Multi-angle absorption photometry - a new method for the measurement of aerosol light absorption and atmospheric black carbon

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Basic Method Characteristics

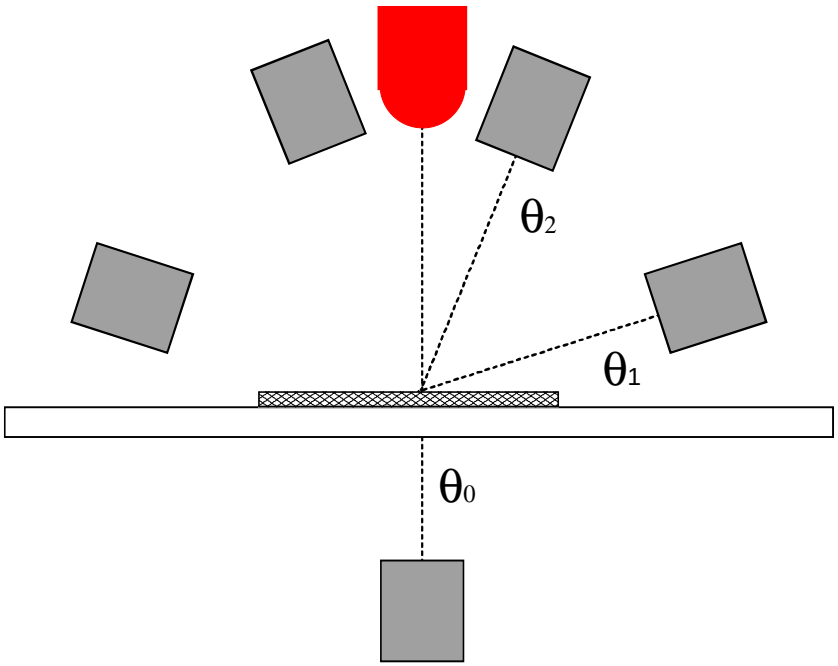
Determination of the aerosol light absorption coefficient from a simultaneous measurement of radiation passing through and scattered back from a particle-loaded fibre filter.

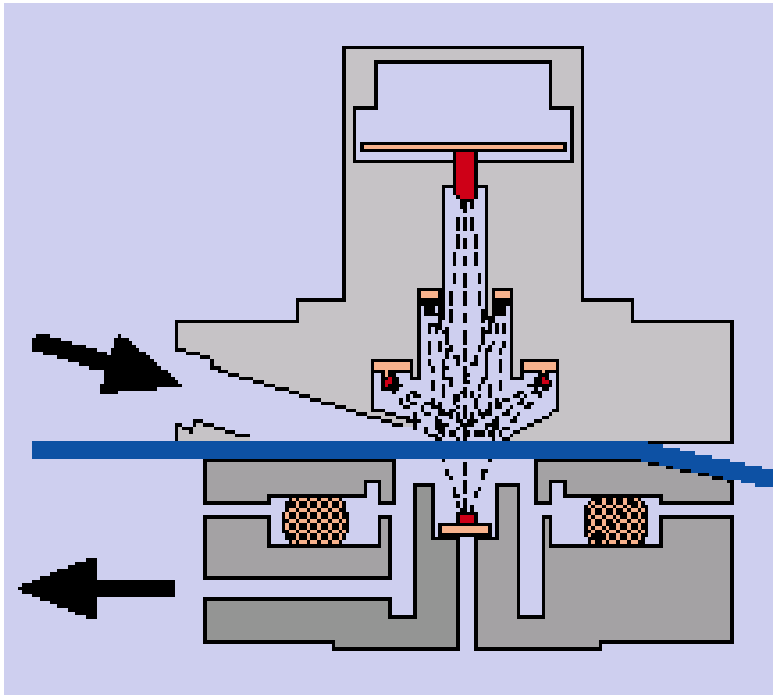
Angular-resolved detection of the back scattered radiation contributes additional information on the light-scattering fraction of the deposited aerosol.

Analysis of the absorbance of the particle-loaded filter via a two-stream approximation radiative transfer scheme.

Reduction of the cross-sensitivity of filter-based absorption measurement methods to light-scattering aerosol components and filter loading effects.

