AEROSOL
MAGEE SCIENTIFIC

AETHALOMETER, TCA08, AND CASS

WEBASOOP PI AND WP LEADERS MEETING

Klemen Kunstelj, Ph.D.

Product Manager, Aerosol d.o.o.

Apr, 2024

History starts in 1980’s

Reprinted from APPLIED OPTICS, Vol. 17, page 3859, December 15, 1978

Identification of the optically absorbing component in urban aerosols

H. Rosen, A. D. A. Hansen, L. Gundel, and T. Novakov
University of California, Lawrence Berkeley Laboratory, Berkeley, California 94720.
Received 29 August 1978.
0003-6935/78/1215-3859$0.50/0.

Aerosol particles may play a significant role in modifying the local and global climate, and therefore it is important to study the optical properties of these suspended particulates. The over-all effect of aerosol particles in heating or cooling the earth's surface depends critically on the relative magnitude of their scattering and absorption coefficients.[1,2] In the past the effects of aerosols were thought to be due almost entirely to their scattering properties, but more recently it has been realized that the absorptivity of these particles is large. Therefore, much more attention has been given to the imaginary index of refraction in heat balance calculations as well as in visibility degradation.[3,4] To model the effects of fossil fuel combustion on climate and visibility, it is important to establish the nature of these absorbing species. In this Letter we will describe the application of Raman spectroscopy and an optical attenuation technique to show that the high optical absorptivity of urban particulates and particles produced directly from various combustion sources is due to graphitic carbon, one component of combustion-produced soot which also contains a complex mixture of organics.

Raman spectroscopy is a highly selective method of analysis, which, until recently, has not been applied to the characterization of air pollution particulates.[5-7] The technique can often be used to make unambiguous identifications since different chemical species have characteristic vibrational modes and therefore characteristic Raman spectra. The Raman spectroscopy apparatus uses a Coherent Radiation argon ion laser producing 1 W of power at 514 nm. The laser beam is focused by a 75-mm focal length cylindrical lens to a spot 0.06 mm × 2 mm on the sample surface via a small mirror, and the backscattered radiation is collected and imaged by an $f/1$ lens onto the slit of a 1-m Jarrell Ashe double monochromator equipped with two 1180-grooves/mm gratings blazed at 5000 Å. The output of the spectrometer is detected by an FW130 photomultiplier cooled to −20°C and used in a photon-counting mode. The pulses, after appropriate shaping, are counted and displayed on a multichannel analyzer. A computer-controlled grating drive made by RKB, Inc., allows a given spectral region to be scanned many times and added to the memory of the multichannel analyzer, greatly improving the SNR. In order to minimize heating effects, the highly absorbing samples used in these experiments are rotated at 1800 rpm by a motor, which increases the area illuminated by the laser beam by a large factor with almost no loss in signal level. The focal spot of the laser is located approximately 5 mm below the axis of rotation so that the effective illuminated area is an annulus of 5-mm radius and 2-mm width, resulting in the low power density of ~1 W/cm^2.

The Raman spectra between 920 cm^{-1} and 1850 cm^{-1} of ambient, automobile exhaust, and diesel exhaust particulates are compared with the spectra of activated carbon and polycrystalline graphite in Fig. 1. It is evident that the spectra of activated carbon, diesel exhaust, automobile exhaust, and the ambient sample are very similar, with the positions of the two Raman modes coincident to within ±10 cm^{-1}, the estimated experimental error. The ambient sample was collected as part of the RAPS program in St. Louis, Missouri; however, the same Raman modes are also evident in every urban sample studied, including samples collected in Buffalo, New York, and Berkeley, Fremont, and Anaheim, California. Koenig *et al.*[9] have studied the Raman spectrum of activated carbon and have identified the modes near 1600 cm^{-1} and 1350 cm^{-1} as being due to phonons propagating within graphitic planes. The close correspondence of the spectra in Fig. 1 indicates the presence of physical structures similar to activated carbon in both source and ambient samples. These graphitic species are formed directly in combustion, and throughout the text we shall use the term graphitic soot to describe them.

Urban and combustion source particulates collected on various filter media have a gray or black appearance. The graphitic species identified by Raman spectroscopy are the most likely candidate for explaining this coloration. To test this hypothesis, we have developed an optical attenuation technique to measure quantitatively various properties of the absorbing species. The optical attenuation apparatus compares the transmission of a 633-nm He–Ne laser beam through a loaded filter relative to that of a blank filter (Fig. 2). The loaded filters are placed in the beam with the loaded side toward the laser: after multiple scattering through the filter substrate, the light is collected by an $f/1$ lens and focused on a photomultiplier tube. The data presented in this paper were obtained from particles collected on Millipore or quartz

ARTICLE 1

Rosen, Hansen (1978) Identification of absorbing material by Raman spectra

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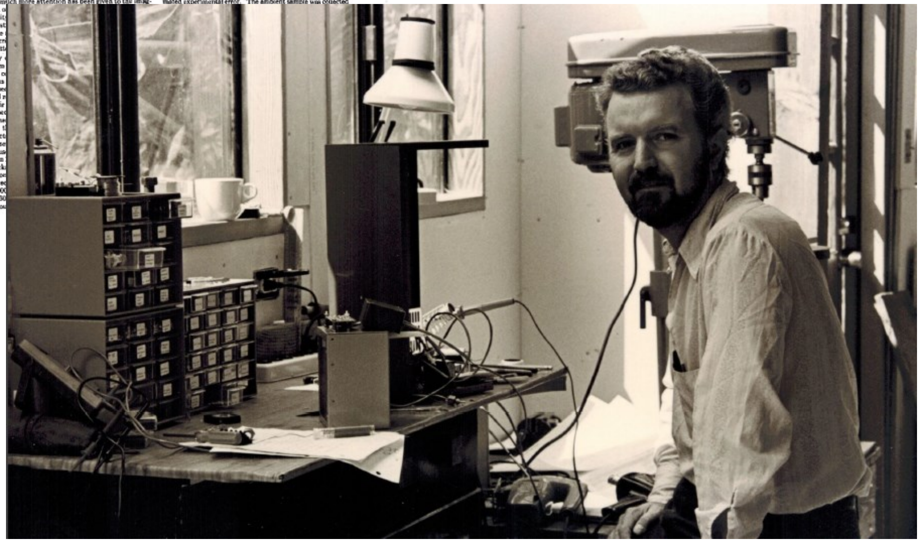
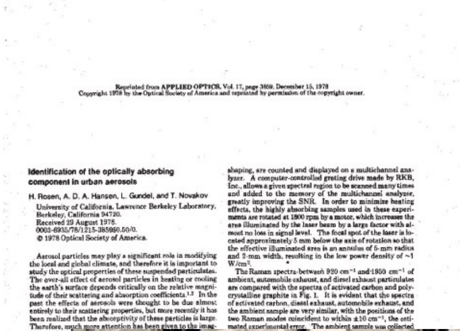


DR. TONY HANSEN

History starts in 1980’s



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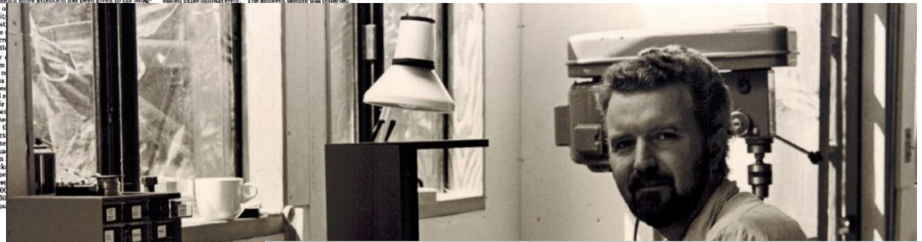


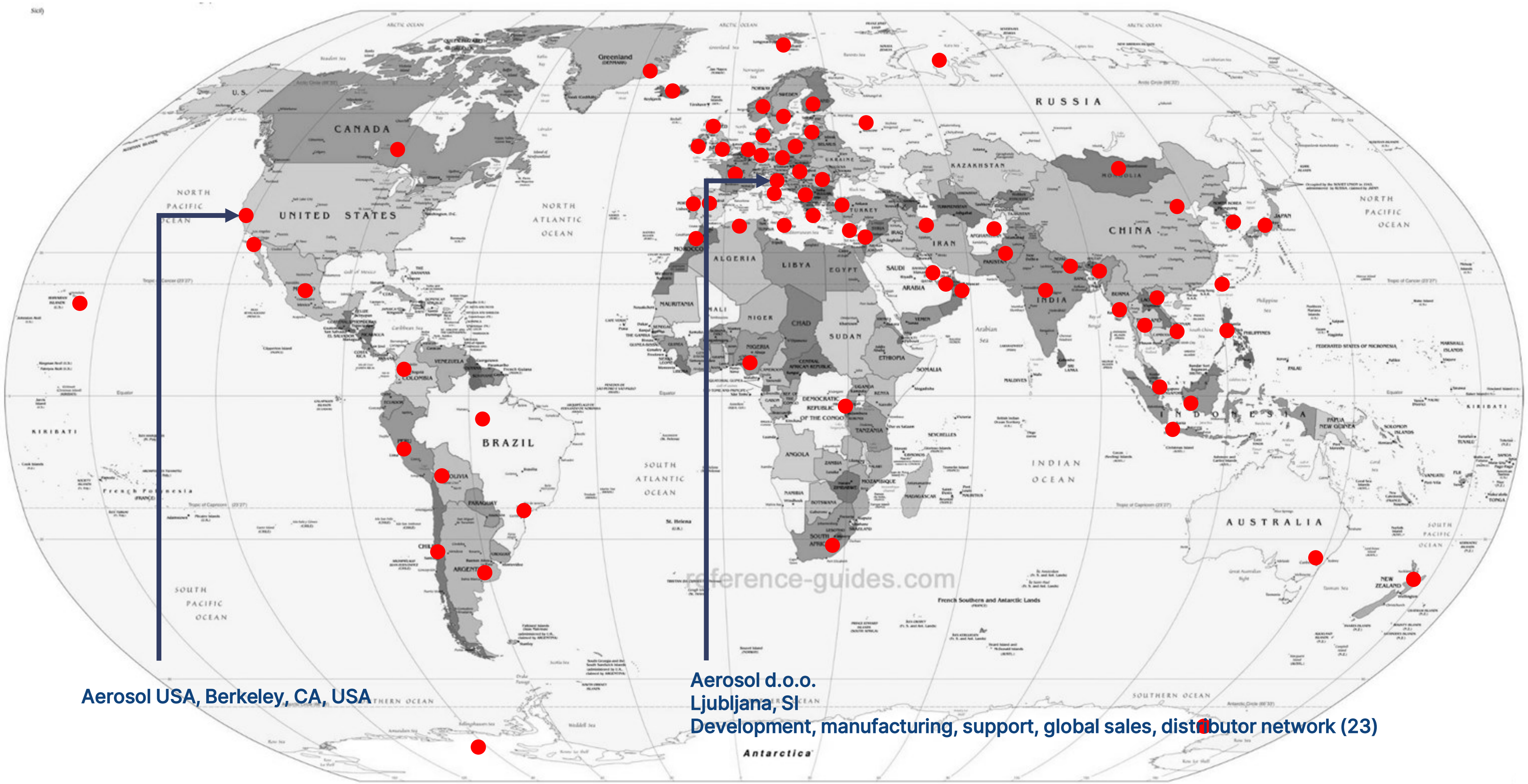
DR. TONY HANSEN

THE FIRST AETHALOMETER

Production year 1983

AEROSOL
MAGEE SCIENTIFIC

● Countries with AE installations



AEROSOL d.o.o. (Slovenia)

- 32 employees
- Strong R&D group (11 people)
- 6 PhDs (~aerosol physics)
- Production - 6 product lines

AEROSOL
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Our Distributor Network (with more than 30 distributors):

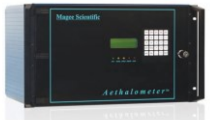
Scandinavia
UK
Swiss
Slovakia, Czech, Poland
Germany
France
Greece
Belgium, Netherland
Estonia
Italy
Spain
China
India
Japan
Australia, New Zealand
Philippines
Pakistan
Malaysia
Taiwan
Korea
Hong Kong
South Africa
Israel
Iran
Turkey
Jordan
Colombia
Peru
Chile
Mexico
Canada
USA

COMPANY DEVELOPMENT

1979
invented Aethalometer® concept

1986 MAGEE SCIENTIFIC
First commercial sale.

1996
production by OEM
in Slovenia (Optotek)



2005
office, professional staff in Berkeley

2007 Aerosol
started fully-owned subsidiary ('Aerosol')
in Slovenia for R&D and production

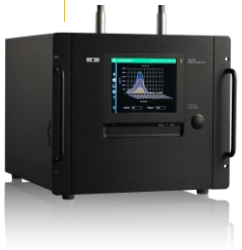
2011
microAE spun-off to AethLabs

2012
Introduction
of AE33

2015

Magee Scientific obtains the DRI2015
manufacturing licence

2017
Introduction of TCA08



2020
CASS

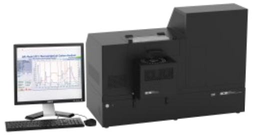
2020
AE43
Portable

2021
CAAT
SW Tool

Mid of 2022
DRI2015 Series 2

2023
AE36+AE36s

2023
DRI with AL



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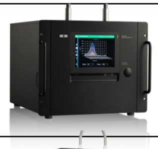
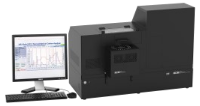
Product portfolio

Product		Product type	Measurement type	Sample type
	OT21	Offline	Optical	BC, BrC
	AE36 + AE36s	Online	Optical	BC, BrC
	AE33	Online	Optical	BC, BrC
	AE43	Online	Optical	BC, BrC
	TCA08	Online	Thermal	TC
	CASS	Online	Thermal Optical	TC, BC, EC, BrC, OC, POA, SOA
	DRI 2015 Series 2	Offline	Thermal Optical	TC, EC, BC, BrC, OC

AEROSOL
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Aethalometers

AE33

AE43

AE36 & AE36s

Aethalometer AE33

KEY FEATURES

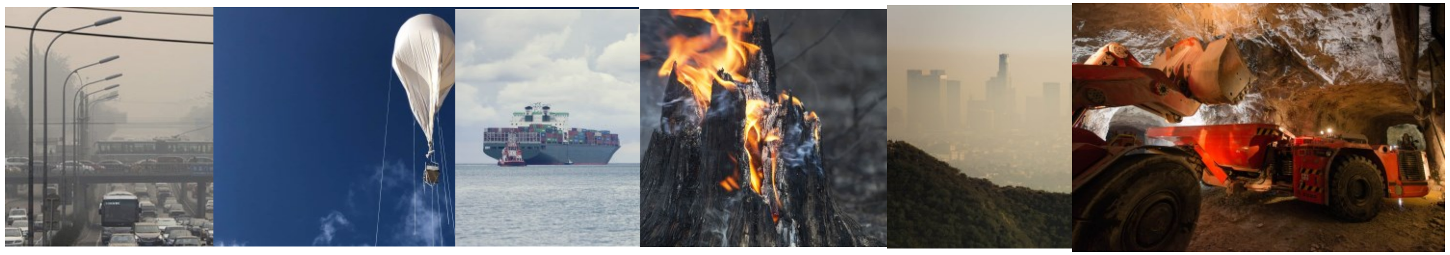
- DualSpot® Technology
- Archive-ready data is streamed in real time with no post-processing required
- Source apportionment
- Built-In Quality Control Tests
- Determination of particle age and composition
- Networking options

Aethalometer AE33

KEY FEATURES

- DualSpot® Technology
- Archive-ready data is streamed in real time with no post-processing required
- Source apportionment
- Built-In Quality Control Tests
- Determination of particle age and composition
- Networking options

APPLICATIONS



Aethalometer AE43

KEY FEATURES

- DualSpot® Technology
- Archive-ready data is streamed in real time with no post-processing required
- Source apportionment
- Built-In Quality Control Tests
- Determination of particle age and composition
- Remote access
- Networking option
- Light weight design

Portable BC analyzer vs Standalone BC Analyzer

Portable		Standalone
11 kg	- 50%	21 kg
20 dm^3	- 50%	40 dm^3

Portable BC analyzer vs Standalone BC Analyzer

Portable		Standalone
11 kg	- 50%	21 kg
20 dm³	- 50%	40 dm³
7 WAVELENGTHS	=	7 WAVELENGTHS
DUAL SPOT	=	DUAL SPOT
SOURCE APPORTIONMENT	=	SOURCE APPORTIONMENT

Motivation for PORTABLE Black Carbon Analyzer

New way for portable application

Motivation for PORTABLE Black Carbon Analyzer

New way for portable application

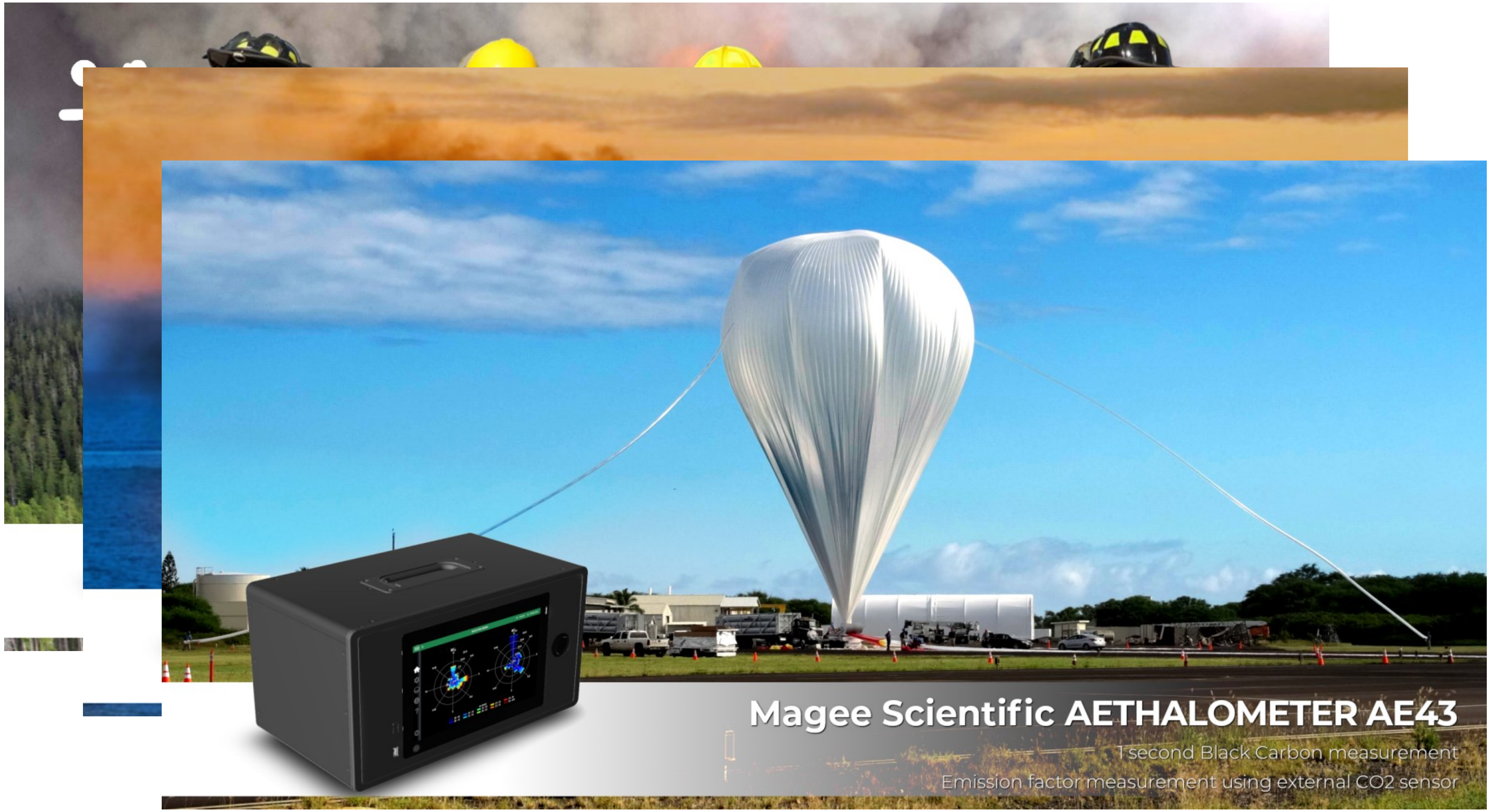
Motivation for PORTABLE Black Carbon Analyzer

