Determinazione termo-ottica a più lunghezze d'onda di Elemental, Organic e Brown Carbon

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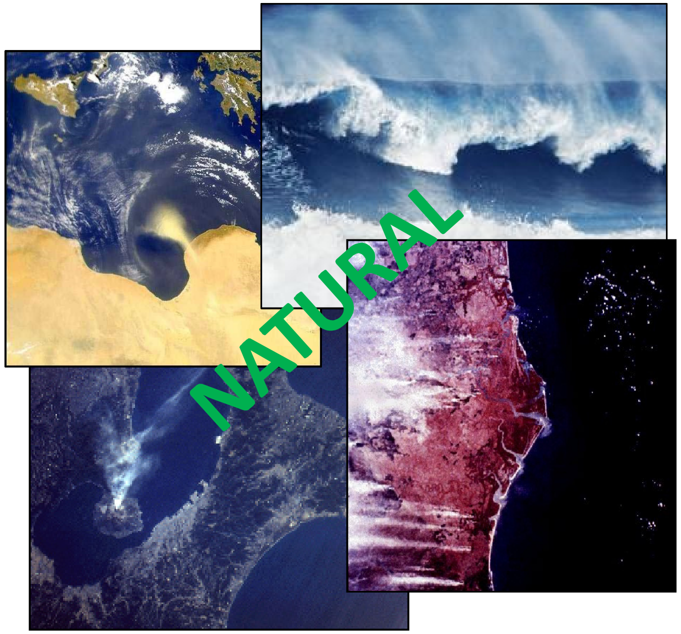
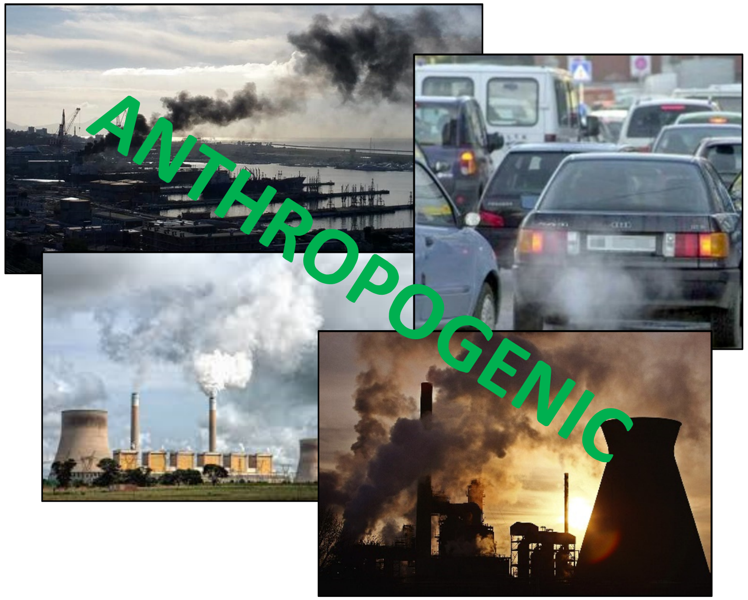
Particulate Matter - PM

System constituted by solid and/or liquid agglomerates of matter ("particles"), dispersed into the atmosphere that differ for:

- **Morphology** and **size** (diameter ranging from a few nm to tens of μm)
- **Sources** and **chemical composition**



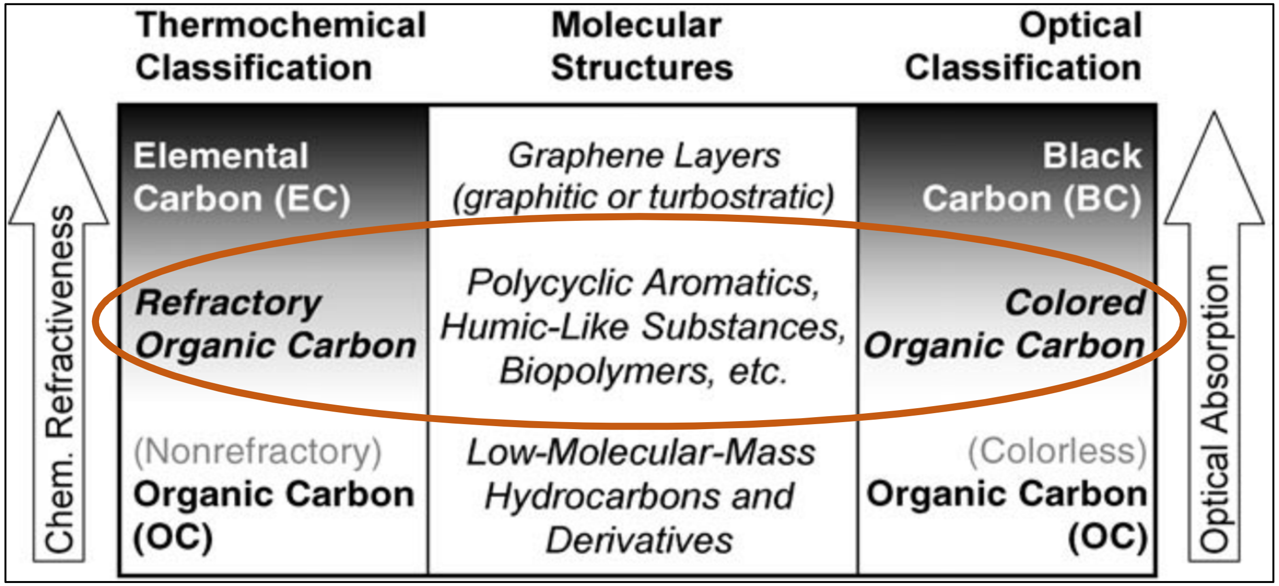


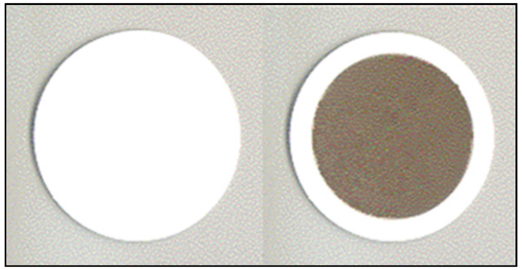
- ✓ **Carbonaceous compounds**
- ✓ Ions
- ✓ Metals
- ✓ Other trace elements

