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Optical Measurement and Aerosol Filter Loading for Climate Studies

(Aethalometer)

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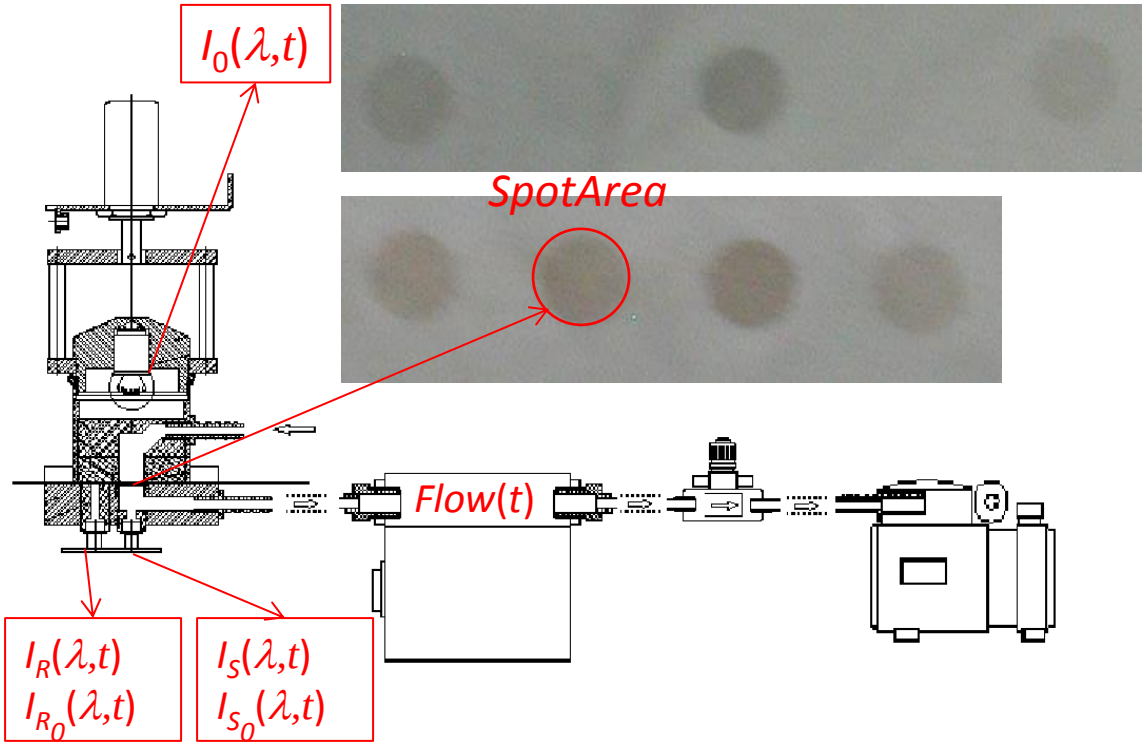
Aethalometer



$$ATN(\lambda,t) = -100 \times \ln\left(\frac{I_S(\lambda,t) - I_{S_0}(\lambda,t)}{I_R(\lambda,t) - I_{R_0}(\lambda,t)}\right)$$

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courtesy of
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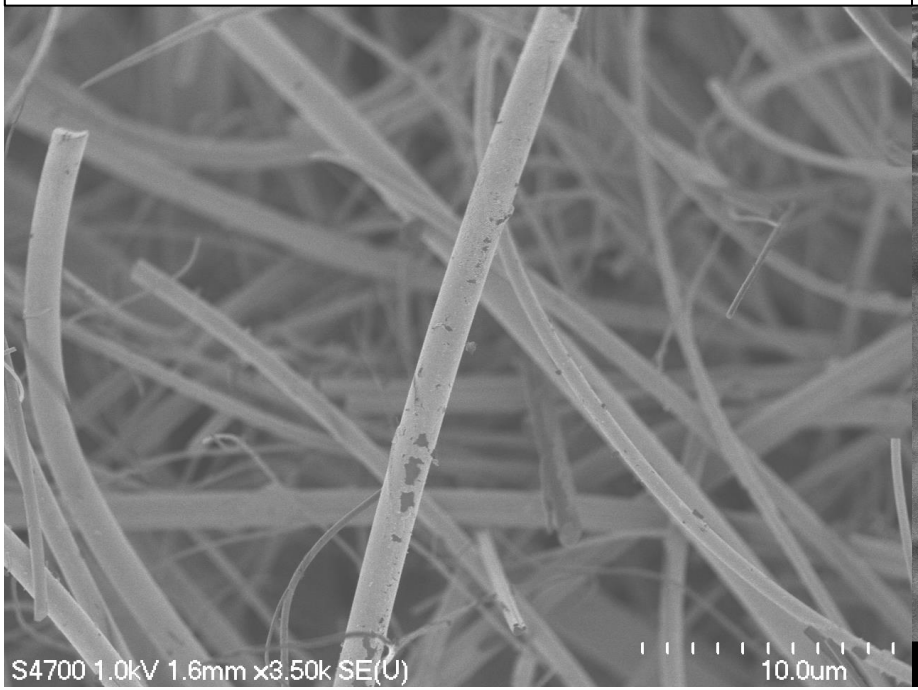
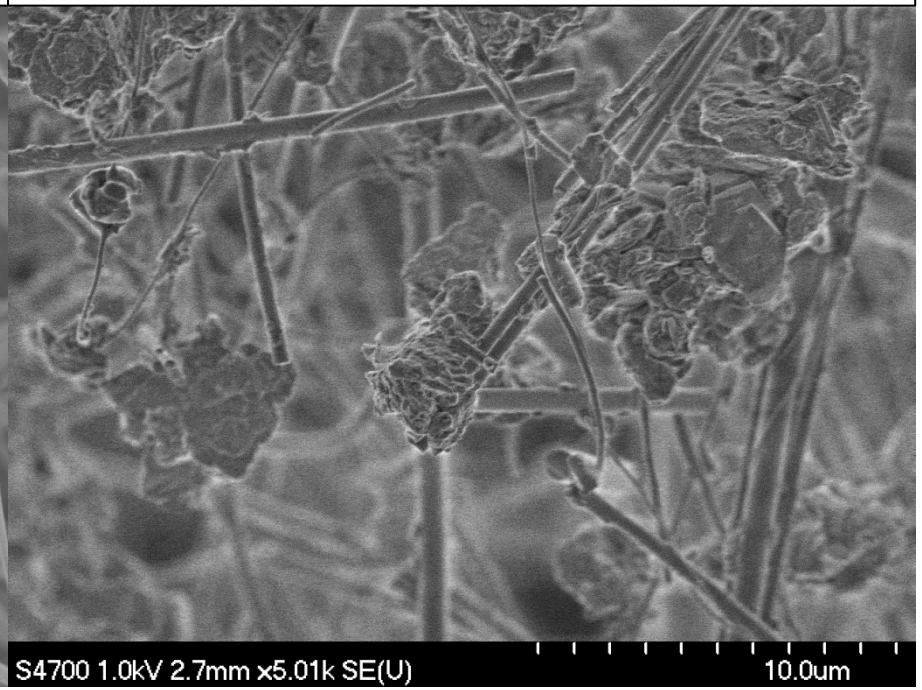
Aethalometer Quartz filter at Pico Mountain Station

(Pictures taken with a 10.0 μm resolution)

Soot (Black Carbon)	Dust & Soot (Iron Oxides and Black Carbon)
	

