TNA User Report

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Project title	Nephelometer inspection and calibration
Name of the accessed chamber	WCCAP-TROPOS
Number of users in the project	1
Project objectives (max 100 words)	1. To assess the Nephelometer (Ecotech Aurora3000 S/N 12-1441) performance by comparing it against WCCAP reference instruments. 2. To ensure that the data yielded by this instrument fulfil the quality standards.
Description of work (max 100 words):	Technical inspection and calibration of 3-wavelength integrating Nephelometer (Ecotech Aurora 3000 S/N 12-1441) and intercomparison along with other instruments against one reference set of devices from WCCAP in TROPOS, Leipzig.

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User status[3]	RES
New user	NO

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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 simulation chamber/ calibration facility
- Method and experimental set-up
- Data description
- Preliminary results and conclusions
- Outcome and future studies
- References

[3] UND= Undergraduate; PGR= Post graduate; PDOC= Post-doctoral researcher; RES= Researcher ENG= Engineer; ACA= Academic; TEC= Technician.

[4] Reproduce the table for each user who accessed the infrastructure

Name of the PI: Esther Coz, Begoña Artíñano
Chamber name and location: WCCAP, Leipzig, Germany
Campaign name and period: Scheduled workshop IN-2020-1 from January 27 to 31 2020.

1. Introduction and motivation

Atmospheric aerosols play a key role in the radiative forcing that determines the radiation balance of the Earth. Understanding and accurately quantifying their optical properties are crucial to minimize uncertainties when modelling their impact on climate and also to estimate their effect on the air quality, an issue of special relevance in urban areas.
Our integrating Nephelometer (Ecotech Aurora 3000, S/N 12-1441) operates continuously for as part of the air quality station at CIEMAT-Madrid to evaluate the optical properties of the atmospheric aerosols for atmospheric and climate-related studies.

According to the WMO and GAW, performance checks, including inter-laboratory intercomparisons is one of the procedures for quality controls in measurements activities (WMO, 2016). Considering to this necessity, networks such as ACTRIS (the European Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases), which this instrument operates for, carry out instrumental comparison and calibration workshops, where operators verify the status of their instruments and compare them with reference equipment to guarantee quality in long-term measurements, which allow identifying trends in global distributions of aerosols.

Thanks to Eurochamp 2020 project, which integrates the most advanced European atmospheric simulation and extend trans-National access to different calibration centres, we were granted to access WCCAP in January 2020 and attend their scheduled workshop IN-2020-1.

2. Scientific Objectives

2.1 To assess the Nephelometer (Ecotech Aurora3000 S/N 12-1441) performance by comparing it against WCCAP reference instruments.
2.2 To ensure that the data yielded by this instrument fulfil the quality standards.

3. Reasons for choosing the calibration facility

The WCCAP facility in TROPOS, Leipzig, Germany, conducts calibrations of physical aerosol measurement instruments as well as environmental and work place measurements of aerosols. In addition, they also perform frequently intercomparison workshops giving special priority to particle mobile size spectrometers, absorption photometers and integrating Nephelometer.

This centre and their technical staff have long experience on inspecting, evaluating and developing the above-mentioned instrumentation so this calibration centre is quite suitable for fulfilling our objectives.

4. Method and experimental set-up

An intercomparison workshop for light scattering integrating Nephelometers (Along with filter-based absorption photometers) was conducted in January 2020 with the objective of investigate the individual behaviour of 3 instruments operated by different research institutions (1 Ecotech Aurora3000 and 2 TSI 3563)) and their comparability.

All the instruments were connected to a mixing chamber through conductive silicone tubes to avoid particle losses and compared with one reference set consisting of an Integrating Nephelometer (Ecotech Aurora 4000), a Multi-Angle Absorption Photometer (MAAP)and three extinction monitors (Cavity Attenuated Phase Shift extinction, CAPS PMex) used to measure the particle light scattering, backscattering, absorption and extinction coefficients.

The intercomparison protocol consisted on cycles with four different phases: Ambient air, pure air (Zero) and different concentration of Ammonium sulphate (SO4NH4) as a test aerosol. In between maintenance is performed evaluating the instrument behaviour before and after the inspection.

a. Calibration

Calibration is achieved by filling the instrument with a particle-free gas that has known scattering coefficients. In our case we used filtered ambient air as the downscale calibration point and CO2 as the upscale point.
Some parameters were set prior to start a full calibration: Cal time was set to 60 minutes, the target stability during calibration over 97%, internal heater off and the filtering parameter in the report preferences menu is set to Kalman.

b. Maintenance

The instrument maintenance basically consisted on cleaning the measuring chamber and performing a leakage test.