Carbonaceous aerosol

Typically the largest component of PM

Sources:
- Fossil and biomass burning
- Incomplete combustion





Quartz-fibre filters

TC (*Total Carbon*) →
- **BC** (*Black Carbon*) + **OC** (*Organic Carbon*)
- **BrC** (*Brown Carbon*)
- **EC** (*Elemental Carbon*) + **OC** (*Organic Carbon*)

MWAA: Multi-Wavelength Absorbance Analyzer

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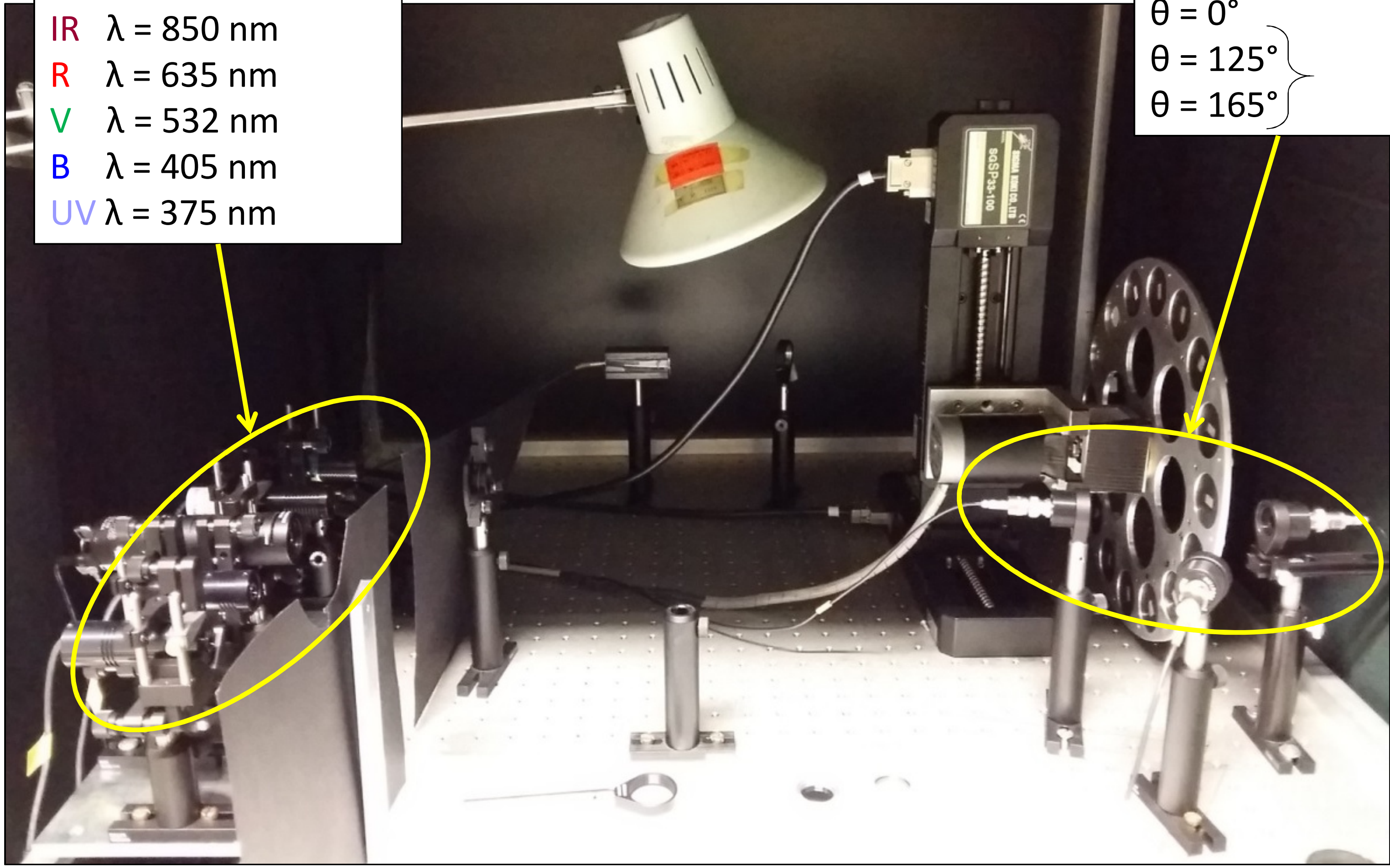
5 LASER diodes:

IR λ = 850 nm
R λ = 635 nm
V λ = 532 nm
B λ = 405 nm
UV λ = 375 nm

Photodiodes:

θ = 0°
θ = 125°
θ = 165°



at every measured λ

$$b_{abs} = ABS\,\frac{A}{V}$$

D. Massabò et al., Atmospheric Environment, 2015

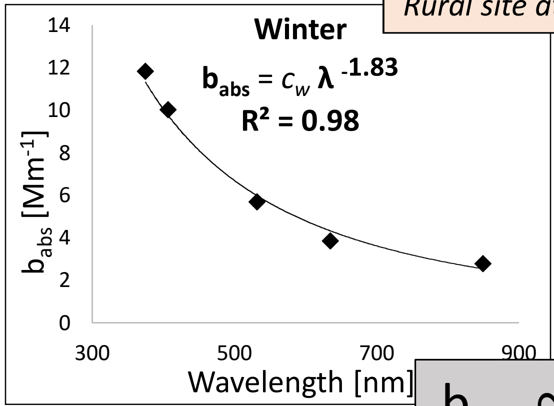
BC and BrC contributes

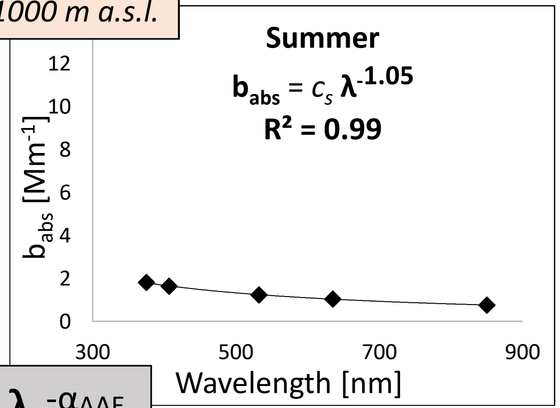
Ångström Absorption Exponent

α_{AAE}: Chemically selective parameter useful to
- ✓ identify the aerosol origin
- ✓ apportion different sources

$\alpha_{AAE} \approx 1$ → PM dominated by FF (BC)
$\alpha_{AAE} > 1$ → presence of WB (BrC)

Rural site at 1000 m a.s.l.





$b_{abs} \propto \lambda^{-\alpha_{AAE}}$

MWAA model

Two different decompositions of $\mathbf{b_{abs}}$, based on:

SOURCES

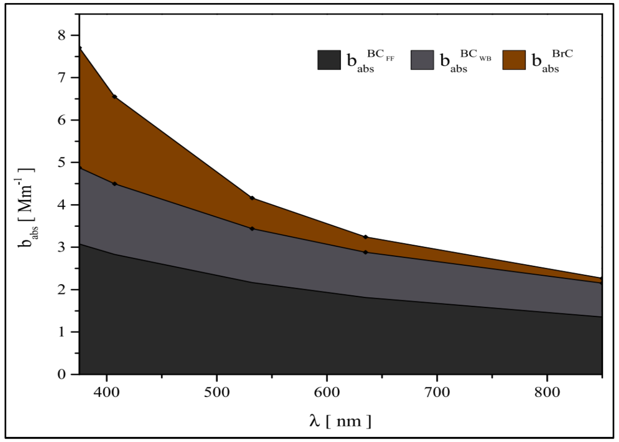
$$b_{abs}(\lambda) = b_{abs}^{FF}(\lambda) + b_{abs}^{WB}(\lambda)$$
$$b_{abs}(\lambda) = a\lambda^{-\alpha_{FF}} + b\lambda^{-\alpha_{WB}}$$

BC and BrC spectral dependences

$$b_{abs}(\lambda) = b_{abs}^{BC}(\lambda) + b_{abs}^{BrC}(\lambda)$$
$$b_{abs}(\lambda) = c\lambda^{-\alpha_{BC}} + d\lambda^{-\alpha_{BrC}}$$

at every measured λ

BC_{FF}, BC_{WB} and **BrC** contribute to b_{abs} (vs **λ**)



D. Massabò et al., 2015

Thermal-optical transmittance analysis

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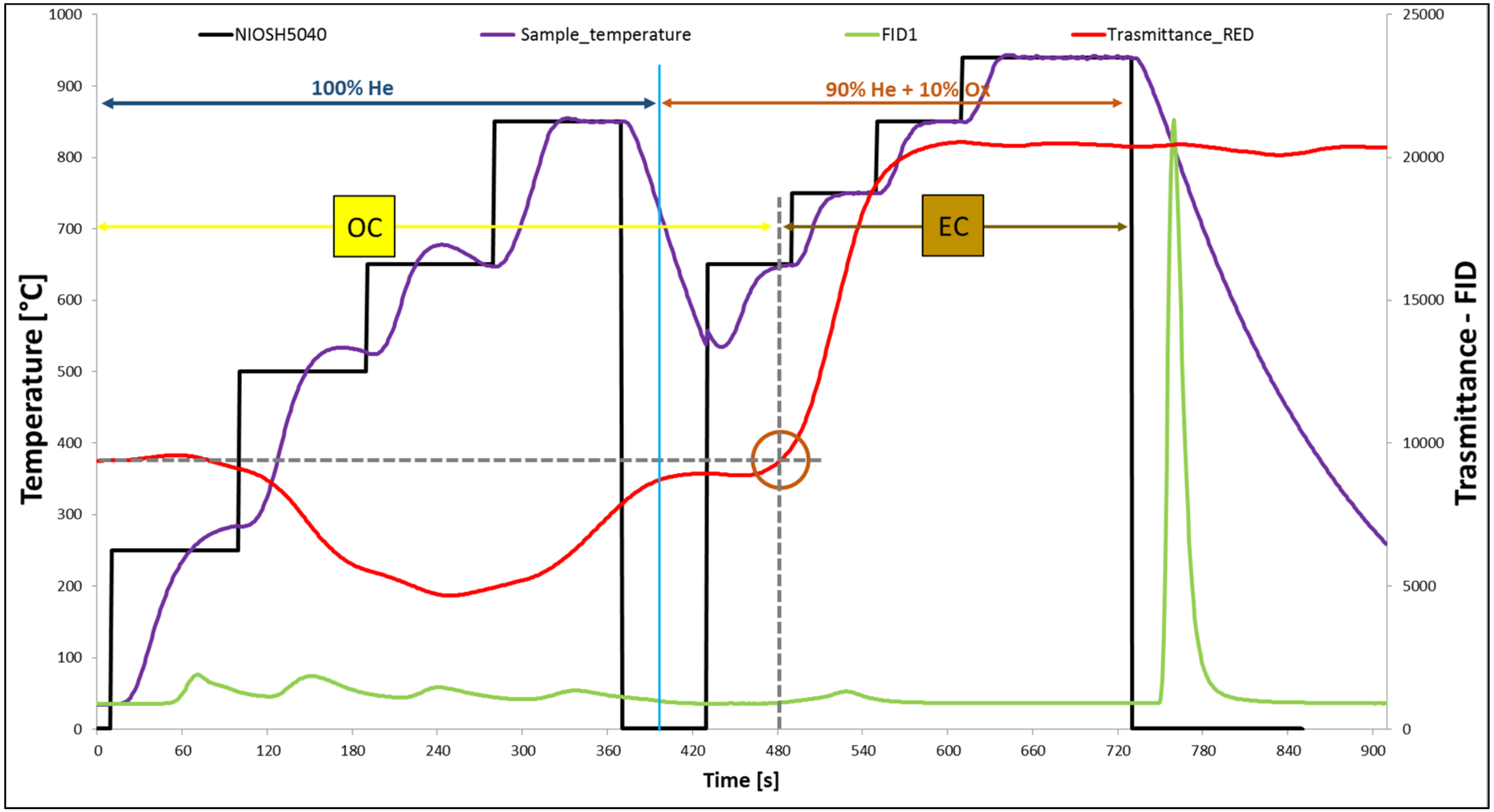