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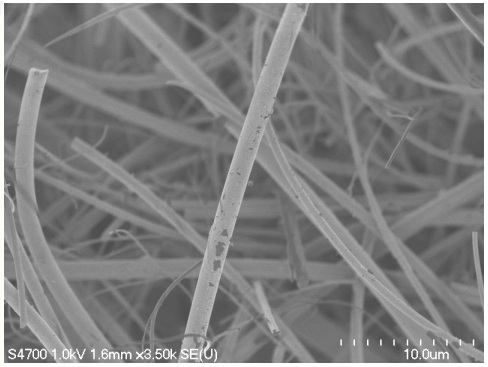
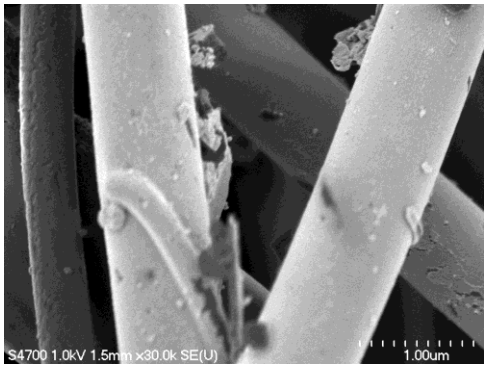
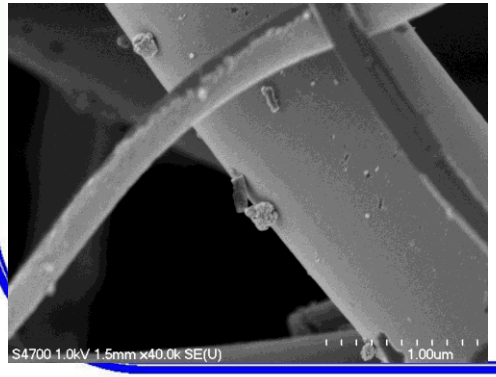
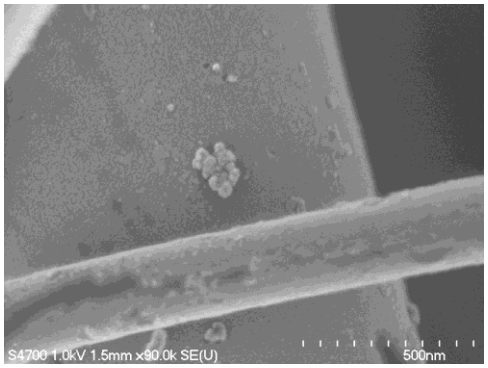
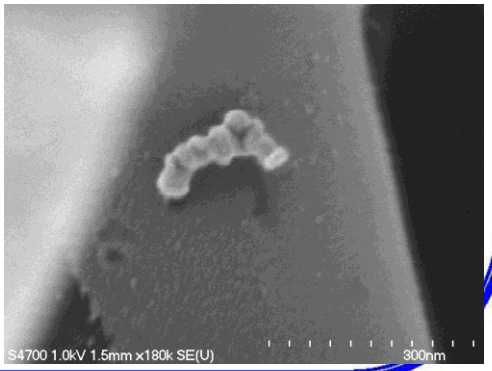
Soot (Black Carbon; AE quartz filter at Pico Station)











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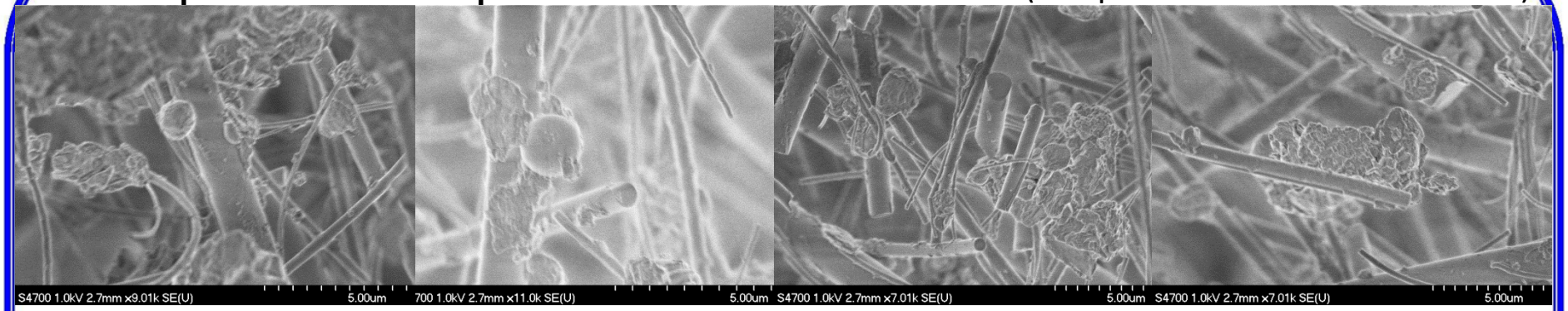
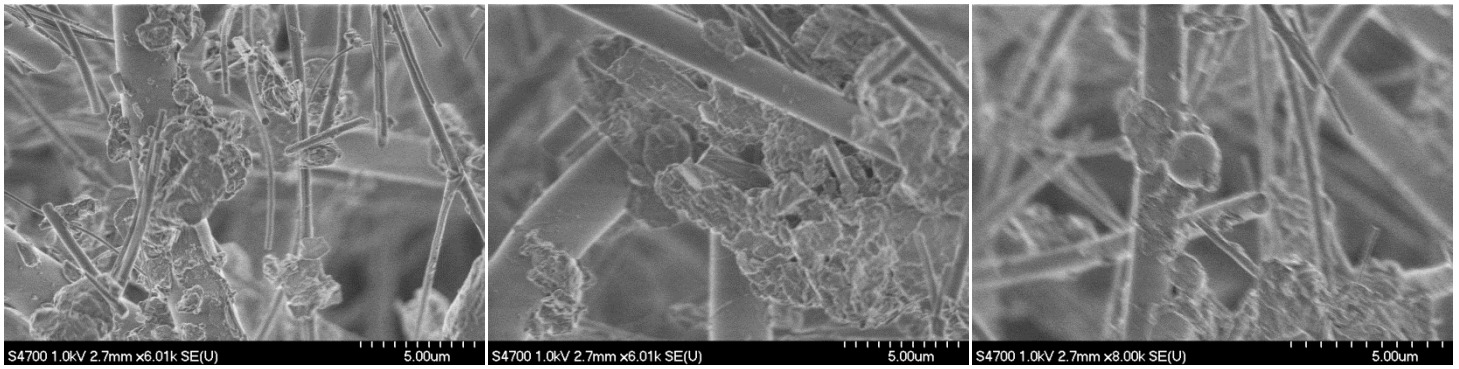
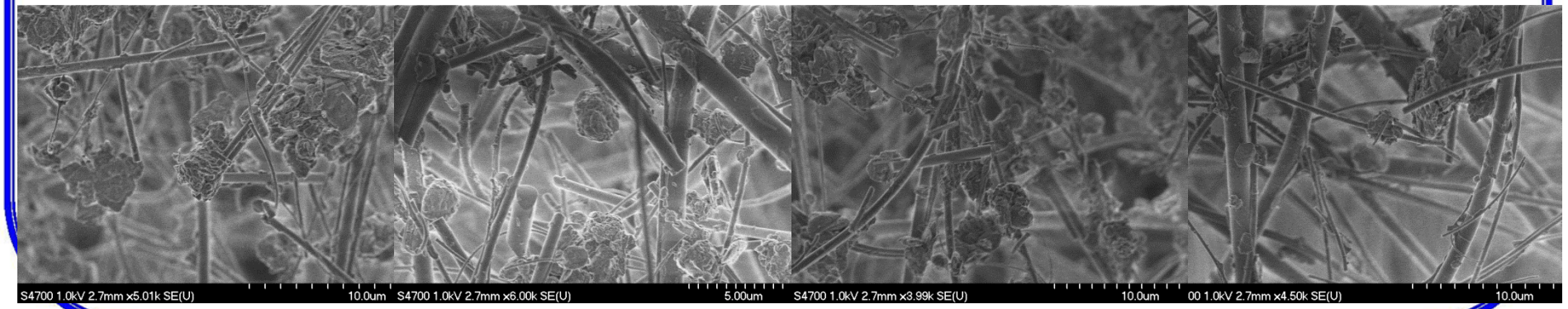
Dust particles sampled with Aethalometer (7-September-2012 at Pico Station)







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Working Equations

- Aethalometer (AE)

$$C_{BC}\left(t\,;g\,m^{-3}\right)=\frac{SpotArea\left(m^2\right)}{\left\langle Flow\left(\Delta t;\mathrm{m}^3\,\mathrm{min}^{-1}\right)\right\rangle\times S_{BC}\left(\lambda;m^2g^{-1}\right)}\times\frac{ATN\left(\lambda,t\right)-ATN\left(\lambda,t-\Delta t\right)}{\Delta t\left(\mathrm{min}\right)}\times10^{-2}$$

$$\sigma_{BC}\left(\lambda,t;m^{-1}\right)=\frac{SpotArea\left(m^2\right)}{\left\langle Flow\left(\Delta t;\mathrm{m}^3\,\mathrm{min}^{-1}\right)\right\rangle}\times\frac{ATN\left(\lambda,t\right)-ATN\left(\lambda,t-\Delta t\right)}{\Delta t\left(\mathrm{min}\right)}\times10^{-2}$$

or

$$\sigma_{BC}\left(\lambda,t;m^{-1}\right)=C_{BC}\left(t\,;g\,m^{-3}\right)\times S_{BC}\left(\lambda;m^2g^{-1}\right)$$

$$with\;\;S_{BC}\left(\lambda;m^2g^{-1}\right)=\left(\frac{14.625\left(m^2g^{-1}\mu m\right)}{\lambda\left(\mu m\right)}\right)$$

