Talking About
Dust Ground Observations

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Summary

Aerosol Measuring problems
Dust: Overview
Source Apportionment of dust

Example: Project CVDUST

- Conditions
- Sampling Quality Control
- PMF/Back Trajectories
- Ionic and Mass Balance

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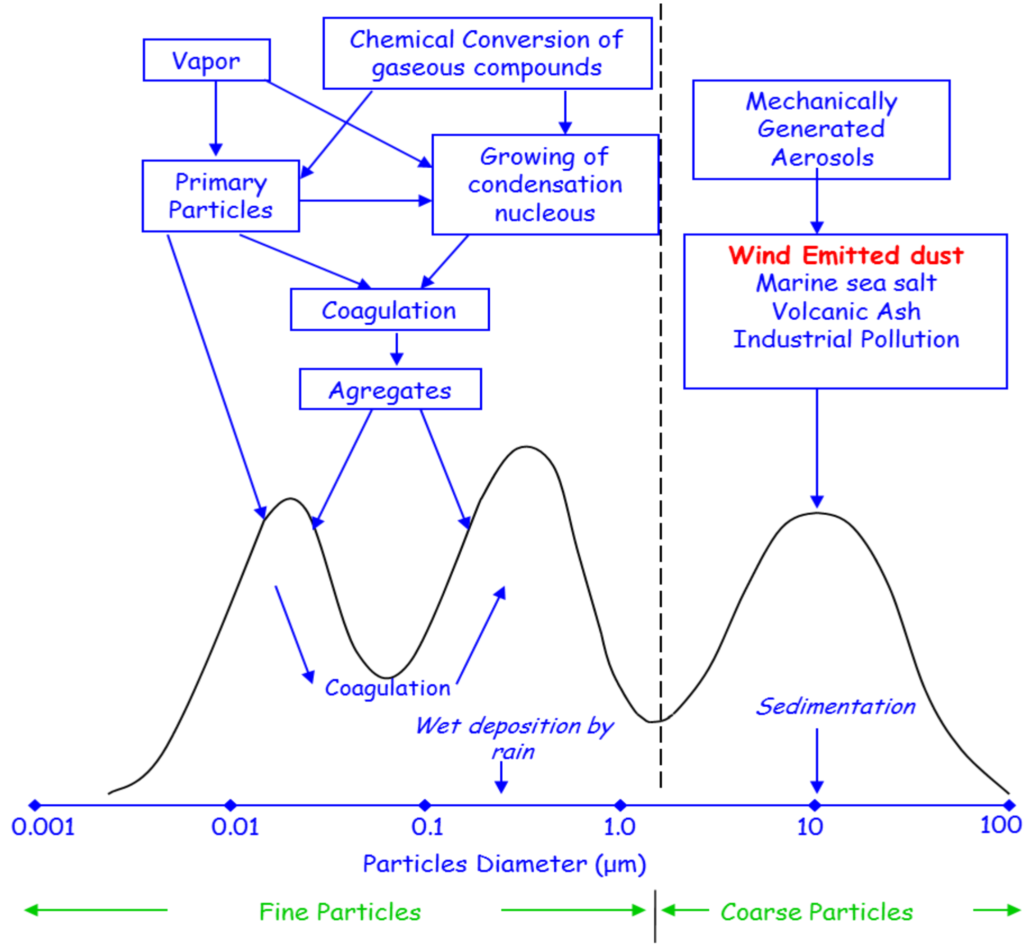
Framing:

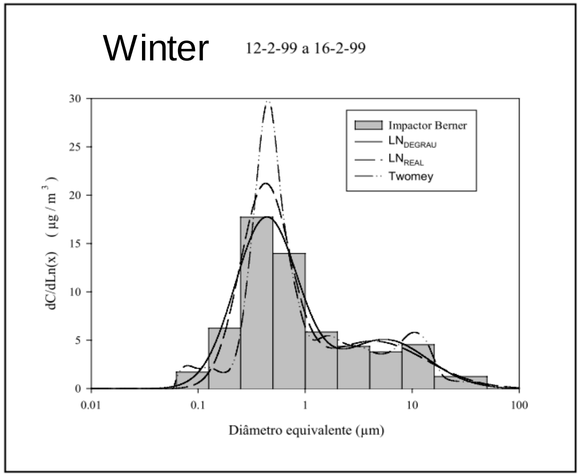
- Aerosol particles are ubiquitous in the Atmosphere.
- Behavior and Effects result from Physical and Chemical Characteristics

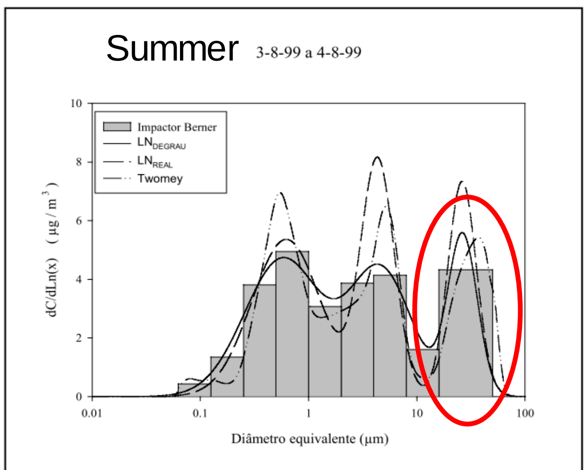
Particle Size is a fundamental property of the aerosol



Schematic Size Distribution of Atmospheric Aerosol with Sources, Processes and Removal Mechanisms (ref: Whitby, 1978)

Size Distribution of Aerosol Mass in Aveiro suburban area





Ref: Rijo et al., (2009)

The problem of measuring **Giant Particles**:

Isokinetic Sampling

TSP HV Sampler

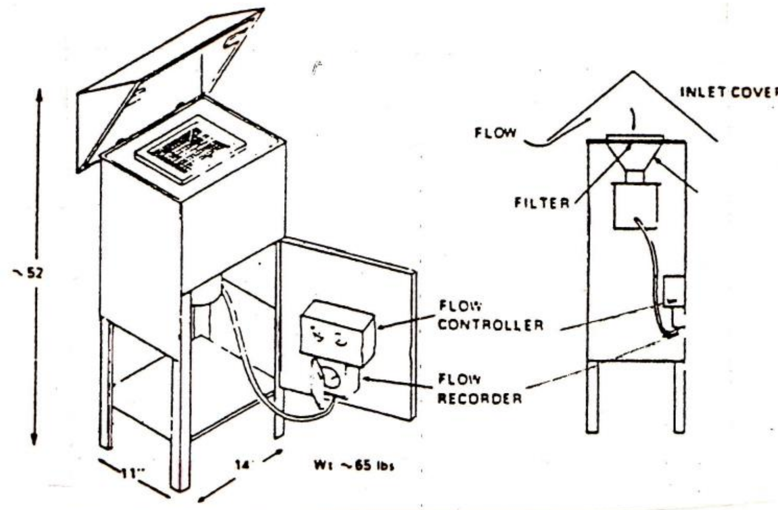


Tabela 4.17: Eficiência do "High Vol. Sampler", com vento de 15 pés/seg.

diâmetro das partículas (um)							
5		15		30		50	
orientação do amostrador							
0o	45o	0o	45o	0o	45o	0o	45o
97%	100%	35%	55%	18%	41%	7%	34%

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Why to study atmospheric dust?

Estimated Global Emission rates of particles into the Atmosphere (Tg yr-1)

	Fine Particles	Coarse Particles
Sea Salt	**82.1**	**2460**
Dust	**250**	**1000-4875**
Carbon	81	
Sulfate	150	
Nitrate	11.3	
Ammonium	33.6	

ref: Raes et al., (2000)

Global Atmospheric dust

Seasonal AOD averaged for 2001-2011 from MISR satellite

- Sahara emissions predominate
- Higher AI values during summer

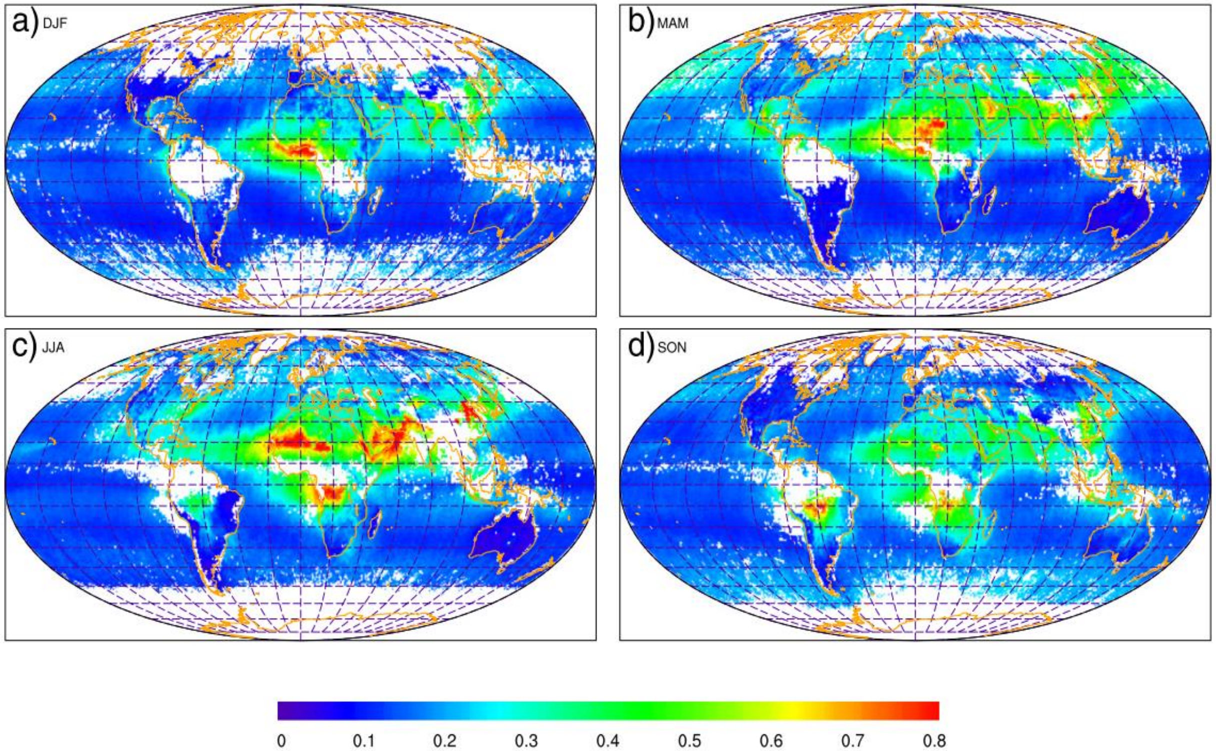
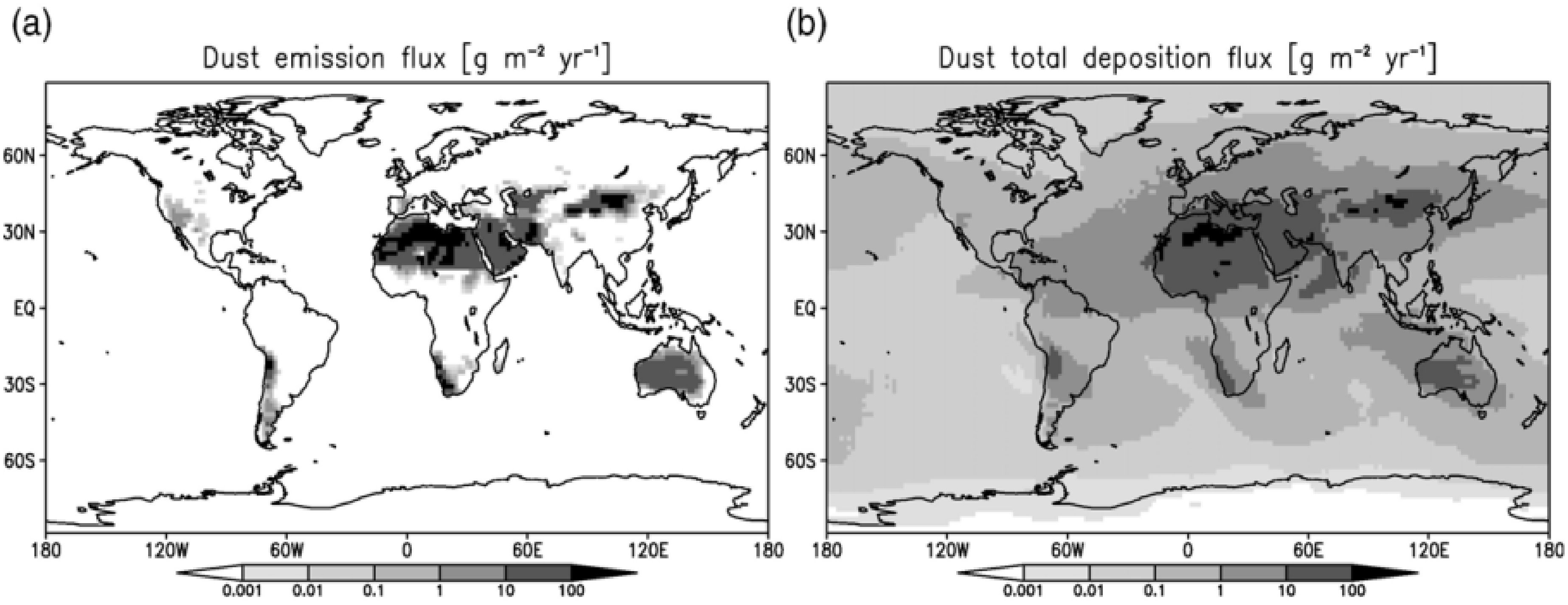


Fig. 1. Seasonally averaged AOD at 0.55 µm from 2001 to 2011 retrieved from the Multiangle Imaging Spectroradiometer (MISR) in (a) DJF, (b) MAM, (c) JJA and (d) SON.