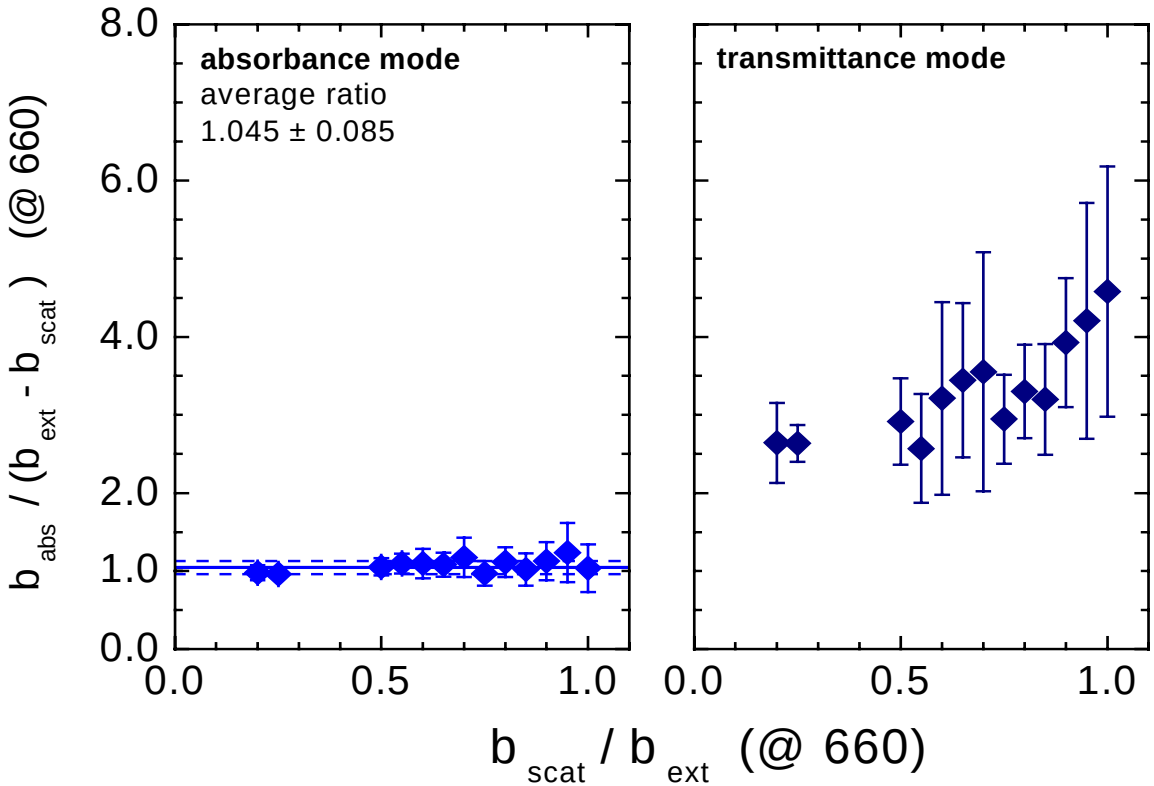
Optical Sensor Unit





Set-up of the multi-angle absorption photometer sensor:
$\theta_0 = 0°$, $\theta_1 = 130°$, $\theta_2 = 165°$

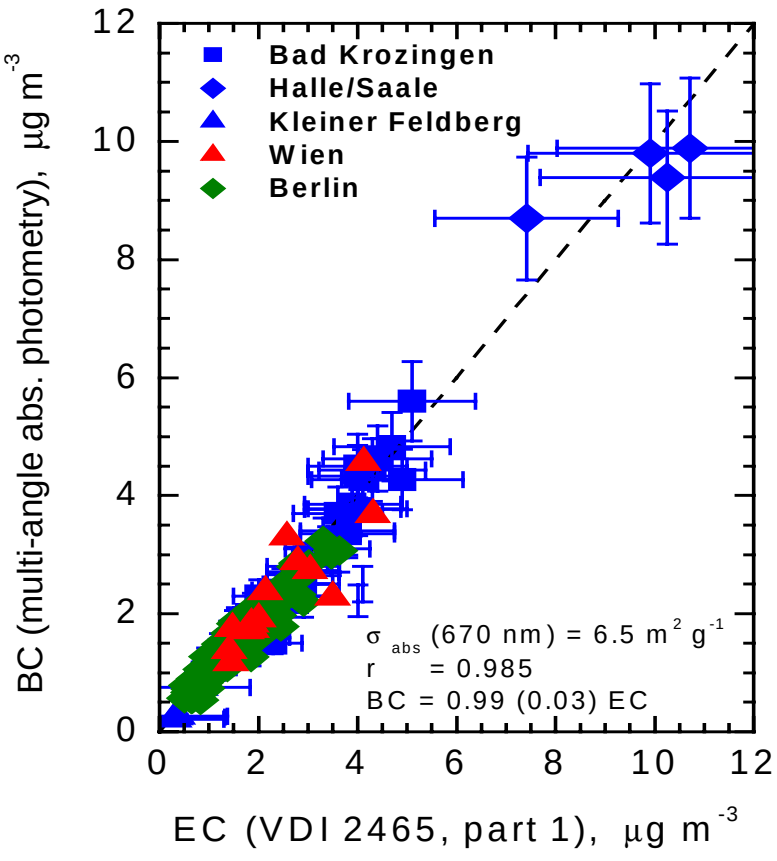
Multi-angle absorption photometer sensor unit for continuous aerosol sampling.