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Working Equations

- Level 1 (STP and Spot size correction)

$$C_{BC;1}\left(t\,;g\;m^{-3}\right)=C_{BC}\left(t\,;g\;m^{-3}\right)\times C_{ref}\left(t\right)\times C_{SpotRacio}$$

with

$$C_{ref}\left(t\right)=\frac{Flow_{AE}\left(t;STP\;m^{3}/\min\right)}{Flow_{cal}\left(t;STP\;m^{3}/\min\right)}\quad and\quad C_{SpotRacio}=\frac{Spot_{measure}\left(m^{2}\right)}{Spot_{AE}\left(m^{2}\right)}$$

- Level 2 (Loading correction) (*Fialho et al.*, 2012)

$$C_{BC;2}\left(t\,;g\;m^{-3}\right)=C_{BC;1}\left(t\,;g\;m^{-3}\right)\times\left(1+k\left(\lambda\right)\times ATN\left(\lambda,t\right)\right)$$

or

$$\sigma_{aerosol;2}\left(\lambda,t\,;m^{-1}\right)=\sigma_{aerosol;1}\left(\lambda,t\,;m^{-1}\right)\times\left(1+k\left(\lambda\right)\times ATN\left(\lambda,t\right)\right)$$

$$with\quad k\left(\lambda\right)=\left(-0.0010\pm0.0005\right)+\frac{\left(2.00\pm0.25\right)\left(nm\right)}{\lambda\left(nm\right)}$$

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Working Equations

- Mixing model (*Fialho et al.*, 2005 & 2006)

$$\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)=\sigma_{BC}\left(\lambda,t;m^{-1}\right)+\sigma_{Fe}\left(\lambda,t;m^{-1}\right)$$

$$\sigma_{BC}\left(\lambda,t;m^{-1}\right)=S_{BC}\left(\lambda;m^{2}g^{-1}\right)\left\langle C_{BC}\left(t;g\ m^{-3}\right)\right\rangle$$

$$\sigma_{Fe}\left(\lambda,t;m^{-1}\right)=S_{Fe}\left(\lambda;m^{2}g^{-1}\right)\left\langle C_{Fe}\left(t;g\ m^{-3}\right)\right\rangle$$

$$\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)=S_{BC}\left(\lambda;m^{2}g^{-1}\right)\left\langle C_{BC}\left(t;g\ m^{-3}\right)\right\rangle+S_{Fe}\left(\lambda;m^{2}g^{-1}\right)\left\langle C_{Fe}\left(t;g\ m^{-3}\right)\right\rangle$$

$$S_{Fe}\left(\lambda;m^{2}g^{-1}\right)=\frac{\left(0.292\pm0.025\right)\left(\mu m^{4}m^{2}g^{-1}\right)}{\lambda\left(\mu m\right)^{4}}$$

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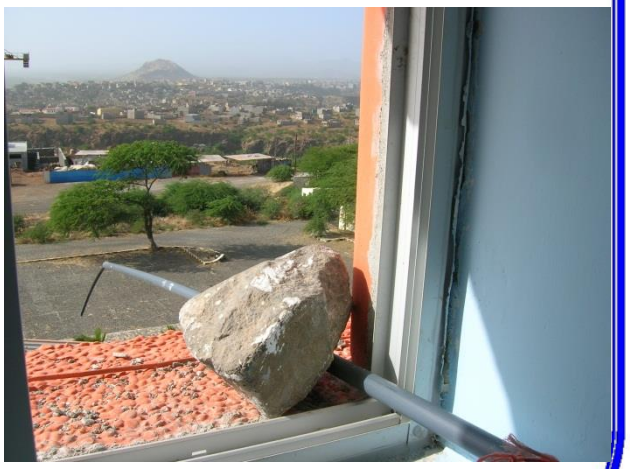
Experimental Setup

(Cape Verde, Praia, 14055'N; 23029'W; 98 m a.s.l.)



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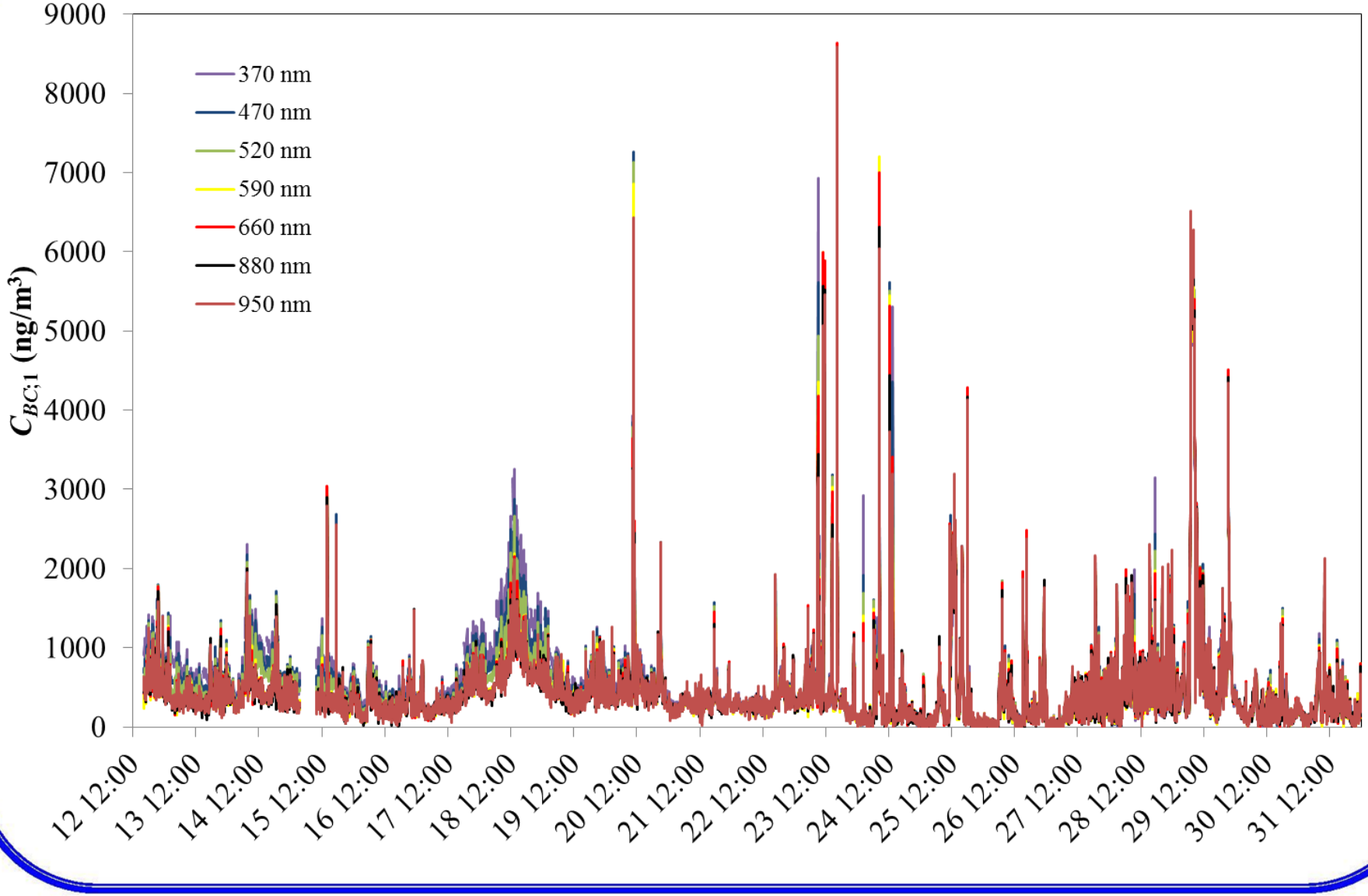