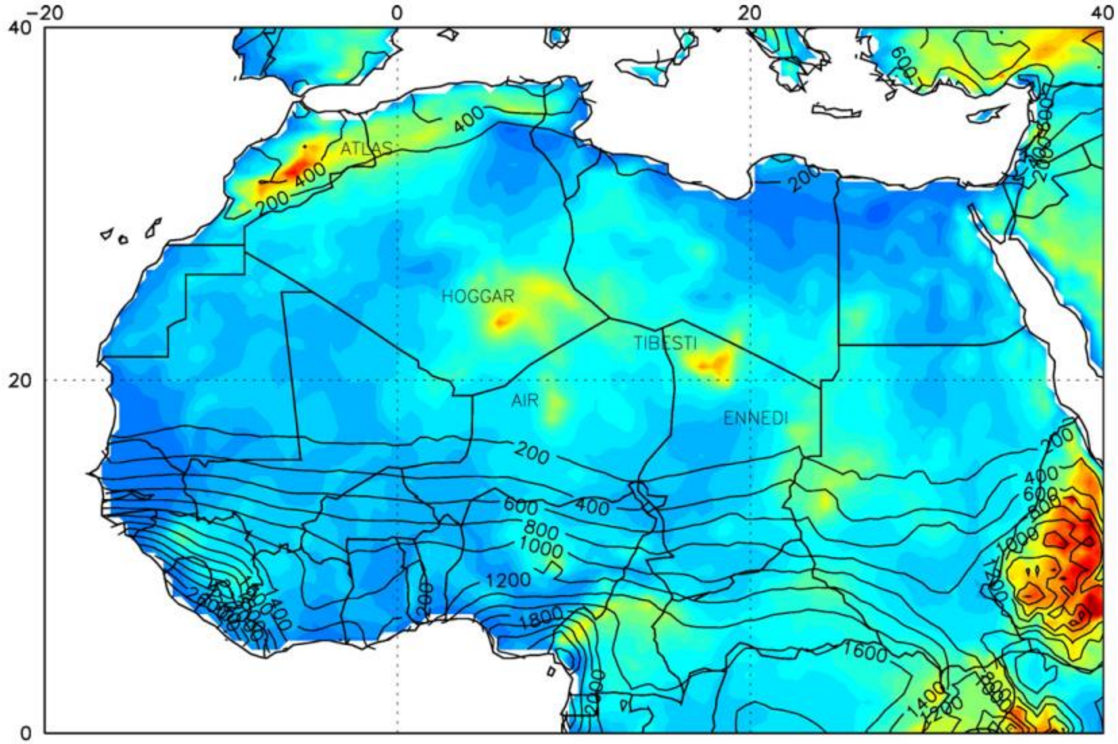
Ref: Shoobari and Sturman, AR (2014)

Global dust budget – Modeled annually averaged values



ref: Tanaka and Chiba, (2006)

Main causes for Sahara dust emissions: dryness



Mean annual rainfall in mm (1961-90). (ref: Engelstaedter, 2006)

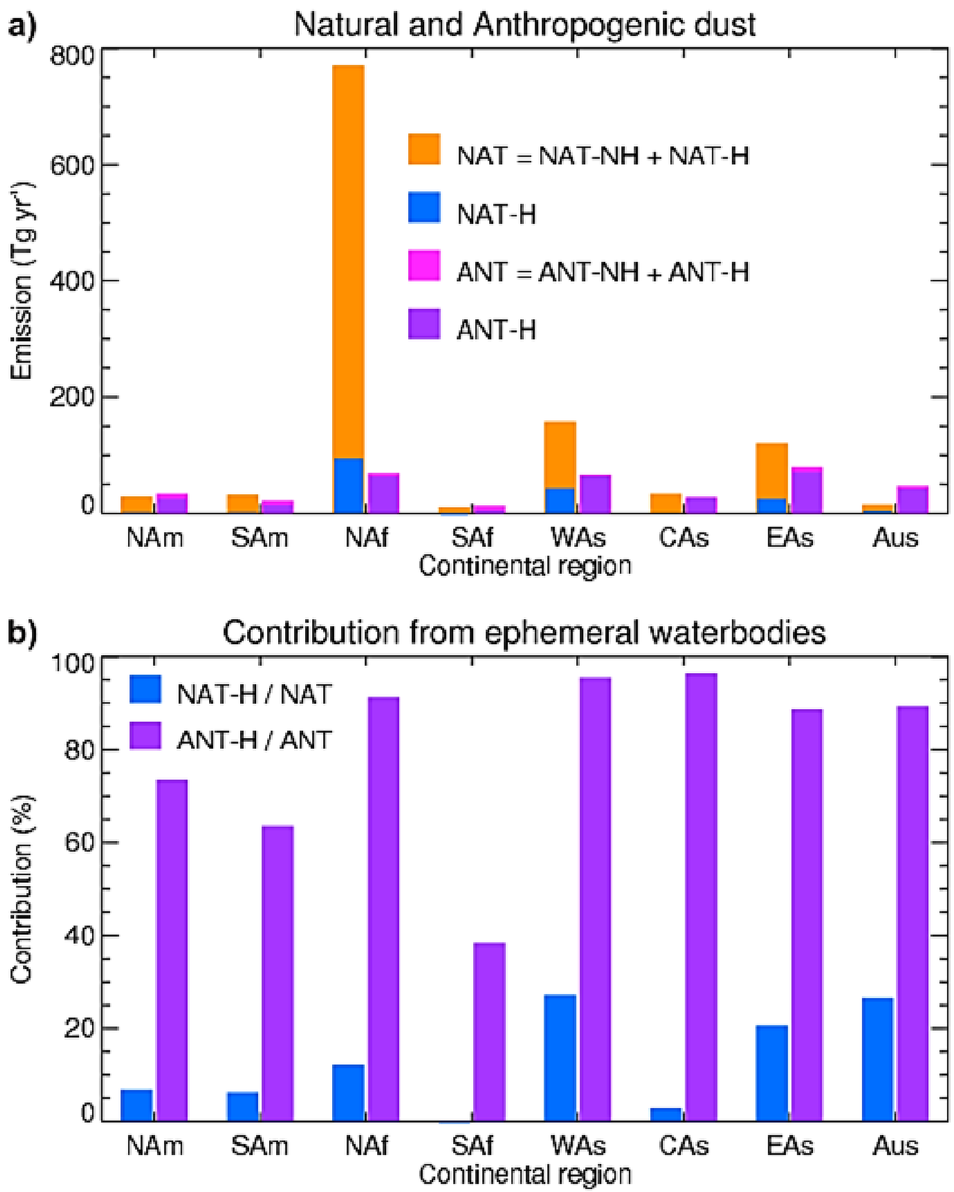
Dust Sources:

- Natural Soil emissions;
- Agriculture (example “Dust Bowl” in USA);
- Transports;
- Building
- Industry (cement; mining)

Natural Dust versus Agricultural Emissions

from MODIS deep blue aerosol products

Ginoux et al (2012)



Sources of Soil Dust:

- North Africa the major source of dust. Estimates of Sahara emissions: 130-760 Tg yr− 1 (Goudie and Middleton, 2001);
- Some estimates annual Saharan dust emission of 1600 Tg yr− 1 (Ozer, 2001).
- Sahel cultivation contributes with up to 15% dust North Africa emissions;
- Other dust sources: Arabian Peninsula, Iran, Turkmenistan, Afghanistan, Pakistan, Northern India, the Namib and Kalahari desert and the Tarim Basin in China.

Sinks of out of Sahara emitted dust:

Kaufman et al. (2005) estimated North Africa annual dust transport to west 240±80 Tg:

- 140 Tg are deposited in the Atlantic Ocean,
- 50 Tg fertilize the Amazon Basin
- 50 Tg are transported to the Caribbean.
- 20 Tg are transported towards Europe.

Impacts of desert dust emissions:

- **Atmospheric Heat Balance and Climate Control**
  - *Weakening of Atlantic Tropical Cyclones*
- **Biogeochemical Cycles**
  - *Biogeochemical Cycles in Atlantic and Amazon Basin*
  - *Toxic Algae Blooms*
- **Human Health**
  - *Spreading of meningitis in Sahel* *(Sultan et al., 2005)*
  - *Kawasaki disease in Japan and Western USA* *(Fraser, 2012)*

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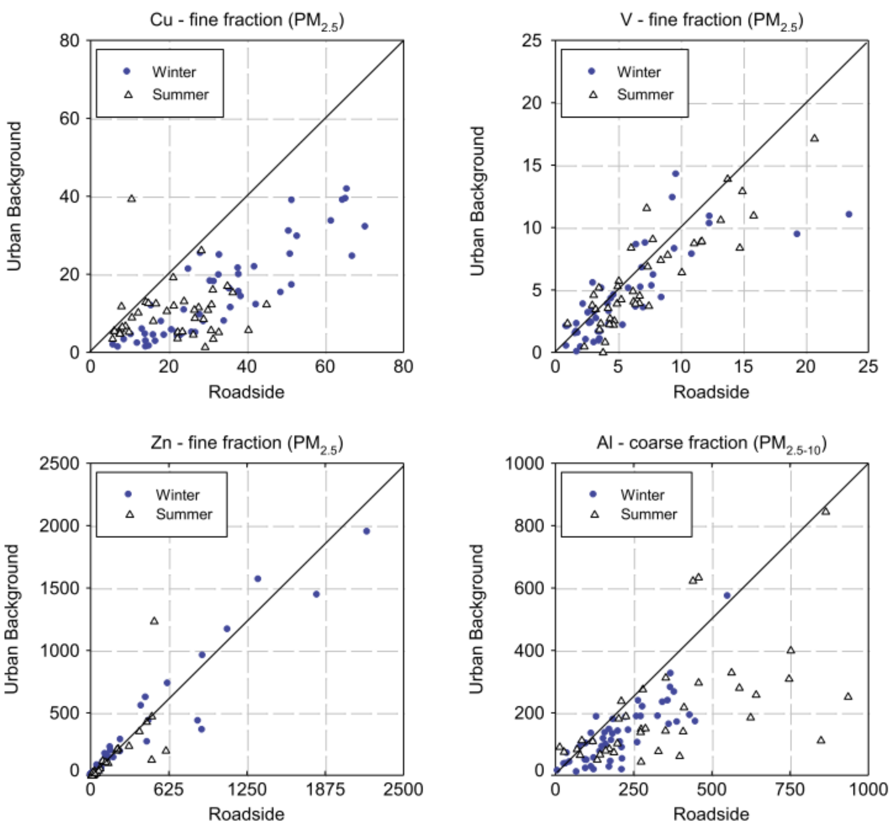
Source Apportionment for Roadside and Urban background sites in Porto

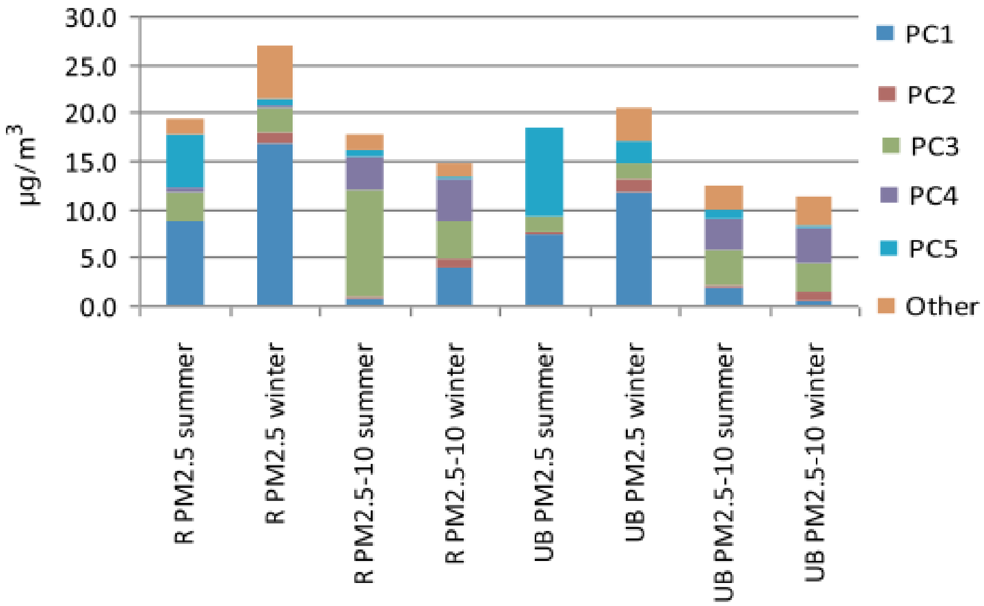
Parallel Sampling



PCA/MLRA for fine and coarse fractions

PC1-Traffic; PC2- Industrial; PC3- Soil dust; PC4- Sea Salt; PC5- Secondary

R- Road-side; **UB**- Urban Background



ref: Oliveira et al., (2010)

Calculation of traffic re-suspended dust in Porto by Inter-site Mass Balance (IMB)

Table 5

Emission Rates (ER) by cars, for Cu and Zr, calculated from equation (1) and fraction traffic contribution (road resuspension) to suspended soil dust (TF) calculated from equations (2) and (3), at R and UB sites, discriminated for $PM_{2.5}$ and $PM_{2.5-10}$. Four estimates are present for each TF case, based in different combinations of tracer elements.