New way for portable application

AEROSOL
MAGEE SCIENTIFIC

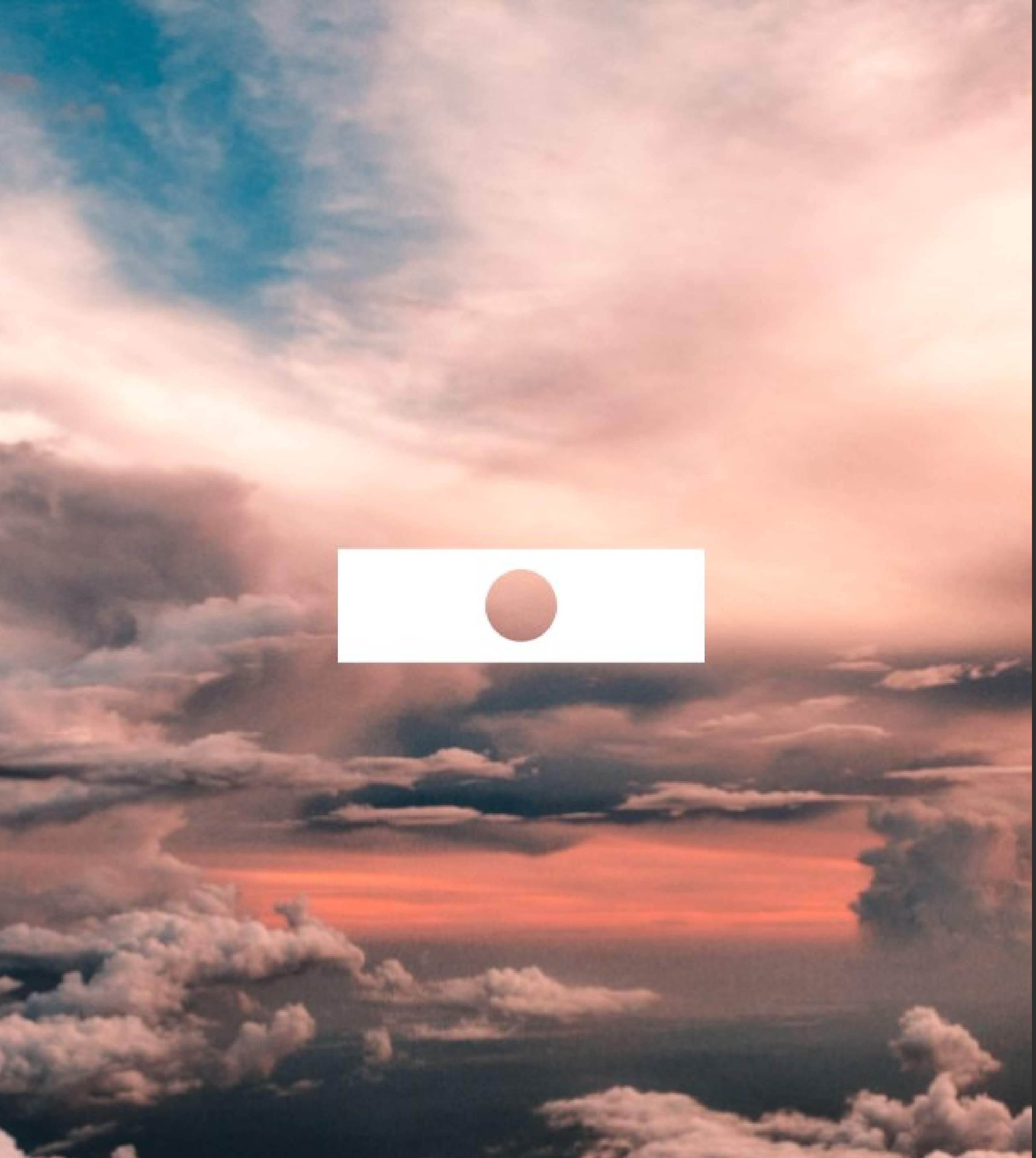
Motivation for PORTABLE Black Carbon Analyzer

New way for portable application



Motivation for PORTABLE Black Carbon Analyzer

New way for portable application



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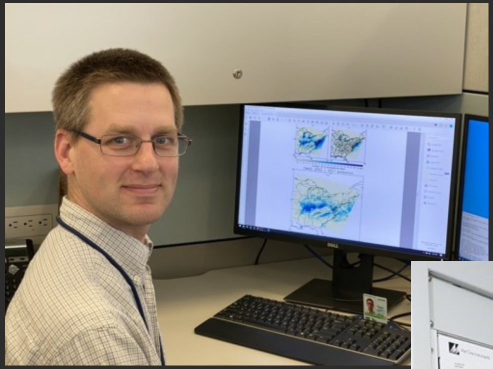
The new Aethalometer AE36s/AE36

AEROSOL
MAGEE SCIENTIFIC

The new Aethalometer AE36s/AE36- customer segmentation



A scientist...looking for advanced data and new research

An AQ specialist...looking for reliable data and long instrument authonomy

Who are the customers interested in Carbonaceous Aerosols?

Who are the people that use our Aethalometers today?

How do they use them and what do they think about them?

What more do they need from the instruments?

AE33 as a predecessor

- TCA08 COMPATIBLE
- DUAL SPOT
- SOURCE APPORTIONMENT
- MULTI WAVELENGTH AEROSOL CHARACTERIZATION

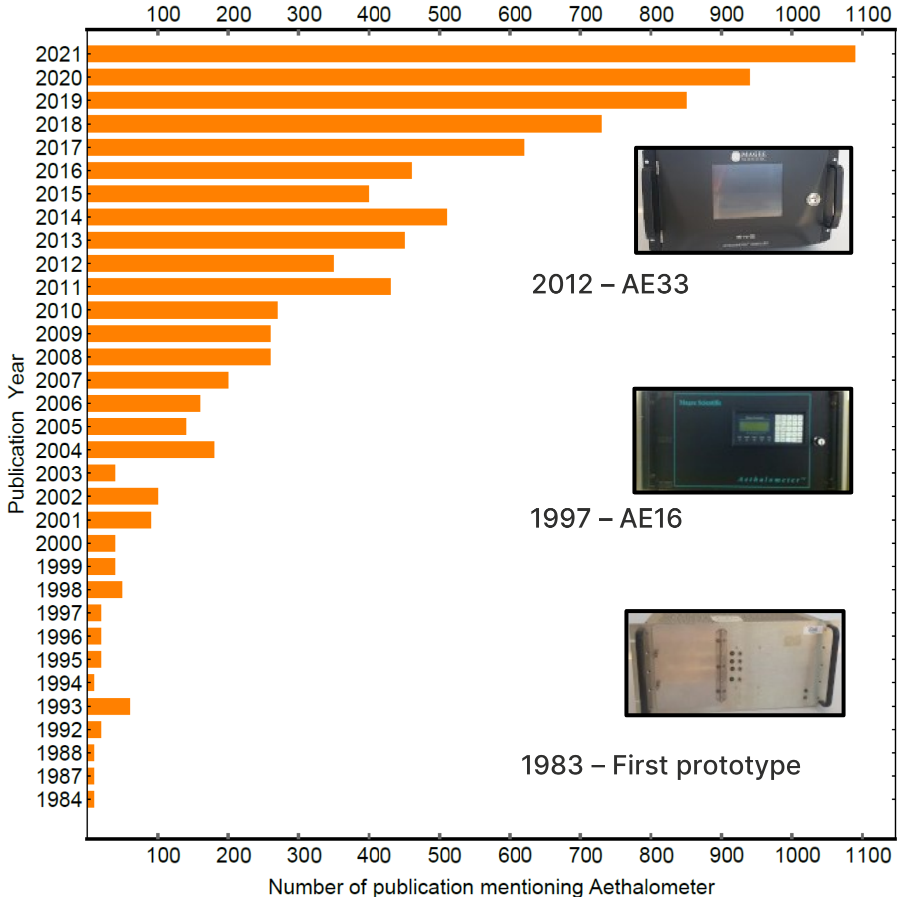
AE36

- REMOTE ACCESS (RAS)
- RH ROBUSTNESS
- SELF-CLEANING
- EXTENDED WAVELENGTH RANGE
- BC INDEX
- LONGER FILTER TAPE

AE36s

Aethalometer

Motivation



- The Aethalometer is a most widely used filter photometer capable of measuring **the light-absorbing properties of aerosol** particles.
- More than **10.000 scientific articles** mentioning Aethalometer.

Source: Google Scholar

Real-time measurement of the absorption coefficient of aerosol particles

A. D. A. Hansen, H. Rosen, and T. Novakov

University of California, Lawrence Berkeley Laboratory, Energy & Environment Division, Berkeley, California 94720.

Received 16 June 1982.

Sponsored by R. W. Terhune, Ford Motor Company

0003-6935/82/173060-03$01.00/0.

© 1982 Optical Society of America.

Recent studies have shown that large concentrations of graphitic carbon particles are found in the atmosphere in both urban and remote locations.[1] These particles are produced in combustion and have a large optical absorption cross section, of the order of 10 m²/g. Their presence affects radiation transfer through the atmosphere, causing visibility degradation[2] and possible changes in the regional or global radiation balance.[3] The size of these effects depends critically on both the particle concentration and their single-scattering albedo,[4] which is determined by the relative magnitude of the scattering and absorption coefficients. The scattering coefficient is easily measured by nephelometry.[5,6] In this Communica-

The "dual-spot" Aethalometer: an improved measurement of aerosol black carbon with real-time loading compensation

L. Drinovec[1], G. Močnik[1], P. Zotter[2,*], A. S. H. Prévôt[2], C. Ruckstuhl[3], E. Coz[4], M. Rupakheti[5], J. Sciare[6], T. Müller[7], A. Wiedensohler[7], and A. D. A. Hansen[1,8]

[1]Aerosol d.o.o., 1000 Ljubljana, Slovenia
[2]Paul Scherrer Institute, 5232 Villigen, Switzerland
[3]inNET Monitoring AG, 6460 Altdorf, Switzerland
[4]Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, 28040 Madrid, Spain
[5]Institute for Advanced Sustainability Studies, 14467 Potsdam, Germany
[6]Laboratoire du Climat et de l'Environnement, CEA/Orme des Merisiers, 91191 Gif-sur-Yvette, France
[7]Leibniz Institute for Tropospheric Research, 04318 Leipzig, Germany
[8]Magee Scientific Corp., Berkeley, California, CA 94703, USA
[*]now at: Lucerne School of Engineering and Architecture, Bioenergy Research, Lucerne University of Applied Sciences and Arts, Horw 6048, Switzerland

Correspondence to: L. Drinovec (luka.drinovec@aerosol.si) and G. Močnik (grisa.mocnik@aerosol.si)

Received: 4 August 2014 – Published in Atmos. Meas. Tech. Discuss.: 30 September 2014
Revised: 16 April 2015 – Accepted: 17 April 2015 – Published: 6 May 2015

Abstract. Aerosol black carbon is a unique primary tracer for combustion emissions. It affects the optical properties of the atmosphere and is recognized as the second most important anthropogenic forcing agent for climate change. It is the primary tracer for adverse health effects caused by air pollution. For the accurate determination of mass equivalent black carbon concentrations in the air and for source apportionment of the concentrations, optical measurements by filter-based absorption photometers must take into account the "filter loading effect". We present a new real-time loading effect compensation algorithm based on a two parallel spot measurement of optical absorption. This algorithm has been incorporated into the new Aethalometer model AE33. Intercomparison studies show excellent reproducibility of the AE33 measurements and very good agreement with post-processed data obtained using earlier Aethalometer models and other filter-based absorption photometers. The real-time loading effect compensation algorithm provides the high-quality data necessary for real-time source apportionment and for determi-

1 Introduction

The combustion of carbonaceous fuels inevitably results in the emission of gas and particulate air pollutants. One of the fractions of the emitted particles are light-absorbing carbonaceous aerosol compounds, in particular black carbon (BC), an aerosol species exhibiting very large optical absorption across the visible part of the optical spectrum. Black carbon is a unique primary tracer for combustion emissions as it has no non-combustion sources. It is inert and can be transported over great distances (Hansen et al., 1989; Bodhaine, 1995; Sciare et al., 2009). Black carbon affects the optical properties of the atmosphere when suspended and is recognized as the second most important anthropogenic forcing agent for climate change after CO_2 (Ramanathan and Carmichael, 2008; Bond et al., 2013). Black carbon is also the leading indicator of the adverse health effects caused by particulate air pollution (Janssen et al., 2011, 2012; Grahame et al., 2014).

Sources: Hansen A.D.A. et al., 1982, Drinovec et al., 2015

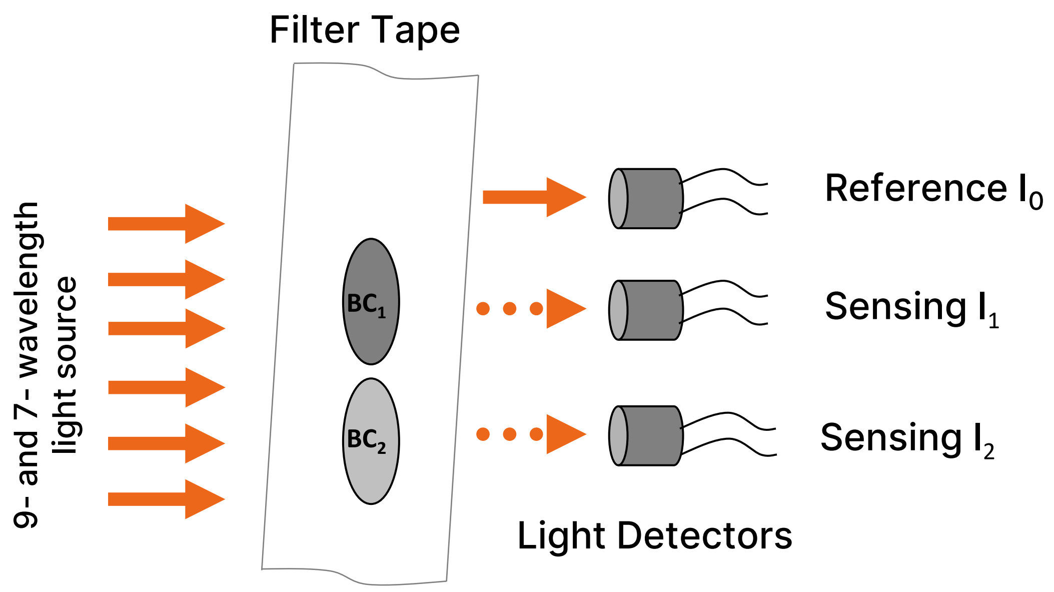
New Aethalometer AE36s and AE36

- 9λ, 340 – 950 nm, characterization of light-absorbing aerosols.
- Real-time Brown Carbon analyses using two new wavelengths, 340 and 400 nm.
- Higher time resolution.
- BC Index
- Longer filter tape
- Equivalence to AE33 according to EN 16450:2017
- Dual spot for filter loading compensation
- Robustness to relative humidity changes.
- Automatic data validation.
- Improved Limit of detection.
- Remote Access Control (RAS).
- Self Cleaning procedure
- Broad range of applications.

Aethalometer AE36s

Principle of operation

The Aethalometer AE36s uses similar optical chamber as AE33:



$ATN_1 = \ln(I_0 / I_1)$

$ATN_2 = \ln(I_0 / I_2)$

Dual Spot algorithm

$$b_{\mathrm{ATN}} = \frac{\boldsymbol{S}}{\boldsymbol{F}}\frac{\Delta\mathrm{ATN}}{\Delta \boldsymbol{t}}\boldsymbol{f}(\mathrm{ATN}) = \mathrm{eBC}\cdot\boldsymbol{\sigma}$$

$$b_{\mathrm{ABS}} = \frac{b_{\mathrm{ATN}}}{\boldsymbol{C}} = \mathrm{eBC}\cdot\mathrm{MAC}$$

C – multiple scattering parameter

Low SSA approximation

General Ängstrom exponent:

$$b_{\mathrm{ABS}} \sim \lambda^{-\alpha}$$

Key features.... model specific

Different wavelength ranges

AE36
Source apportionment
FF vs BB

7λ

vs

AE36s
Advanced Brown Carbon analysis

9λ

Different wavelength ranges

AE36
Source apportionment
FF vs BB

7λ

vs

AE36s
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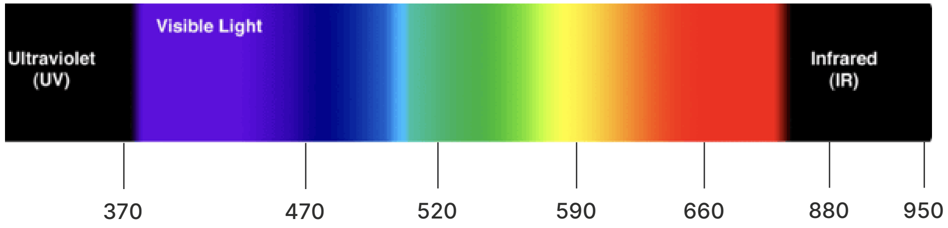
9λ



Different wavelength ranges

AE36
Source apportionment
FF vs BB

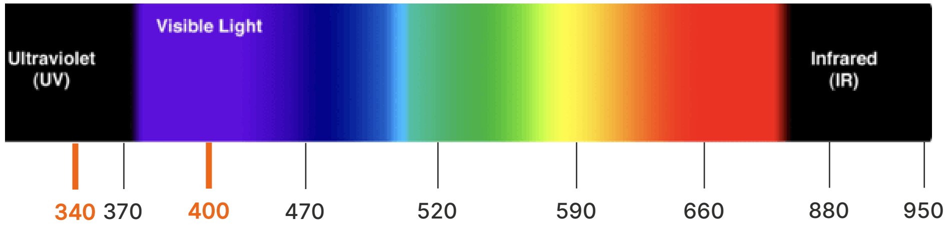
7λ

vs

AE36s
Advanced Brown Carbon analysis

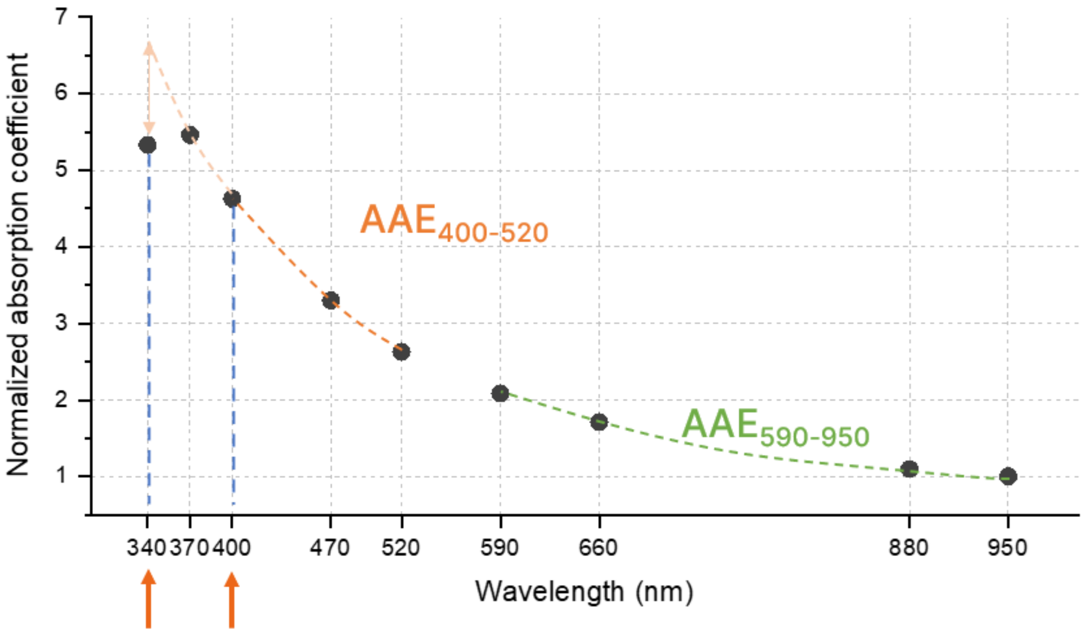
9λ

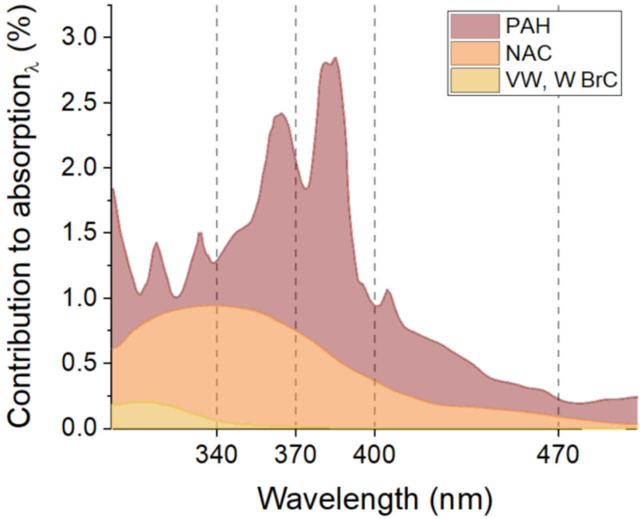
Additional λ



Analyses of absorption spectral features: AE36s

- **340 nm** – to extend the measurement range in the UV spectrum
- **400 nm** – to enhance the resolution of BrC absorption