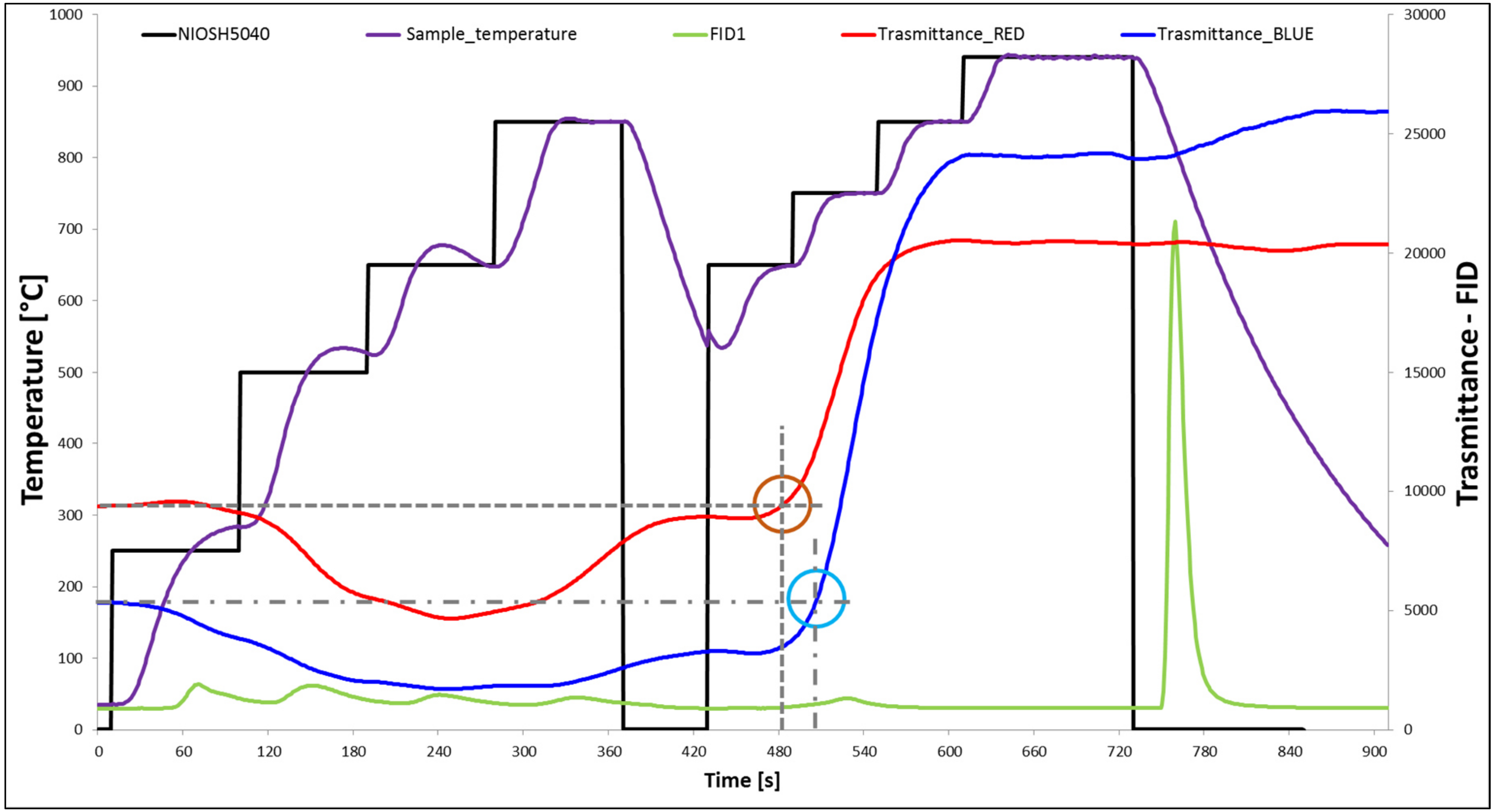
SUNSET OC/EC analyzer

µg/m³

- ✓ OC
- ✓ EC
- ✓ BrC

D. Massabò et al., Atmospheric Environment, 2016

2-λ Sunset: 658 nm and 405 nm



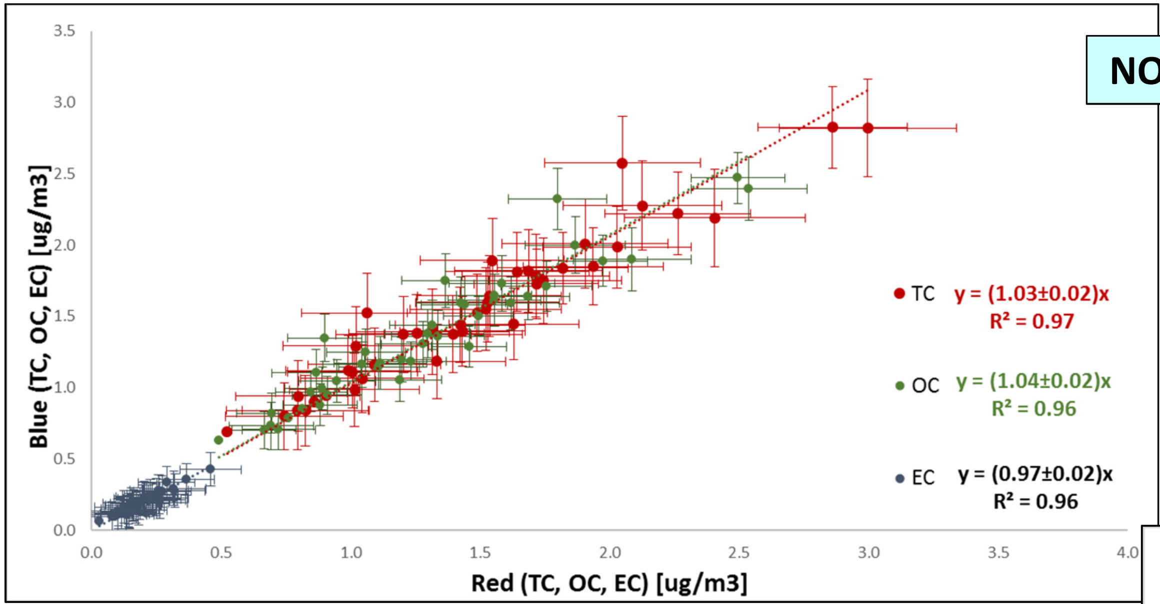