Inter-site mass balance	Emission factors ($\mu g\ veh^{-1}\ km^{-1}$)		Fraction from traffic (TF_R)				Fraction from traffic (TF_{UB})			
	Cu	Zr	(Cu, Al)	(Zr, Si)	(Cu, Si)	(Zr, Al)	(Cu, Al)	(Zr, Si)	(Cu, Si)	(Zr, Al)
Winter coarse day	357	47	0.53	0.57	0.58	0.53	0.25	0.28	0.29	0.24
Winter coarse night	406	36	0.51	0.66	0.58	0.51	0.25	0.44	0.31	0.29
Winter fine day	264	24	0.34	0.49	0.56	0.34	0.19	0.26	0.36	0.16
Winter fine night	297	22	0.55	0.40	0.45	0.55	0.38	0.23	0.29	0.35
Summer coarse day	312	36	0.81	0.89	0.91	0.81	0.63	0.75	0.81	0.62
Summer coarse night	371	36	0.72	0.74	0.72	0.72	0.53	0.55	0.53	0.53
Summer fine day	263	15	0.66	0.94	0.81	0.66	0.46	0.89	0.65	0.50
Summer fine night	293	17	0.63	0.31	0.33	0.63	0.47	0.19	0.20	0.46

ref: Oliveira et al., (2010)

ER- Emission Rate

$$ER_{Cu} = ER_{NO_x}(Cu_R - Cu_{UB})/(NO_{x_R} - NO_{x_{UB}})$$

ref: Johanson et al., (2009)

IMB- Inter-site Mass Balance

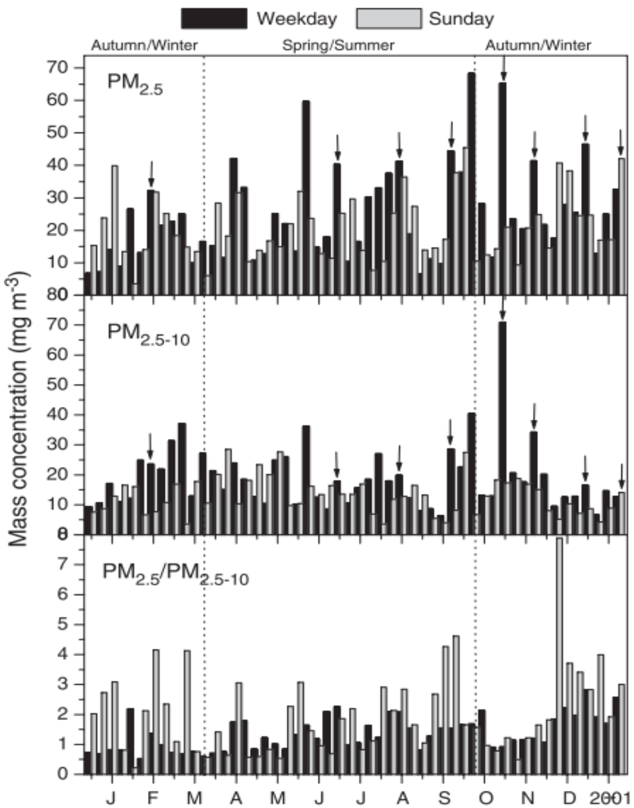
$TF_R = RIs/RIc$ =Soil Traffic Fraction at Roadside

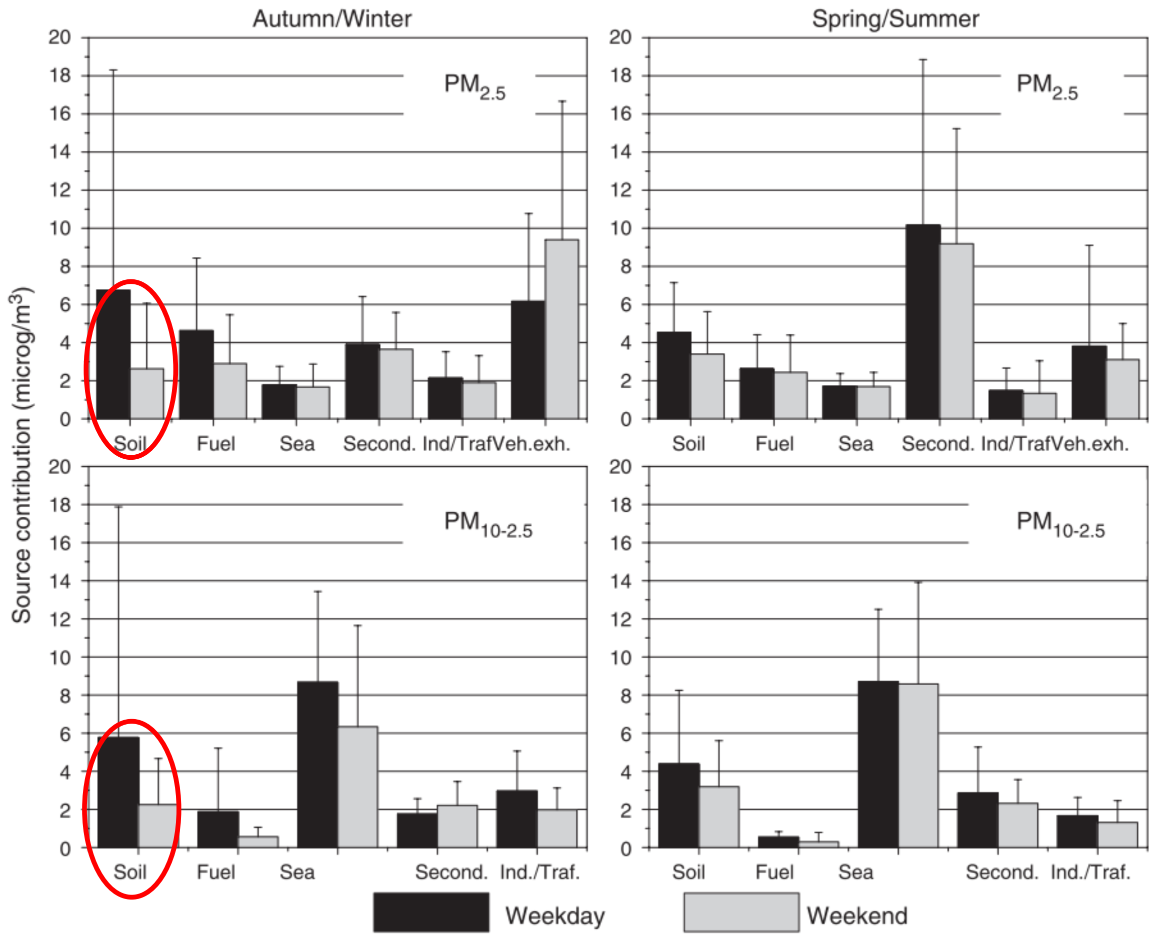
$TF_{UB} = (RIs/RIc)(1 - RIc)/(1 - RIs)$ =Soil Traffic Fraction at UB

RI=(R-UB)/R= Road Impact Factor

Weekend/weekday ratios applied in anthropogenic dust evaluation

PCA/MLRA applied to Lisbon suburban aerosol





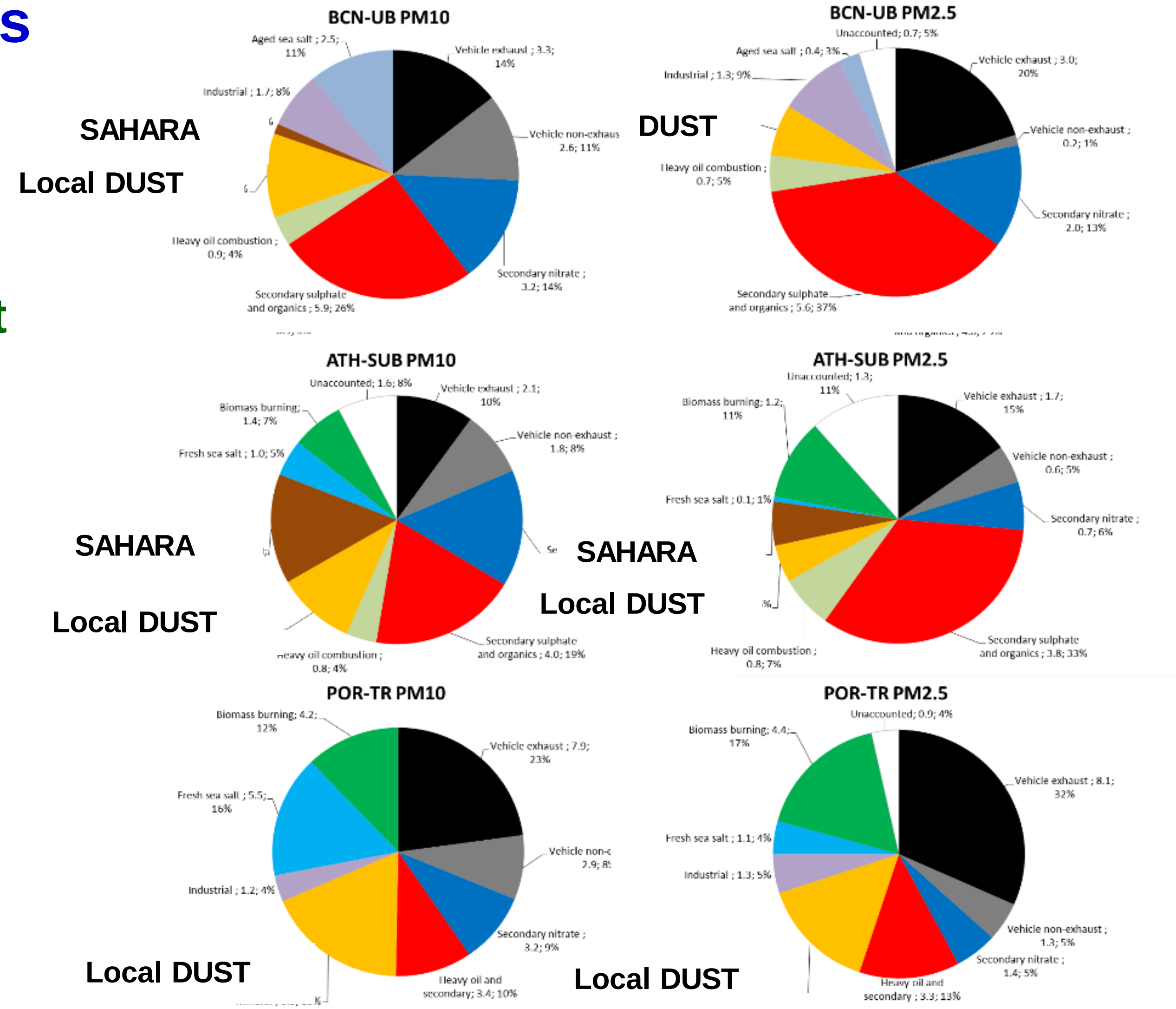
Ref: Almeida et al., 2006

The problem of differentiating natural from anthropogenic dust in urban areas

PMF
Source Apportionment of urban aerosol from Jan13 to Feb14

AIRUSE Project

BCN-UB - Barcelona
ATH-SUB - Athens
POR-TR - Porto



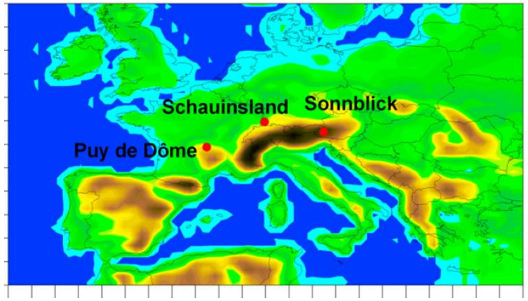
Ref: Amato et al., subm APC (2015)

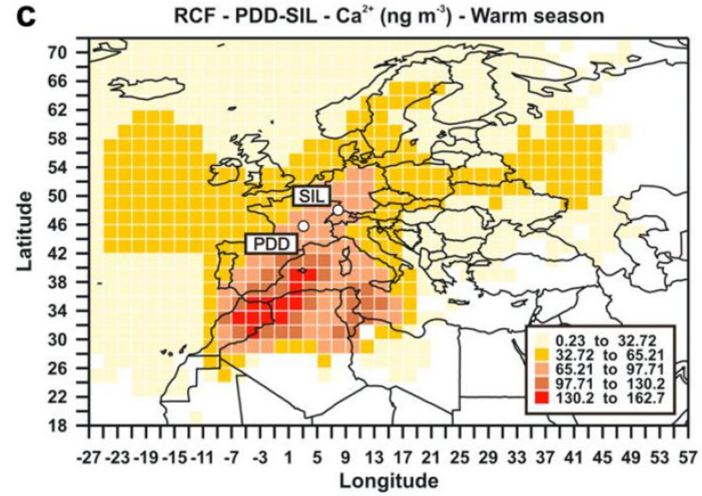
Back-Trajectory Statistical Methods. Redistributed Concentration Field method (RCF)

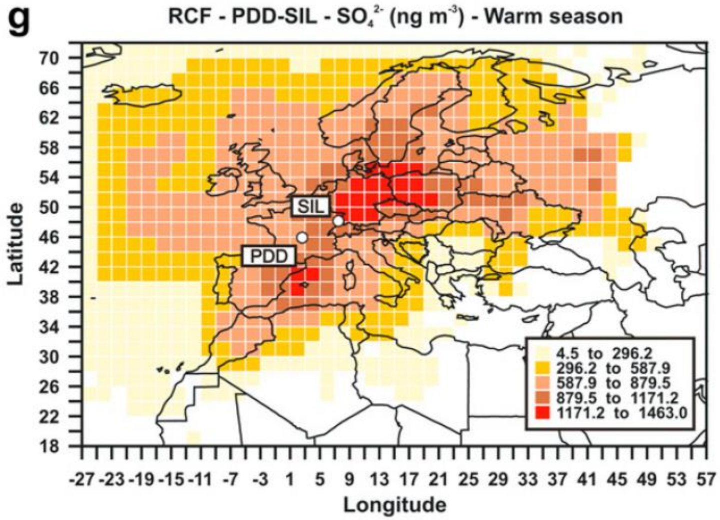
(Stohl, 1996)