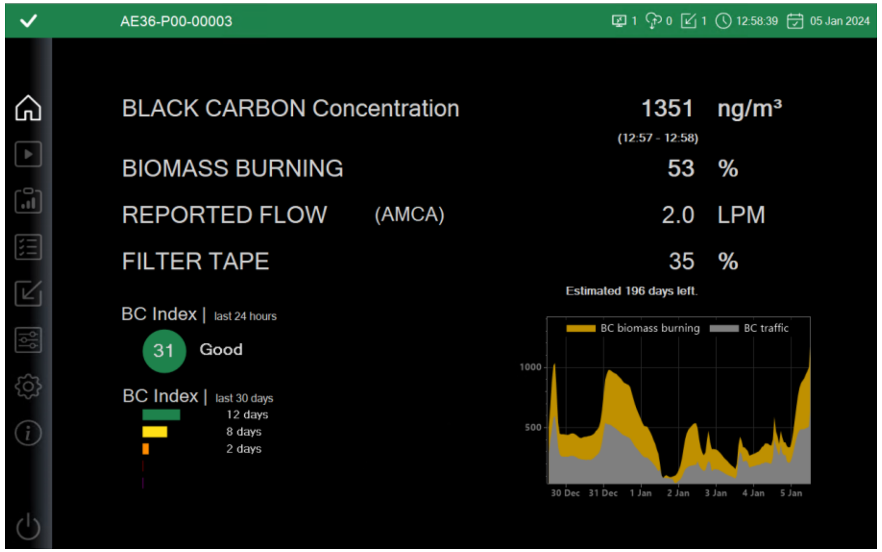


Source: Gregorič et al., EAC 2023, Yuan et al., ACP, 2020

Graphical User Interface of AE36 with BC Index (GUI)

AE36

New feature – **BC index (registered TM)**



Why **BC index:**

BC, as a side product of incomplete combustion, consists mostly of agglomerated sub-micron PM. BC is, therefore, a good indicator of combustion emissions because BC concentration can associate better with health effects of aerosol particles than just PM, which does not solely originate from combustion sources (WHO, 2012)

Index value	$PM_{2.5}$ (μg m^{-3})	PM_{10} (μg m^{-3})	O_3 (μg m^{-3})	NO_2 (μg m^{-3})	CO (mg m^{-3})	SO_2 (μg m^{-3})	BC (μg m^{-3})	LDSA (μm^2 cm^{-3})	PNC (10^3 cm^{-3})
Very poor (>150)	>76	>201	>181	>201	>31	>351	>12.1	>121	>101
Poor (101–150)	51–75	101–200	141–180	151–200	21–30	251–350	7.1–12	81–120	61–100
Fair (76–100)	26–50	51–100	101–140	71–150	9–20	81–250	3.1–7	41–80	31–60
Satisfactory (51–75)	11–25	21–50	61–100	41–70	5–8	21–80	1.1–3	21–40	16–30
Good (<50)	<10	<20	<60	<40	<4	<20	<1	<20	<15

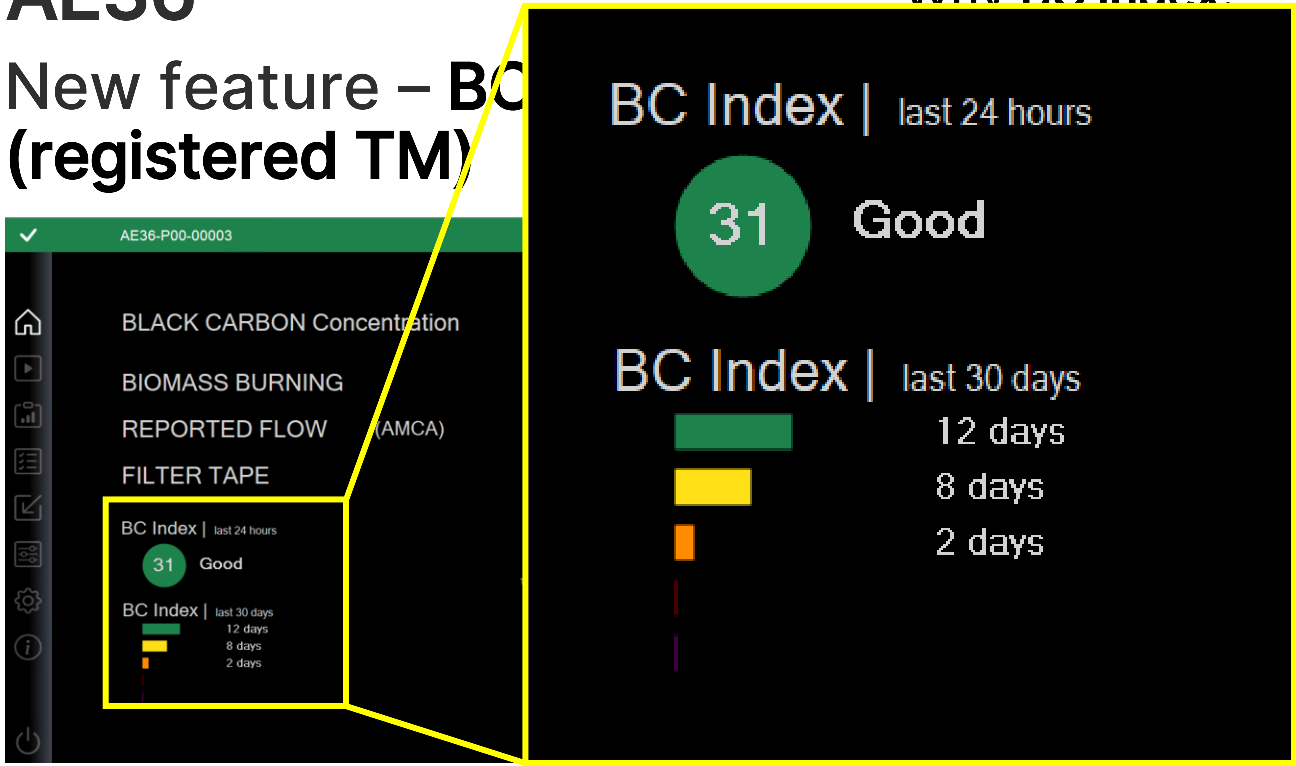
P.L. Fung, et.al. Science of The Total Environment Volume 844, 20 October 2022, 157099

A. Gregorič TIM DDF4CE – to be published

Graphical User Interface of AE36 with BC Index (GUI)

AE36

New feature – **BC Index (registered TM)**



Why BC index:

of incomplete combustion, consists
ed sub-micron PM. BC is, therefore, a
bustion emissions because BC
ociate better with health effects of
just PM, which does not solely originate
ces (WHO, 2012)

O_3 ($\mu g\ m^{-3}$)	NO_2 ($\mu g\ m^{-3}$)	CO ($mg\ m^{-3}$)	SO_2 ($\mu g\ m^{-3}$)	BC ($\mu g\ m^{-3}$)	LDSA ($\mu m^2\ cm^{-3}$)	PNC ($10^3\ cm^{-3}$)
>181	>201	>31	>351	>12.1	>121	>101
141–180	151–200	21–30	251–350	7.1–12	81–120	61–100
101–140	71–150	9–20	81–250	3.1–7	41–80	31–60
61–100	41–70	5–8	21–80	1.1–3	21–40	16–30
<60	<40	<4	<20	<1	<20	<15

P.L. Fung, et.al. Science of The Total Environment Volume 844, 20 October 2022, 157099

A. Gregorič TIM DDF4CE – to be published

BC index™ AE36

How it is calculated:

$$AQI_{BC} = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} (C - C_{low}) + I_{low}$$

C … 24 h running average of BC concentration

C_{low}, C_{high} … Low and High limit of the BC concentration

I_{low}, I_{high} … Low and High value of each Index class which corresponds to C_{low} & C_{high}

BC Index rate	BC index value	BC concentration (µg m^{-3})
Very poor	>150	> 12.1
Poor	101 – 150	7.1 – 12
Fair	76 – 100	3.1 – 7
Satisfactory	51 – 75	1.1 – 3
Good	< 50	< 1

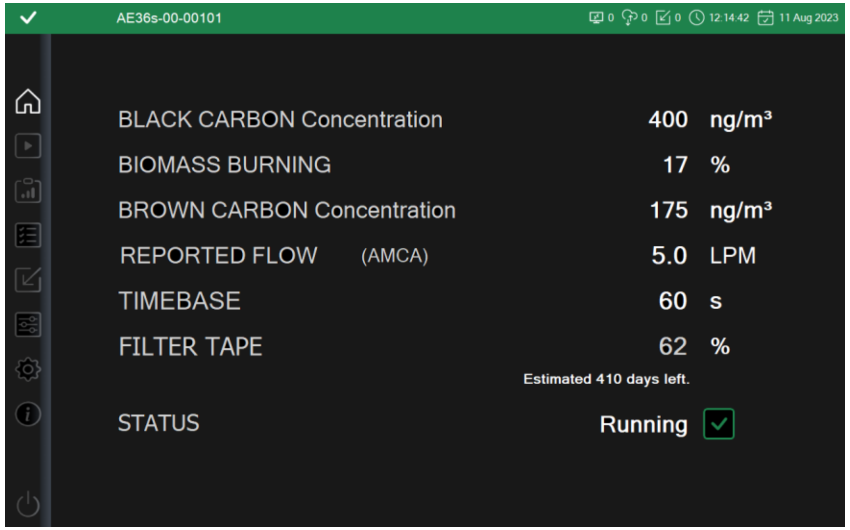
P.L. Fung, et.al. Science of The Total Environment Volume 844, 20 October 2022, 157099

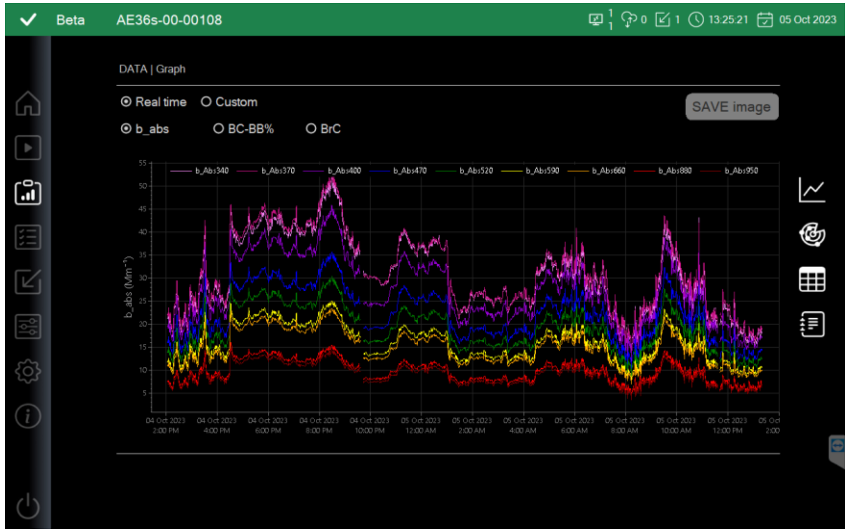
A. Gregorič, TIM DDF4CE – to be published

Graphical User Interface of AE36s (GUI)

AE36s

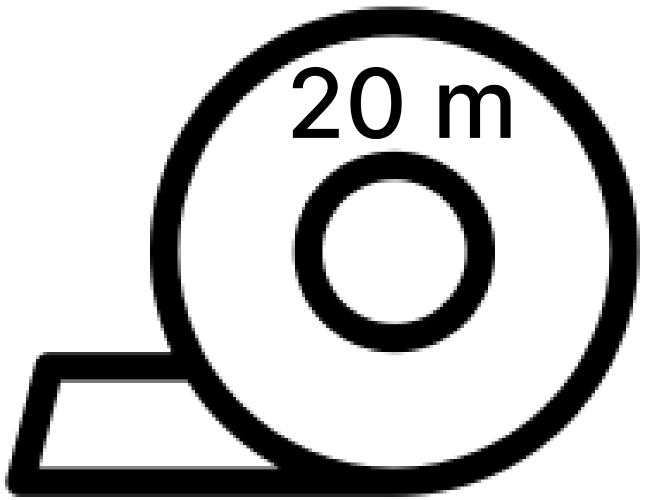
Advanced GUI – with advanced real time charting

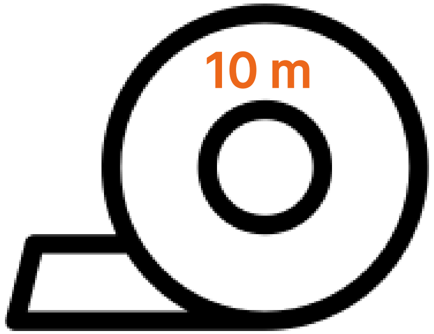




Different length of the filter tape

AE36 vs AE36s





Different time base settings

AE36

vs

AE36s

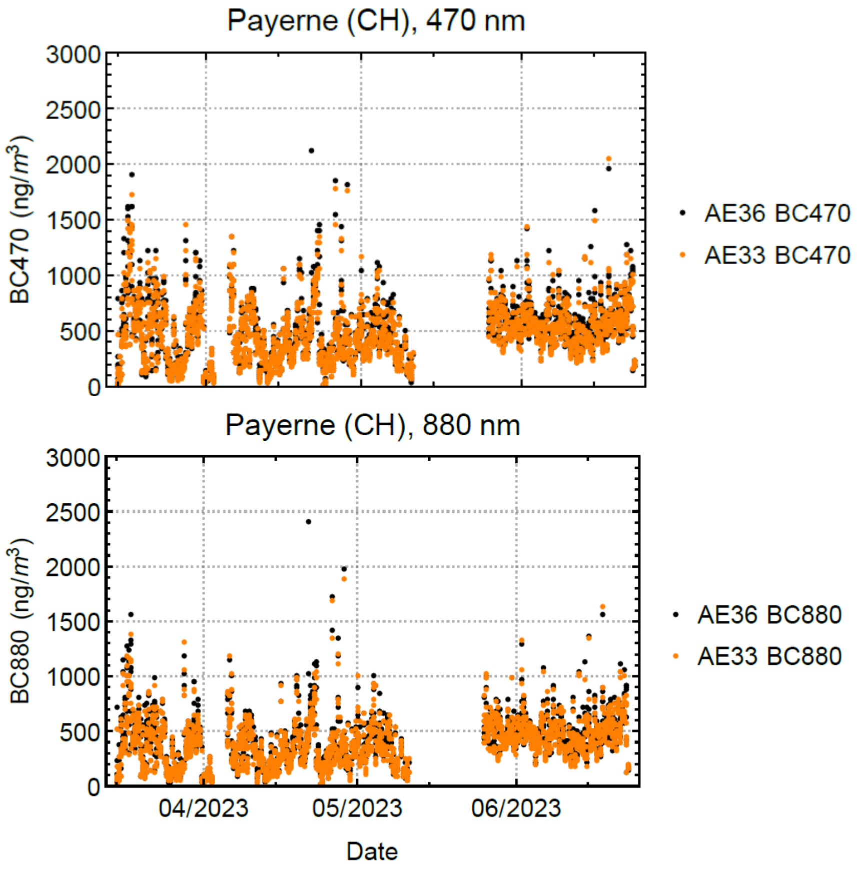
Key features...common

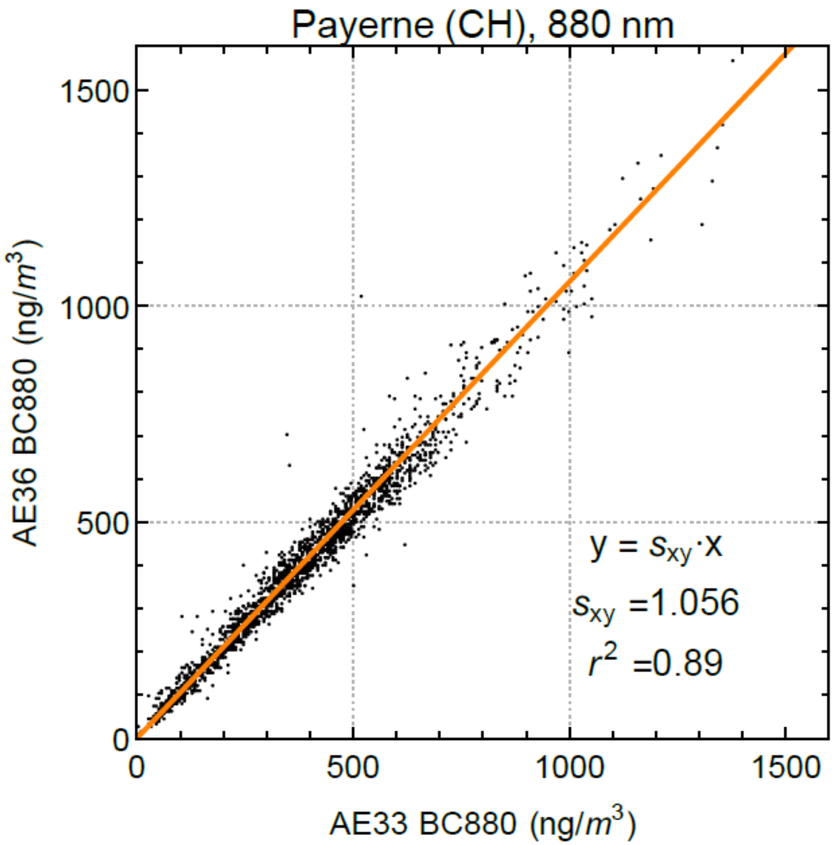
AEROSOL
MAGEE SCIENTIFIC

PSI,
Payerne, CH

Demonstration of equivalence: AE36s (AE36) - AE33

Payerne (CH) – Rural Background site



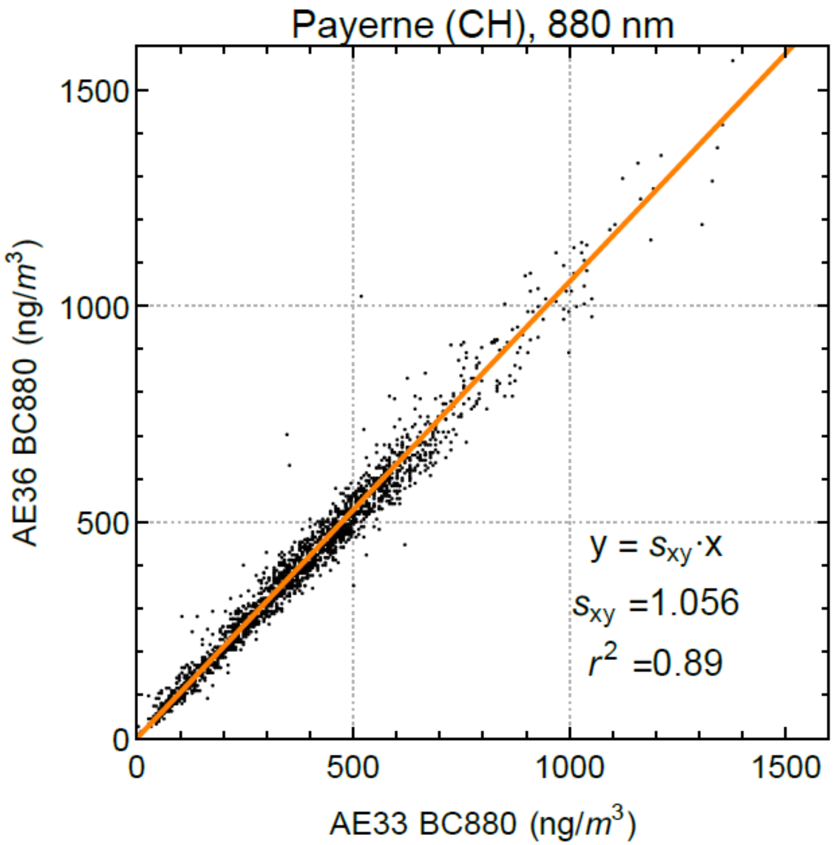


PSI,
Payerne, CH

Demonstration of equivalence: AE36s (AE36) - AE33

Payerne (CH)

	s_{xy}	σ_s	r^2
370 nm	1.043	0.002	0.91
470 nm	1.052	0.002	0.91
520 nm	1.058	0.002	0.91
590 nm	1.08	0.002	0.9
660 nm	1.078	0.003	0.9
880 nm	1.056	0.003	0.89
950 nm	1.046	0.003	0.89

