EMPIR Black Carbon project
July 2017 – December 2020

Stakeholder teleconference

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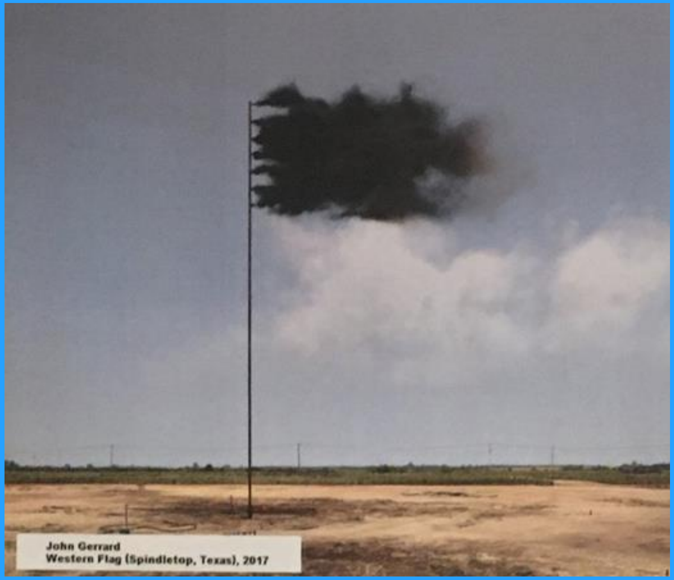
26 November 2020



Overview: metrology for light absorption by atmospheric aerosols

WP1
High accuracy
SI-traceable
filter-free
methods

Potentially
improved filter-free
field instruments

WP2
Aerosol sources
characterised by
SI-traceable
methods

WP3
Traceable
calibration methods
for filter-based field
instruments

Particle types to use for calibration

Two “extreme representative” types of calibration aerosol were agreed in Deliverable D3 (and modified at M18 meeting):

(1) “fresh combustion particles”:
size 50 - 100 nm, SSA 0.05 – 0.2 at 550 nm

(2) “aged combustion particles”:
size 200 - 400 nm, SSA 0.7 – 0.9 at 550 nm.

In both cases, the absorption coefficient should cover the range from 0 to 50 Mm^{-1} at 880 nm.

Light absorption by aerosol particles

WP1 SI traceability for in situ methods:

extinction minus scattering
photoacoustic
photothermal interferometry

- Understand the uncertainties of each method and implementation
- Refine methods to reduce uncertainties
- Choose the best method(s) for general or specific aerosols

Light absorption by aerosol particles

WP2 Aerosol sources for calibrating filter-based instruments:

diffusion flame
graphite spark
black PSL

fullerene BC
colloidal graphite

- Choose the desired aerosol particle optical and physical properties
- Develop and testing sources, especially for reproducibility
- Characterise aerosol particle absorption (with WP1) and other properties
- Deliverable 4 found suitable “fresh” and “aged” sources

Light absorption by aerosol particles

WP3 Traceable calibration methods for field instruments

- Understand the requirements of common field instruments
- Test calibration systems – can be field or lab based
- Trials with field instruments in Pallas (Finland) Summer 2019 and Athens (Winter 2019/20).

More details on each WP will follow

WP1: SI traceability for in situ methods:

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Objectives

- Refine methods to reduce uncertainties and develop corrections for measuring the particle light absorption coefficient
- Guidance on the selection of the most suitable method for specific applications

Methods

- Extinction ($CAPS_{pmex}$) minus Scattering (Nephelometer)
- Extinction minus Scattering ($CAPS_{ssa}$)
- Photothermal Interferometry (PTI)
- Photoacoustic photometry (PAX)

WP1: SI traceability for in situ methods:

Inter-comparison measurement campaigns

- Inter-comparison of methods with different types of soot and compare also with filter-based methods ➤ link to WP2
- Major campaigns at TROPOS and METAS
- Laboratory inter-comparison prior to Athens field experiment
- Due to COVID19 no inter-comparison of all methods in one experiment could take place. Nevertheless, there is enough overlap between the experiments to ensure that all methods can be validated against each other.

Evaluation criteria in general and for specific applications

- Traceability
- Detection limit
- Portability
- Cross sensitivity to absorbing gases
- Capability for SI traceable calibration in the laboratory and in the field

WP1: SI traceability for in situ methods:

Results

Extinction minus scattering techniques

- Require minimum concentration for sufficient signal to noise ratio
- Detection limit of $CAPS_{ssa}$ lower than $CAPS_{pmex}$ & Nephelometer making it a better choice for ambient measurements
- Potential cross sensitivity to absorbing gases
- Truncation corrections necessary
- Traceability can be established by two calibrations (gas calibration, and cross calibration) for $CAPS_{pmex}$ & Nephelometer