D. Massabò et al., AMT 2019

- Sampling on a 48 hours basis
- Quartz - fibre filters analyzed by
  - ✓ MWAA
  - ✓ 2-λ SUNSET

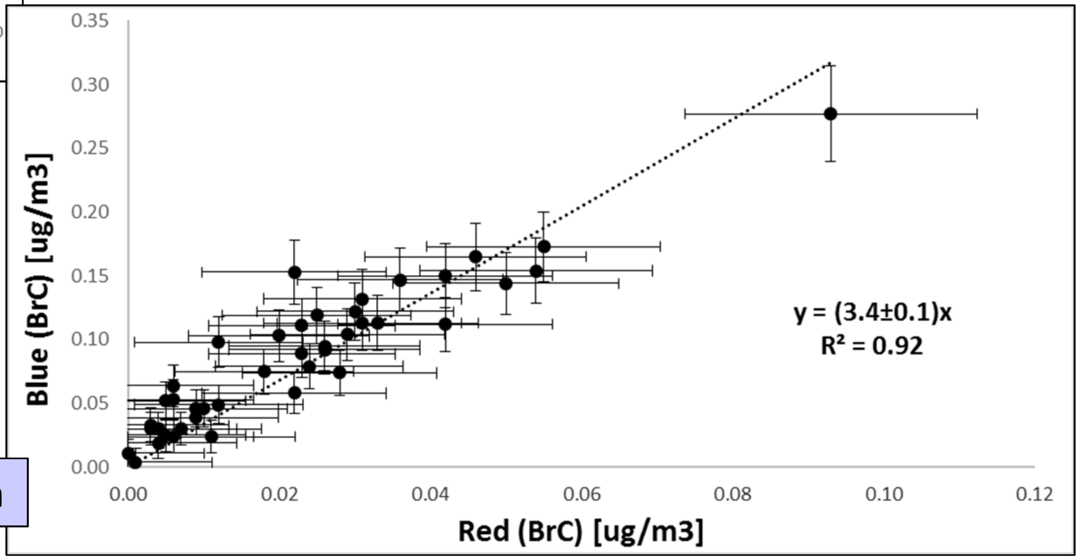
Winter samples from a rural site → *large amount of BrC expected*