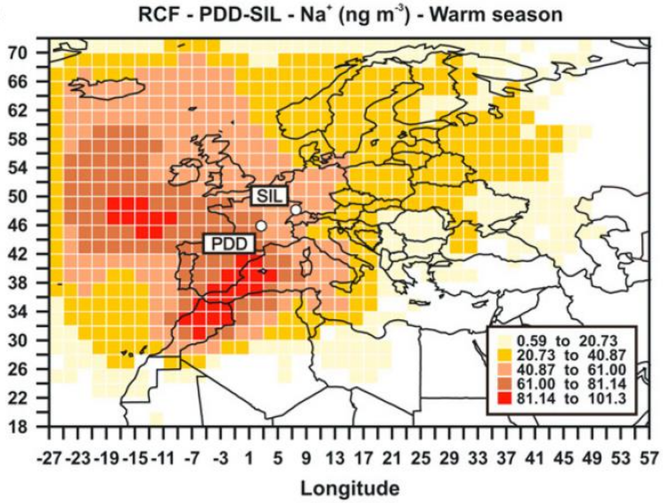
Compounds footprint applied to CARBOSOL measured compounds at mountain sites

ref: Salvador et al., (2010)









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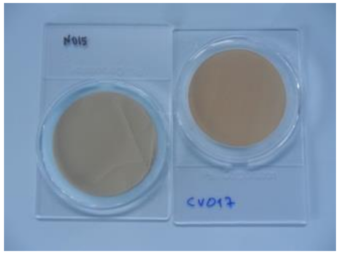
Monitoring and Sampling:

Performed at Cape Verde, Praia during one year (Jan2011-Jan2012)



Equipment:

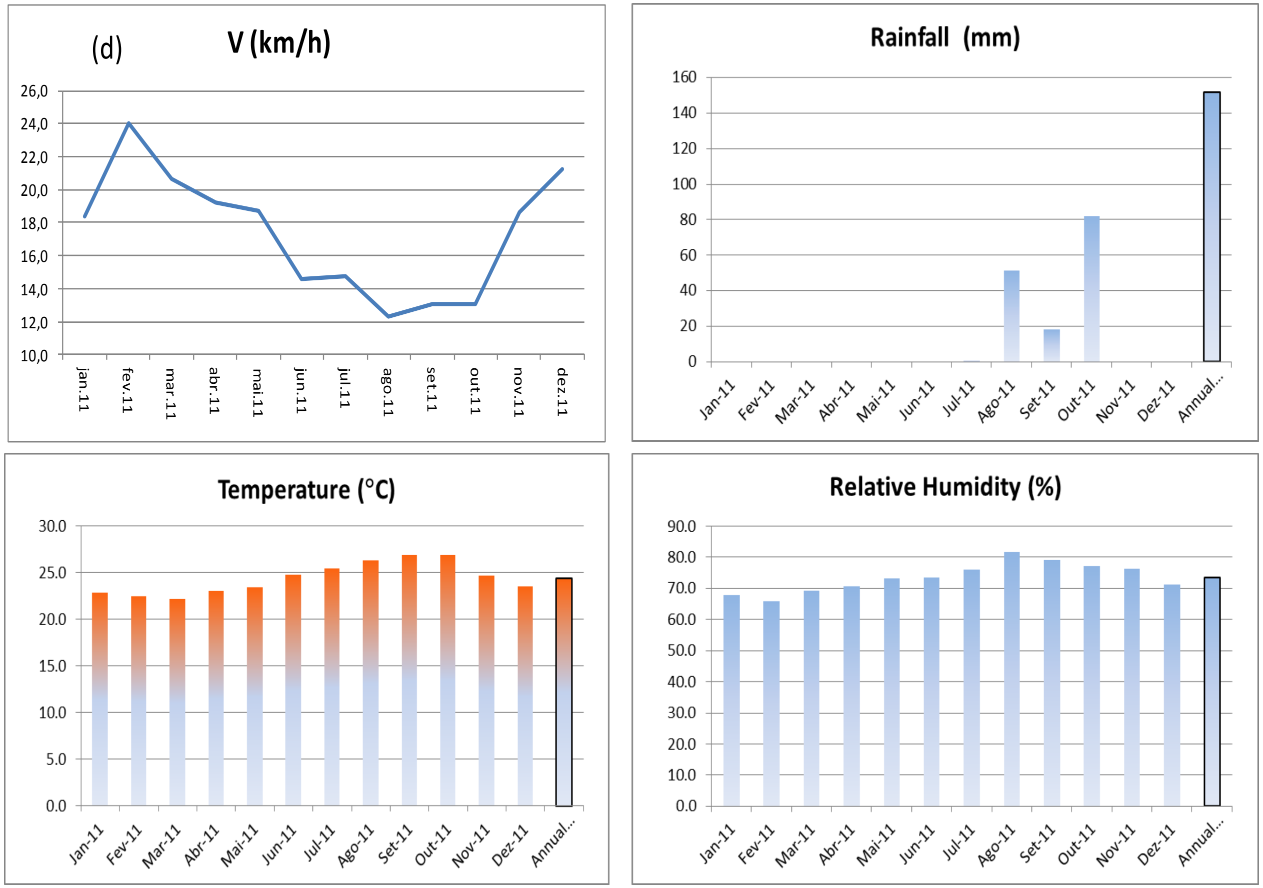
2 PM10 LowVol filter samplers; 1 PM10 HighVol filter sampler

Chemical characterization of collected samples:

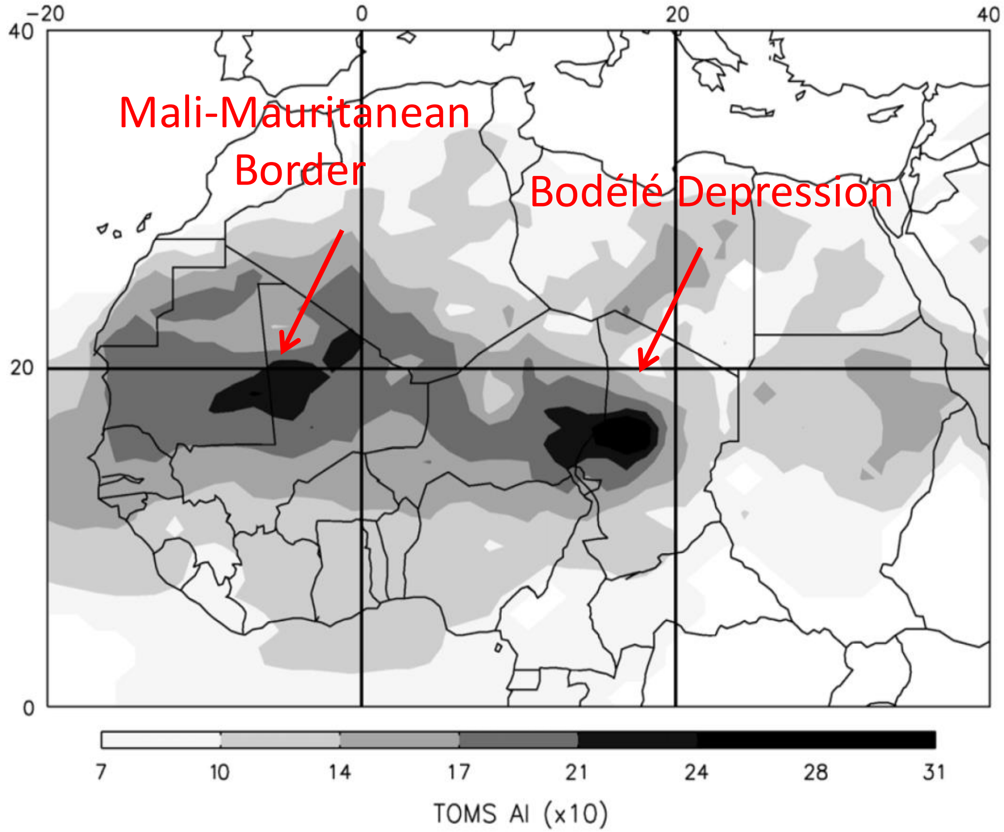
PM10 mass concentration; Water Soluble ions; Carbonate and Carbonaceous forms; Elemental Composition (PIXE; INAA)

Monthly averaged meteorological conditions at Praia, during 2011

- **Harmattan Trade Winds from North-East, with exception of rainy season**

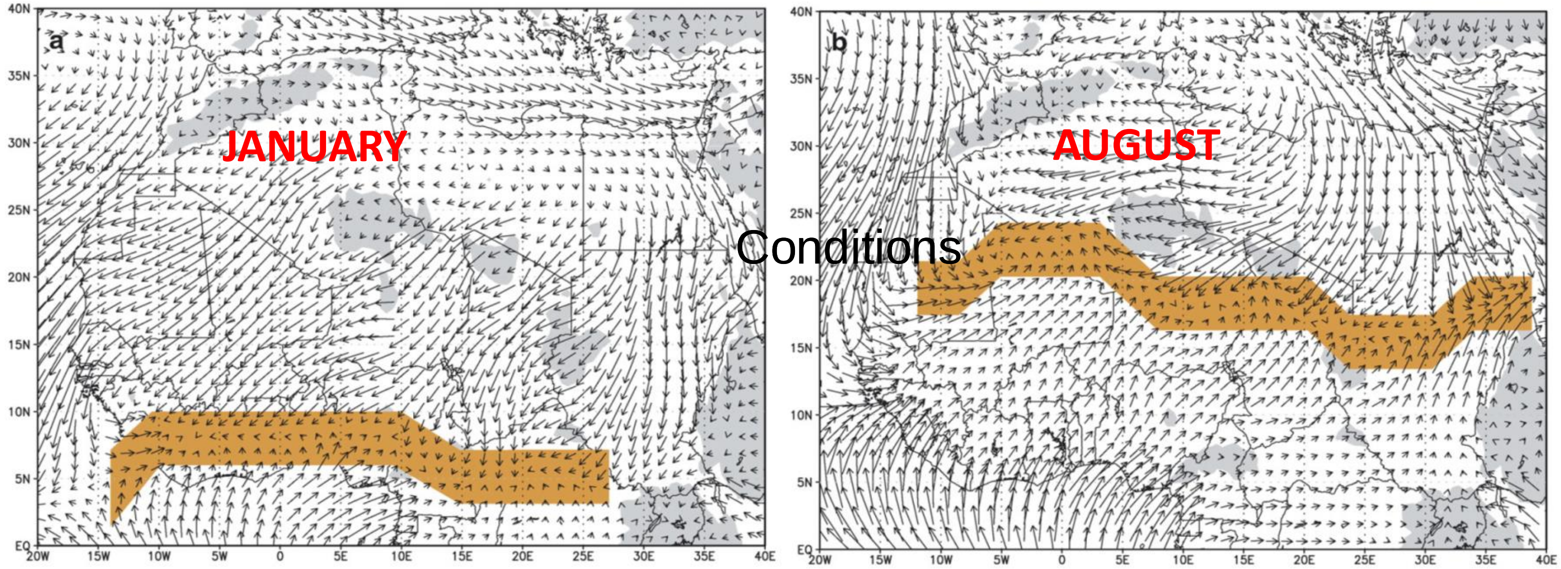


Dust emission Regions in Sahara, from TOMS Abs. Index (1980-92)



(ref: Engelstaedter, 2006)

Why “Bruma Seca” Season during October-April periods?



Surface wind Speed in North Africa (1980-92). ITCZ in orange (ref: Engelstaedter, 2006)

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Quality prevention / Quality Control

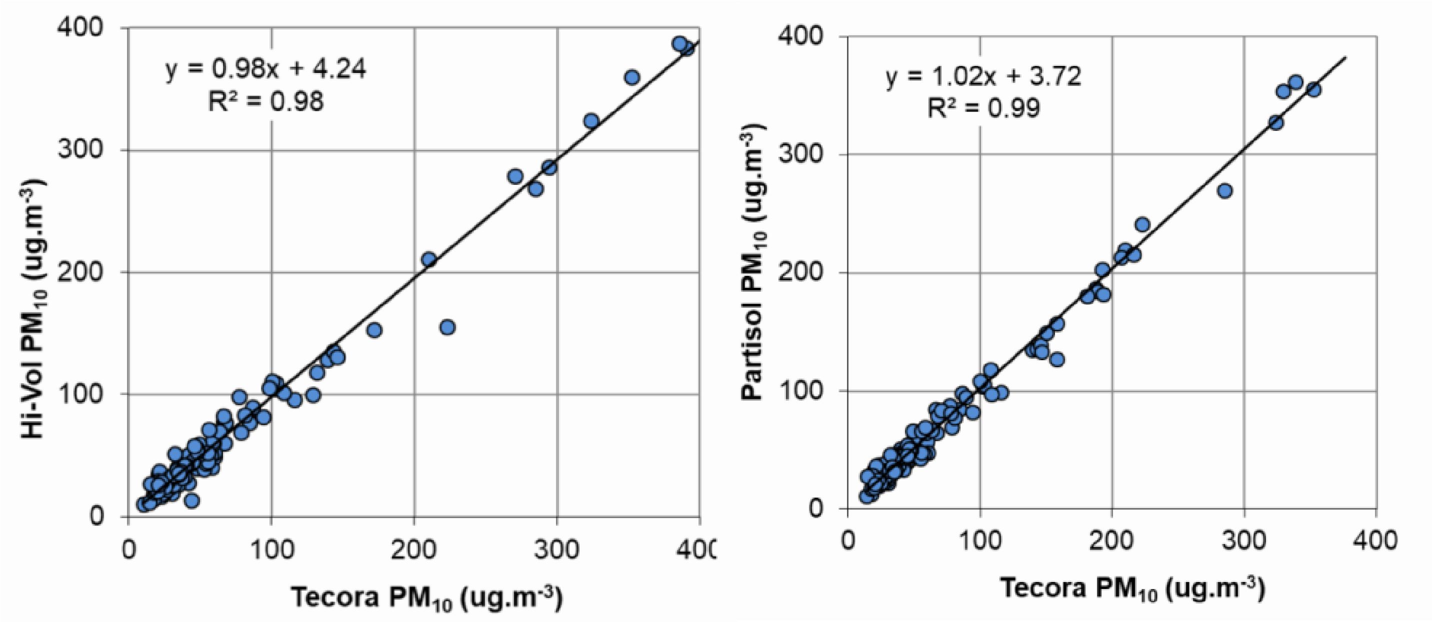
- Initial station mounting and training at Aveiro
- Prevention for electric supply instabilities and failure
- Spare equipment and spare parts
- Tough program of frequent testing, calibration and maintenance
- Close contacts and rapid answer to new situations
- Rapid evaluation of collected samples and data
- Continuous inter-comparison of results during analysis
- Inter-calibration with external equipment