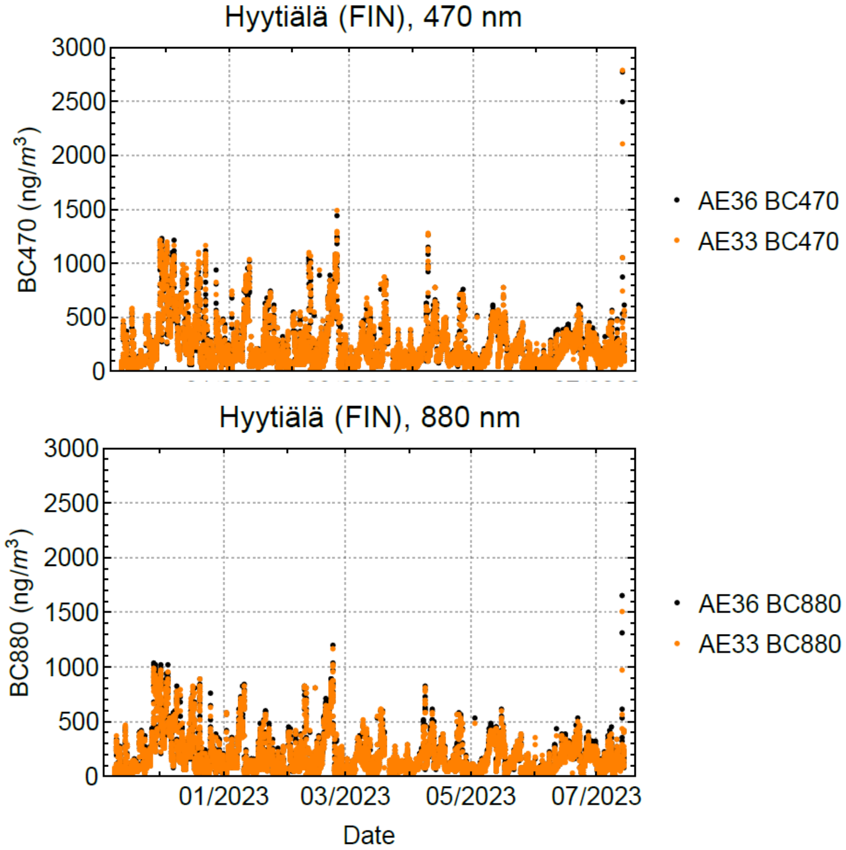


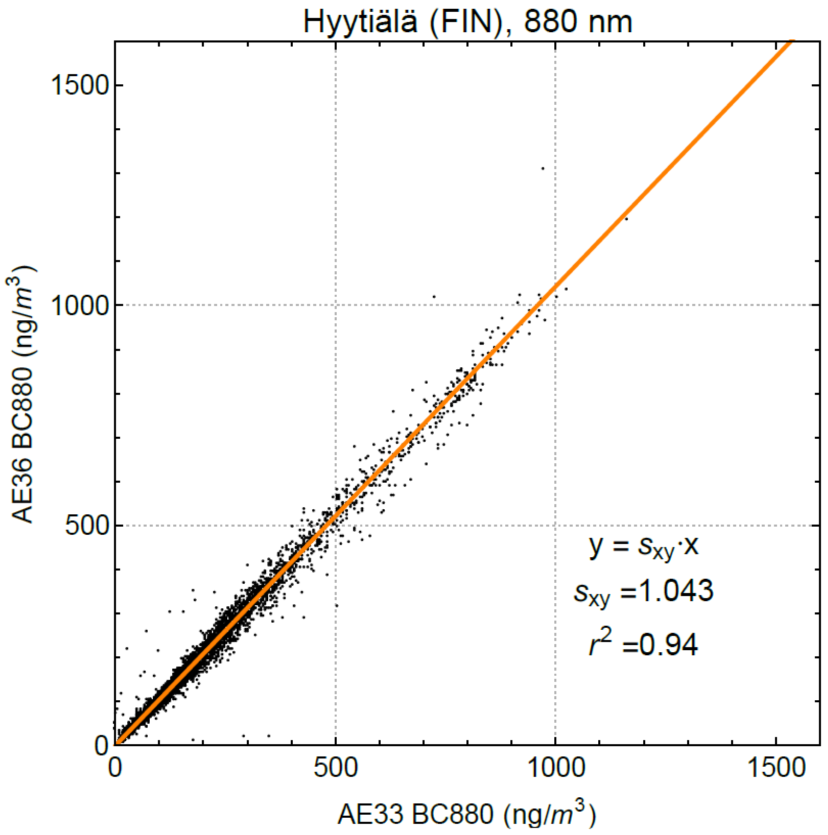
AEROSOL
MAGEE SCIENTIFIC

SMEAR II,
Hyytiälä, FIN

Demonstration of equivalence: AE36s (AE36) - AE33

Hyytiälä – SMEAR II (FIN), remote



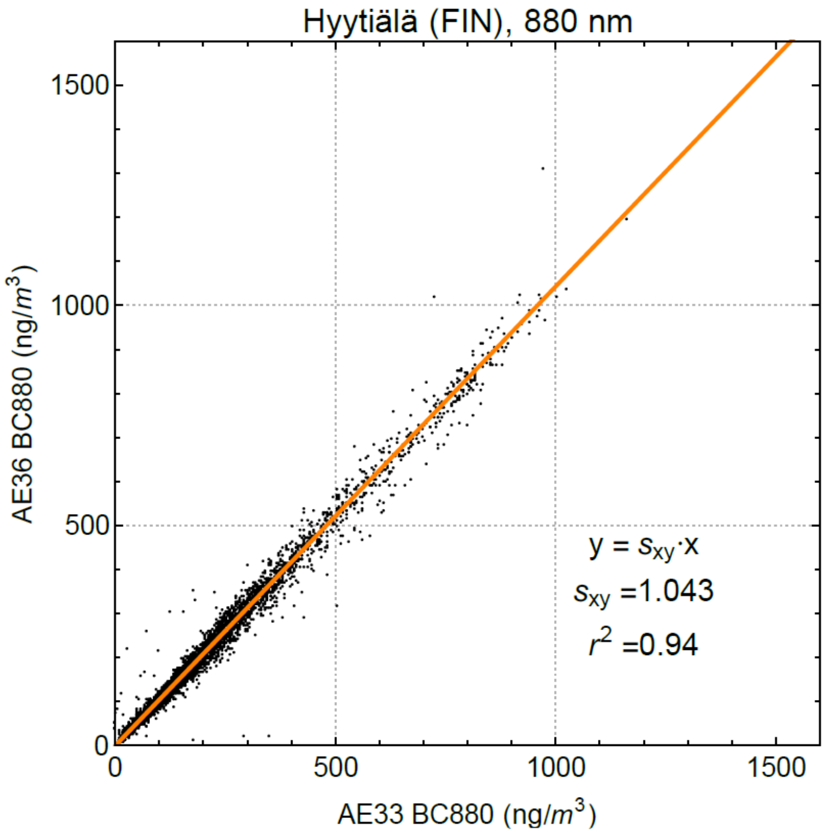


SMEAR II,
Hyytiälä, FIN

Demonstration of equivalence: AE36s (AE36) - AE33

Hyytiälä – SMEAR II (FIN)

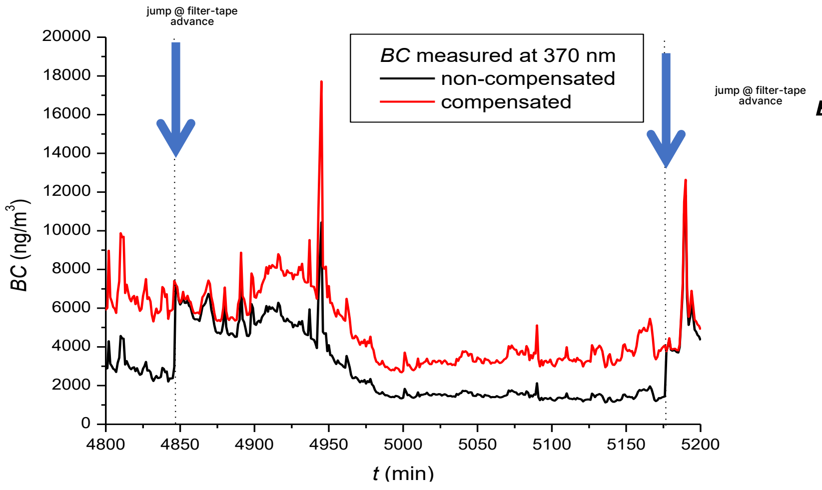
	s_{xy}	σ_s	r^2
370 nm	1.033	0.001	0.93
470 nm	0.999	0.001	0.94
520 nm	1.018	0.001	0.94
590 nm	1.02	0.001	0.94
660 nm	1.03	0.001	0.94
880 nm	1.043	0.001	0.94
950 nm	1.02	0.001	0.94

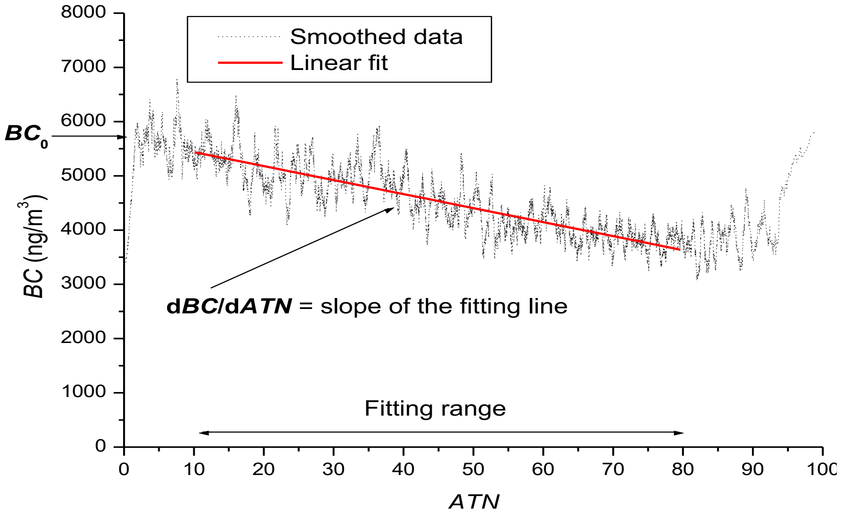


Loading effect compensation

As the loading of particles on the filter increases, **the existing particles may "*shadow*" the freshly-collected ones.**

Linear reduction of the instrumental response due to loading of the filter fiber. Jump at the tape advance (Virkkula 2007)

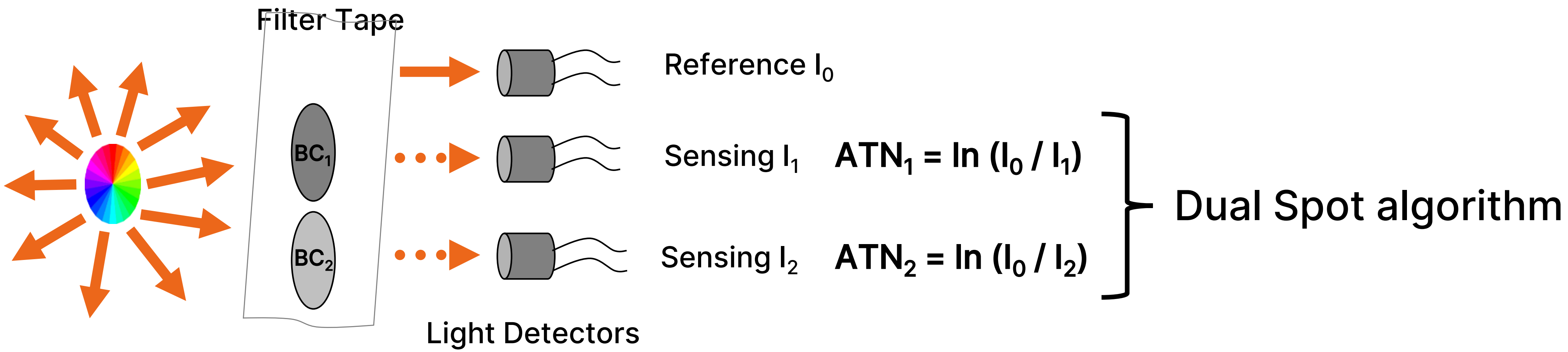




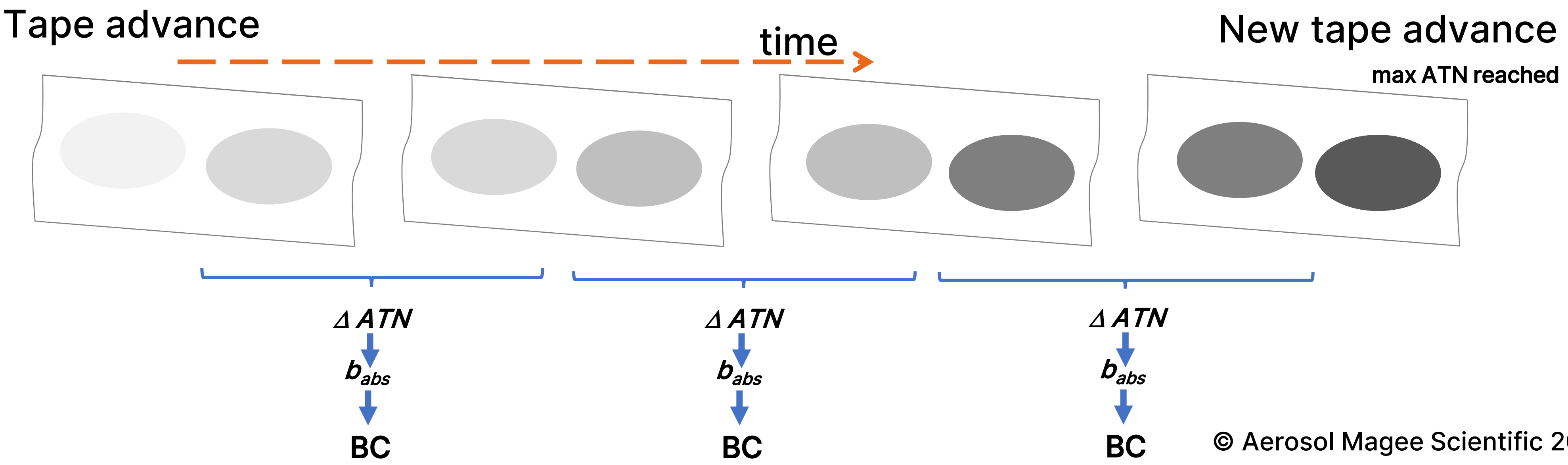
BC (reported) = BC (zero loading) · { 1 - *k* · ATN }

- ambient data – no dependence of BC on ATN
- slope *k* variable: site, source, aerosol age, composition
- need to determine it dynamically – do not assume, reather **measure**

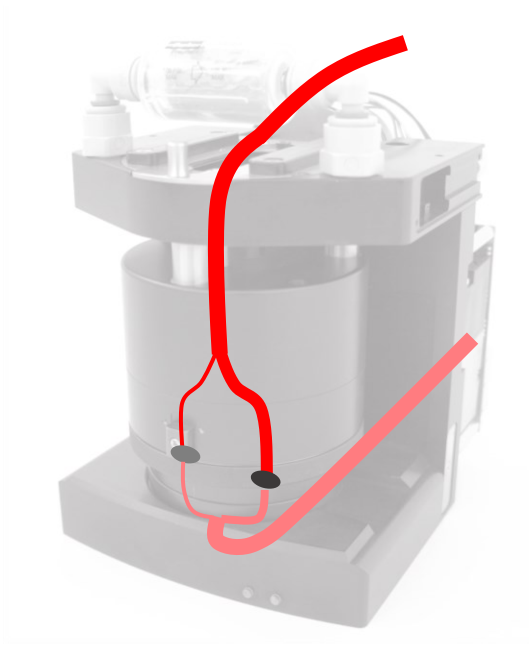
Loading effect compensation – DualSpot method

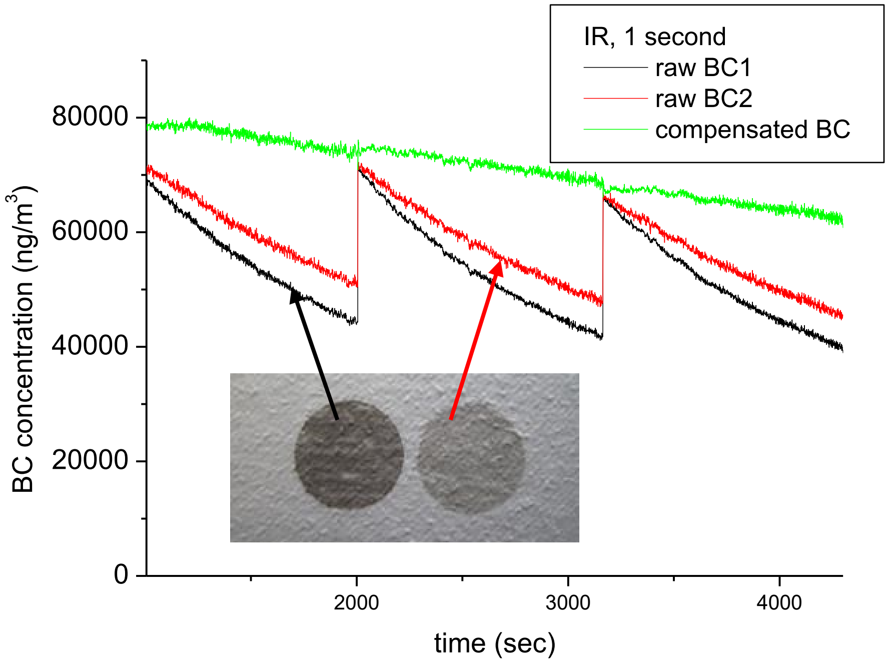


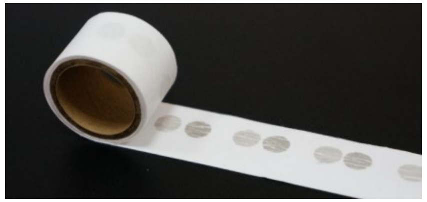
Two parallel spots with different flow -> **different loading and attenuation.**



Loading effect compensation - DualSpot method



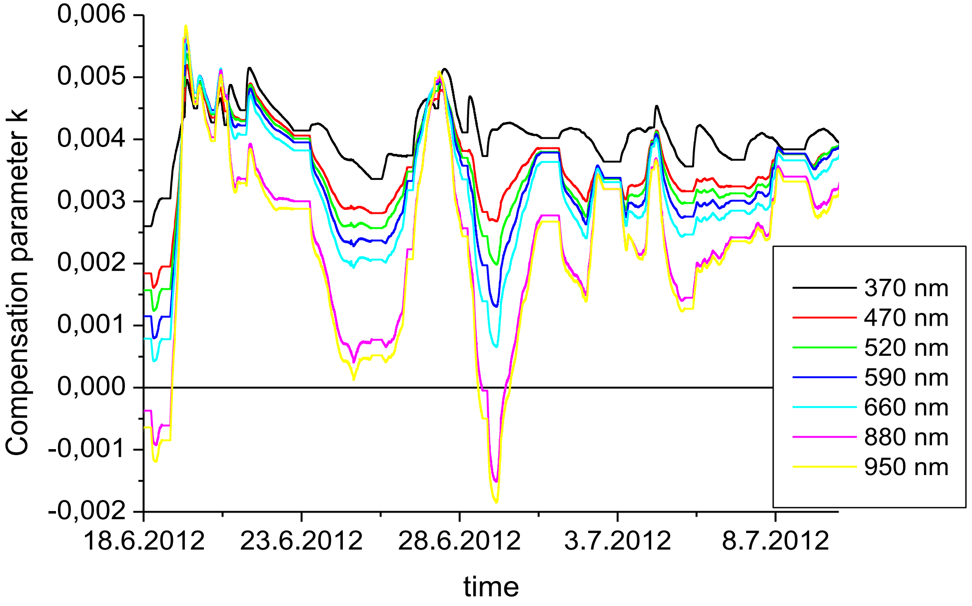




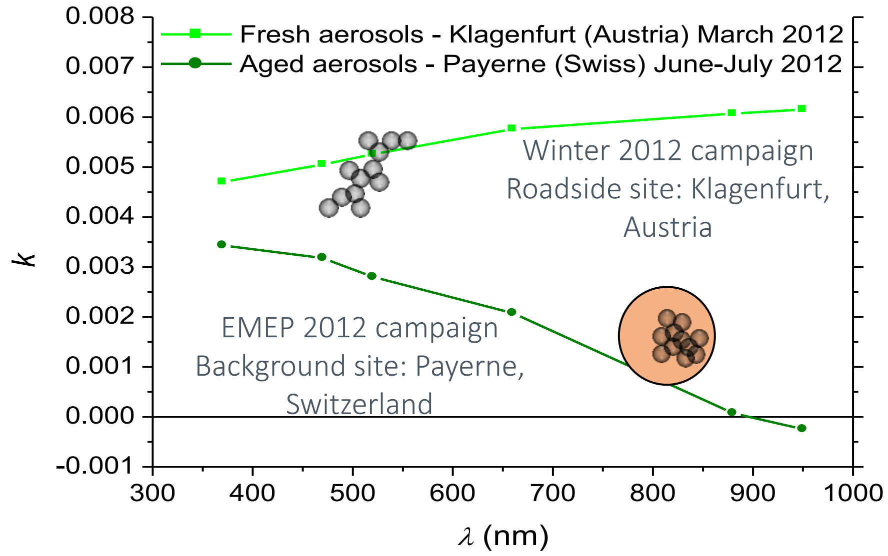
Two parallel spots with different flow, therefore **different loading and attenuation.**

Calculate loading compensated **BC** and ***k*!**

Loading effect depends on the mixing state



Spectral fingerprint of parameter *k*



Atmos. Meas. Tech., 10, 1043–1059, 2017
www.atmos-meas-tech.net/10/1043/2017/
doi:10.5194/amt-10-1043-2017

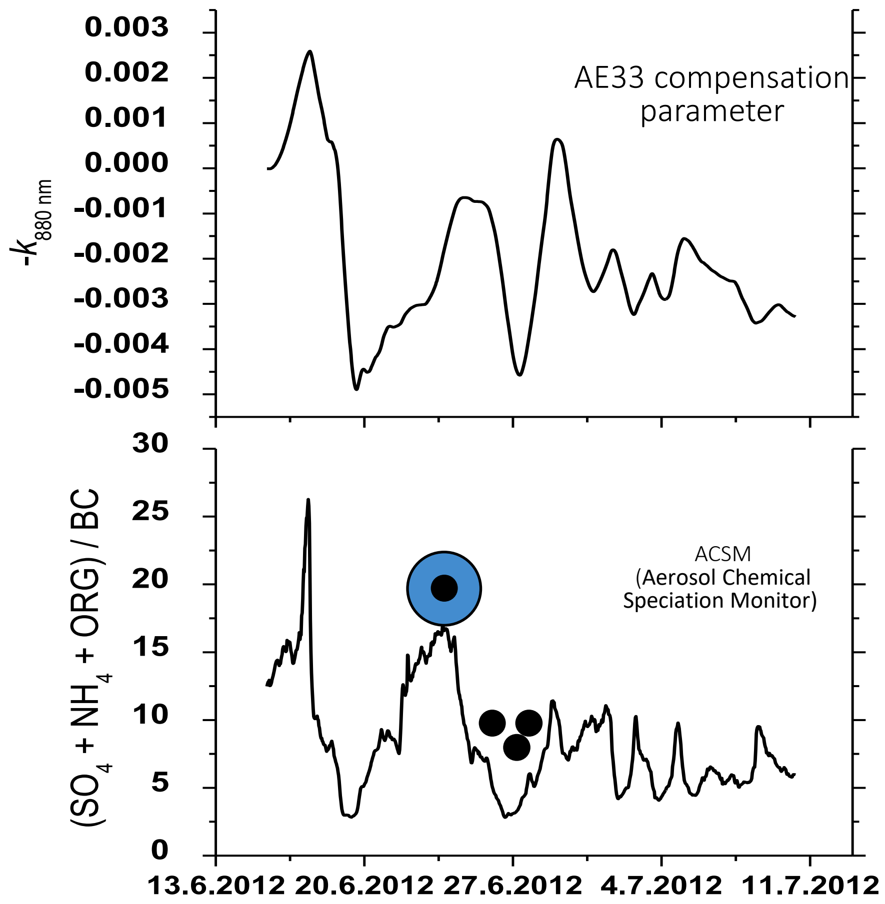
Atmospheric Measurement Techniques

The filter-loading effect by ambient aerosols in filter absorption photometers depends on the coating of the sampled particles

Luka Drinovec[1,2], Asta Gregorič[3], Peter Zotter[4,a], Robert Wolf[4], Emily Anne Bruns[4], André S. H. Prévôt[4], Jean-Eudes Petit[5,6,b], Olivier Favez[5], Jean Sciare[6,7], Ian J. Arnold[8,c], Rajan K. Chakrabarty[8,d], Hans Moosmüller[8], Agnes Filep[9], and Griša Močnik[1,2]

Drinovec, L., Gregorič, A., Zotter, P., Wolf, R., Bruns, E. A., Prévôt, A. S. H., Petit, J. E., Favez, O., Sciare, J., Arnold, I. J., Chakrabarty, R. K., Moosmüller, H., Filep, A., and Močnik, G.: The filter-loading effect by ambient aerosols in filter absorption photometers depends on the coating of the sampled particles, *Atmos. Meas. Tech.*, 10, 1043-1059, 2017.