Test the procedure and the BrC definition/quantification at two different λ

2-λ Sunset: Blue vs Red

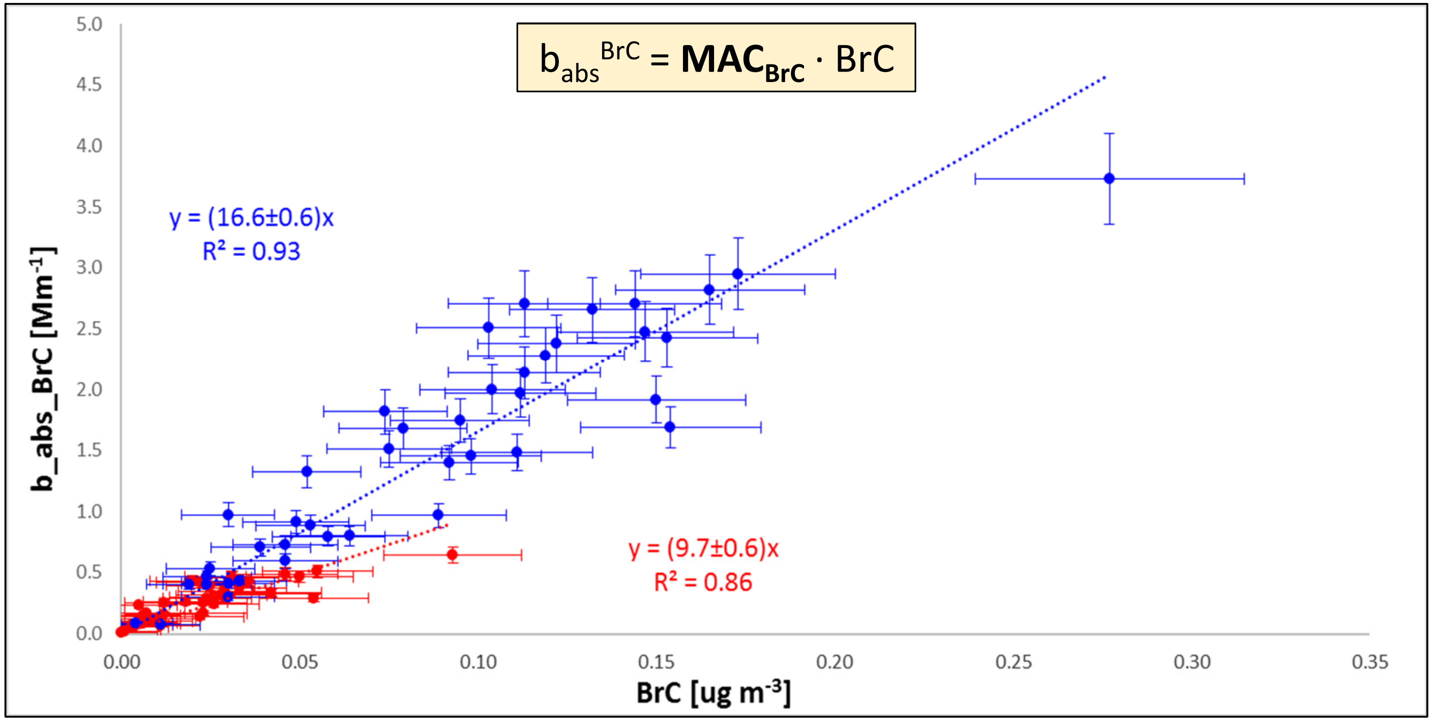


NOT λ - dependent concentration



λ - dependent concentration

Mass Absorption Coefficient - MAC



<u>MAC BrC</u>

(λ = 635 nm) = (9.7 ± 0.6) m^2 g^{-1}

(λ = 405 nm) = (16.6 ± 0.6) m^2 g^{-1}

<u>Good agreement with previous work</u>

	AMT 2019	AE 2016
MAC	9.8 ± 0.4	7.0 ± 0.6
MAC	23 ± 1	---

Conclusions

- ✓A Sunset EC/OC analyzer has been modified to perform **2-λ TOT OC/EC analyses** (*Massabò et al., AMT, 2019*)
- ✓The **coupling of MWAA and 2-λ TOT** allows for better insights on BrC behavior/nature (i.e. concentration and MAC) following (*Massabò et al., Atmos. Environ., 2016*)
- ✓Reproducible values of **MAC(BrC)** @ λ = 635 & 405 nm
- ✓BrC concentration appears to vary with the λ of the TOT analysis: artifact or real effect?

Thank you for your kind attention!

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From MWAA to ABS

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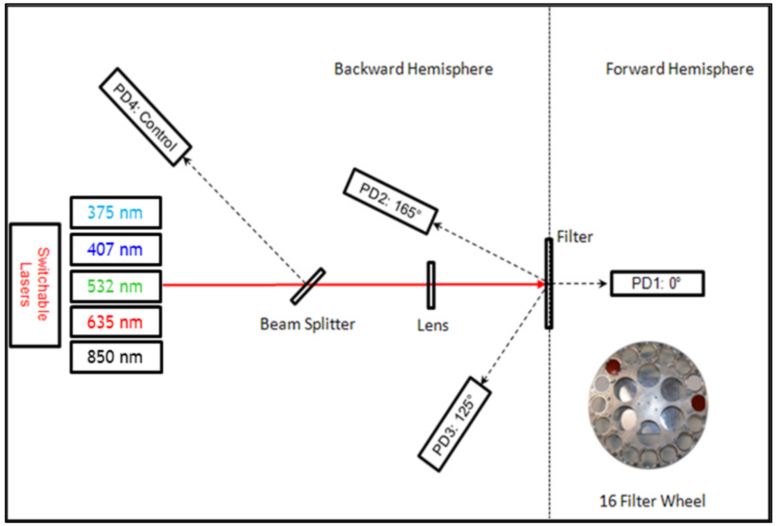
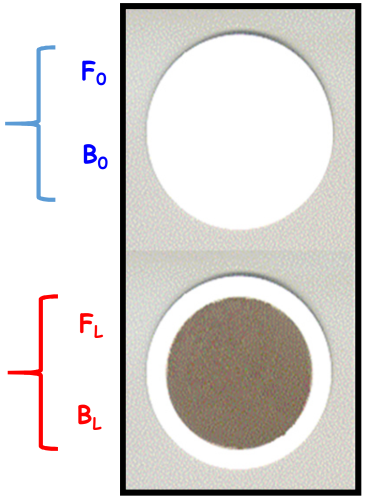
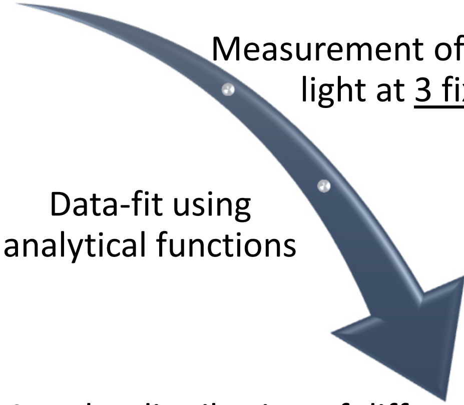
The knowledge of the intensity distribution of the light diffused by filter before sampling (blank filter) and after aerosol collection (loaded filter) is at the basis of the approach.