87% measuring efficiency

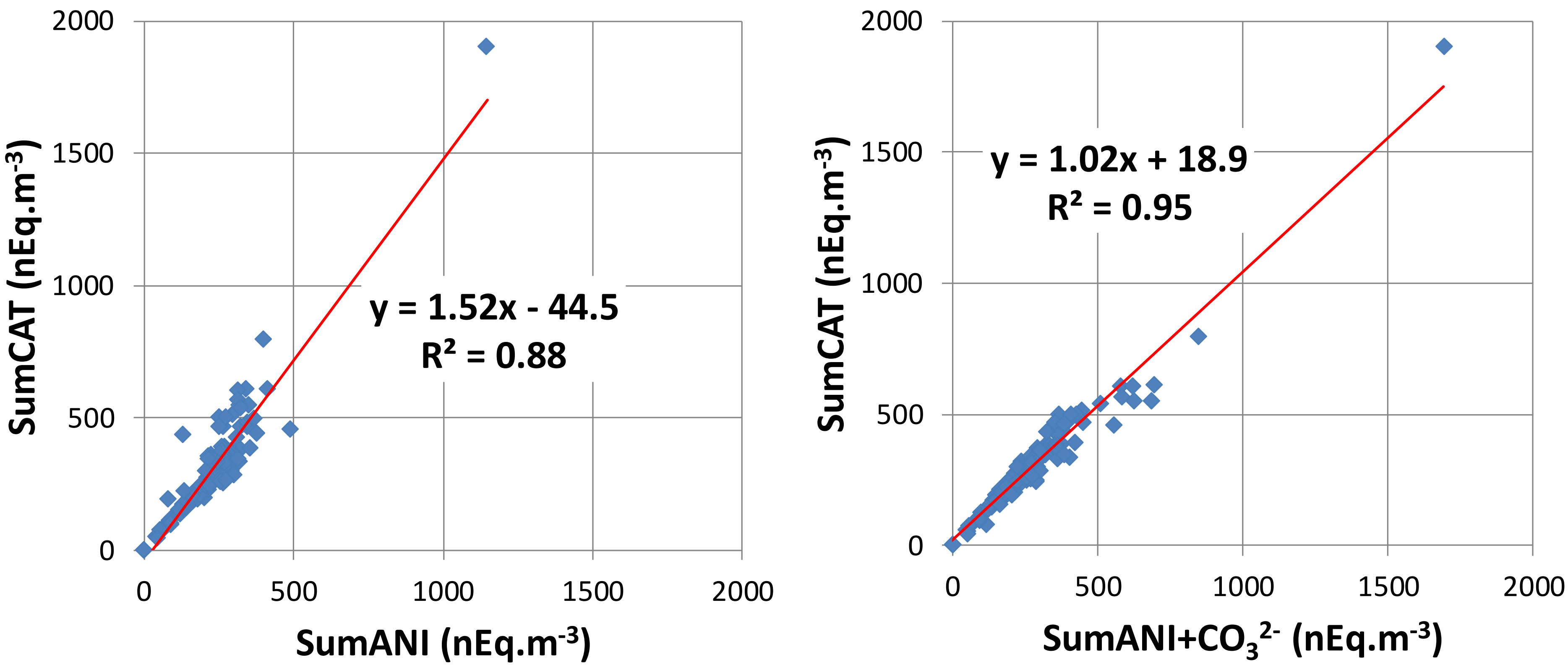
140 PM10 filtering periods
11 HV Impactor sampling periods
5 Berner Impactor sampling periods

24 HV flow calibrations
25 LV flow calibrations

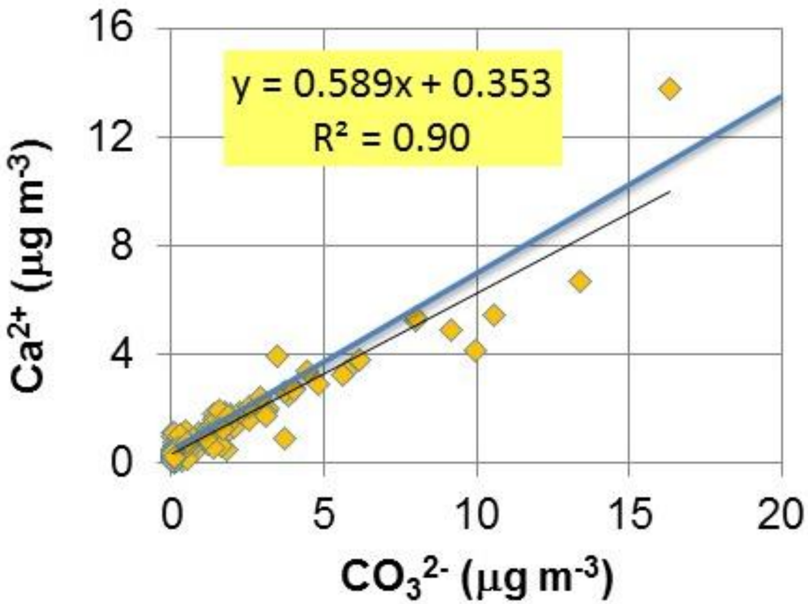
Mass balance evaluation and comparison



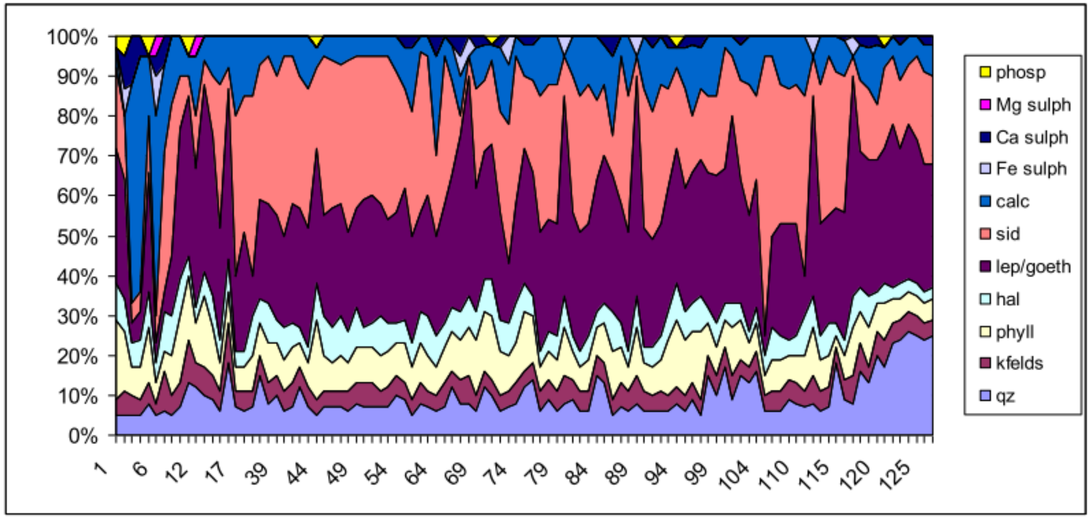
Ionic Balance without and with Carbonates



Evaluation of Calcium carbonate presence



XRD mineral composition of aerosol dust during the whole sampling period



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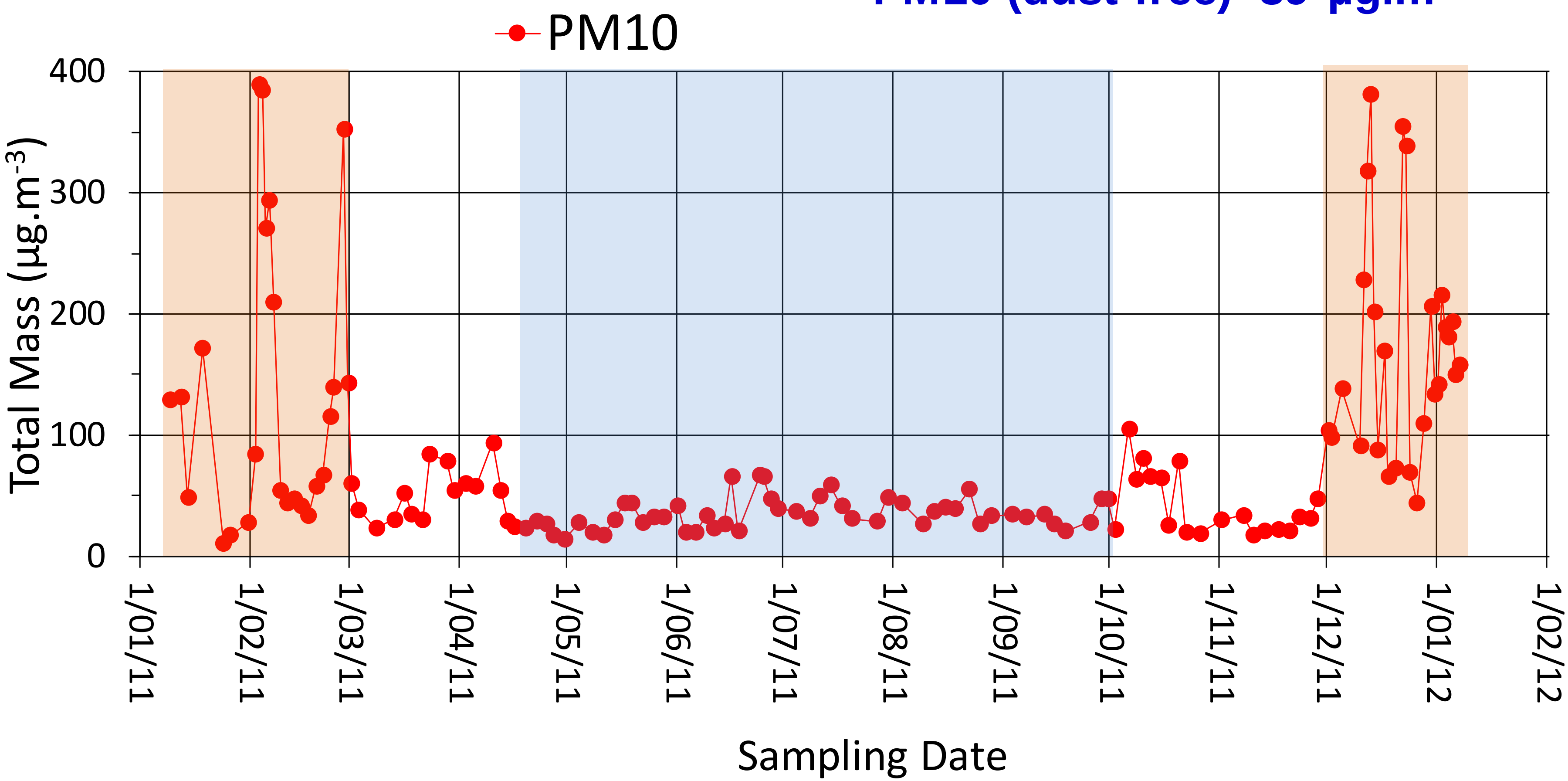
PM10 (dry-haze)=117 µg.m^{-3}