Compensation depends on the aerosol type



EMEP summer campaign 2012

Paris, Gif sur Yvette

site operated by LSCE, CNRS/CEA/UVSQ

Compensation parameter and sum of anorganic secondary aerosol + organic aerosol correlate well.

Drinovec, L., Gregorič, A., Zotter, P., Wolf, R., Bruns, E. A., Prévôt, A. S. H., Petit, J. E., Favez, O., Sciare, J., Arnold, I. J., Chakrabarty, R. K., Moosmüller, H., Filep, A., and Močnik, G.: The filter-loading effect by ambient aerosols in filter absorption photometers depends on the coating of the sampled particles, *Atmos. Meas. Tech.*, 10, 1043-1059, 2017.

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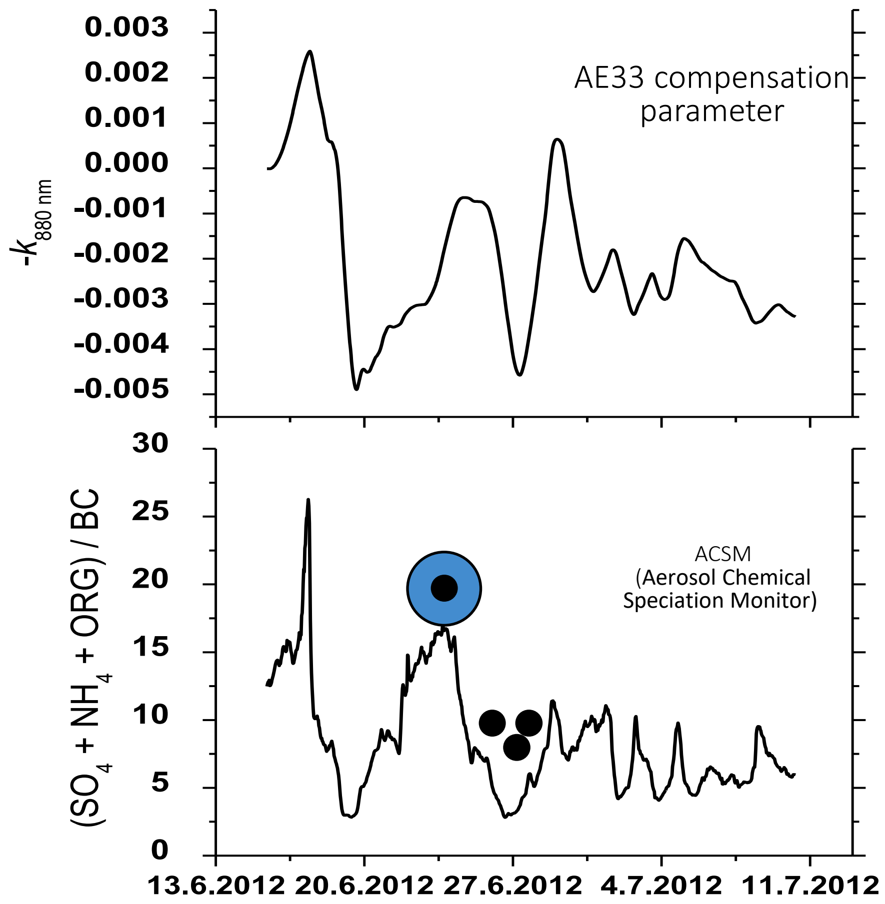


EMEP summer campaign 2012

Paris, Gif sur Yvette

site operated by LSCE, CNRS/CEA/UVSQ

Compensation parameter and sum of anorganic secondary aerosol + organic aerosol correlate well.

We can **discriminate** between fresh & old: **local & regional.**

Drinovec, L., Gregorič, A., Zotter, P., Wolf, R., Bruns, E. A., Prévôt, A. S. H., Petit, J. E., Favez, O., Sciare, J., Arnold, I. J., Chakrabarty, R. K., Moosmüller, H., Filep, A., and Močnik, G.: The filter-loading effect by ambient aerosols in filter absorption photometers depends on the coating of the sampled particles, *Atmos. Meas. Tech.*, 10, 1043-1059, 2017.

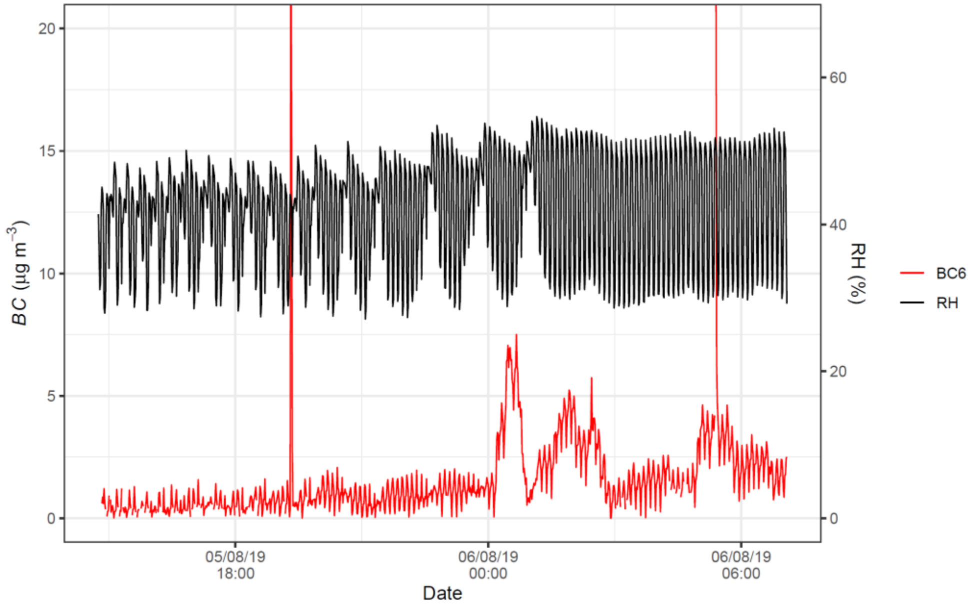
Filter photometers and sensitivity to dRH/dt

Aerosol samples and instrument surrounding air contain **water vapor**, which can be adsorbed to the fibres or to the binding material of the **filter tape** used in filter photometers.

Water vapor can reach the filter through:

- the **sample inlet (**Smart sensor to prevent water ingression through sample inlet**)**

- or enter through **openings in the filter tape (FT) compartment**, especially in environments where relative humidity changes rapidly (**air-conditioned (AC) containers, mobile stations**, etc.)



Example of the effect of AC on AE33 data.

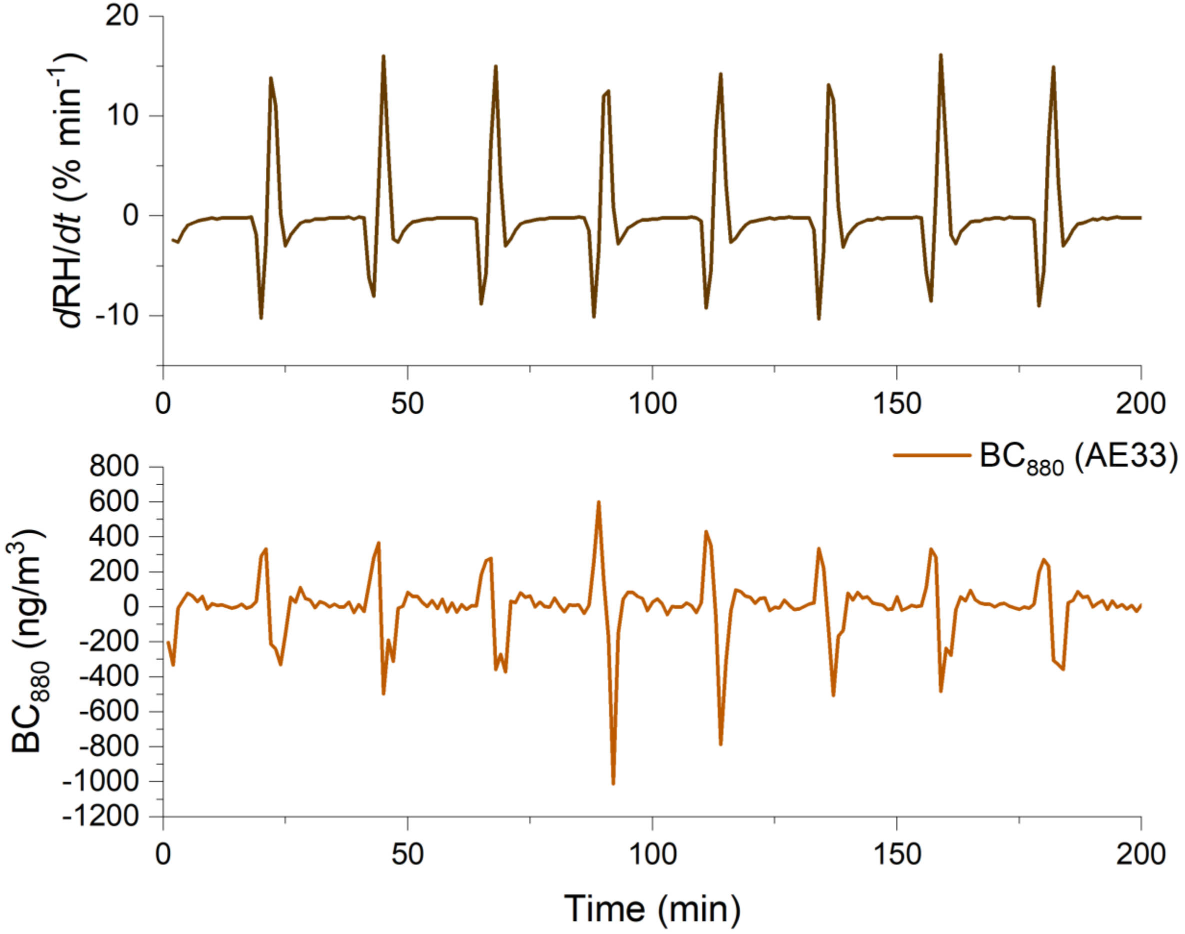
Source: Düsing S., et al., Atmos. Meas. Tech., 12, 5879–5895, 2019

Filter photometers and sensitivity to dRH/dt

Controlled T and RH changes inside the simulation chamber.

Clean air with stable RH used as sample.

Simulation chamber with AE33. The humidity in the surroundings of the instrument changed rapidly, simulating the fluctuation of RH introduced by AC.



Filter photometers and sensitivity to dRH/dt

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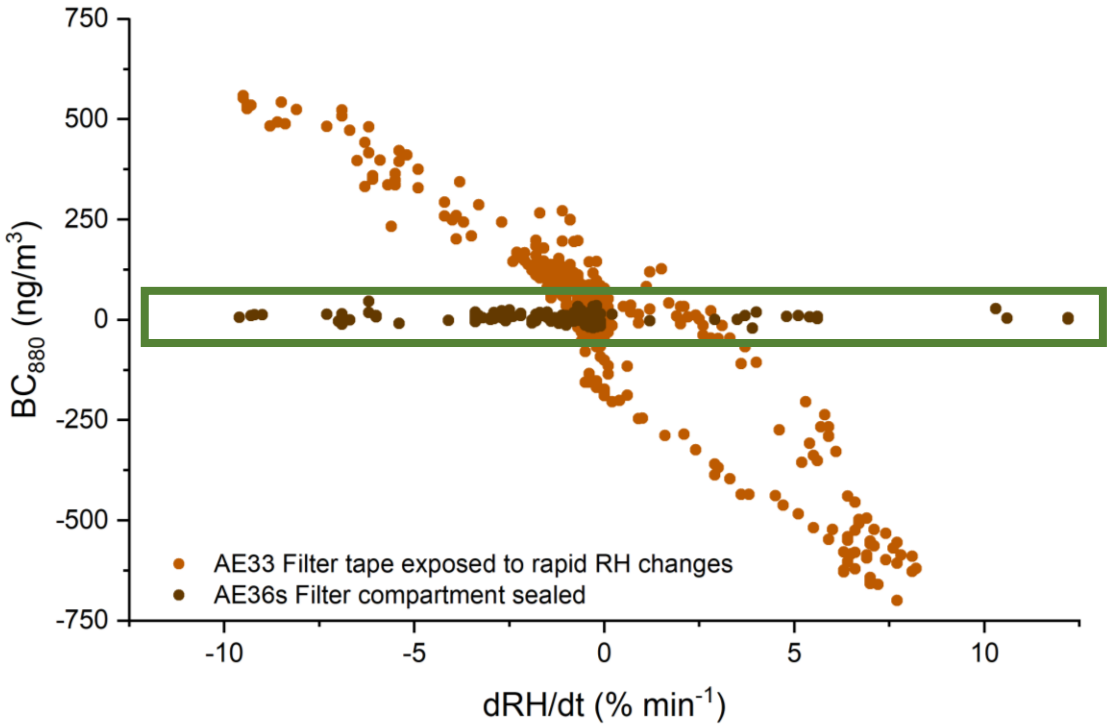


Skylab Aerosol, SI

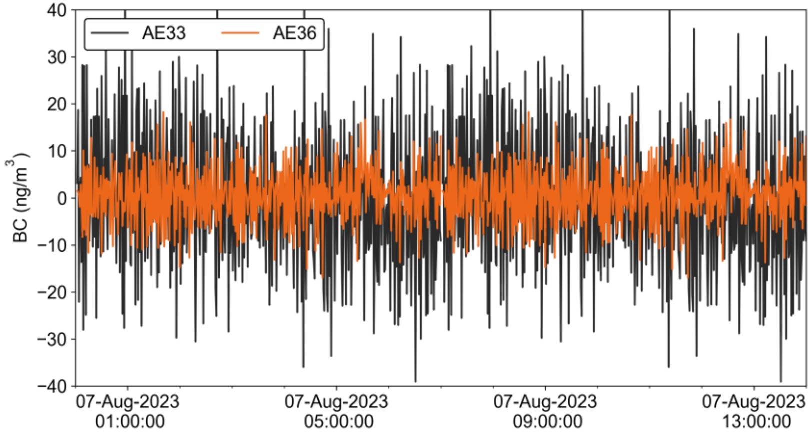
Improved performance with respect to its predecessor:

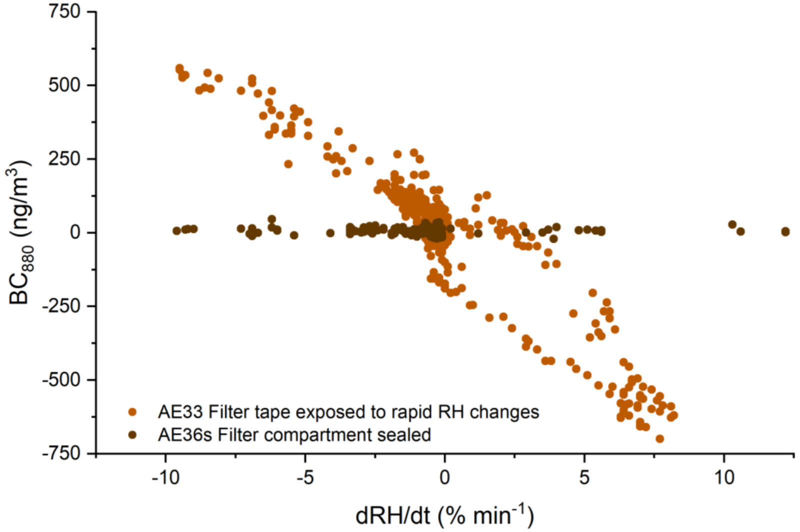
Limit of detection (mean ± 2σ, 3.8 LPM, 1 min):

- **AE33:** 40 ng/m³
- **AE36s:** **15 ng/m³**

Robustness to RH ($s_{BC\text{-}dRH/dt}$ ± 2σ) :

- **AE33:** ~ 100 ng BC /%RH/min
- **AE36s:** **>1 ng BC /%RH/min**





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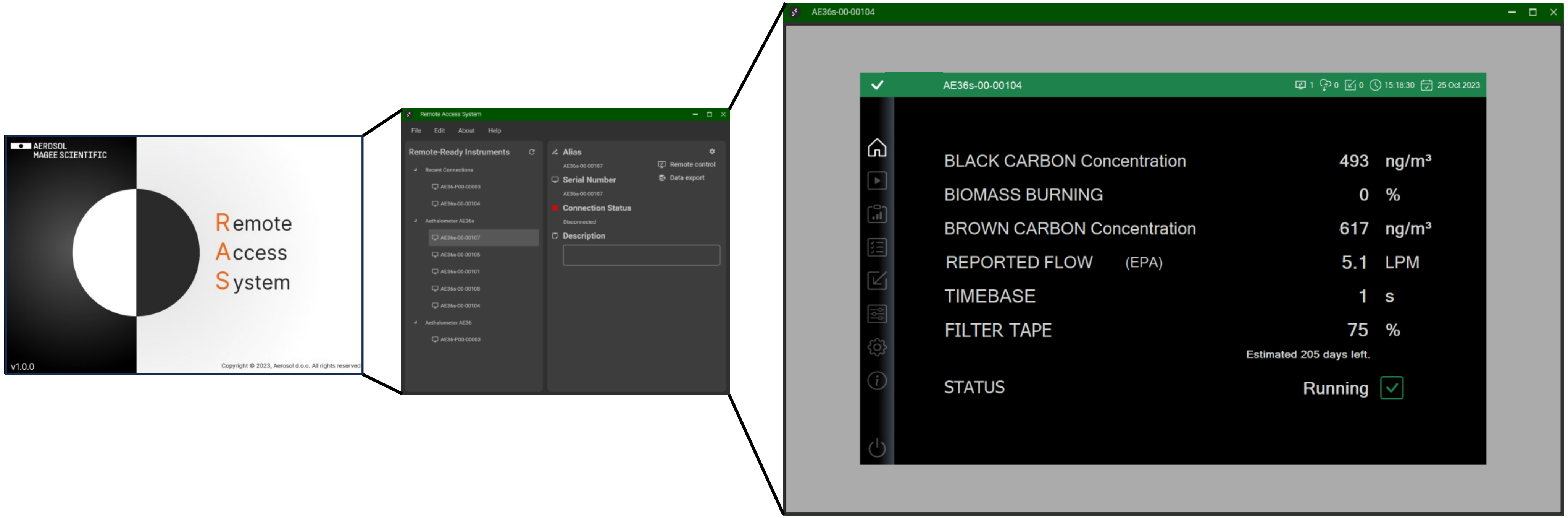
Remote Access System (RAS)

Available as a separate Software application or part of the CAAT software:

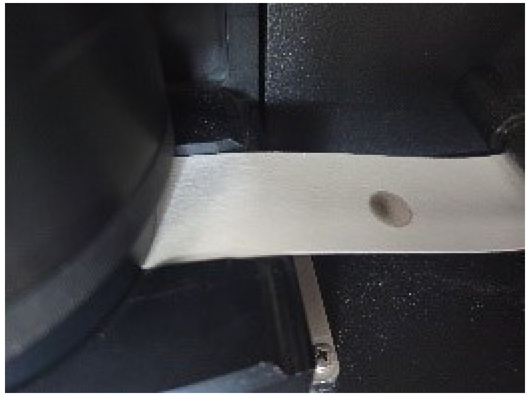


Remote access to the **instrument** and **data** through Aerosol Magee Scientific RAS software application – instrument must be connected to the same network via internet cable.