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- Aerosol Angström exponent, $\alpha_{aerosol}$

$$\sigma_{aerosol}\left(\lambda, t; m^{-1}\right) = C_{aerosol}\left(t; g/m^3\right) \times S_{aerosol}\left(\lambda; m^2/g\right)$$

with

$$S_{aerosol}\left(\lambda; m^2/g\right) = K_{aerosol} \times \lambda^{-\alpha_{aerosol}}$$

$$\sigma_{aerosol}\left(\lambda, t; m^{-1}\right) = C_{aerosol}\left(t; g/m^3\right) \times K_{aerosol} \times \lambda^{-\alpha_{aerosol}}$$

$$\underbrace{\ln\left(\sigma_{aerosol}\left(\lambda, t; m^{-1}\right)\right)}_{y} = \underbrace{\ln\left(C_{aerosol}\left(t; g/m^3\right) \times K_{aerosol}\right)}_{\text{intercept}} \underbrace{-\alpha_{aerosol}}_{slope} \times \underbrace{\ln(\lambda)}_{x}$$

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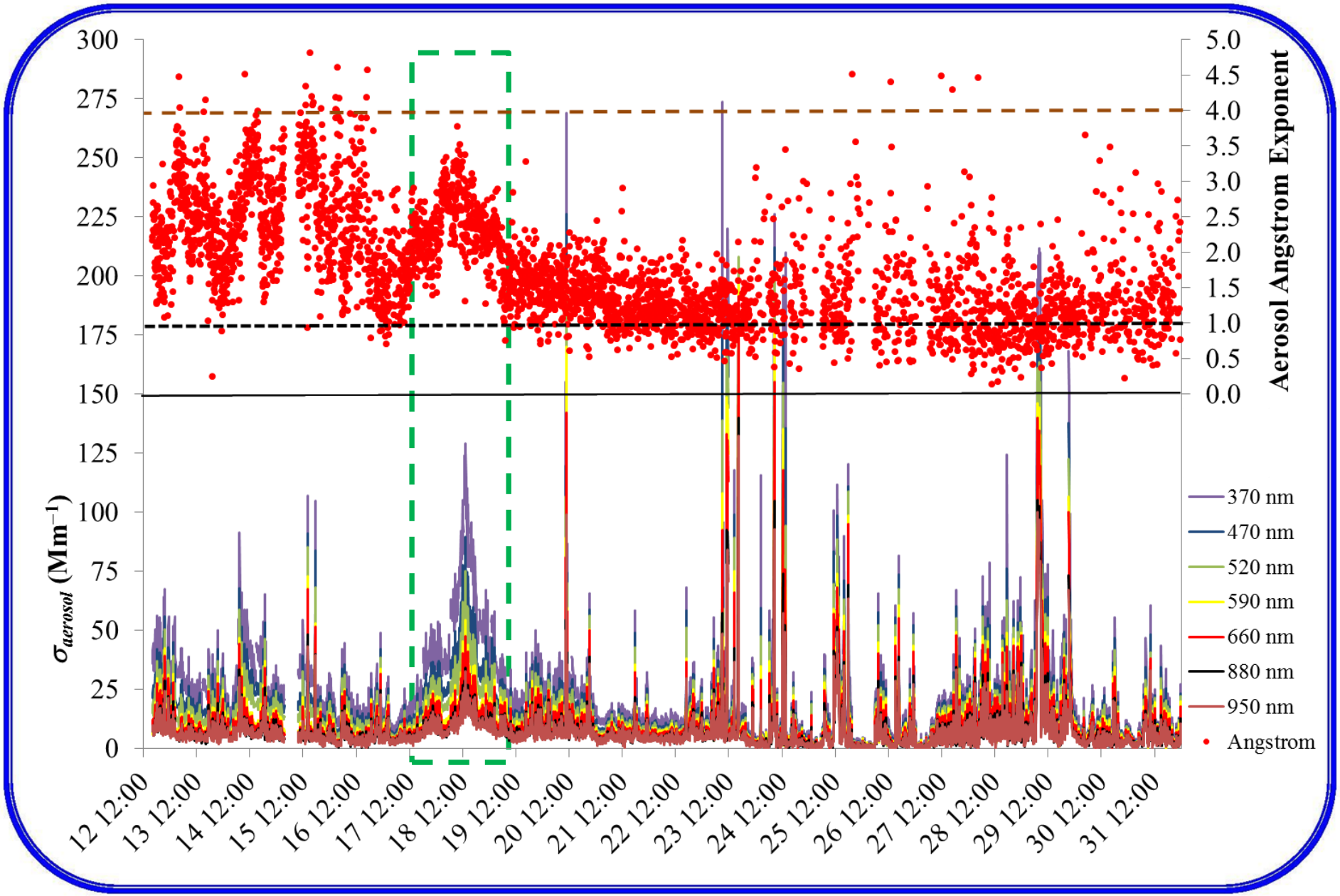

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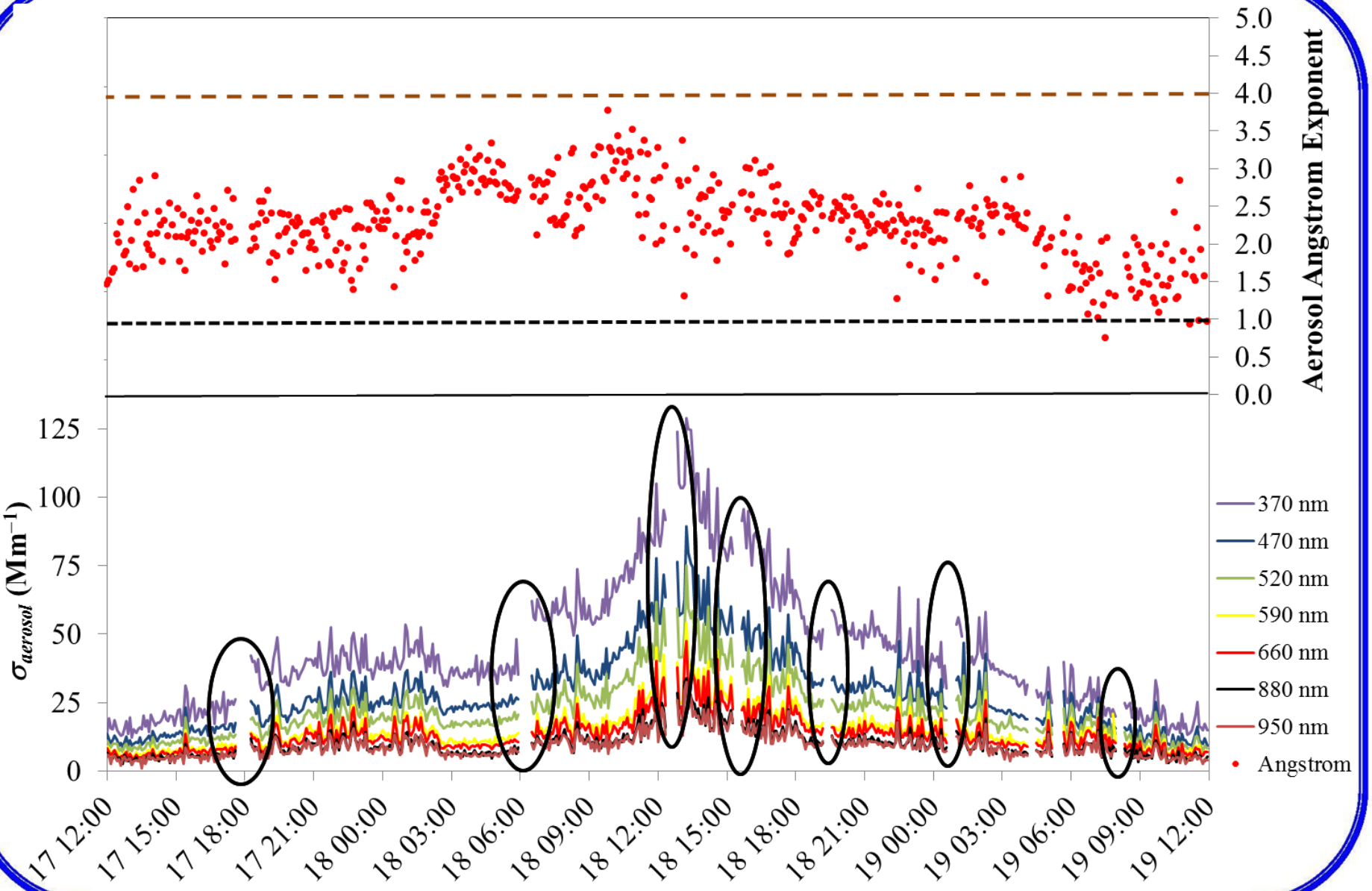