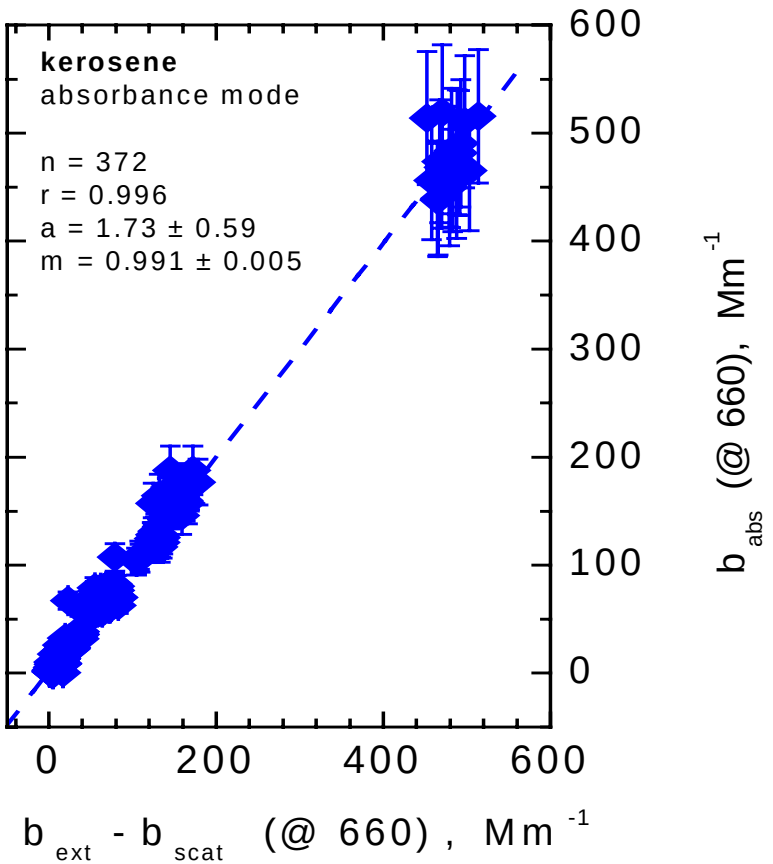


Method response in terms of measured absorption coefficient b_{abs} vs. in-situ reference value $b_{ext} - b_{scat}$ at λ = 660 nm to a kerosene soot / ammonium sulphate mixture of b_{scat} / b_{ext} = 1 (white aerosol) to 0.2 (black aerosol)

- absorbance mode = multi-angle absorption photometry,
- transmittance mode = conventional filter transmission measurement;

no dependence of measured b_{abs} on b_{scat} / b_{ext} for the absorbance mode.