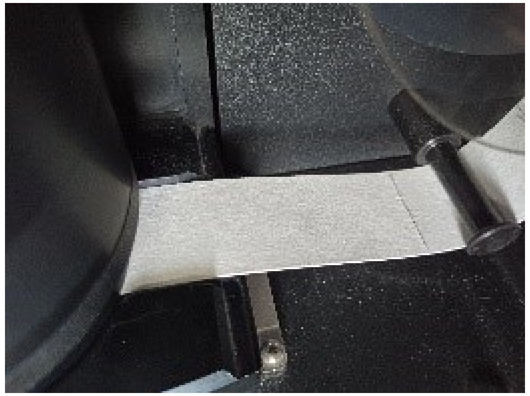
Self-cleaning procedure (SCP)

How it works:

1. AE36s uses its internal pump to create under-pressure conditions in the pulse damper compartment (CRC), which is located between the chamber and the pump (CRC).
2. Under pressure is created by running the pump at full speed while the ball valve and solenoid configuration disables the flow to run through the chamber.
3. Under pressure is rapidly released firstly through Spot 1 and secondly through Spot 2 by opening the appropriate solenoid valves.
4. Rapid release of the under-pressure temporarily creates high flows that clean that flush debris accumulated in the instrument.

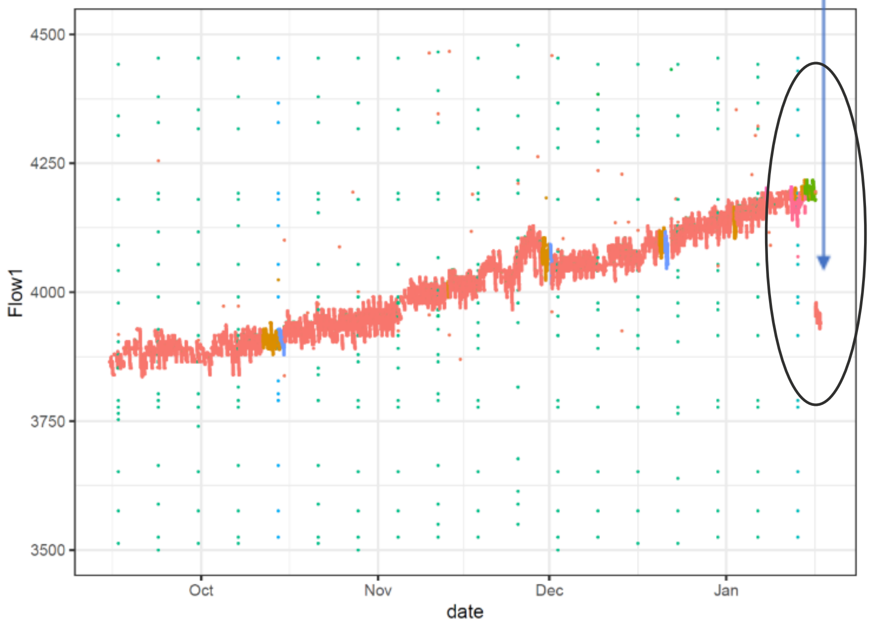


Iteration #1



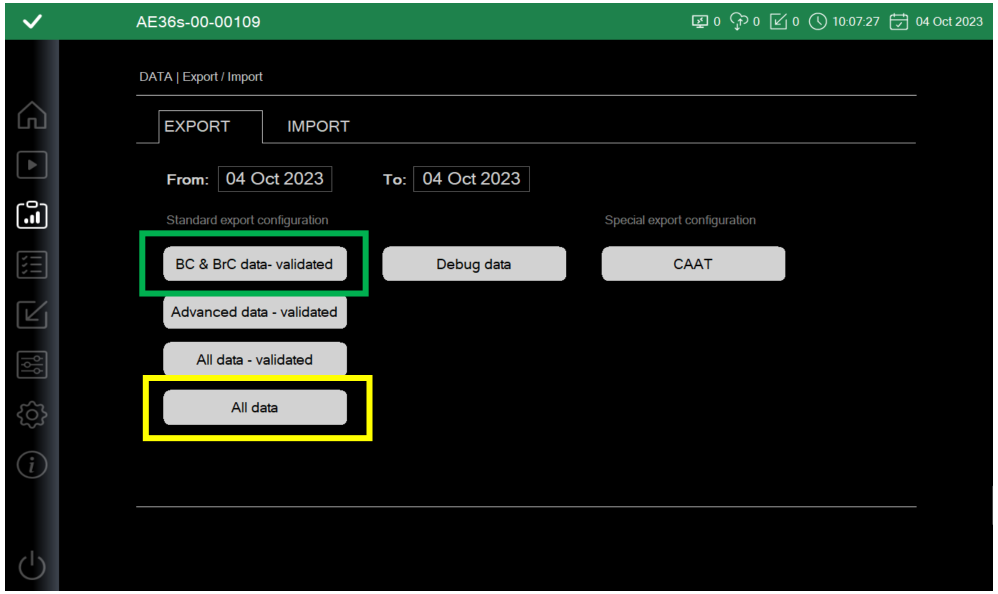
Final result after several SCP repetitions.

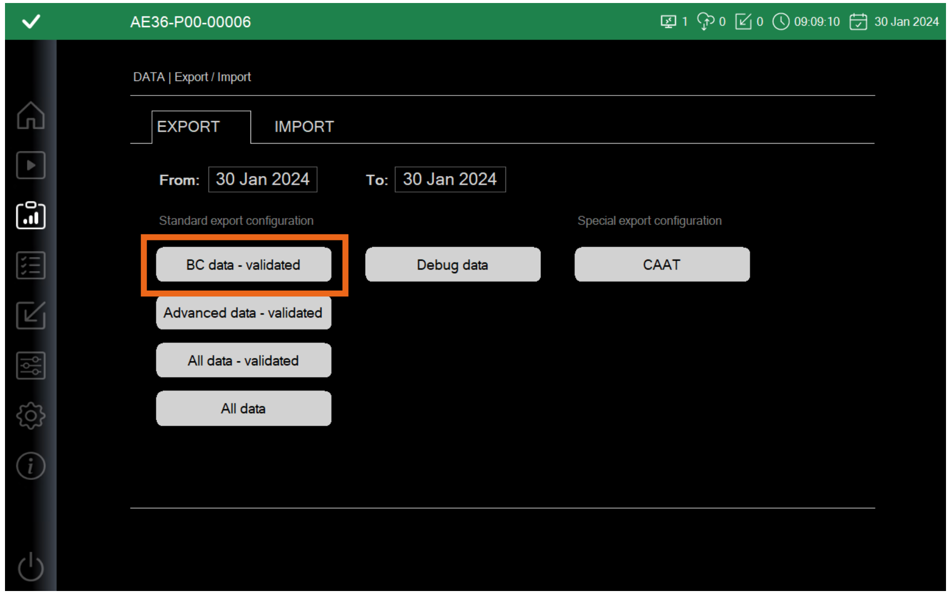
Flow ratio improved after SCP



Automatic data validation

Performed through the Graphical User Interface – DATA/Export screen:



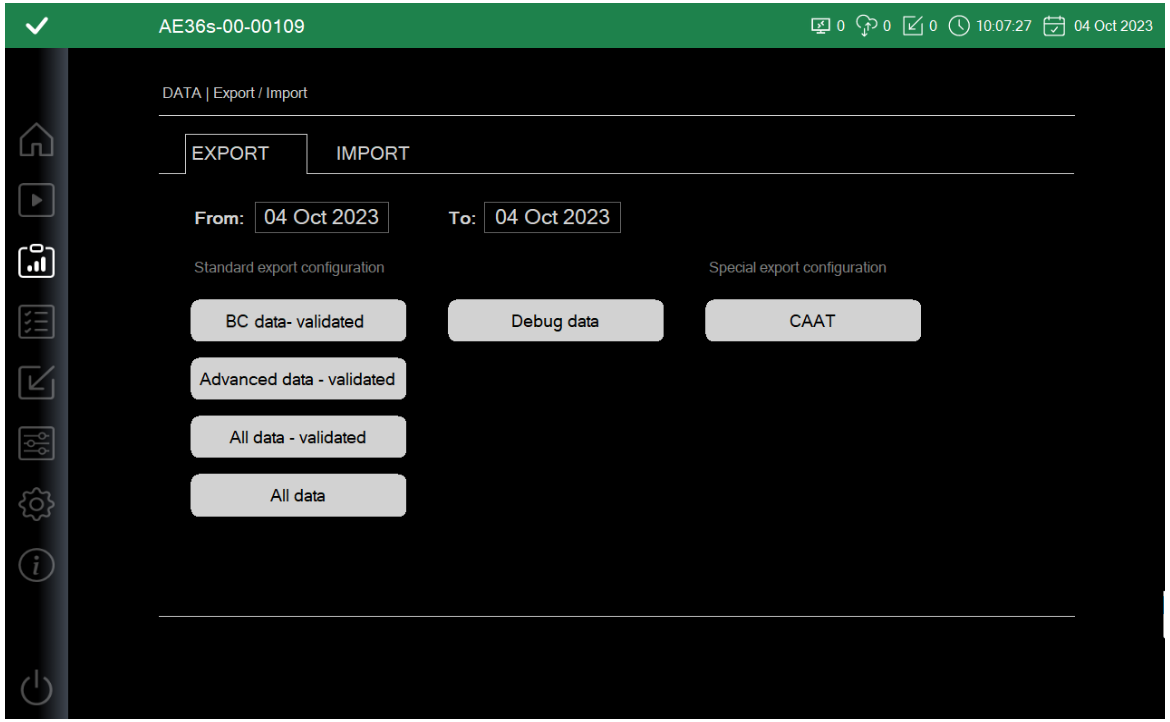


Several export options: they offer different selection of the data, from all data to the most simplified BC&BrC data (for AE36s) or BC data (for AE36).

Automatic data validation

Performed through the Graphical User Interface – DATA/Export screen:

Includes only data with G1=1



Excludes of all other data, e.g.:

Description
Tape advance (tape advance, self-testing)
First measurement – obtaining ATN0
Stopped
Calibrating LED
Calibration error
LED error
Chamber error
Tape error (tape stuck, tape end)
Stability test
Clean air test
Tape change procedure
ND test
Leakage test (inlet, filter)

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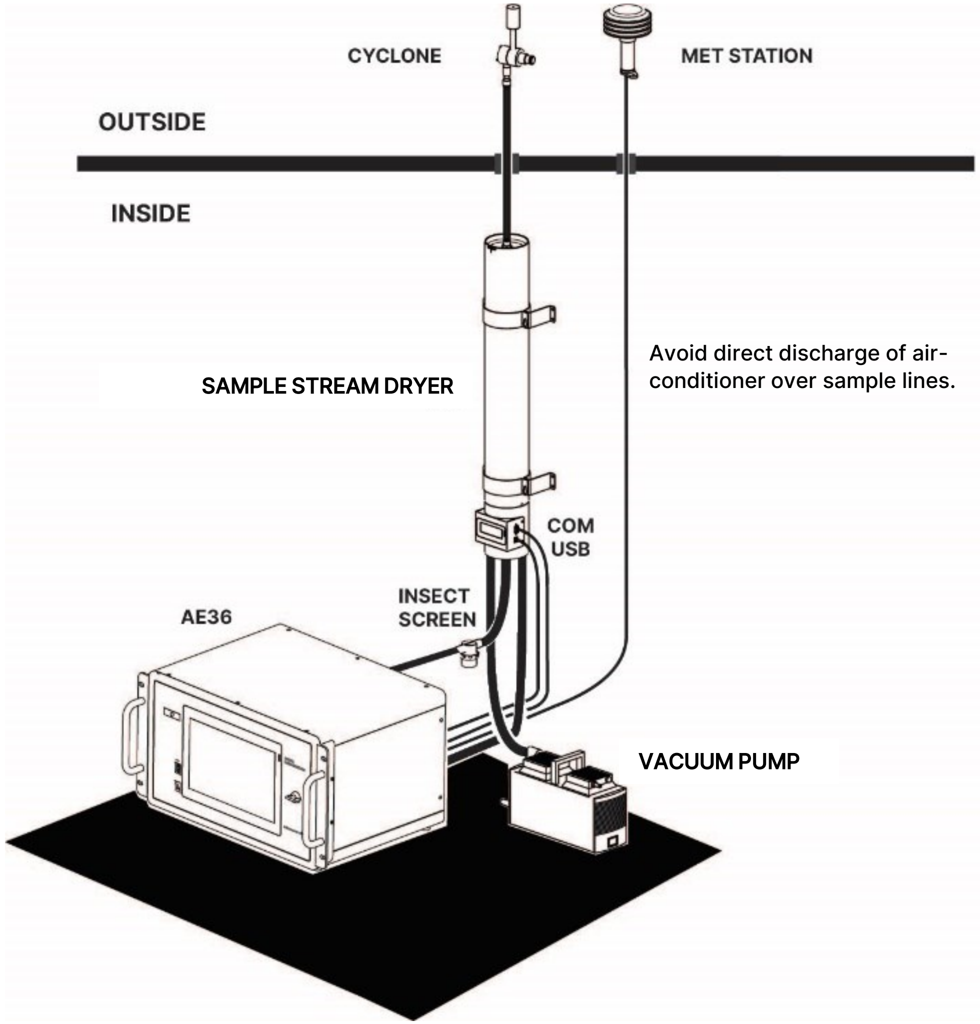
AE36(s) INSTALLATION



- Easy installation
- Flexible sampling system
- For indoor installations only
- Operational altitude: up to 3000 m
- Operational temperature range: 5°C – 55°C
- Operational relative humidity range: 5% - 95%, non-condensing
- Inlet protection from rain by using a cyclone (also for PM2.5). Ensure periodical cleaning
- Insect screen/water trap for additional instrument inlet protection
- Sample Stream Dryer in cases when outside Dew point is higher than the temperature in the station.

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Applications

AE36

- Ambient air quality monitoring network
- Community monitoring
- Long-term stationary monitoring
- Fence line monitoring
- Near-road monitoring

AE36 and AE36s

- Black carbon source apportionment
- Stationary source emissions
- Public and occupational health
- Marine and air transport pollution

AE36s

- Ambient air quality monitoring, supersite
- Brown carbon measurement
- Vehicle emission factors
- Vertical profiles
- Climate change research
- Visibility research

Final REMARKS

AE36...

- ...helps Air Quality specialists increase understanding of particulate matter (PM) air pollution.
- Gain insights into Black Carbon.
- Get accurate data you can trust, with less workload.

Final REMARKS

AE36...

...Smartest way to monitor Black Carbon

Final REMARKS

AE36s...

-...creates breakthrough aerosol research.

- Extended wavelength range offers high-quality data for carbonaceous aerosols, and provides advanced Black Carbon source apportionment and Brown Carbon analysis.

- Better understanding of the environmental challenges

Final REMARKS

AE36s...

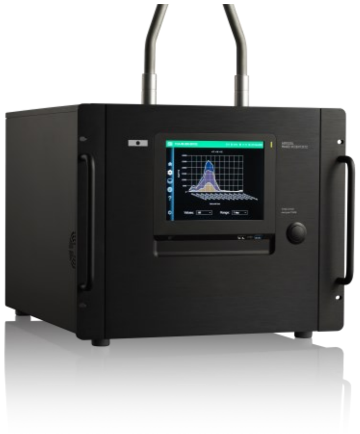
Final REMARKS

AE36s...

Expand the frontiers of aerosol science with cutting-edge Black Carbon instrument

AEROSOL
MAGEE SCIENTIFIC

Total Carbon Analyzer
&
Carbonaceous Aerosol Speciation System CASS



&

AEROSOL
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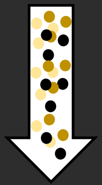
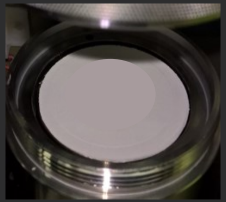
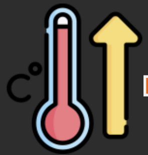
Total Carbon Analyzer TCA08

