- Data description
- Preliminary results and conclusions
- Outcome and future studies
- References

Name of the PI: Krista Luoma

Calibration center's name and location: WCCAP, Leipzig, Germany

Campaign name and period: AP-2019-3, 7. – 11. October 2019

Text:

Introduction and motivation

This report presents the methods and results from an absorption photometer intercomparison and calibration workshop held at the World Calibration Center for Aerosol Physics (WCCAP) in Leibniz Institute for Tropospheric Research (TROPOS). The results are based on the WCCAP reports, which are published in webpage of European Center for Aerosol Calibration (ECAC; https://www.actris-ecac.eu/ap-2019-3.html).

Absorption photometers measure the light absorption of aerosol particles at different wavelengths. The light absorption is described by the absorption coefficient (σ_{abs}) and it is typically reported in the units of Mm^{-1}. The σ_{abs} is an important parameter in determining the direct effects of aerosol particles on the climate. Also, the black carbon (BC) concentration is typically derived from the σ_{abs} by using the mass absorption cross section (MAC).

The Institute for Atmospheric and Earth System Research (INAR) attended the workshop with two instruments: Continuous Light Absorption Photometer (CLAP) and Multi-Angle Absorption Photometer (MAAP; Thermo Fischer model 5012). The MAAP measures σ_{abs} at red wavelength (637 nm) and the CLAP at blue, green, and red wavelengths (468, 529, and 653 nm). More detailed information about MAAP and CLAP is presented by Petzold & Shönlinner (2004) and Ogren et al. (2017), respectively. The instruments are deployed for long-term measurements at the SMEAR II station in Hyytiälä, southern Finland. SMEAR II is part of the ACTRIS research infrastructure, which requires regular instrument calibration and intercomparison.

Scientific objectives

The aim of the absorption photometer intercomparison and calibration workshop was to verify that the instruments measure light absorption within the accepted uncertainty range. Comparison with a reference instrument reveals possible systematic errors and instrumental malfunctions.

The instruments were calibrated and cleaned during the workshop and therefore the workshop also gives some hands-on experience to the users about the maintenance of the instruments.

Reason for choosing the calibration facility

WCCAP provides regular calibration and intercomparison workshops for absorption photometers. They have a well-equipped laboratory and a lot of experience running these workshops.

Method and experimental set-up

In total, there were three absorption photometers verified in the workshop: MAAP and CLAP from INAR, and another MAAP from Deutscher Wetterdienst (DWD). In addition to these three instruments, the experimental set-up included reference instruments, particle generators, and a chamber to which all the instruments were connected.

The reference instruments at the WCCAP were: MAAP; 7-wavelength Aethalometer (Magee Scientific model AE33); three extinction monitors (Aerodyne research, CAPS PM_{ex} Monitors for blue, green, and red wavelengths); and an integrating nephelometer (Ecotech model Aurora 4000). MAAP and Aethalometer measure σ_{abs} of particles by collecting the particles on a filter. The extinction monitor and the integrating nephelometer measure extinction and scattering coefficients (σ_{ext} and σ_{sca}) of

particles suspended in air. Therefore, by measuring extinction and scattering separately, it is possible to determine the σ_{abs}, which is $\sigma_{abs} = \sigma_{ext} - \sigma_{sca}$, for particles that are suspended in air.

First, the noise for each instrument was determined by measuring particle-free air. After the filtered air runs, the instruments measured different types of particles that were generated in the laboratory and injected in the chamber. For example, absorbing soot particles were generated with a miniCAST. Also, ambient outdoor air was measured.

The CLAP data was corrected by using the correction scheme suggested by Bond et al. (1999). Since we operated CLAP with Azumi filters (model 371M), the concentrations were multiplied by 0.8, as suggested by Ogren et al. (2017).

Data description

Figure 1 presents an example of the absorption time series measured by CLAP and the reference instrument (PM_{ex} and Nephelometer) during the intercomparison. In the example, the σ_{abs} was varied from 0 to about 100 Mm^{-1}.

Figure shows how the absorption measured by CLAP deviated from the reference and the deviation depended on the transmittance (Tr) of the CLAP filter. The Tr describes the transmission of light trough the filter so that for clean filter the Tr is 1. The correction scheme by Bond et al. (1999) takes the effect of decreasing Tr into account, but as it is seen from Fig. 1 the correction algorithm does not remove the effect completely.