Measurement of the transmitted light at 3 fixed angles



Data-fit using analytical functions

Angular distribution of diffused light in the two hemispheres

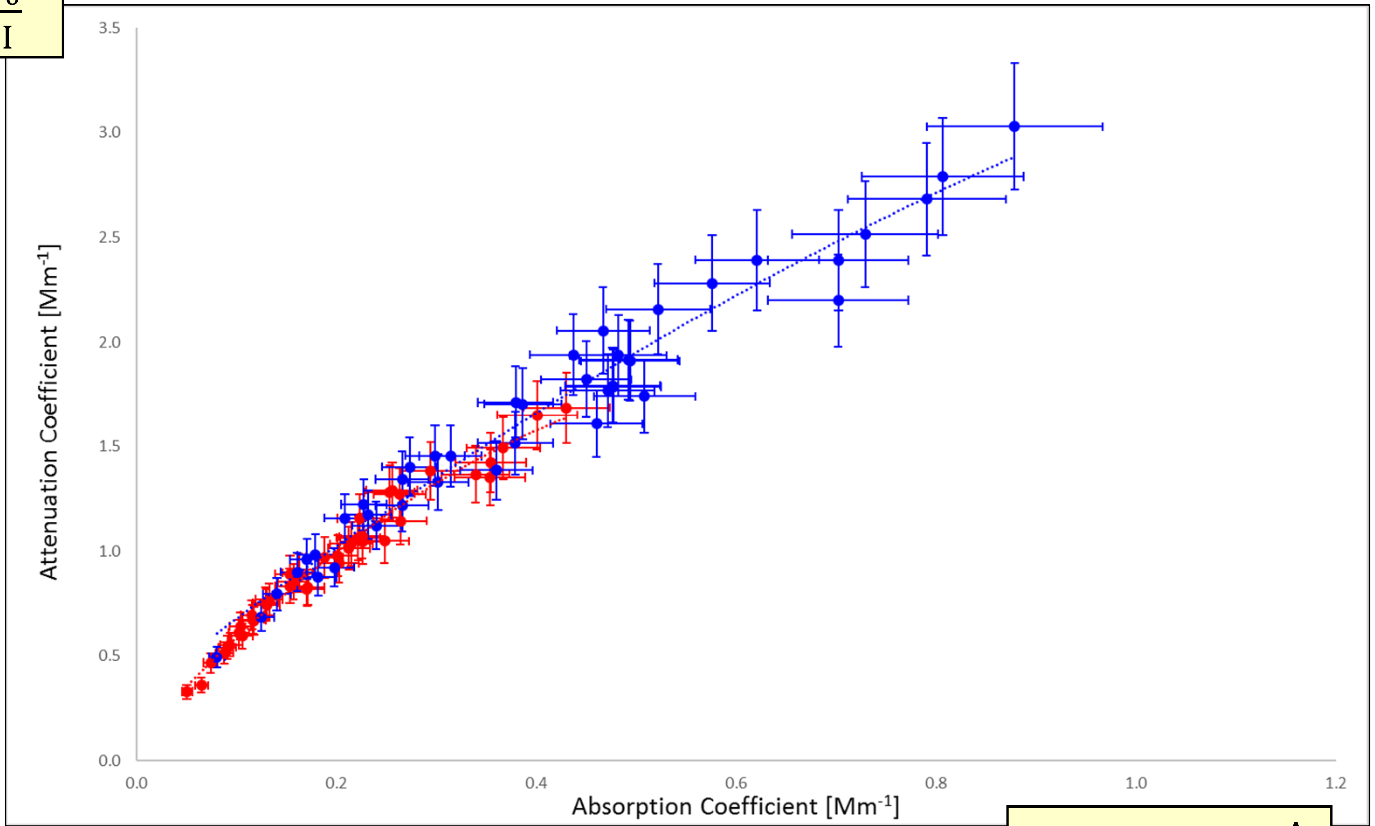
→ Once F_0, B_0, F_L and B_L are determined, an iterative method can be initialized to derive the absorption coefficient