Sampling

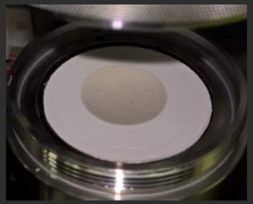




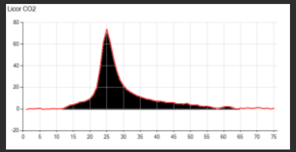
Heating



+ O_2

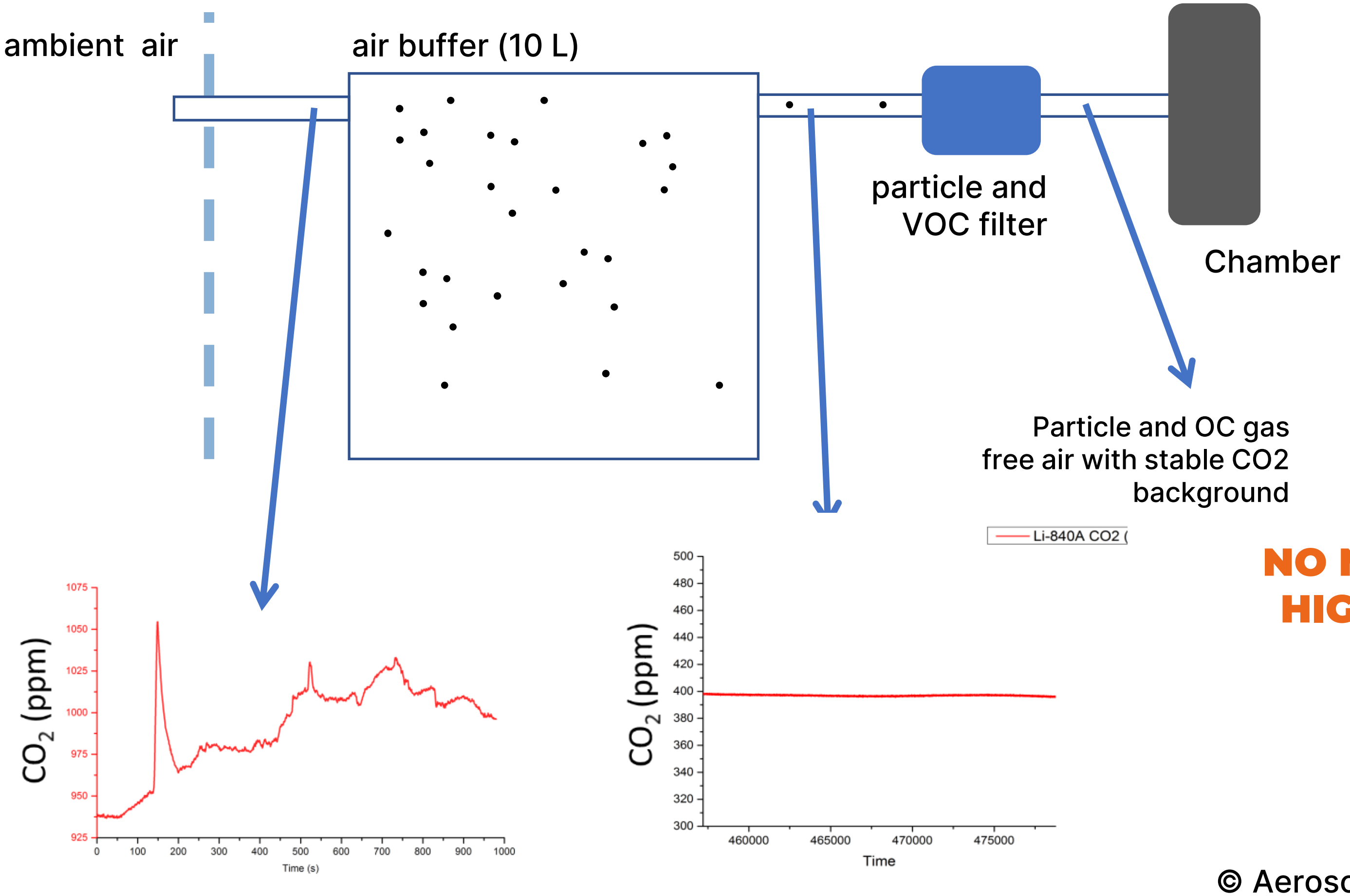


Analyzing

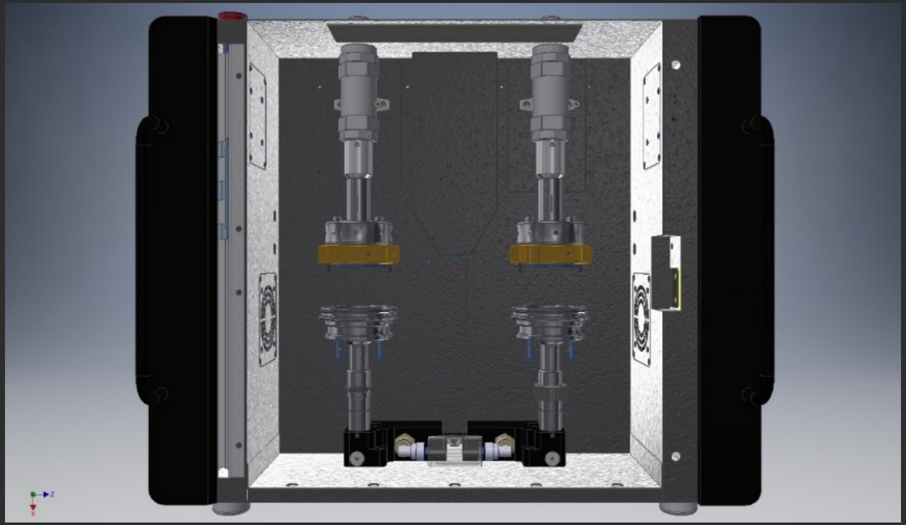


Total Carbon Analyzer TCA08

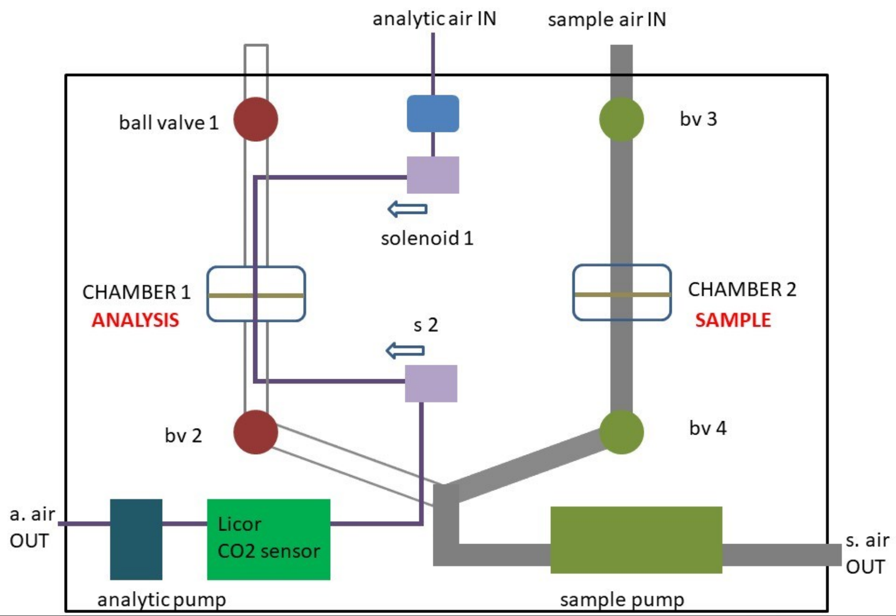
Analytic air

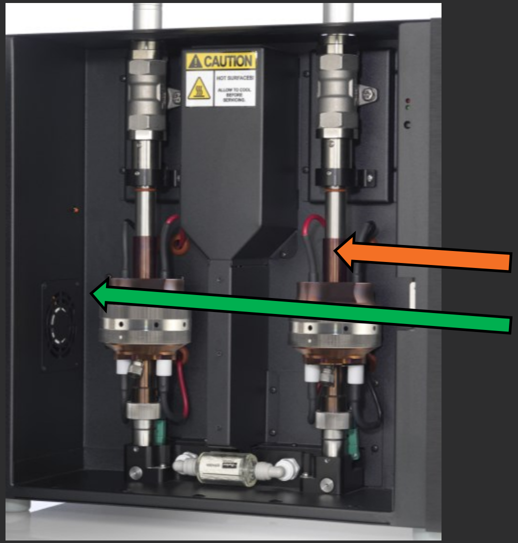


NO NEED FOR HIGH PURITY GASES!



CONTINUOUS OPERATION and ANALYSIS



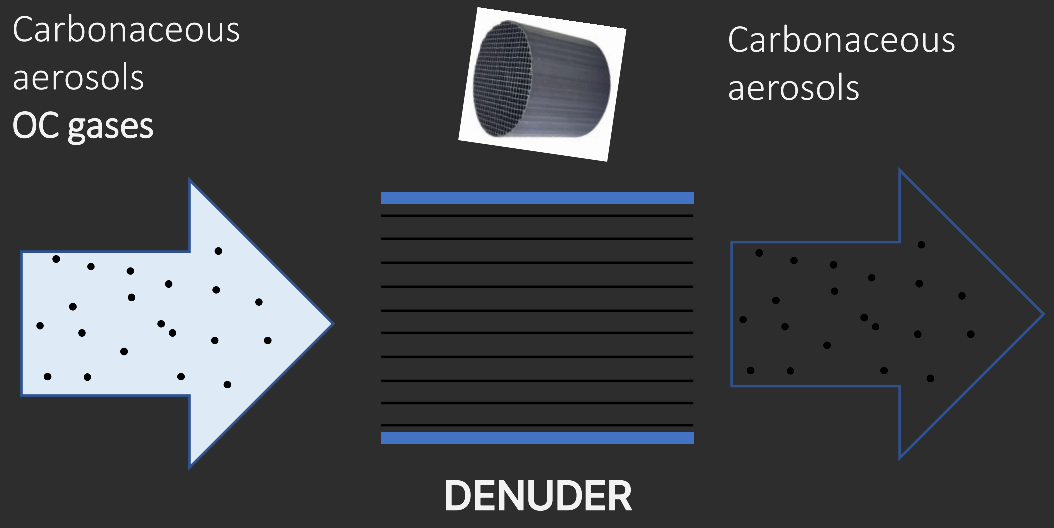


While one channel is collecting its sample, the other channel analyzes an already collected one.

Total Carbon Analyzer TCA08

Sampling Artefact

SAMPLING ARTEFACTS: positive artefact = **VOC absorption**



Total Carbon Analyzer TCA08

Sampling Artefact

SAMPLING ARTEFACTS: positive artefact = **VOC absorption**

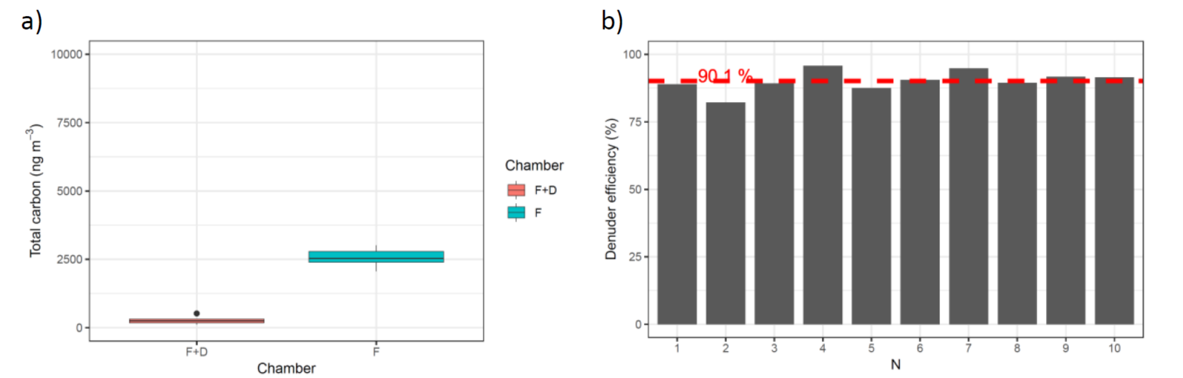
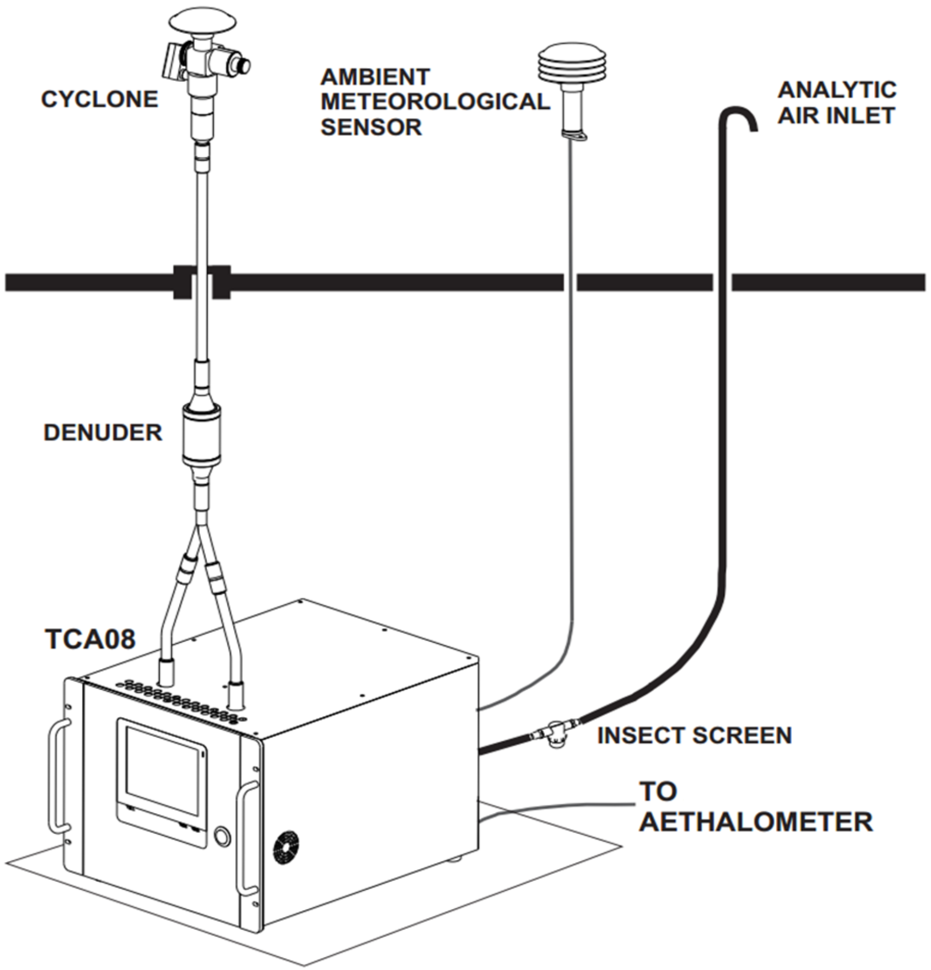


Figure 2: Example of denuder efficiency test results. a) Statistical summary of measured carbon content (presented by box-plots) for chamber 1 (F+D) and chamber 2 (F) and b) calculated denuder efficiency with ref line representing the mean value of D_E.

TCA08 INSTALLATION



- Easy installation
- Custom sampling system
- For indoor installations only
- Operational altitude: up to 3000 m
- Operational temperature range: 10°C – 35°C
- Operational relative humidity range: 30% - 80%, non-condensing

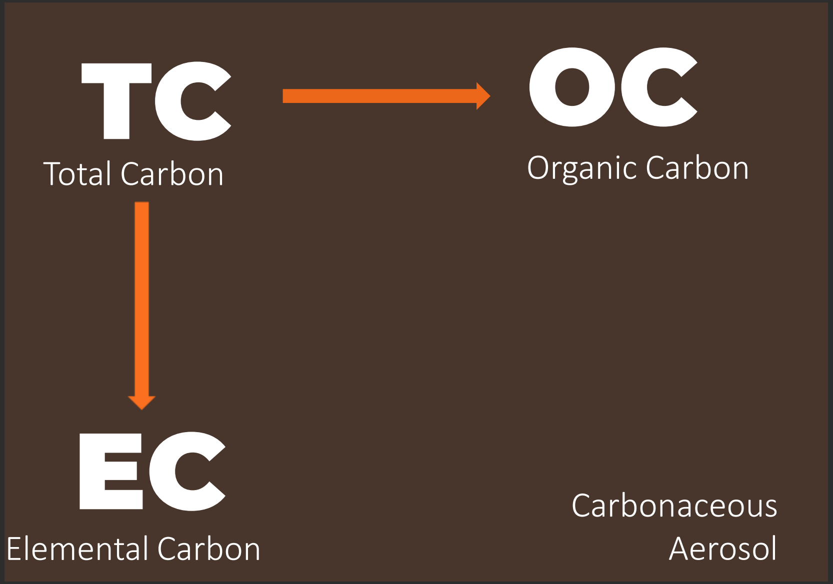
Carbonaceous Aerosols

Carbonaceous aerosols are extremely diverse.

They are often the dominant fraction of PM2.5.

They impact air quality, public health, visibility, cloud nucleation, the planetary radiation balance, and climate forcing.

The OC fraction is the **largest** and the **least understood**.



A revolutionary OC/EC Analyzer

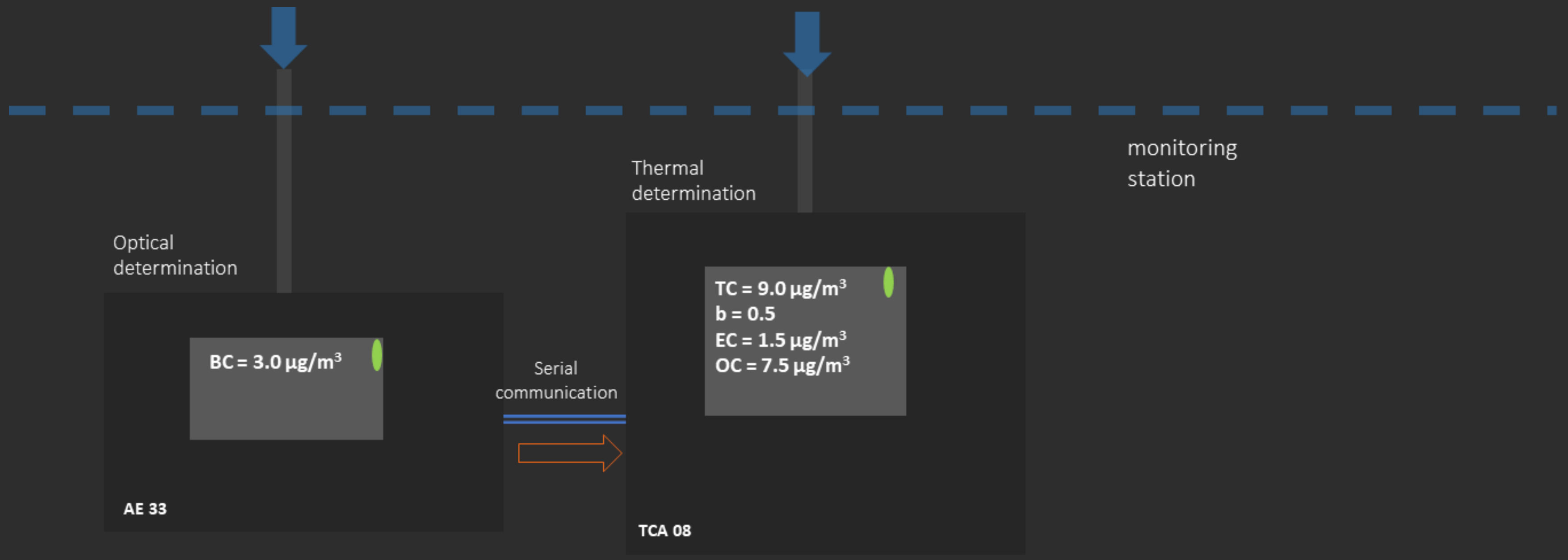
Optical measurement of BC with Aethalometer

Thermal measurement of TC with the TCA08

Online

No gas, no glass

High time resolution

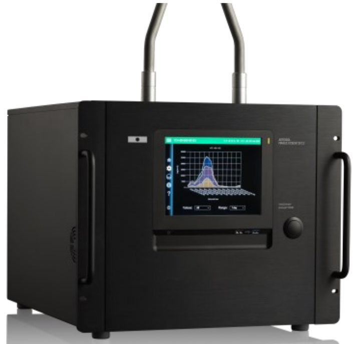


CASS MEASUREMENT PRINCIPLE

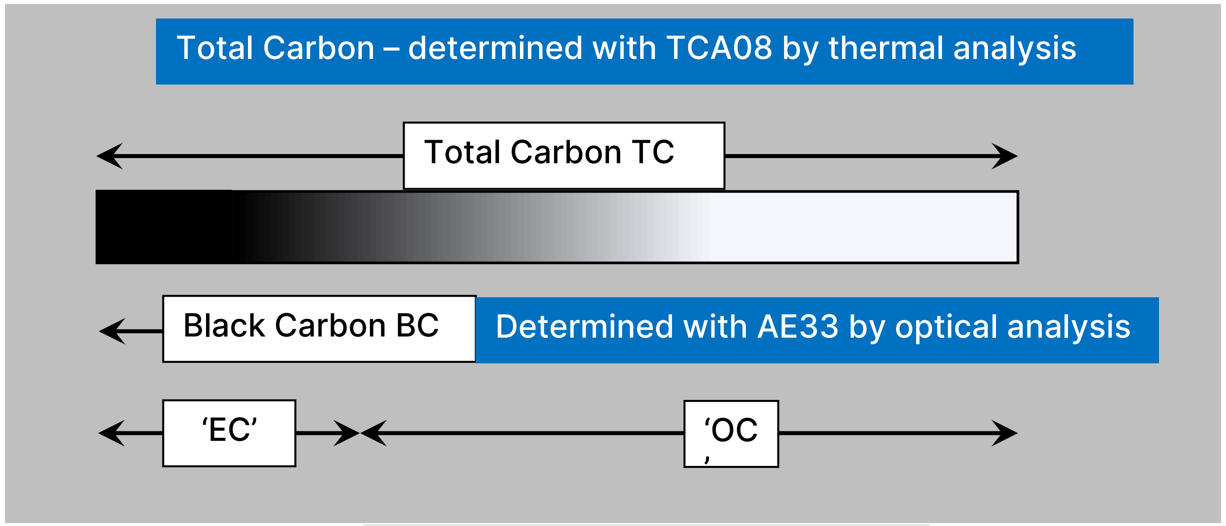
AE33
or
AE36s
or
AE36

Optical analysis: BC

TCA08



Thermal analysis: TC



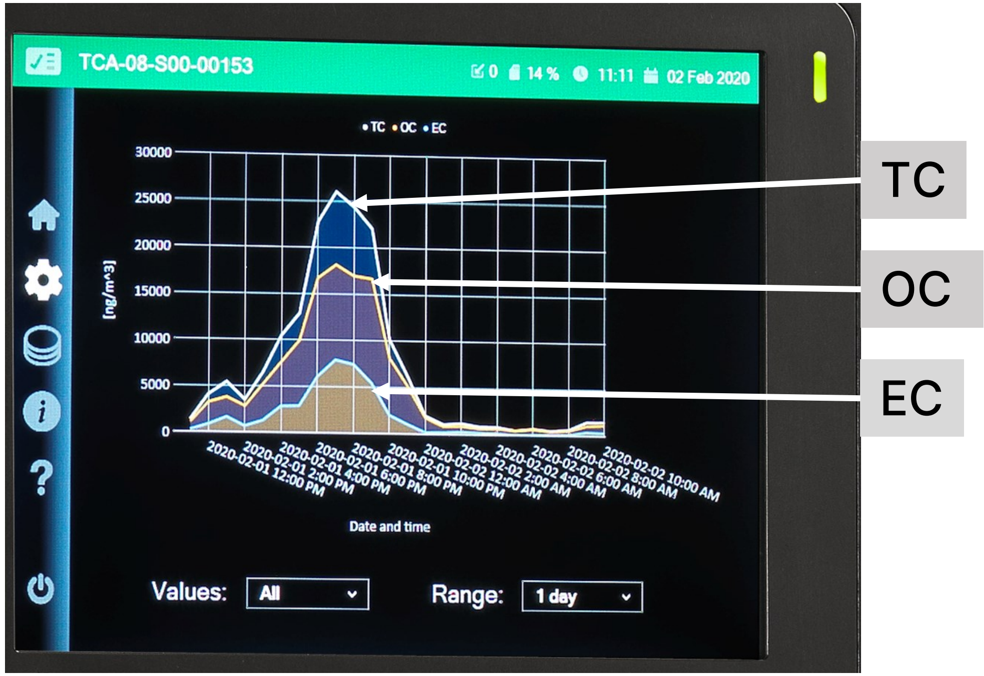
$$OC = TC - EC$$

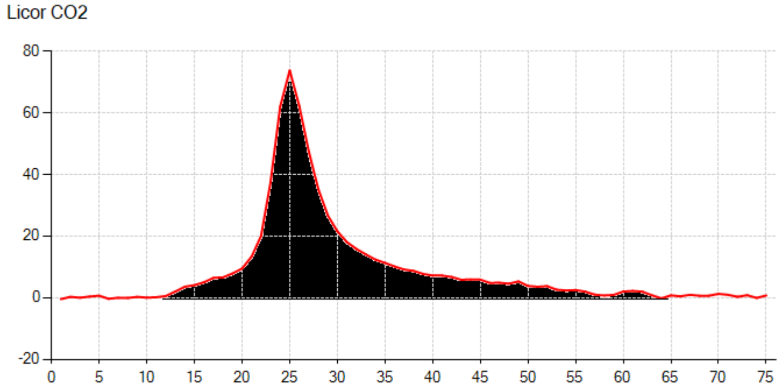
$$OC = TC - b \cdot BC$$

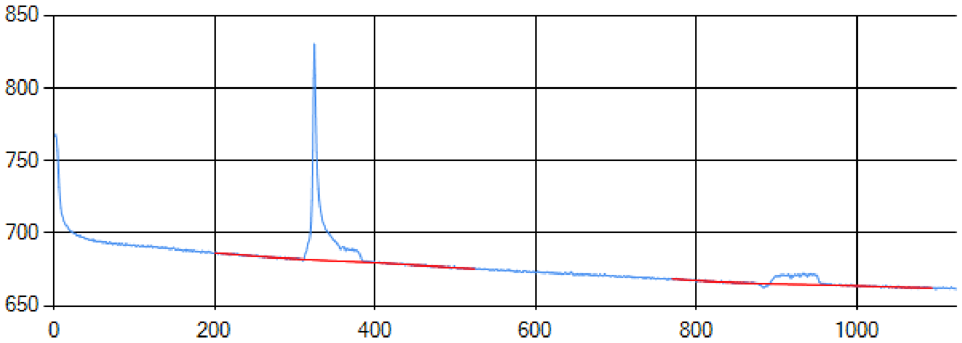
b is region specific factor.