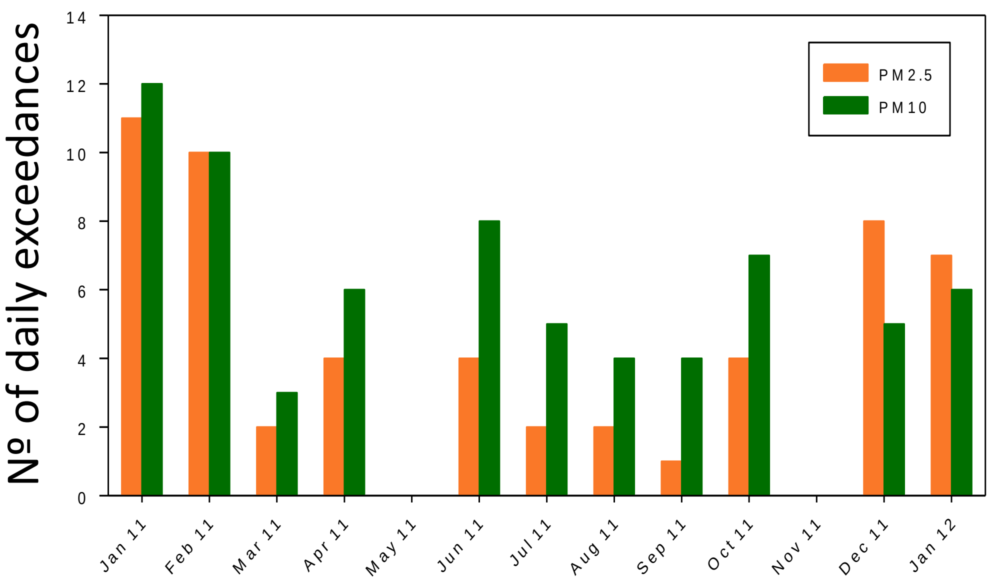
PM10 (dust-free)=39 µg.m^{-3}



Particulate Pollution Levels and daily exceedances, at Praia

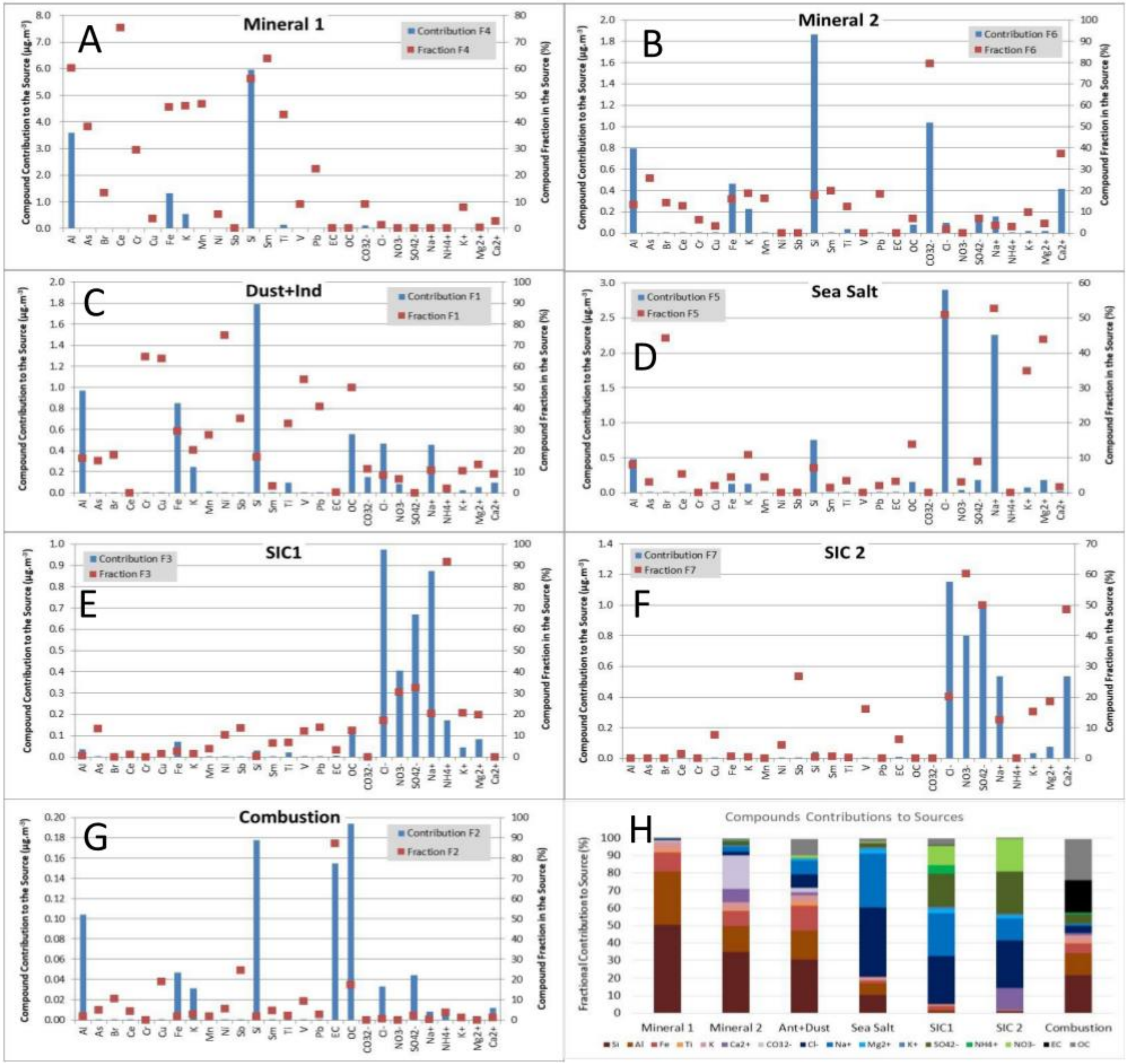
- Particulate pollution levels clearly exceed WHO Guides and probably affect local Human Health, principally during "BRUMA SECA" Season

Parameter	Annual Average* (μg/m³)	WHO Guide Values (μg/m³)
$PM_{2.5}$	17.5	10
PM_{10}	37.5	20
TSP	66.0	-

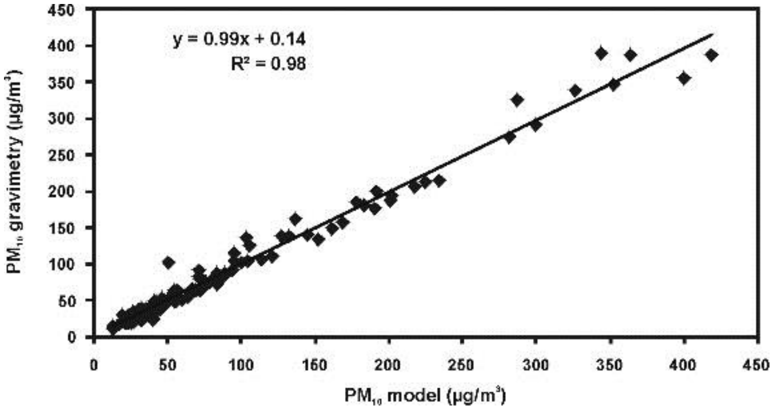


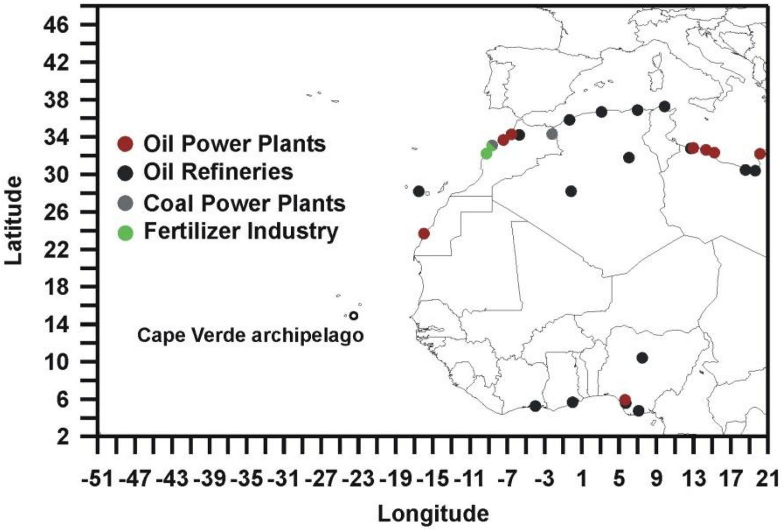
PMF Analysis

PMF Source Contributions and Profiles for the seven identified factors (Graphs A-G). Graph H presents the fraction contribution of each main compound to each source.



PMF Analysis: Continuation





70% Soil

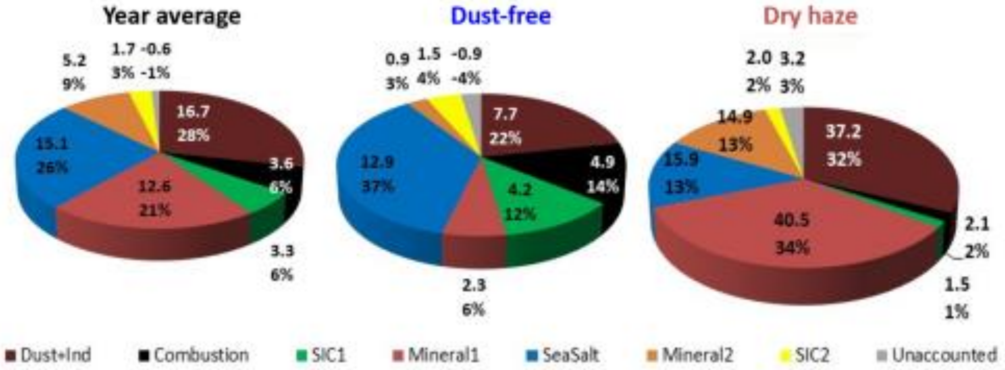
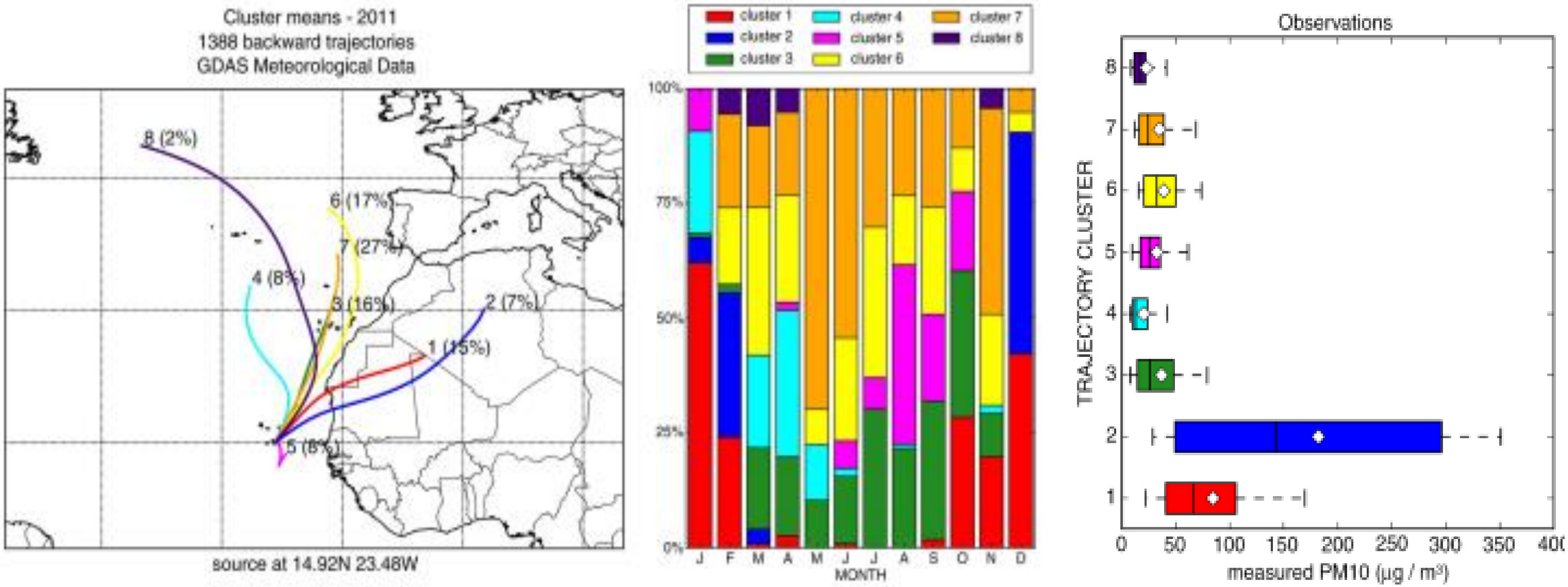


Figure 6. PMF source apportionment results for the total campaign and during the two pollution seasons. Values are in $\mu g\,m^{-3}$ and percentage of measured total mass.

Backward Trajectory Analysis and concentrations



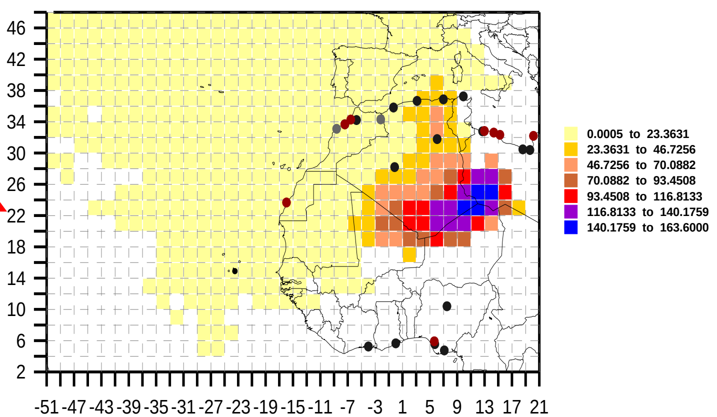
ref: Gama et al., (2015)

Back-Trajectory Statistical Analysis. Redistributed Concentration Field method (RCF)

❖ **RCF applied to PMF Source calculated contributions**

Clay Mineral

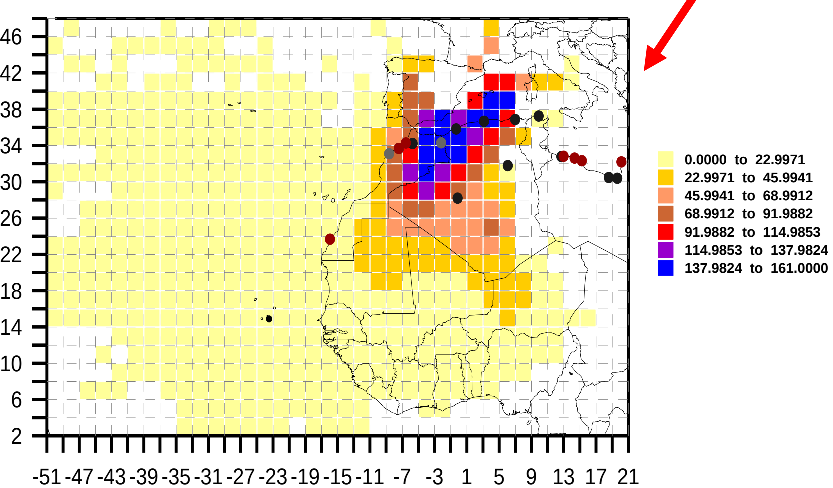
RCF PMF: ARCILLAS
Back-trajectories 500 m AGL