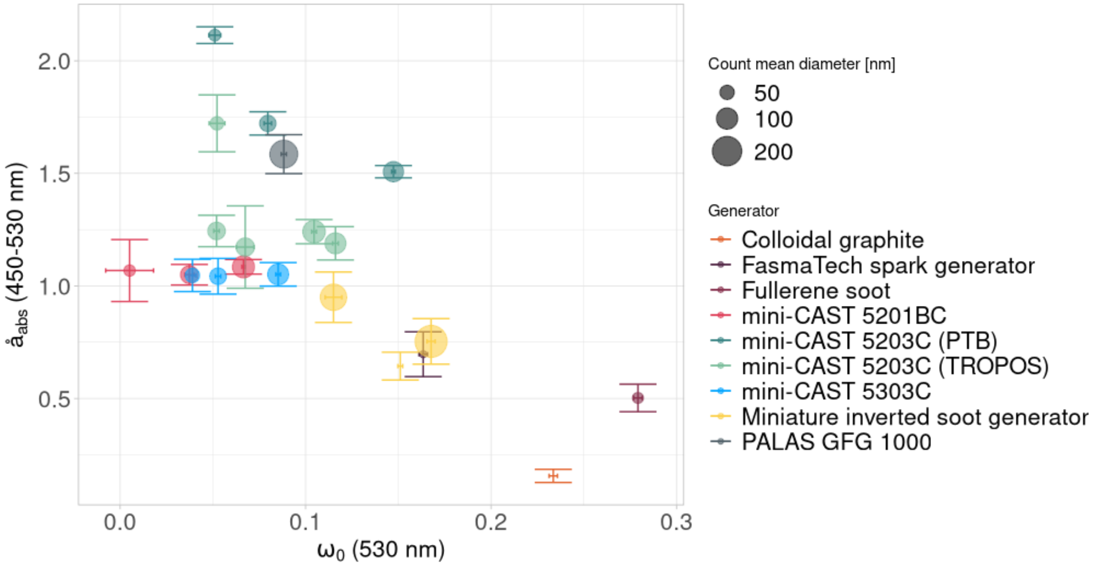
PAX

- Calibration (using aerosols) affected by ‘truncation’ of internal scattering measurement. Dedicated Experiments have been performed.

PTI

- Prototype shows low detection limit with less than 0.5 Mm^{-1}
- Two independently developed instruments showed good agreement
- No cross sensitivity to gas absorption
- Traceable calibration using gas absorption (NO_2)

Generator comparison (fresh soot)

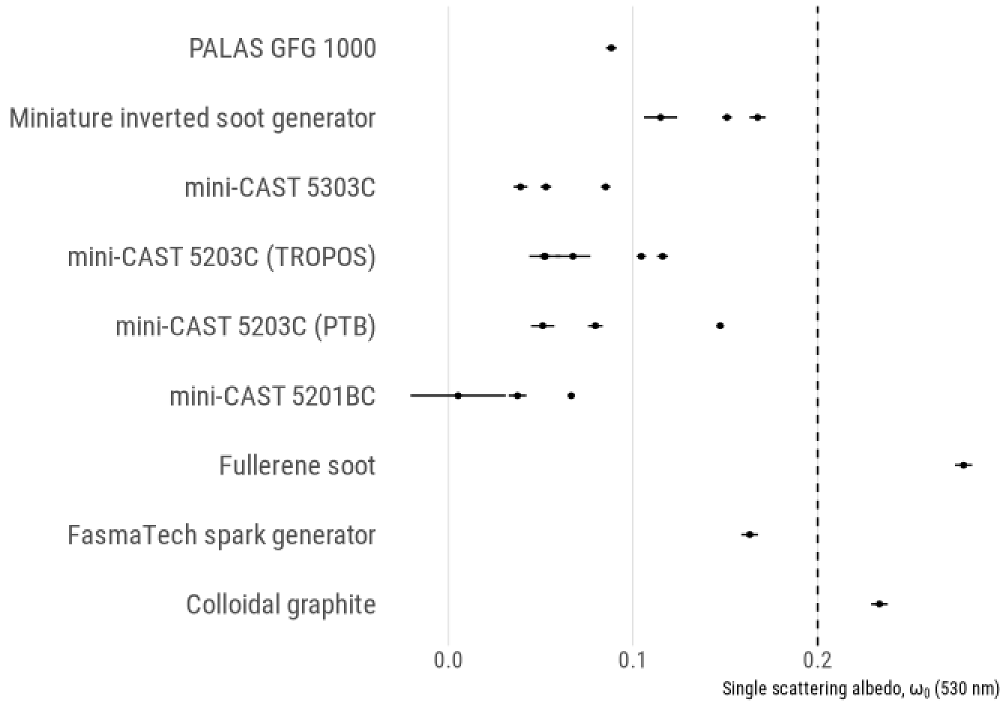


Results from the generator comparison workshop

mini-CAST fulfilled all the project targets for a fresh-like soot generator.

