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Current challenges in atmospheric black carbon determination: A traceable calibration for aerosol light absorption measurement

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BACKGROUND

The measurement of particles in air characterized as black carbon (BC) is important both for its role in climate change and as a measure of combustion products associated with health effects. Measurements are made very widely, and compact, precise, real-time, relatively inexpensive instruments are available. Although it is conceptually a simple measure of the light absorbing properties of airborne particles, the metric does not currently have SI traceability, with consequences for the comparability and interpretation of data.

METROLOGY PROJECTS
EMPIR Black Carbon | 2017–2020
https://empirblackcarbon.com

Metrology Partnership StanBC | Starting 2023

EURAMET

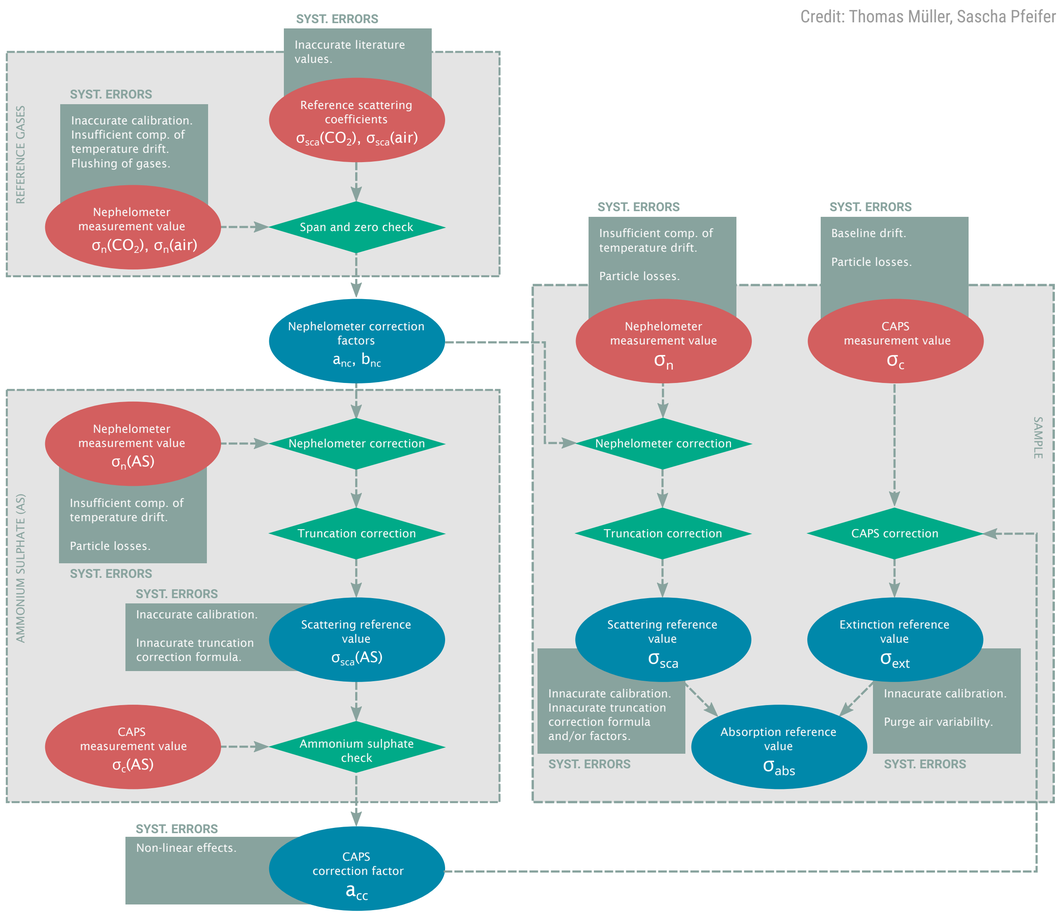
EMPIR BLACK CARBON

LIGHT ABSORPTION MEASUREMENT TECHNIQUES

	TRACEABLE TO SI	INSTRUMENTS AVAILABLE
EMS EXTINCTION MINUS SCATTERING	✓	**CAPS PMssa** (Aerodyne Research)
PTI PHOTOTHERMAL INTERFEROMETRY	✓	**PTAAM** (Haze Instruments)
PAS PHOTOACOUSTIC SPECTROMETRY	✓	**PAX** (Droplet Measurement Technologies) **PAAS** (SchnaitTEC)
FBM FILTER-BASED METHODS	✗	**Aethalometer** (Magee Scientific) **PSAP** (Radiance Research)