Soil dust Footprint

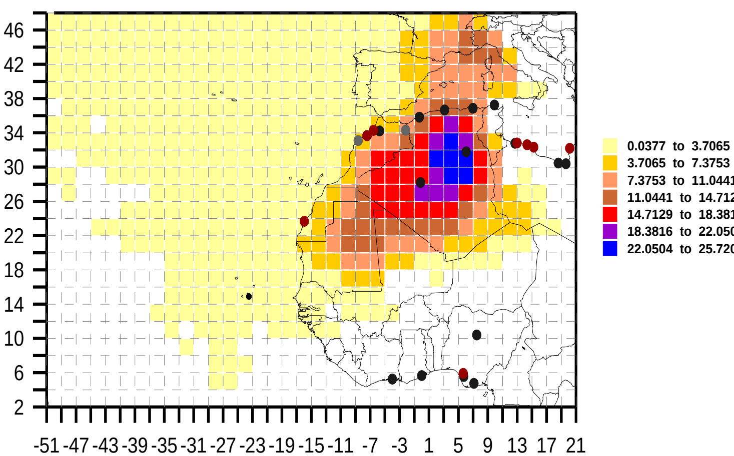
Dust+Industrial

RCF PMF: INDUSTRIAL
Back-trajectories 1500 m AGL



Carbonates

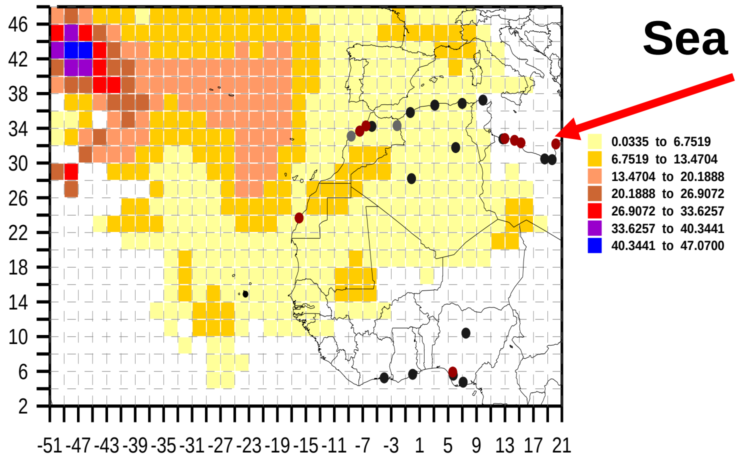
RCF PMF: CARBONATOS
Back-trajectories 500 m AGL



Redistributed Concentration Field method (RCF)

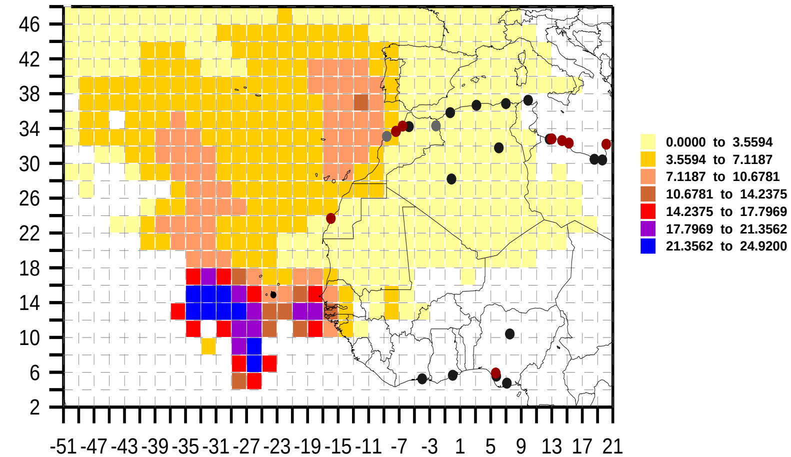
Non Soil Sources

RCF PMF: MARINE
Back-trajectories 500 m AGL



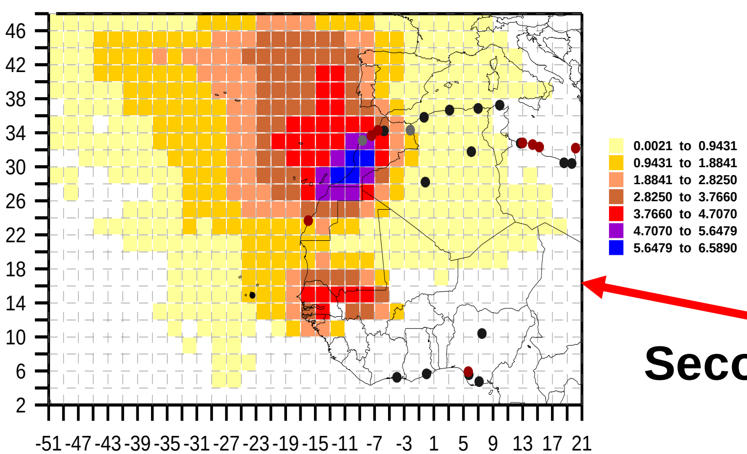
Sea salt

RCF PMF: COMBUSTION
Back-trajectories 500 m AGL



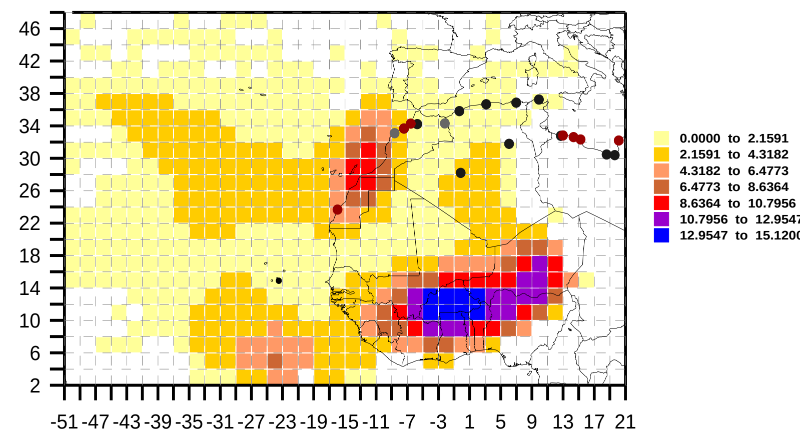
Combustion

RCF PMF: CIS
Back-trajectories 500 m AGL



Secondary

RCF PMF: COMBUSTION2
Back-trajectories 1500 m AGL



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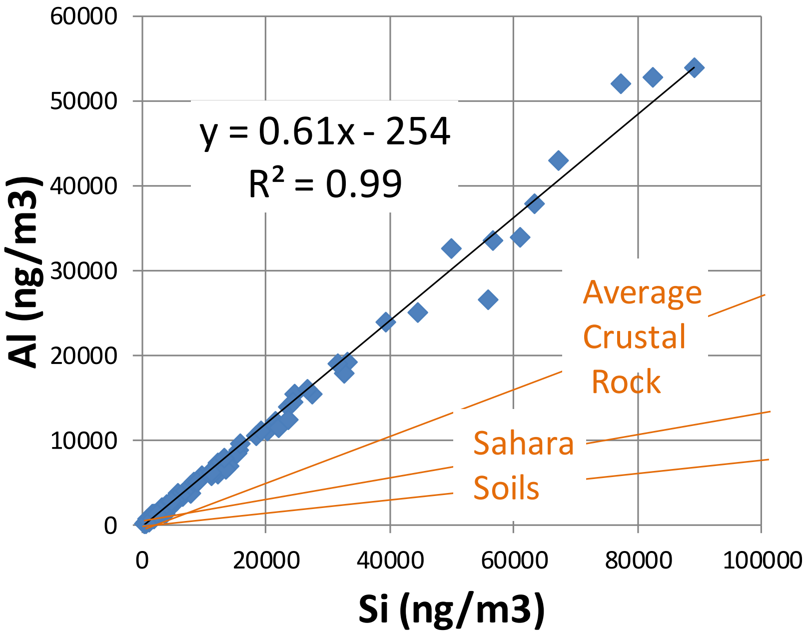
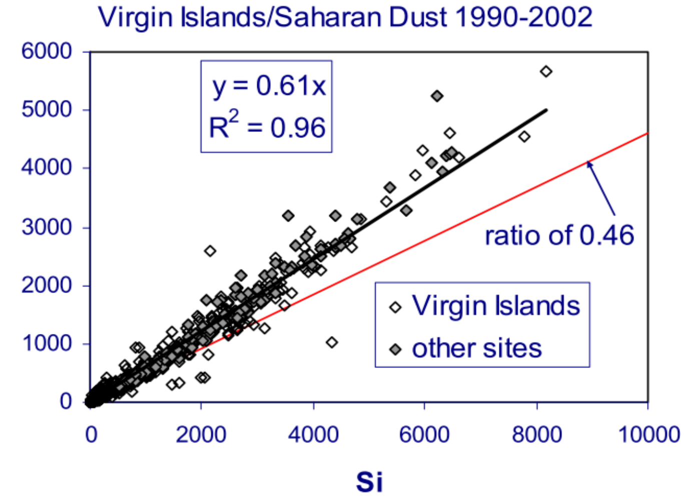
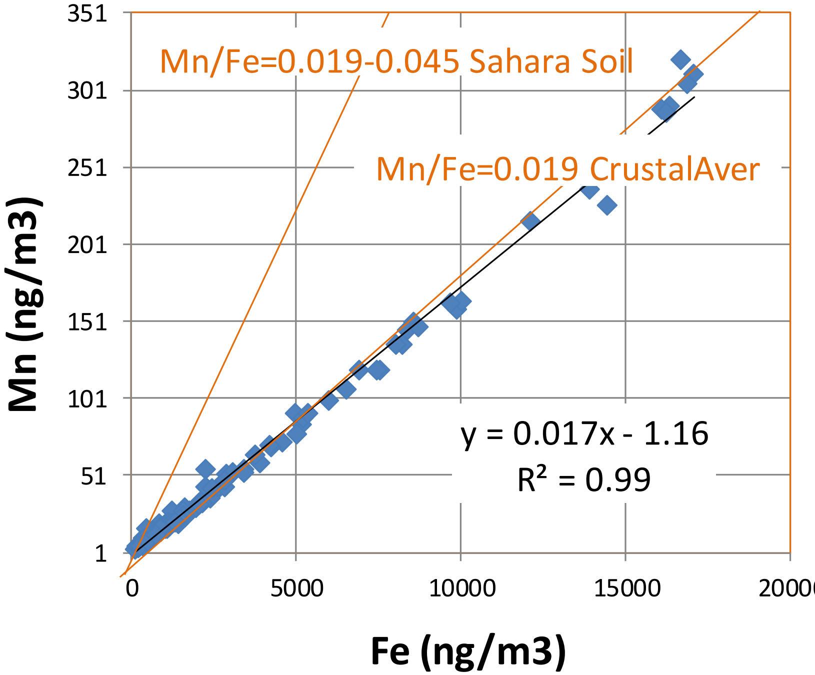


Comparison of Al and Si for samples at the Virgin Islands and at continental sites during selected summer episodes. All units are ng/m3 (ref: Eldred 2003)



Ratios of soil dust elements in CV aerosol and comparison with Sahara Soils and crustal averages



Concentrations of major elemental species (as oxides) at nine sites in Sahara region, according to Moreno et al., (2006), and average crustal levels taken from Manson and Moore, (1982). The table presents also the estimation of factor F

Soil dust mass =SiO2 + Al2O3 + Fe2O3 + MnO + TiO2 + etc.

Soil dust mass =F(2.14Si + 1.89Al + 1.43Fe+ 1.39Mn + 1.67Ti + etc.)

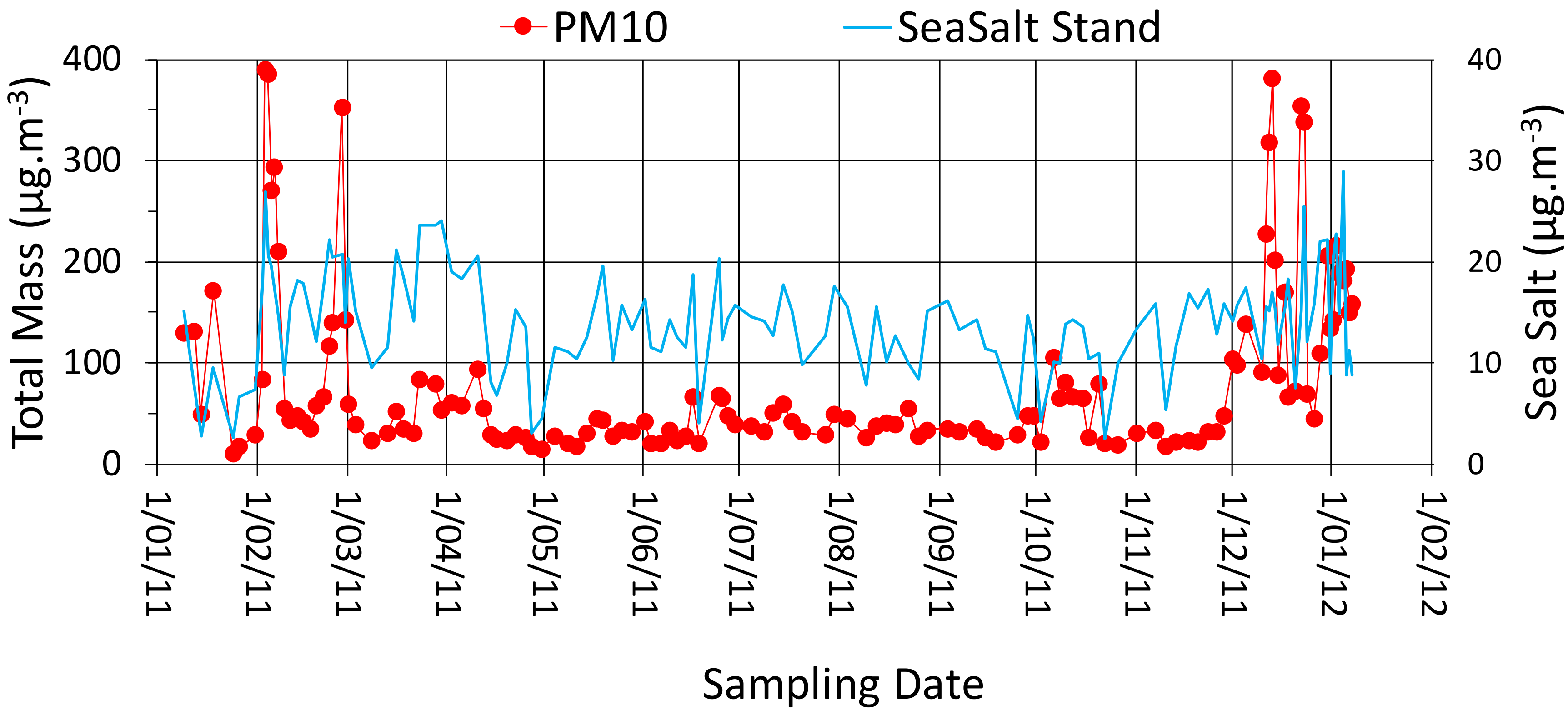
Soil dust =1.15(2.14Si + 1.89Al + 1.43Fe + 1.39Mn + 1.67Ti +1.66MgSoil + 1.40Casoil + 1.20Ksoil),