MISG produced aerosol with the desired optical properties but particle diameter was above 100 nm for the tested OPs.

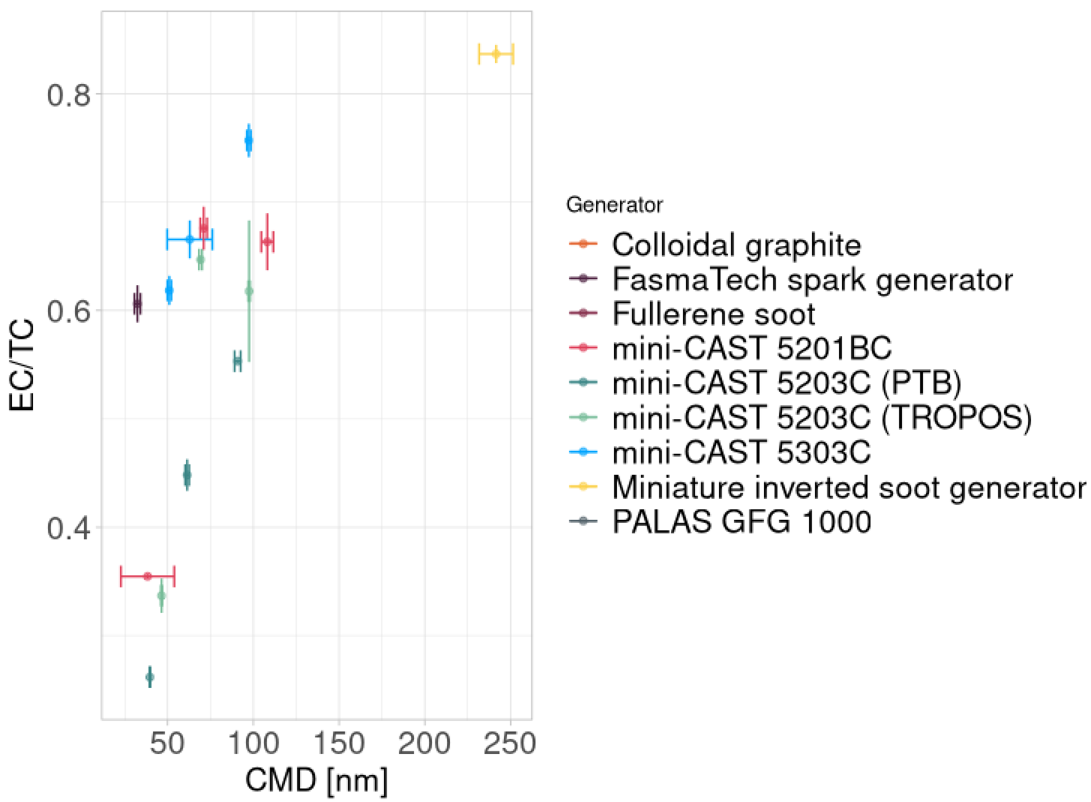
Generator comparison - SSA



Single scattering albedo at 530 nm

Most of the generators produced soot particles with SSA lower than 0.2.

Generator comparison – EC/TC



EC/TC ratio
EUSAAR2 protocol
Excluding results obtained with the NIOSH5040 protocol.

Higher organic content for particles with diameter < 50 nm.

Overview of WP3

Task 3.3: Field trials of calibration methods for instruments commonly used in Europe & recommended protocols

- ❑Test the practicality of proposed calibration methods in the field
- ❑Assessment of the stability and reproducibility of calibrated systems under ambient conditions

A3.3.1 Field campaign with calibrated instruments at a location with high abs levels (Athens) and at a clean background area (Palas) (NCSRD)
A3.3.2 Sensitivity analysis on the uncertainty budget for aerosol absorption levels in ambient air by intercomparison exersice (round robin), employing the same CAL against intruments (NPL)
A3.3.3 Protocols on recommended calibration and operating procedure for black carbon instruments (NPL)

→ ***D5: "Recommendations and protocols for a validated transfer standard for the traceable in-field calibration of black carbon monitors commonly used in Europe", Jun 2020 M36)***