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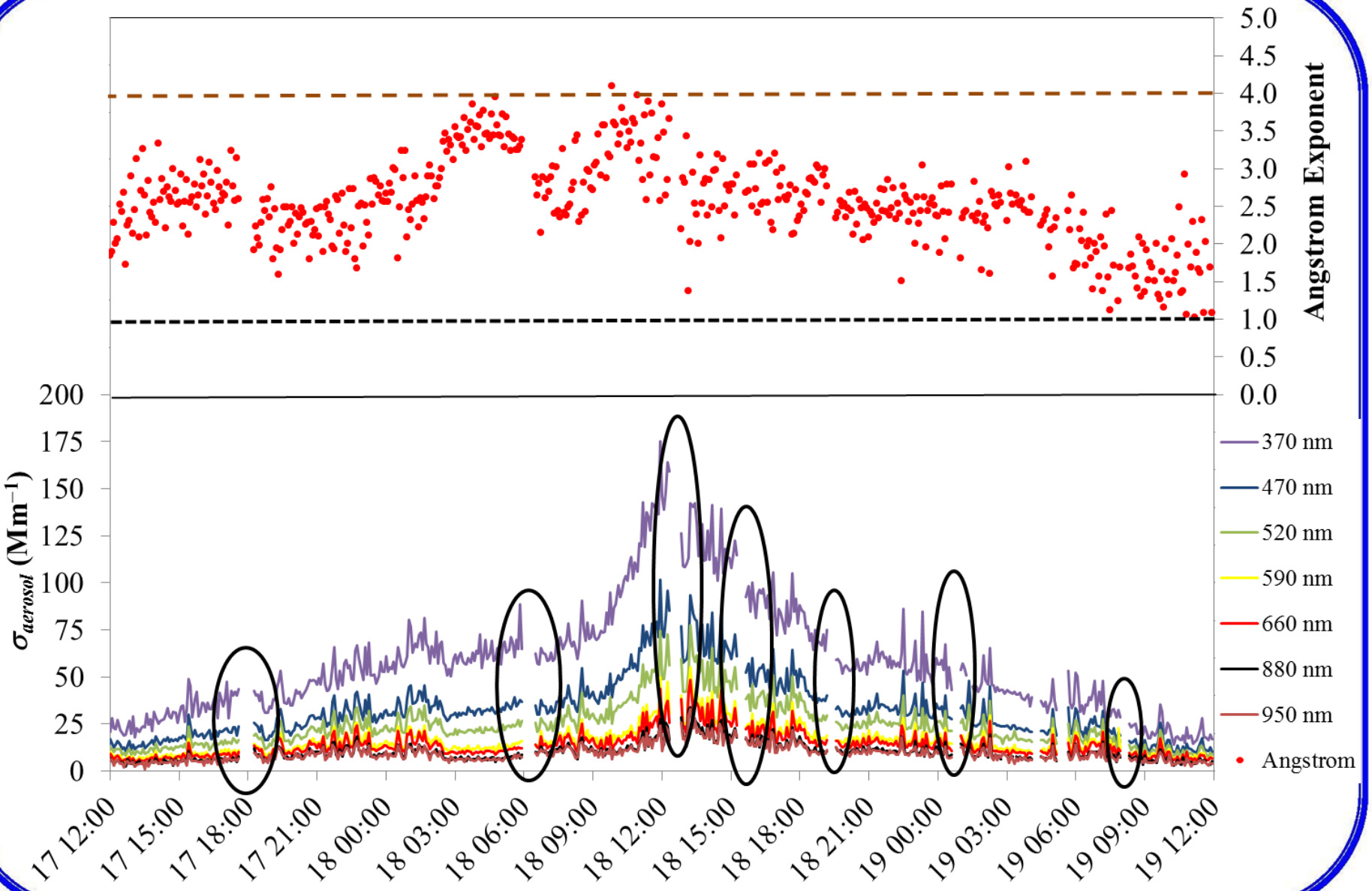

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- Mixture composition

$$\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)=C_{BC}\left(t;g/m^{3}\right)\times S_{BC}\left(\lambda;m^{2}/g\right)+C_{Fe}\left(t;g/m^{3}\right)\times S_{Fe}\left(\lambda;m^{2}/g\right)$$

$$\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)=C_{BC}\left(t;g/m^{3}\right)\times K_{BC}\times\lambda^{-1}+C_{Fe}\left(t;g/m^{3}\right)\times K_{Fe}\times\lambda^{-4}$$

$$\begin{cases}\underbrace{\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)\times\lambda}_{y(1)}=\underbrace{C_{BC}\left(t;g/m^{3}\right)\times K_{BC}}_{\text{intercept}(1)}+\underbrace{C_{Fe}\left(t;g/m^{3}\right)\times K_{Fe}}_{\text{slope}(1)}\times\underbrace{\lambda^{-3}}_{x(1)}\\ \textit{or}\\ \underbrace{\sigma_{aerosol}\left(\lambda,t;m^{-1}\right)\times\lambda^{4}}_{y(2)}=\underbrace{C_{BC}\left(t;g/m^{3}\right)\times K_{BC}}_{\text{slope}(2)}\times\underbrace{\lambda^{3}}_{x(2)}+\underbrace{C_{Fe}\left(t;g/m^{3}\right)\times K_{Fe}}_{\text{intercept}(2)}\end{cases}$$

$$\begin{cases}C_{BC}\left(t;g/m^{3}\right)=\dfrac{\text{intercept}(1)}{K_{BC}}\quad\textit{and}\quad C_{Fe}\left(t;g/m^{3}\right)=\dfrac{\text{slope}(1)}{K_{Fe}}\\ \textit{or}\\ C_{BC}\left(t;g/m^{3}\right)=\dfrac{\text{slope}(2)}{K_{BC}}\quad\textit{and}\quad C_{Fe}\left(t;g/m^{3}\right)=\dfrac{\text{intercept}(2)}{K_{Fe}}\end{cases}$$

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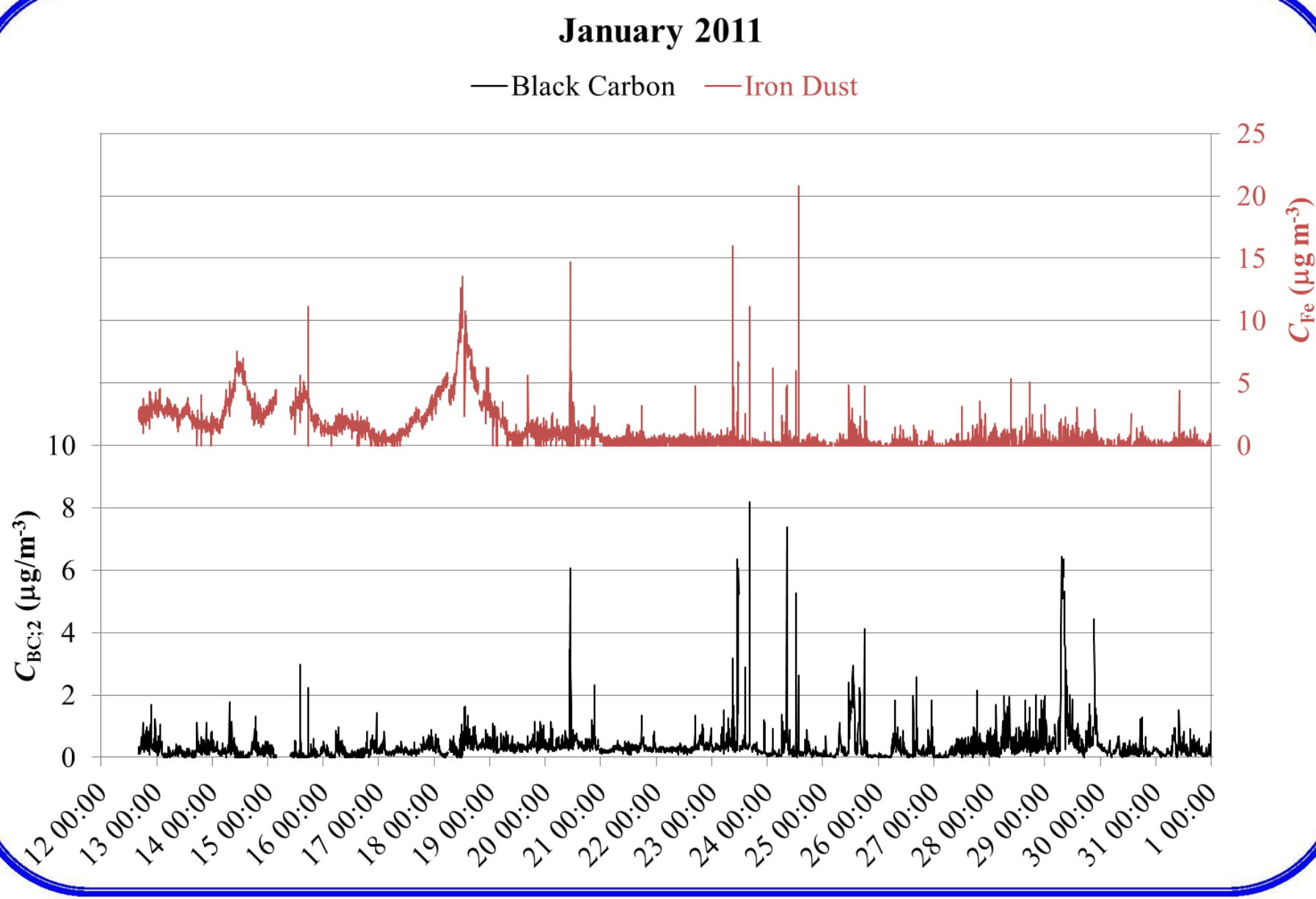