ERROR PROPAGATION FOR EMS

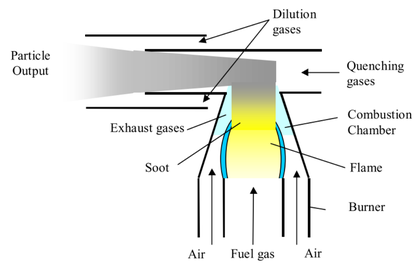
Credit: Thomas Müller, Sascha Pfeifer



AEROSOL GENERATION

🔥 **DIFFUSION FLAME GENERATOR (miniCAST)**

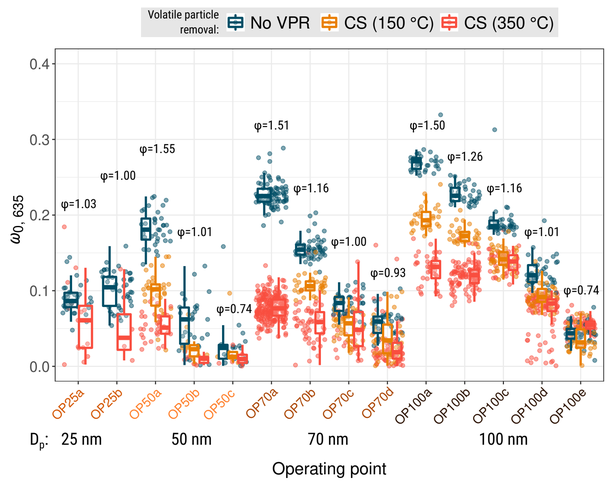
FRESH-LIKE BLACK CARBON TARGET AEROSOL PROPERTIES



PARTICLE DIAMETER
D_p **25 - 100 nm**

ABSORPTION ANGSTRÖM EXPONENT
AAC **~1.0**

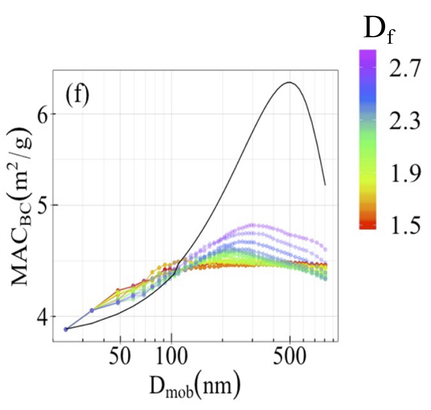
SINGLE SCATTERING ALBEDO
SSA **<0.1**



φ ↗ → ω ↗
Fuel-rich combustion produces particles with higher SSA

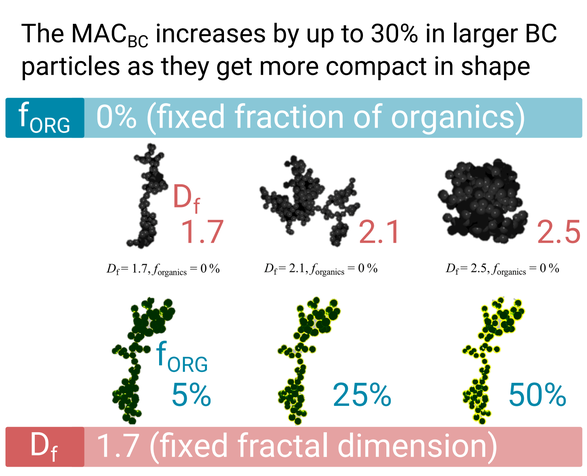
VPR
No VPR required for fuel-lean combustion

MODELING BLACK CARBON FRACTAL AGGREGATES



Romshoo et al., 2021.
https://doi.org/10.5194/acp-21-12989-2021

The MAC_{BC} increases by up to 30% in larger BC particles as they get more compact in shape



CONCLUSIONS AND OUTLOOK

- Extinction minus scattering offers the possibility of measuring light extinction in a traceable way. The determination of the uncertainties of light scattering coefficients is possible within certain limits.
- miniCAST diffusion or pre-mixed flame generators are suitable for producing fresh-like soot particles with a low organic carbon fraction. The fuel to oxygen ration of the generator can be tuned to fulfil the required aerosol properties.
- Using aerosol electrical mobility and other physico-chemical properties (fractal dimension, primary particle size and fraction of organics), it is possible to model the optical properties.
- Other techniques, like PTI and PAS, offer a good opportunity to achieve a traceable calibration chain for aerosol light absorption and for instrumental inter-comparison.

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