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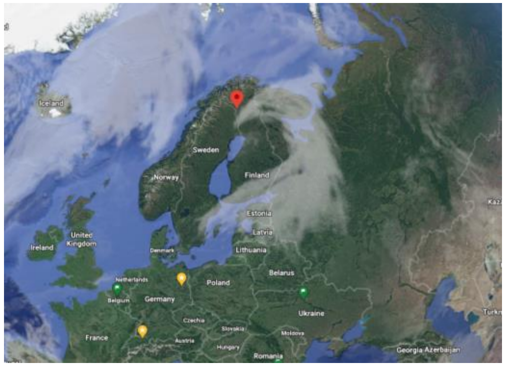
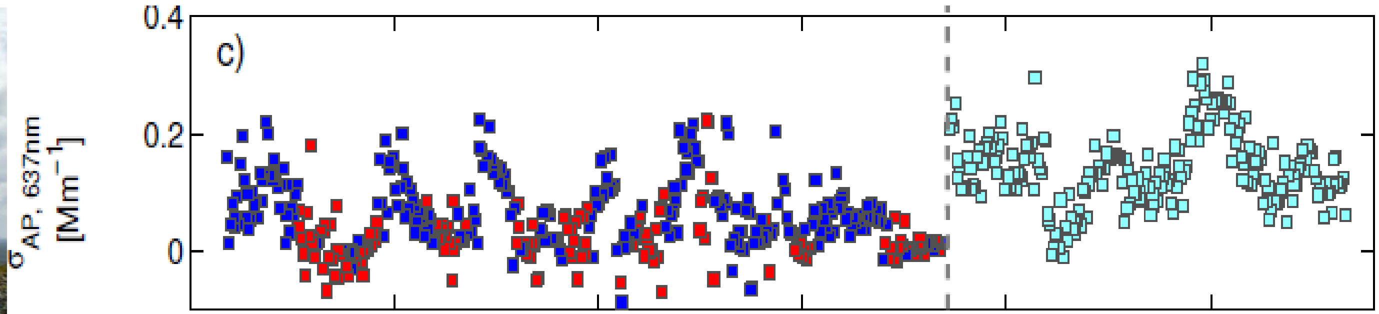
Pallas campaign (19.6 – 17.7.2019)

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE



Absorption coefficient $\sigma_{AP,\ 637nm}$ (MAAP)



Period 1: σ_{AP} = 0.055 ± 0.062 (Mm^{-1})
Period 2: σ_{AP} = 0.141 ± 0.065 (Mm^{-1})

Asmi E., et al. (2020) Characterizing the Arctic absorbing aerosol with multi-instrument Observations. AMTD, https://doi.org/10.5194/amt-2020-400 (in review)
Asmi E., et al (2020) Measuring the Arctic absorbing aerosols: Results from Pallas summer 2019 multi-instrument campaign. INAR National network seminar, Finland, 23-24 November.
Asmi E., et al., (2019) THE PALLAS SUMMER 2019 AEROSOL BLACK CARBON CAMPAIGN. Proceedings of The Center of Excellence in Atmospheric Science
(CoE ATM), Annual Seminar 2019

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Athens Lab Campaign

Campaign instrumentation and obtained data (green)

	MiniCast	Aquadaq	Spark Palas	Spark Fasmatech	Field campaign
AE33					PM10
AE31					
OCEC					PM2.5
PAX*					PM10
CAPS					PM10
PSAP					PM10
MAAP					PM10
SP2					PM10
Aurora 4000					PM10
Aurora 3000					PM10
TEOM					PM10

***Uncalibrated**

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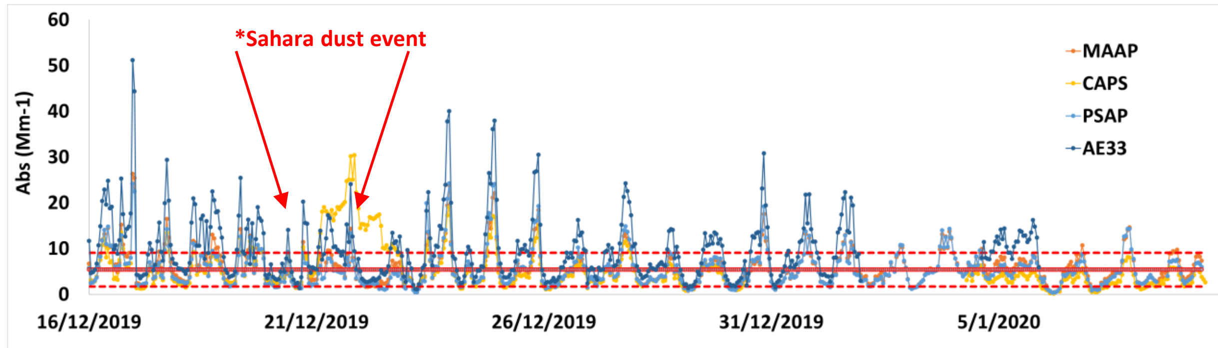
Athens Demokritos field campaign



b_{abs} (Mm-1)	MAAP	PSAP	CAPS	CAPS*	AE33	PAX
Average	5.4	5.2	4.3	5.0	9.4	1.5
Stdev	3.7	3.8	2.9	4.3	6.7	1.0
Min	0.3	0.3	0.1	0.1	0.6	0.1
Max	26.3	24.2	19.1	30.4	51.2	6.6

*Inc. Sahara dust event