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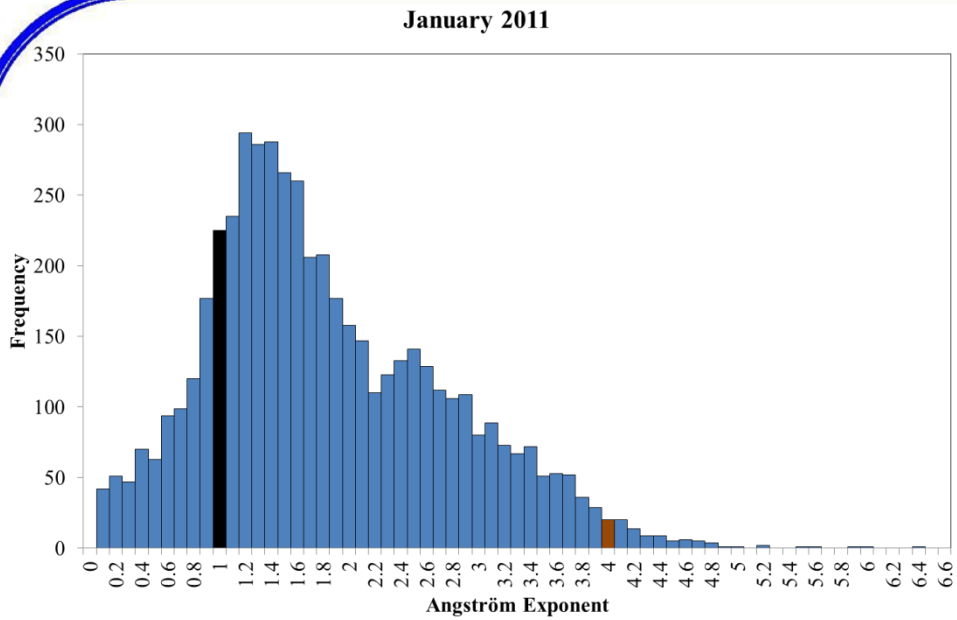

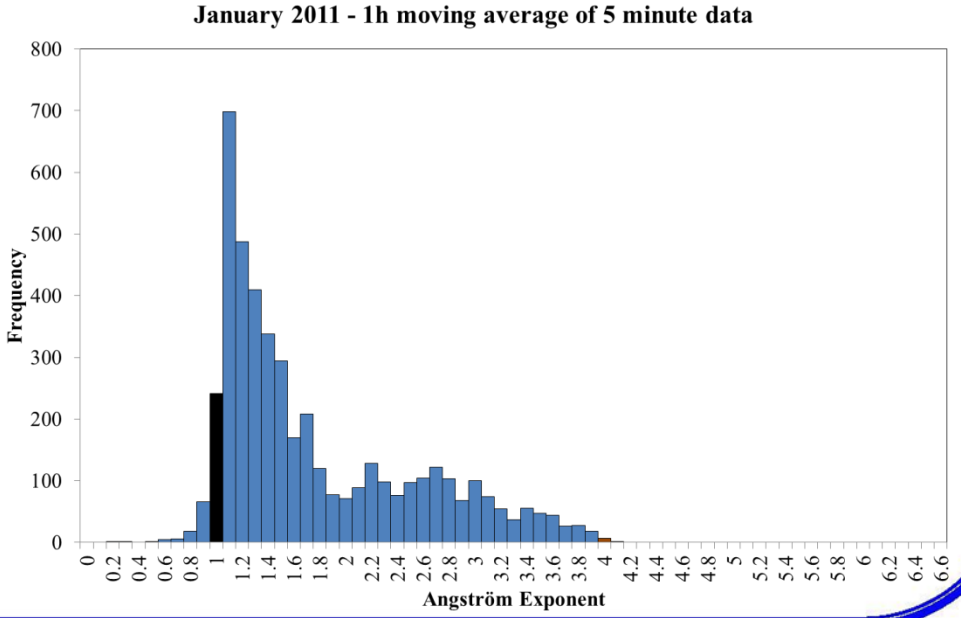

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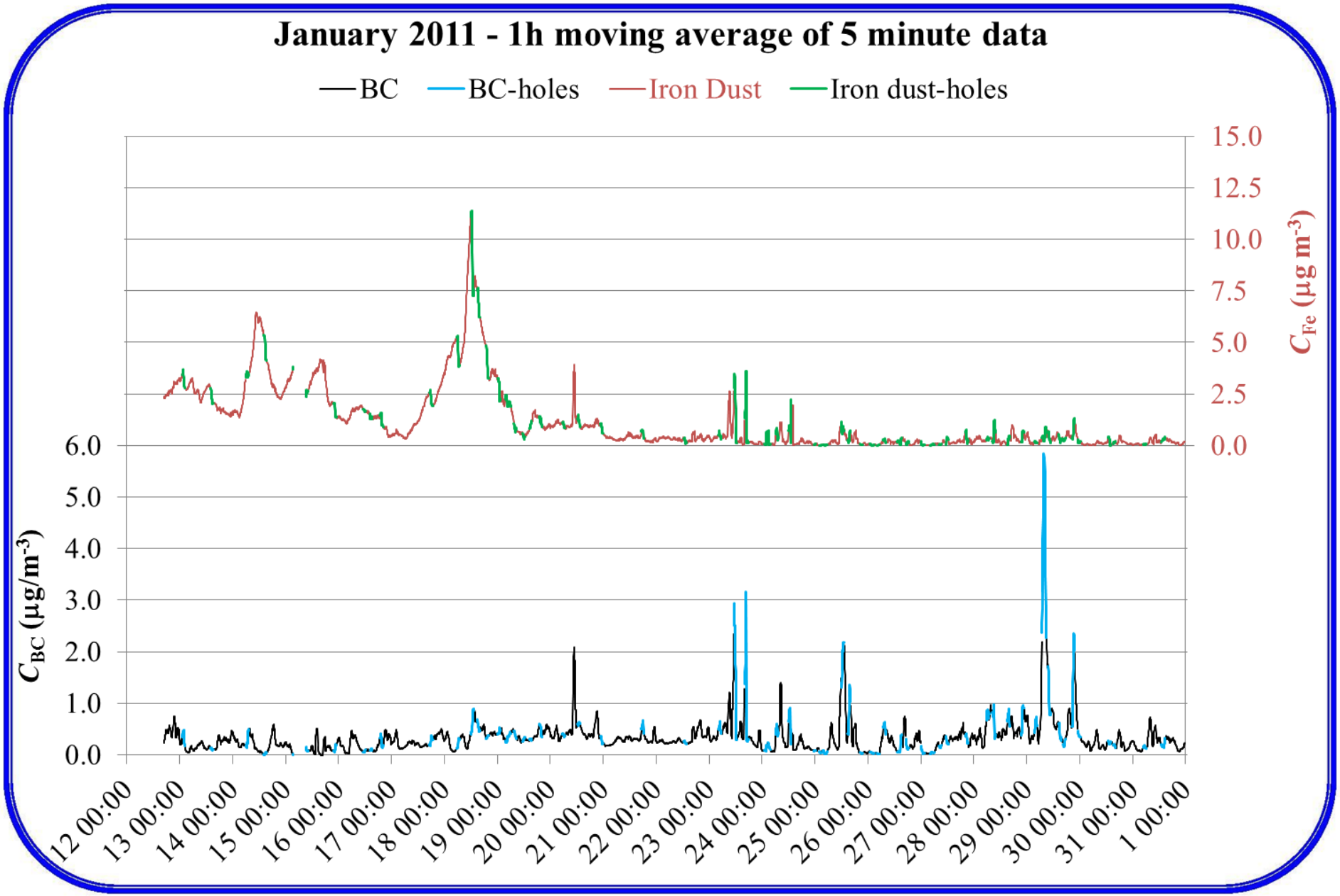