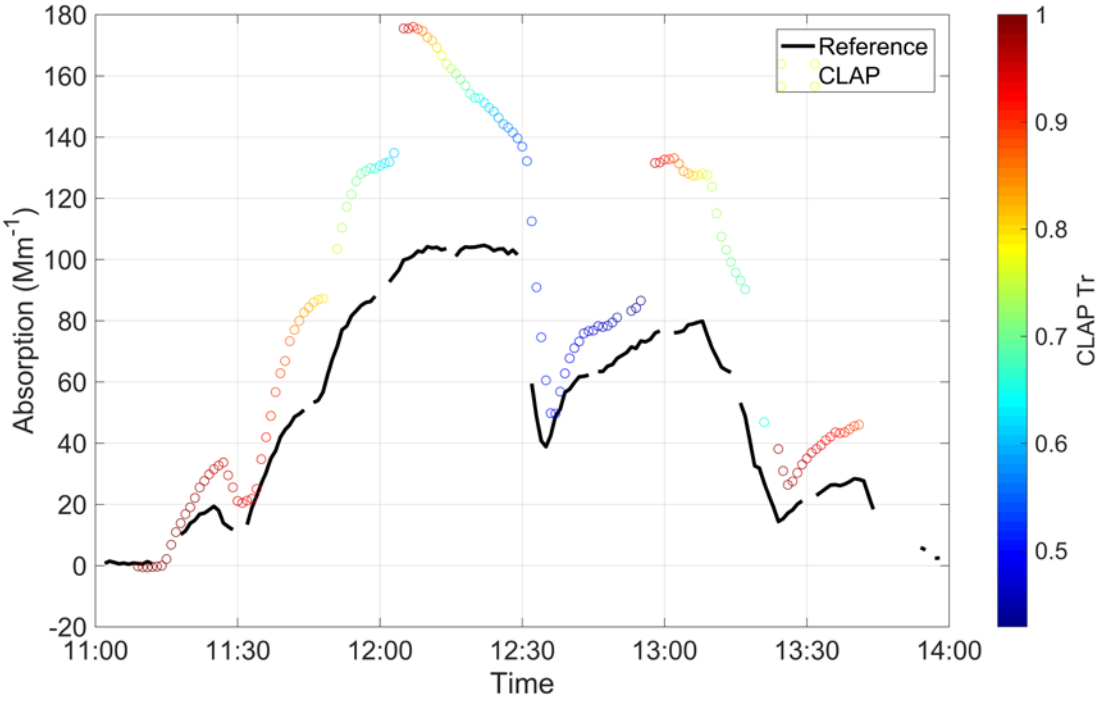

Figure 1 : An example of the absorption data measured on 9th October 2019 at the AP-2019-3 workshop. The figure shows the reference absorption determined as the difference between extinction and scattering coefficients. The CLAP data is colored by the transmission (Tr) of CLAP filter (i.e. higher Tr indicates clean filter spot). The time series are plotted for red wavelength.

Preliminary results and conclusions

The MAAP from INAR had an acceptable noise level. Inspection revealed that the measurement cell was contaminated with dust and the inner walls were covered with oily liquid. Therefore, the cell was cleaned. The spot size was evenly round and well defined. The flow reported by the MAAP was only about 3 % smaller than the measured flow. The measured concentration correlated well with the reference (R^2 = 0.988) and the measured BC concentration was only 1.1 % higher than measured by the reference MAAP so the instrument met the requirements. For more detailed information, see WCCAP report AP-2019-3-2.

The CLAP from INAR also had acceptable noise level. We did not observe any contamination in the inspection and the filter spots were evenly round and well defined. Therefore, no cleaning was needed. The flow reported by the instrument was only about 1 % lower than measured. In the comparison with different reference instruments CLAP did not correlate as well as MAAP ($R^2 \approx 0.95$). For more detailed information, see WCCAP report AP-2019-3-3.

Outcome and future studies

Since the INAR MAAP met the requirements, no further measures for improving the data quality were needed. The concentration measured with the CLAP from INAR, however, deviated from the concentration measured with the reference instruments. Therefore, we will use the measurements conducted at the workshop to test different correction algorithms and see, if other correction schemes and coefficient would make the data more comparable to the reference.

References

Bond, T. C., Anderson, T. L., & Campbell, D. (1999). Calibration and intercomparison of filter-based measurements of visible light absorption by aerosols. *Aerosol Science & Technology*, *30*(6), 582-600.

Ogren, J. A., Wendell, J., Andrews, E., & Sheridan, P. J. (2017). Continuous light absorption photometer for long-term studies. *Atmospheric Measurement Techniques*, *10*(12), 4805.

Petzold, A., & Schönlinner, M. (2004). Multi-angle absorption photometry—a new method for the measurement of aerosol light absorption and atmospheric black carbon. *Journal of Aerosol Science*, *35*(4), 421-441.

WCCAP report AP-2019-3-2 (2019): Intercomparison of absorption photometer Project No.: AP-2019-3-2, published in https://www.actris-ecac.eu/ap-2019-3.html.

WCCAP report AP-2019-3-3 (2019): Intercomparison of absorption photometer Project No.: AP-2019-3-3, published in https://www.actris-ecac.eu/ap-2019-3.html.