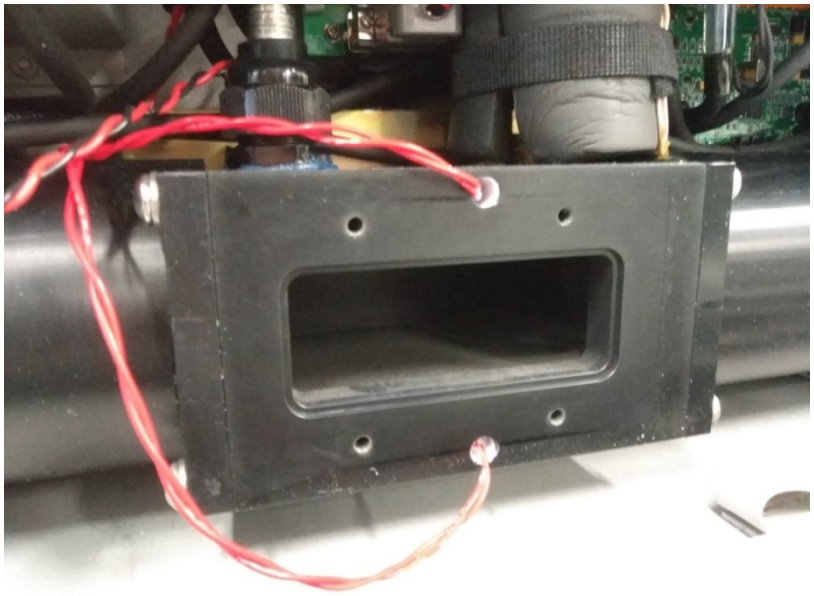
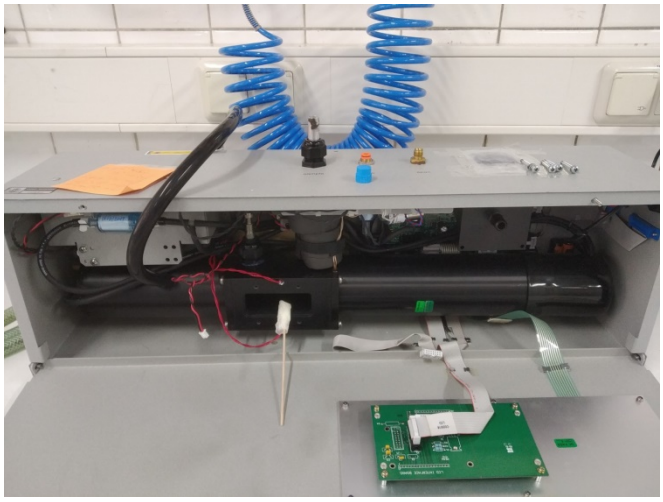


Figure 1 Measuring cell with dust inside.

Removing the front panel of the Nephelometer and carefully sliding out the light source we find the measuring cell. Cleaning starts first by using a vacuum system (Never compressed air to avoid dust and particles reach both extremes of the chamber contaminating detector and laser) followed by mopping inside with deionized water and a lint free cloth being especially incident on the corners and bends. We must avoid the use of any solvent because they could dissolve and remove the cell coating.



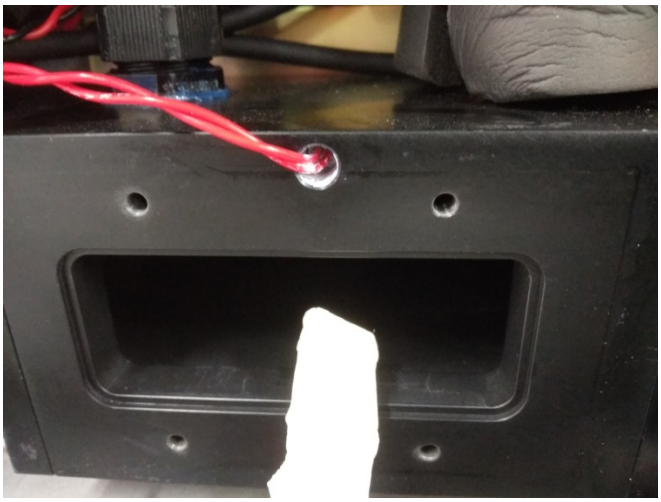


Figure 2 cleaning the measuring cell with a lint-free cloth

After cleaning we continue with the Leak test which we can automatically execute from the display menu. By connecting the exhaust to the inlet, pressure in the circuit is generated and the pressure drop is measured for a short period. In this first attempt the test was successful.