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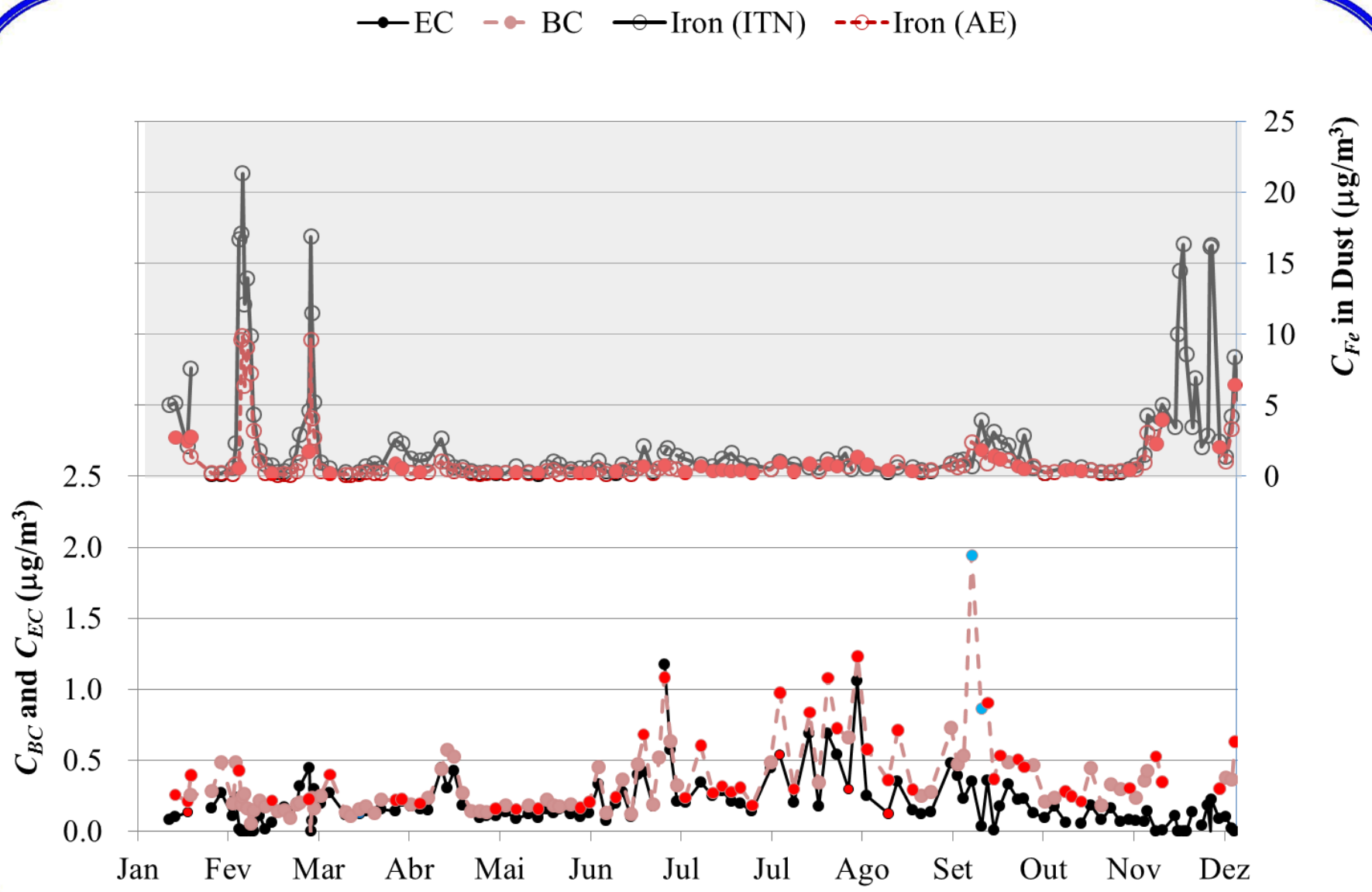

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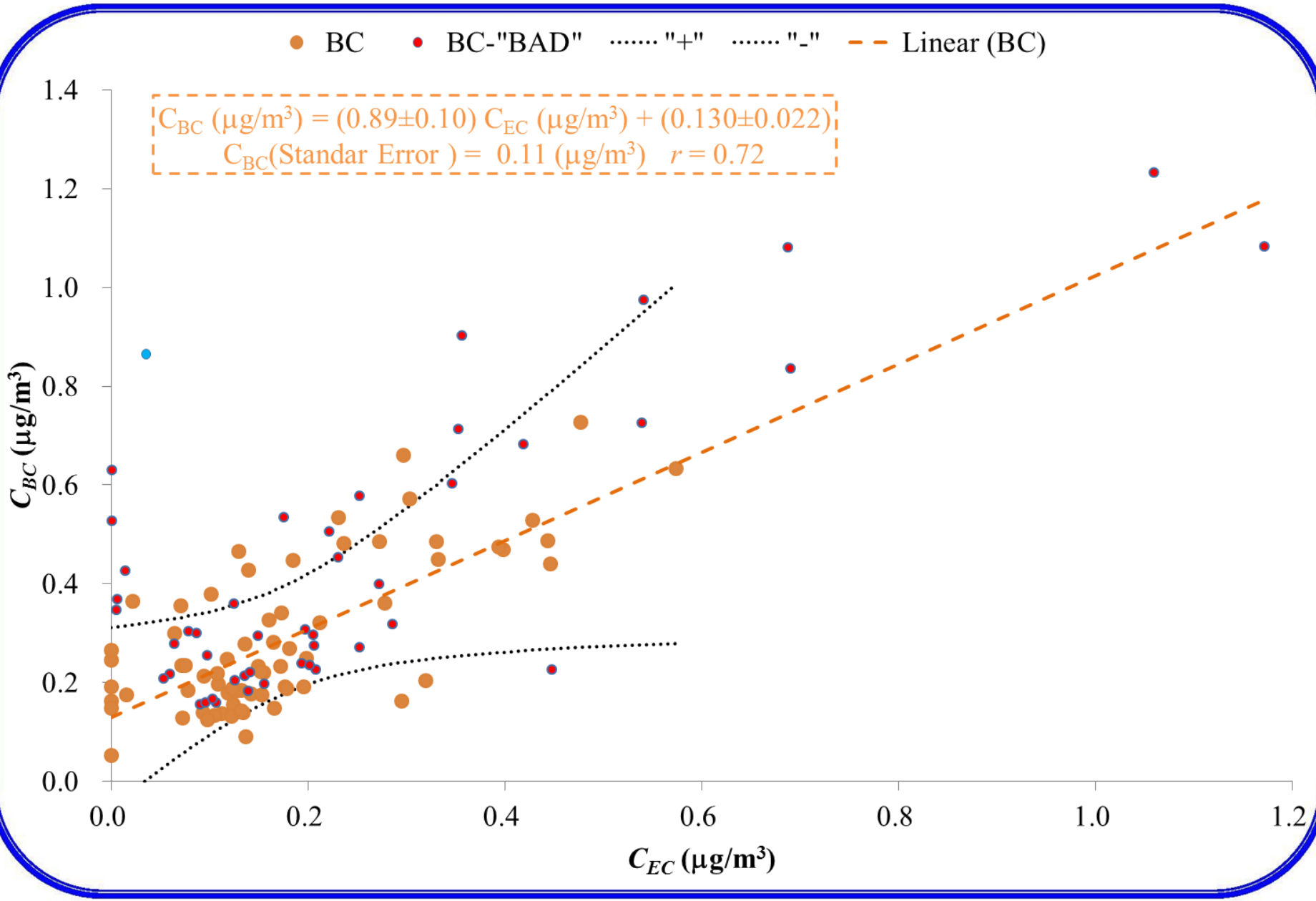