Determination of TC, BC and equivalent OC and EC fraction

Data is displayed on graphical user interface in real time:



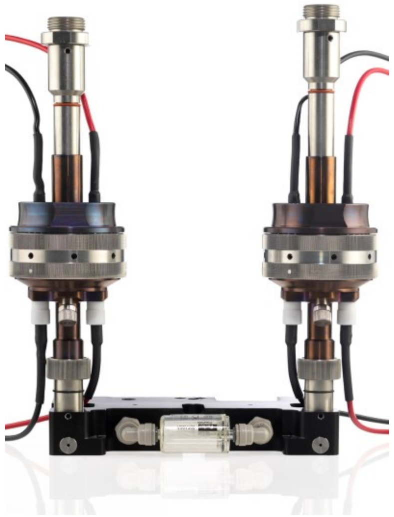




RUGGED and RELIABLE

CASS for a LONG and UNATTENDED operation

Contains NO special quartz GLASS



PATENTED

NO special GAS and NO CATALYST required

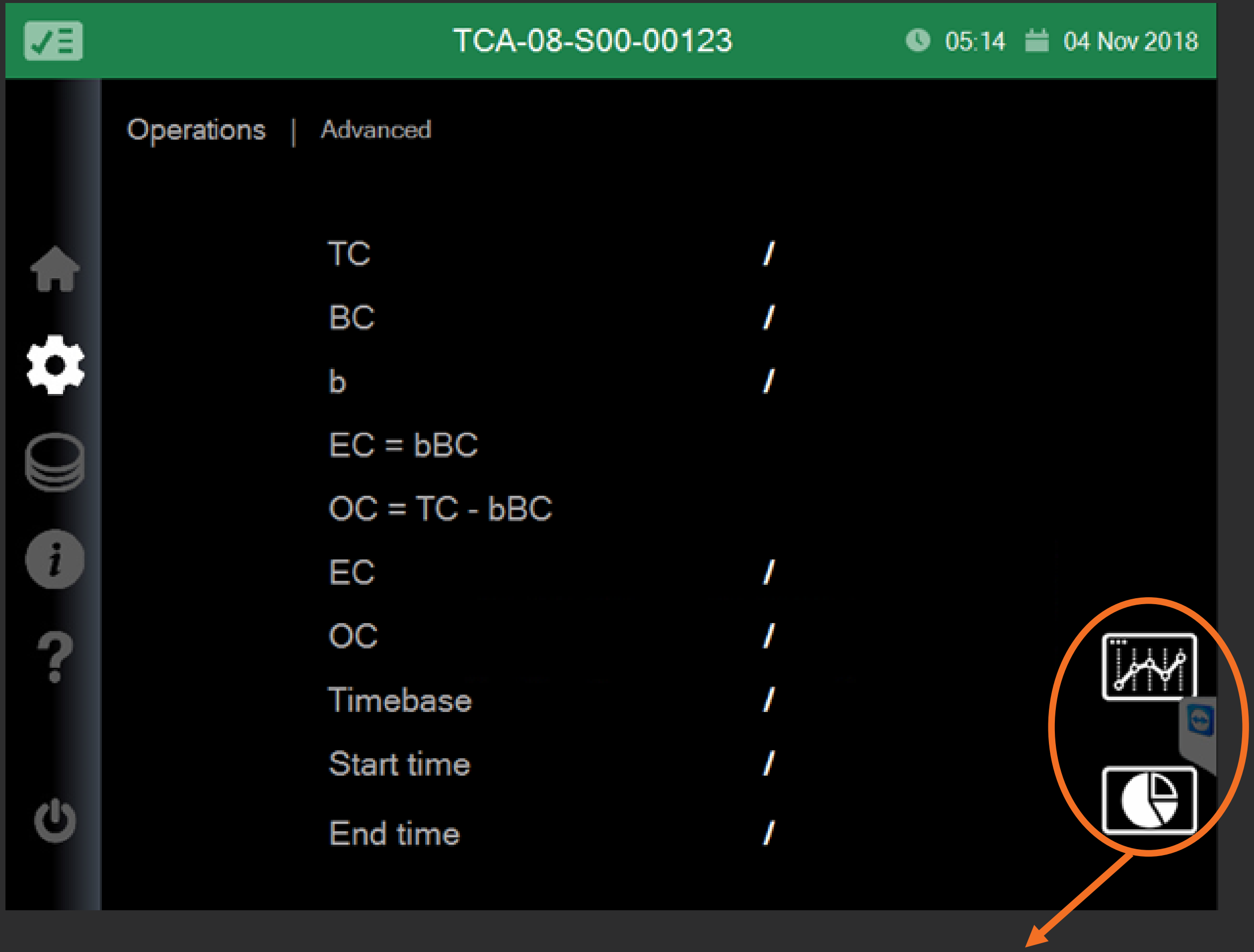
AEROSOL
MAGEE SCIENTIFIC

Near Real-
Time determination
of CARBONACESOUS
AEROSOLS

....and autonomy for
long-term campaigns
with REMOTE access.

A revolutionary OC/EC Analyzer

User interface/advanced screen



Total carbon concentration

Black carbon concentration

EC/BC ratio b

OC concentration

EC equation

OC equation

EC equation

Sample time base setting

Start time of the sampling

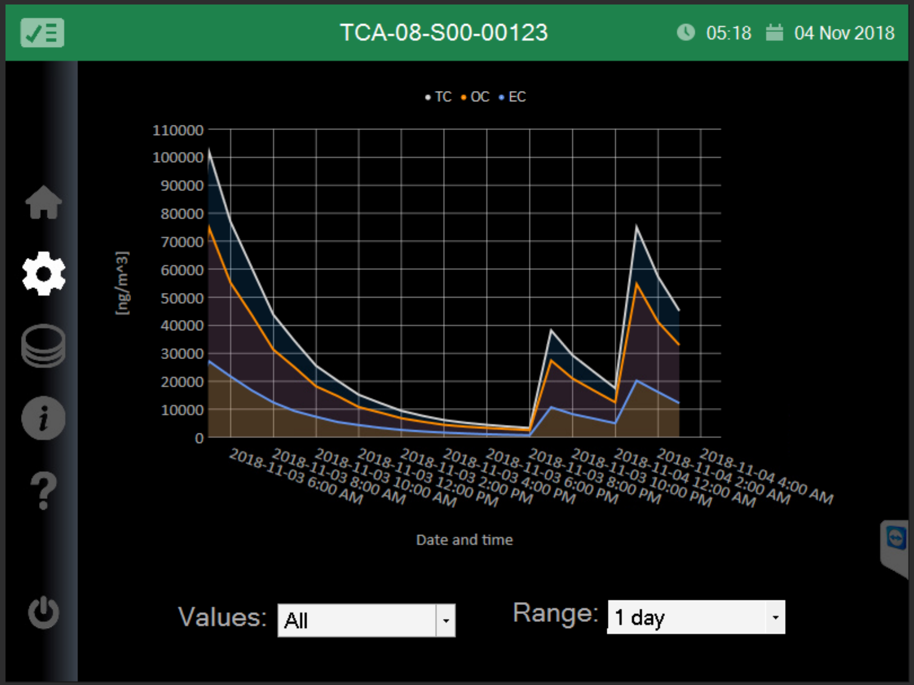
End time of the sampling

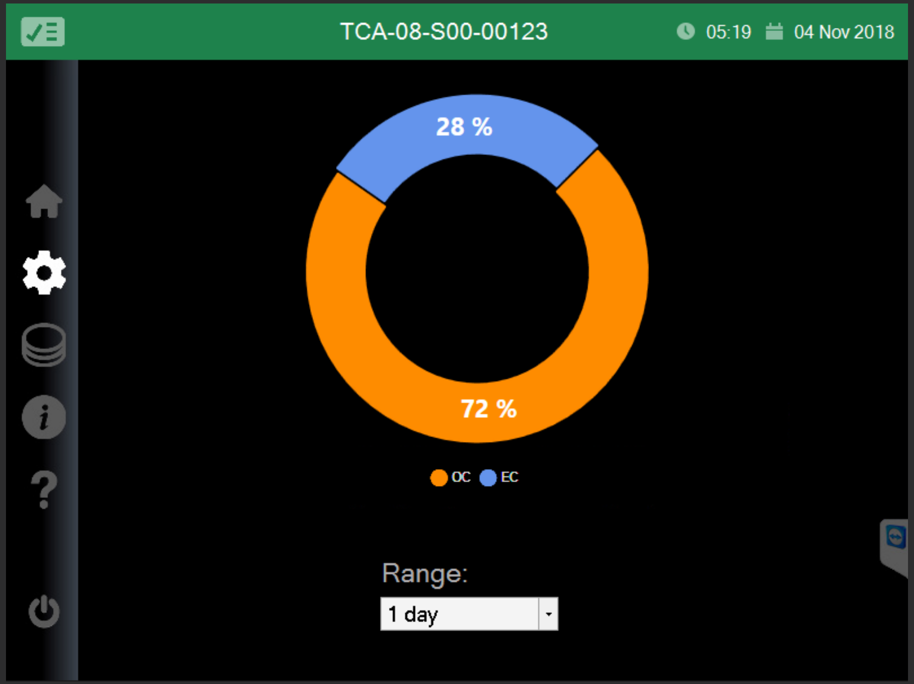
TC / EC / OC Series and Pie chart

AEROSOL
MAGEE SCIENTIFIC

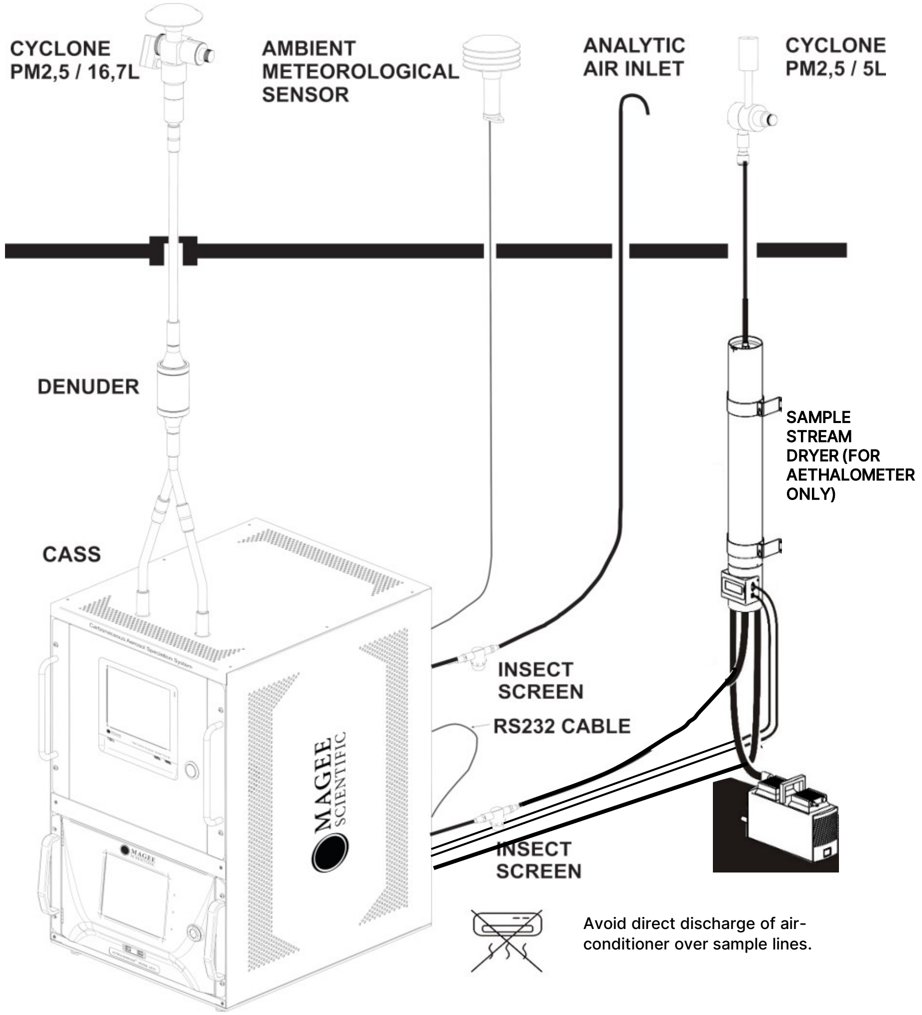
A revolutionary OC/EC Analyzer

User interface/advanced screen



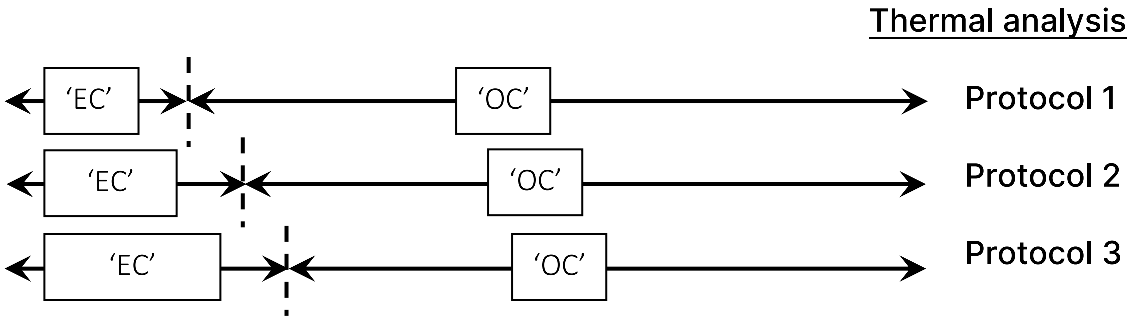


CASS INSTALLATION



- Easy installation
- Two separate sampling system
- For indoor installations only
- Operational altitude: up to 3000 m
- Operational temperature range: 10°C – 35°C
- Operational relative humidity range: 30% - 80%, non-condensing
- Inlet protection from rain by using a cyclone (also for PM2.5). Ensure periodical cleaning
- Insect screen/water trap for additional instrument inlet protection
- Sample Stream Dryer in cases when outside Dew point is higher than the temperature in the station.

STANDARD OC/EC



Ambient Air — Equivalence of automatic measurements of elemental carbon (EC) and organic carbon (OC) in PM

16909 for offline OC/EC
16450 for equivalence (90 days measurements)

CEN/TC 264/WG 35 in progress

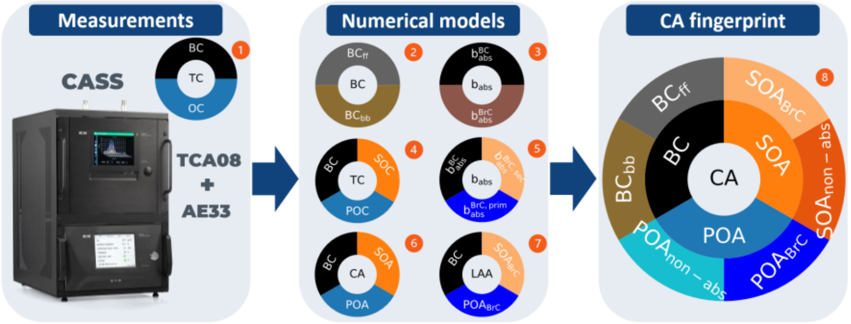
Rigler et al. Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-13-4333-2020
Ivančič et al. Science of the Total Environment 848 (2022) 157606

APPLICATIONS

OC/EC analyzer

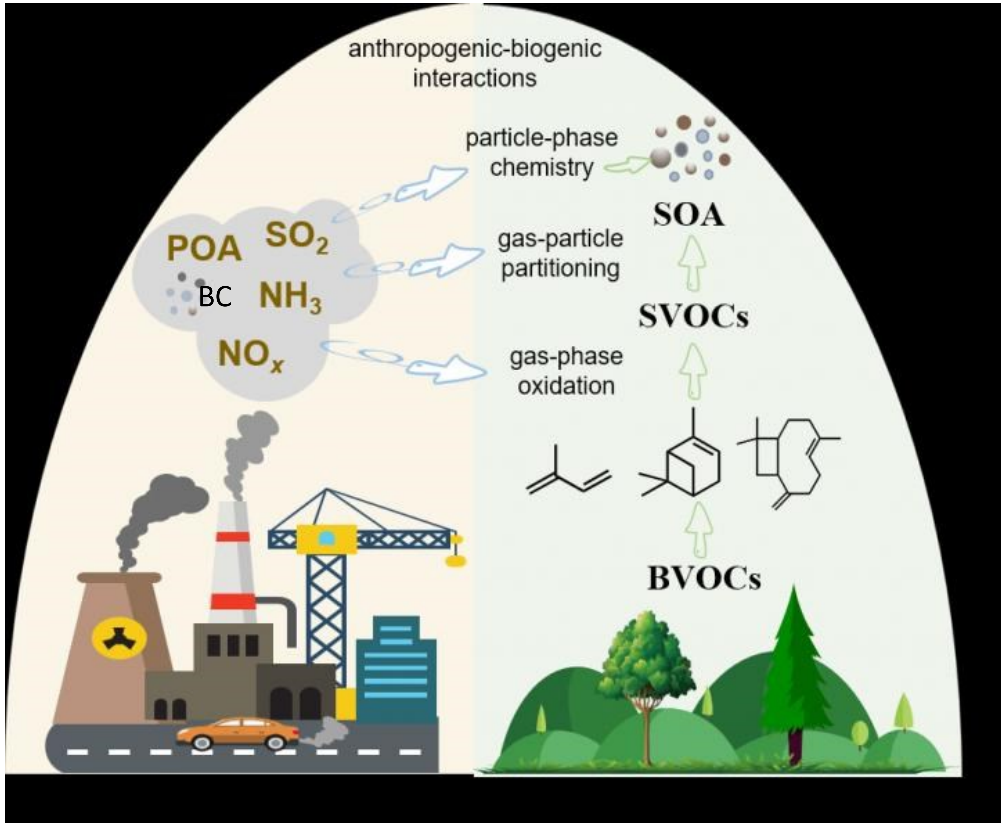
Public Health effect studies

Advanced apportionment of CA



Impact on Climate Change, Primary and Secondary CA formation, BrC

PATENTED



SOURCE: https://www.eurekalert.org/news-releases/552378

CA = BC + POA + SOA

BVOCs are major SOA precursors

POA modify also SOA concentrations through antropogenic biogenic interactions

Specific measures to control CA concentrations – only through limitations of BC and POA emissions

WE NEED MEASUREMENTS

FINAL REMARKS

- TC/BC as a standardized OC/EC method
- Health effect studies: Environmental and workplace monitoring of carbonaceous aerosols
- AQ monitoring and advanced research of CA: Source apportionment and optical characterization of Carbonaceous Aerosols at different wavelengths

Final REMARKS

Carbonaceous Aerosol Speciation System – „CASS“

KEY FEATURES

- Continuous analysis of Carbonaceous Aerosols
- Sampling time 20 min to 24 hours
- Sampling *vs.* analysis switched between 2 channels
- **No carrier gas required**
- **No Glass : Rugged, All-Steel Construction**
- **No Catalyst**: all carbon detected all the time
- Very little attention required

Thank you for your kind attention!

kkunstelj@aerosolmageesci.com