$$ABS = \tau \cdot (1 - \omega)$$

$$b_{abs} = \frac{A}{V}$$

MWAA data

$$\text{ATN} = \ln \frac{I_0}{\text{I}}$$

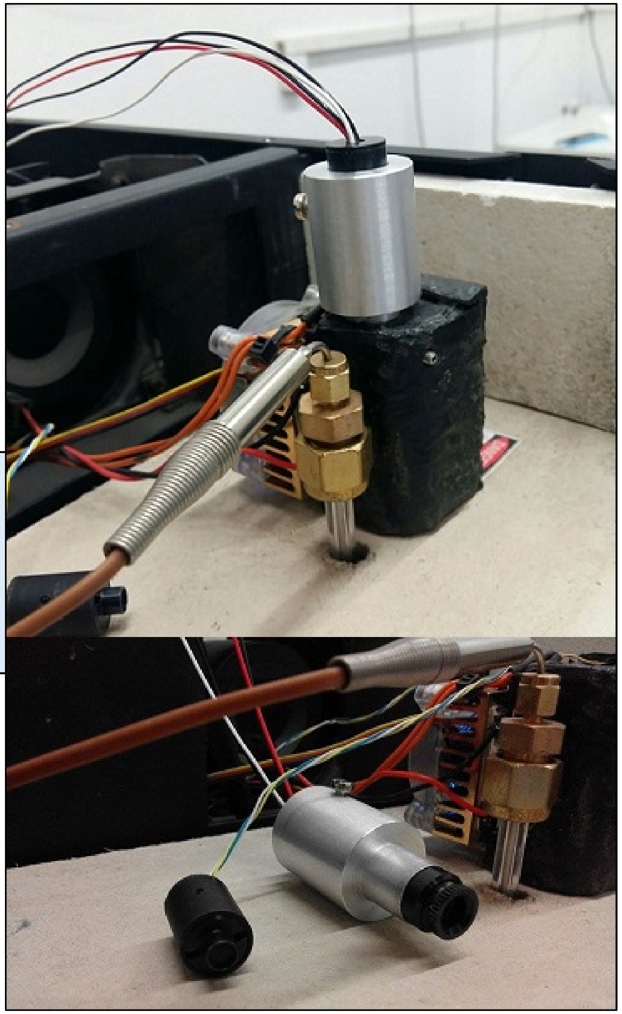


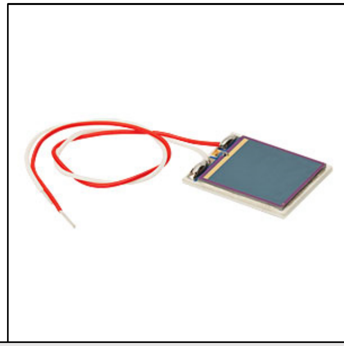
$$\text{b}_{\text{abs}} = \text{ABS}\,\frac{\text{A}}{\text{V}}$$

New set-up (TOT, λ = 405 nm)

Sunset EC/OC analyzer

1) LASER source λ = 405 nm
with housing in Al
Power: 50 mW
Rise time < 15 ms



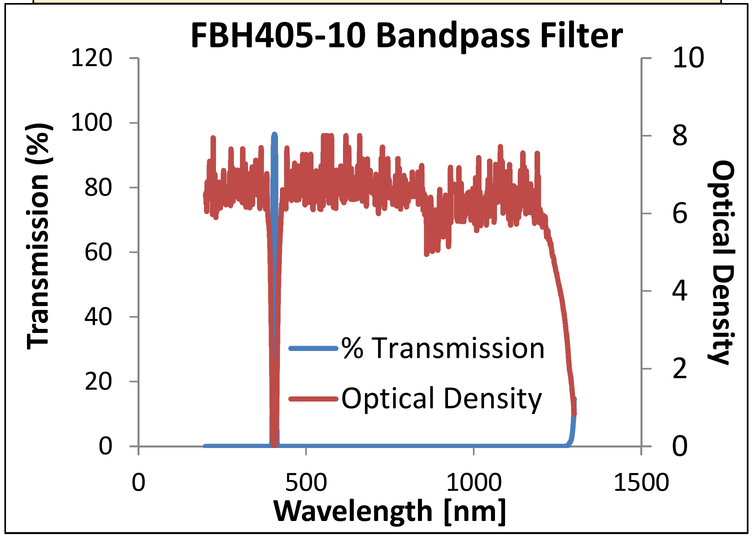


2) Si Photodiode ≈ 0.1 A/W
@405 nm
Response time: 15 ns

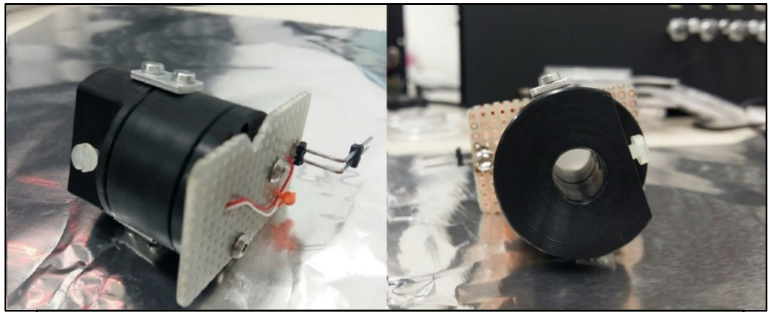
D. Massabò et al., AMT 2019

New set-up (TOT, λ = 405 nm)

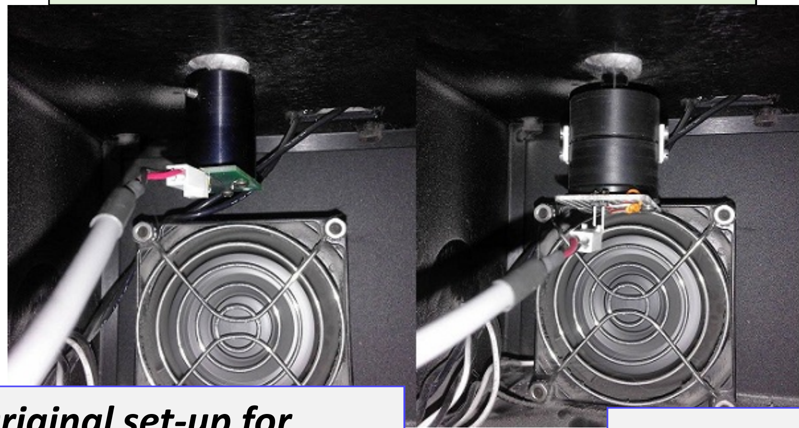
3) Band pass filter around λ = 405 nm



D. Massabò et al., AMT 2019



4) New chassis for photodiode and band pass filter housing



Original set-up for transmittance measurement

New set-up