5. Data description

The Ecotech Aurora 3000 Integrating Nephelometer measures σ_{sp}, the scattering coefficient of light due to particles at three wavelengths (SP1 at 635nm, SP2 at 525nm & SP3 at 450nm).
It also measures Backscatter as σ_{bsp} (BSP1 at 635nm, BSP2 at 525nm & BSP3 at 450nm) and demonstrates the proportion of scattering over an integration angle of 90° -170°.
The dimension of σ_{sp} (and σ_{bsp}) is inverse length. The Aurora 3000 reports σ_{sp} in units of the inverse Megametre (Mm-1) = 10-6m-1(inverse metres).

6. Preliminary results and conclusions

Preliminary test on arrival showed noise out of the normal range. The background level (Zero) was inacceptable with deviations of less equal 4.12 Mn-1 for all wavelengths as well as the span check with deviations of less equal 24.9% from calibration gas (CO2).

Zerocheck

Wavelength	Total Scattering		Backscattering	
[nm]	Mean [Mm-1]	Std. Dev. [Mm-1]	Mean [Mm-1]	Std. Dev. [Mm-1]
450	3.51	0.41	4.12	0.39
525	-0.72	0.41	0.95	0.34
635	-0.72	0.52	-0.07	0.36

Table 1 Noise parameters of the Nephelometer (SN 12-1441) measured with filtered air.

Spancheck

	CO2	Before Inspection	Deviation from Co2
sp1_635	11.15	8.15	-27%
sp2_525	23.86	21	-12%
sp3_450	44.21	46.4	5%
bsp1_635	5.58	2.24	-60%
bsp2_525	11.93	10.54	-12%
bsp3_450	22.11	25.13	14%

Table 2 Percentage deviations from measured values from Nephelometer to theoretical values for CO2

As expected **before maintenance** and recalibration the deviations of intercomparison to reference device were inacceptable with deviations in the range of -14% to 19.7 %.

Wavelength	Total Scattering		Backscattering	
[nm]	Slope	R2	Slope	R2
450	1.014	1	1.034	0.998
525	1.057	1	1.02	0.997
635	1.197	0.999	0.86	0.995

Table 3 Comparison between Nephelometer (SN 12-1441) before inspection and reference Aurora 4000 (SN-14-1408) with NH4SO4 as a test aerosol.

Once the whole procedure specified in section 4 was completed, we proceeded to repeat the protocol cycle. Recalibration values shown deviations from the calibration gas less to 4% as presented in table 4.

Spancheck

	CO2	After Inspection	Deviation from CO_2
sp1_635	11.15	11.3	1%
sp2_525	23.86	23.92	0%
sp3_450	44.21	44.26	0%
bsp1_635	5.58	5.83	4%
bsp2_525	11.93	12.05	1%
bsp3_450	22.11	22.11	0%

Table 4 Percentage deviations from measured values from Nephelometer to theoretical values for CO2 after inspection.

The results from intercomparison to reference device with Ammonium Sulphate aerosol were acceptable with deviations in the range of -4.3% to 10%.

Wavelength	Total Scattering		Backscattering	
[nm]	Slope	R2	Slope	R2
450	0.974	0.999	0.957	0.995
525	1.016	0.999	1.027	0.993
635	1.059	0.999	1.1	0.987

Table 5 Comparison between Nephelometer (SN 12-1441) after inspection and reference Aurora 4000 (SN-14-1408) with NH4SO4 as a test aerosol.

Participation in such events like this intercomparison is a vital tool for evaluating research instrumentation performance as well as ensuring quality control.
From our experience in IN-2020-1 with our Nephelometer Ecotech Aurora3000, it bring to light the importance of keeping a regular maintenance of the instrument, and more specifically the cleaning of the measuring cell which is directly related to noise.

7. Outcome and future studies

After the thorough inspection of the internal parts of the Nephelometer with the invaluable support from the WCCAP experts, we can conclude that our instrument meets the quality requirements and manufacturer´s specifications.
This instrument will keep on providing quality data for minimizing uncertainties when modelling their impact on climate and also to estimate their effect on the air quality.

8. Reference

WMO (2016). WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations2nd Edition. Switzerland: World Meteorological Organization & Global Atmosphere Watch.

Aurora 3000. Multi Wavelength. Integrating. Nephelometer. (with backscatter). User Manual. Version 1.5. www.ecotech.com