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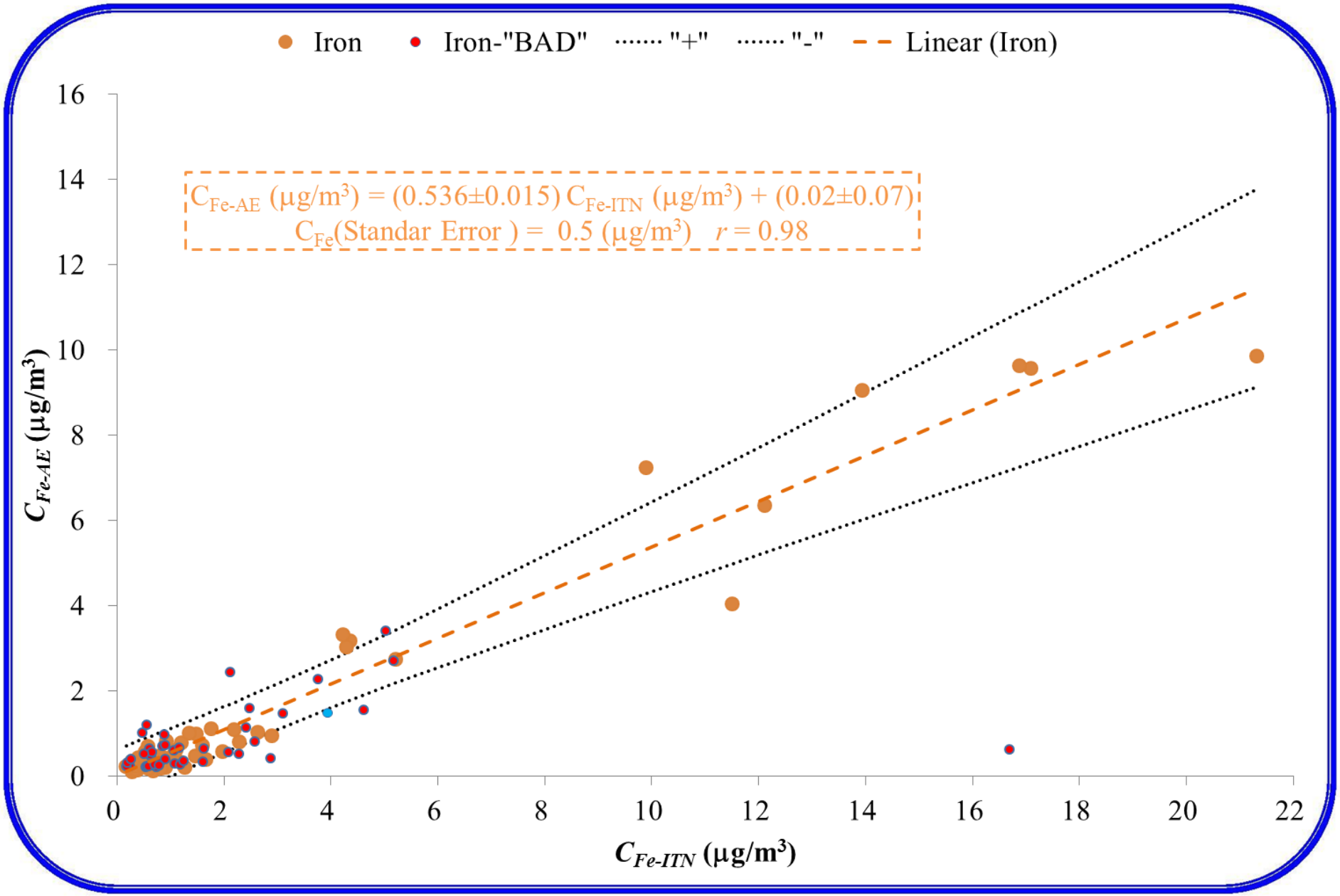

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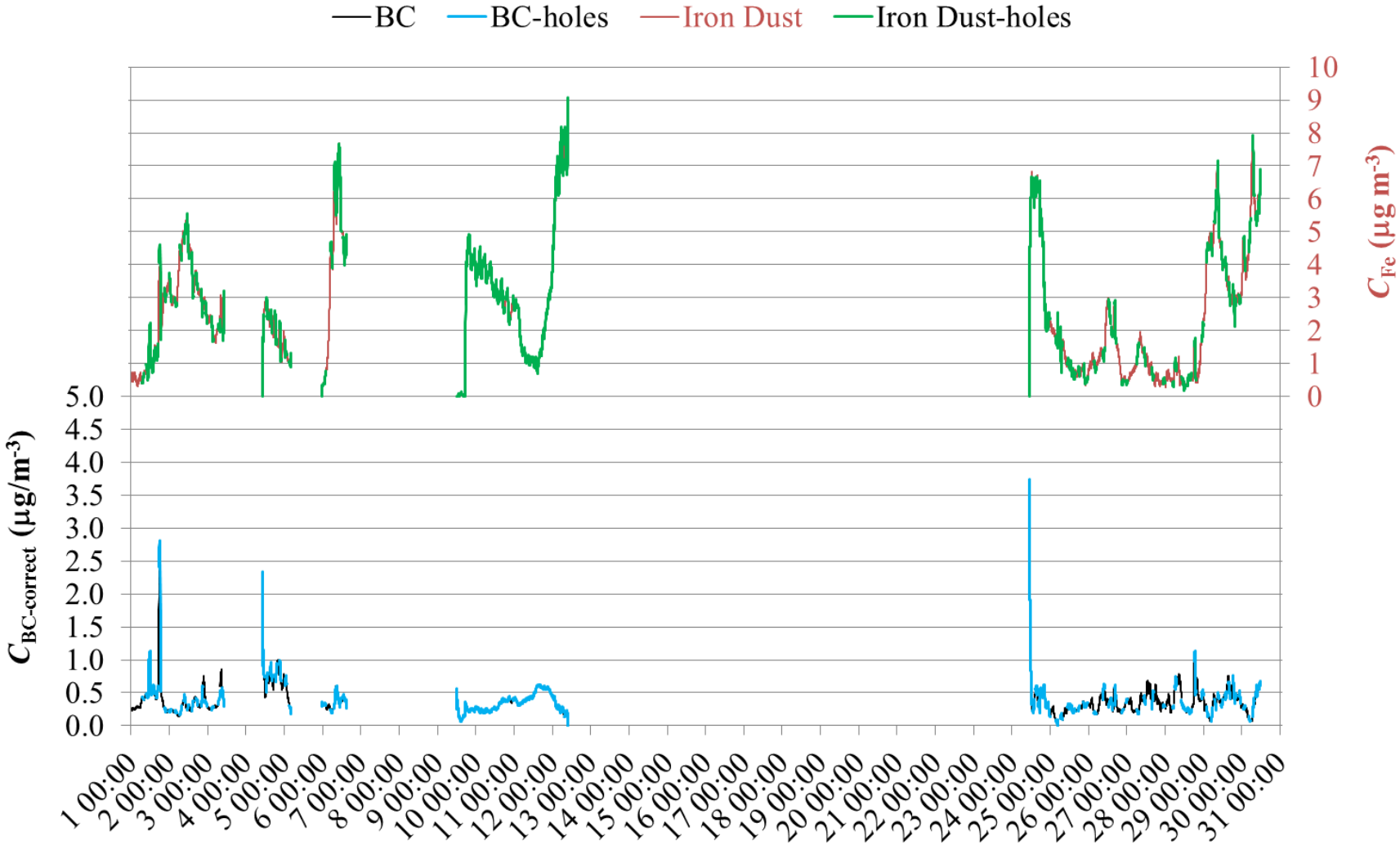

Thank you for your attention

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Referências

- Fialho, P., Hansen, A.D.A., Honrath, R.E., **2005**, *Absorption Coefficients by Aerosols in Remote Areas: A New Approach to Decouple Dust and Black Carbon Absorption Coefficient Using Seven-Wavelength Aethalometer data*. Journal of Aerosol Science, 36(2), 267-282, DOI:10.1016/j.jaerosci.2004.09.004.

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- Fialho, P., Müller, T., Henzing, B., Eleftheriadis, K., Mocnik, G., Virkkula, A., Wiedensohler, A. and de Leeuw, G., **2012**, *Improved compensation function to account for the non-linear behaviour of optical measurements as a result of aerosol accumulation on a filter*, paper underwork.