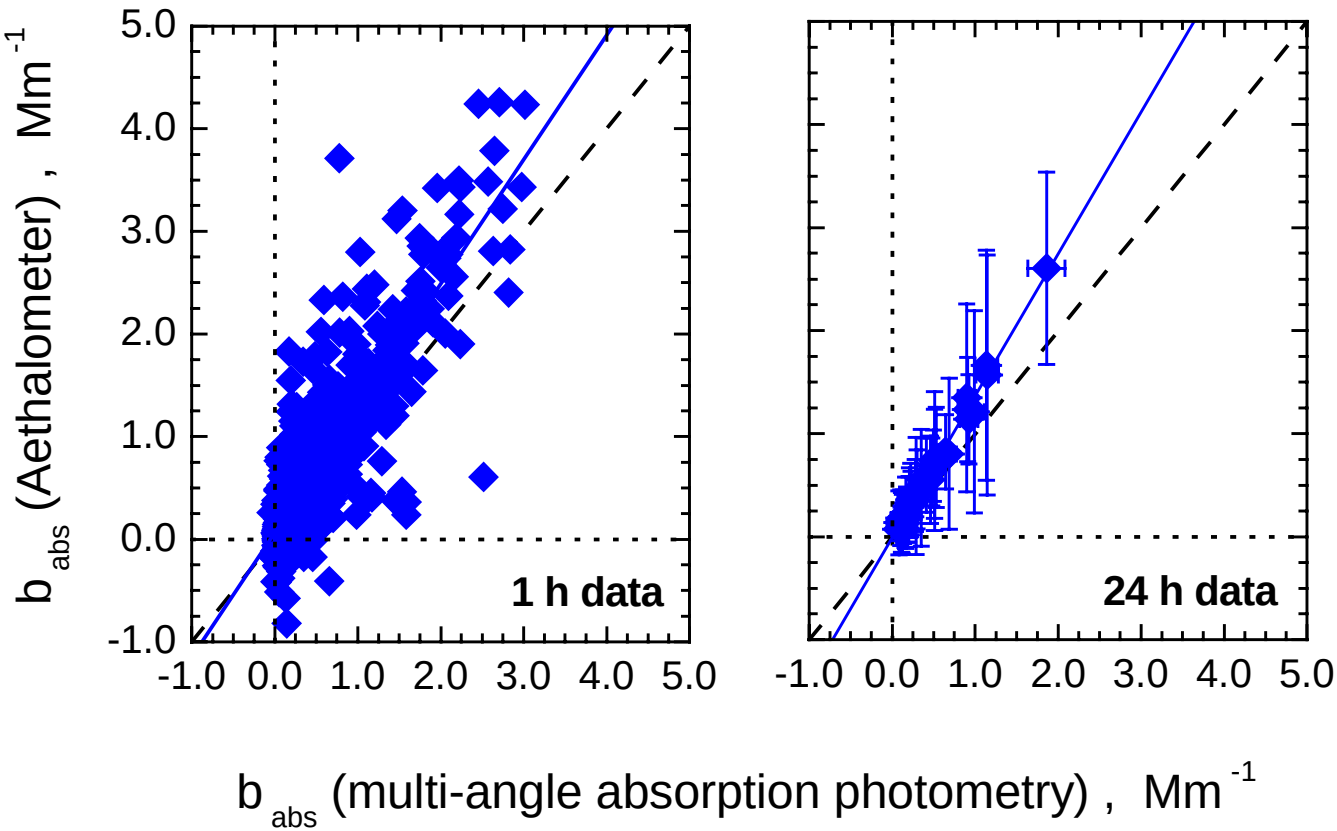




Method calibration studies:

left: BC mass in urban aerosol, reference method is VDI 2465, part 1;

right: absorption coefficient b_{abs} of a kerosene soot- ammonium sulphate mixture, reference method is $b_{ext} - b_{scat}$ at $\lambda = 660$ nm.



b_{abs} (λ = 0.67 µm) measured at the high-alpine site Jungfraujoch using multi-angle absorption photometry and an Aethalometer (transmission method) which is corrected for filter multiple-scattering effects; improved b_{abs} measurement by multi-angle absorption photometry, Aethalometer overestimates b_{abs} ($m = 1.38 \pm 0.02$) compared to multi-angle absorption photometry .

Summary

Multi-angle absorption photometry is a filter-based aerosol absorption measurement method which compensates effects of filter loading and aerosol light scattering on the absorption coefficient measurement. Method features are:

- strong correlation to in situ methods (extinction - scattering, photoacoustic spectroscopy);
- reduced cross-sensitivity to light-scattering components;
- no influence of filter loading on the measurement;
- aerosol absorption coefficient equals reference value as determined by in situ methods;
- simple in operation, suitable for long-term monitoring;
- robust determination of black carbon mass concentration;
- detection limit is 7×10^{-8} m^{-1} (approx. 10 ng BC m^{-3}) for 1 m^3 of sampling volume.

See http://www.esm-online.de/andersen/product/CARUSSO-Brochure.pdf for more information.