	CrustalAver	Hoggar Massif		Chad Basin		Niger		Western Sahara			Sahara
		HM1	HM2	CB1	CB2	MON	HAR	WS1	WS2	WS3	Average
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
SiO_2	59.3	62.1	62.5	63.2	70.2	69.5	66.7	49.4	46.2	56.8	60.7
TiO_2	0.7	1.4	1.2	1.0	1.2	1.4	1.2	0.6	0.4	0.9	1.0
Al_2O_3	15.4	14.7	13.6	14.0	11.7	11.6	12.2	8.8	7.0	5.1	11.0
Fe_2O_3	7.2	6.1	5.2	6.7	4.7	4.4	5.7	4.4	2.8	4.2	4.9
MnO	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1
MgO	3.5	1.8	1.6	1.2	0.8	0.5	0.9	2.9	2.6	1.9	1.6
CaO	5.1	2.4	2.0	1.4	1.4	0.4	1.6	12.9	17.7	12.2	5.8
K_2O	3.1	2.5	2.5	1.5	1.5	1.2	1.8	1.9	1.7	1.4	1.8
SUM	**94.4**	**91.0**	**88.6**	**89.0**	**91.5**	**88.9**	**90.1**	**80.9**	**78.5**	**82.6**	**86.8**
Na_2O	3.8	1.6	1.9	1.1	0.5	0.4	0.6	0.9	0.7	0.8	0.9
P_2O_5	3.1	2.5	2.5	1.5	1.5	1.2	1.8	1.9	1.7	1.4	1.8
SO_3	0.1	0.2	0.2	0.3	0.2	0.0	0.1	0.1	0.1	0.1	0.1
TOTAL	**98.5**	**93.1**	**91.0**	**90.6**	**92.3**	**89.4**	**91.0**	**82.2**	**79.7**	**83.9**	**88.1**

F=100/86.8= 1.15

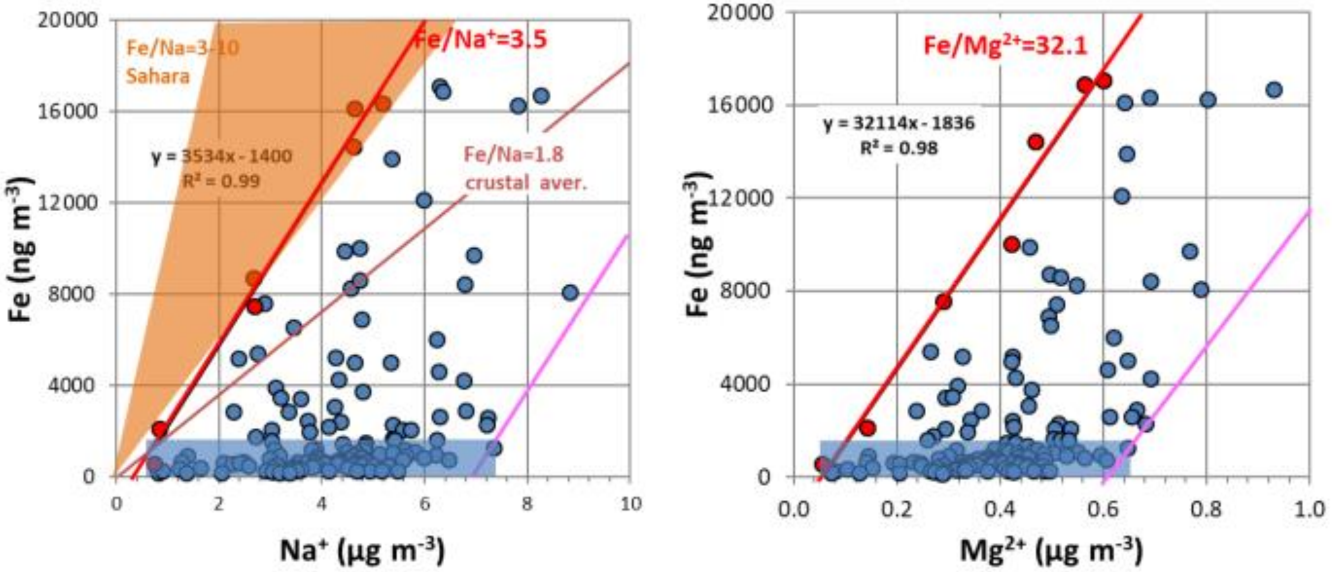
Sea Salt concentrations calculated from the values of Na^+

:Sea Salt increases during dust intrusions



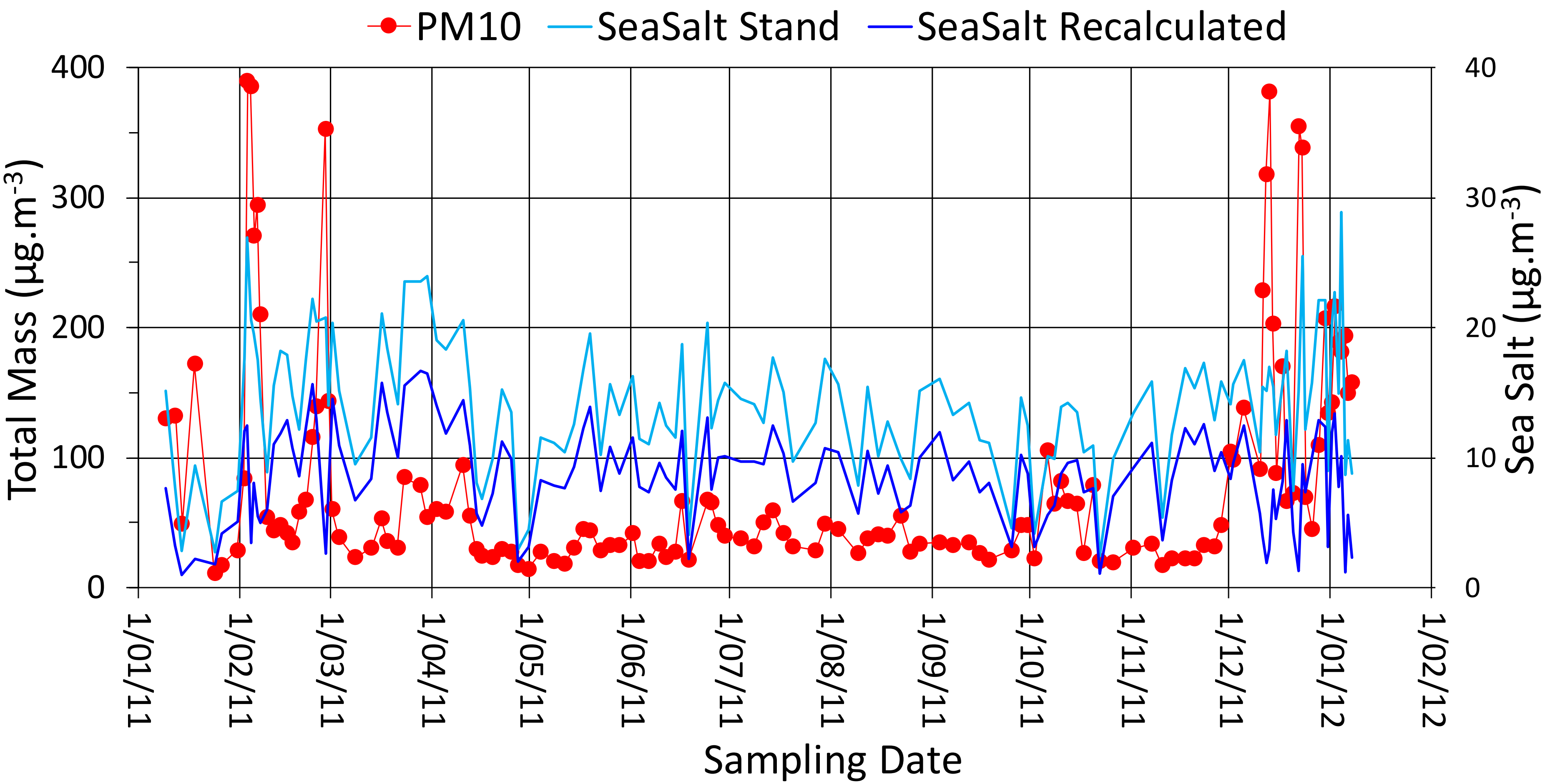
Mass and Ionic Balance for Sea Salt:

1. Start calculating SoilNa$^+$ and SoilMg^{2+} from Fe/Na$^+$ and Fe/Mg^{2+} edge lines.
2. Recalculate Sea Salt Na$^+$ and Mg^{2+} using Na/Mg ratio in sea water.
3. Calculate Sea Salt Mass concentration and Composition from sea water ratios.



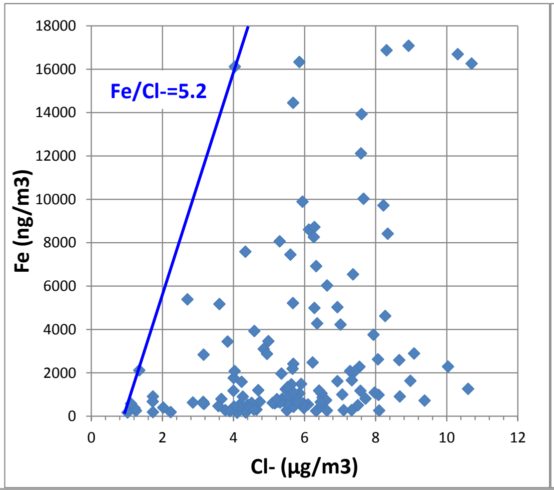
SeaSaltStand (dry-haze)= 14.2 µg.m^{-3}
SeaSaltStand (dust-free)= 14.1 µg.m^{-3}

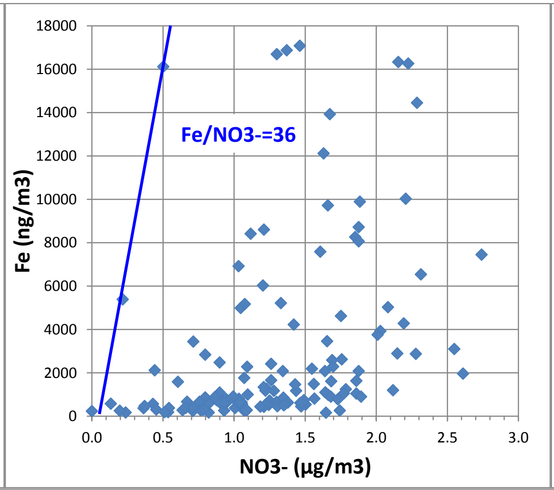
SeaSaltRec (dry-haze)= 7.8 µg.m^{-3} (7%)
SeaSaltRec (dust-free)= 9.7 µg.m^{-3} (25%)

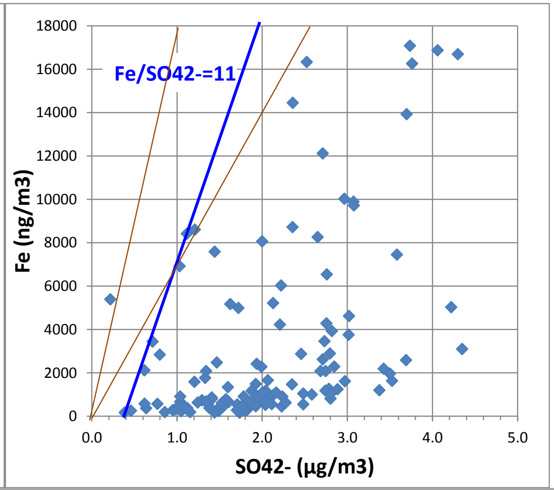


Ionic Balance (continuation):

4. From difference between total and sea salt calculate soil Na^{+}, Mg^{2+}, K^{+} and Ca^{2+}.
5. Calculate Non Sea Salt SO_4^{2-}, NO_3^{-} and Cl^{-}.
6. Associate sequentially free SO_4^{2-} and NO_3^{-} with NH^{4+} until all NH^{4+} is neutralized.
7. Associate free NO_3^{-} sequentially with free sea salt cations and dust cations.
8. Associate totally CO_3^{2-}, sequentially with free soil Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}
9. Associate free Sulphate sequentially wit Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}
10. Associate free Cl^{-} with free Na^{+} and Mg^{2+}. Any excess Cl^{-} is associated with K^{+}
11. Calculate total masses of water soluble soil sulphate, nitrate and chloride.
12. Edge line ratios between Fe and sulphates, nitrates and chlorides permit a rough calculation of the fraction of these compounds that are present in the soil or that result from secondary reaction with atmospheric produced acids.







Calculation of Water Soluble dust and Secondary Inorganic Compounds

SoilDust $_{\text{WaterSoluble}}$ (dry-haze)= 6.6 µg.m^{-3}
SoilDust $_{\text{WaterSoluble}}$ (dust-free)= 0.8 µg.m^{-3}

SIC $_{\text{ammonium}}$ (dry-haze)= 0.4 µg.m^{-3}
SIC $_{\text{ammonium}}$ (dust-free)= 1.1 µg.m^{-3}

SIC $_{\text{SSalt+Dust}}$ (dry-haze)= 1.8 µg.m^{-3}
SIC $_{\text{SSalt+Dust}}$ (dust-free)= 2.4 µg.m^{-3}

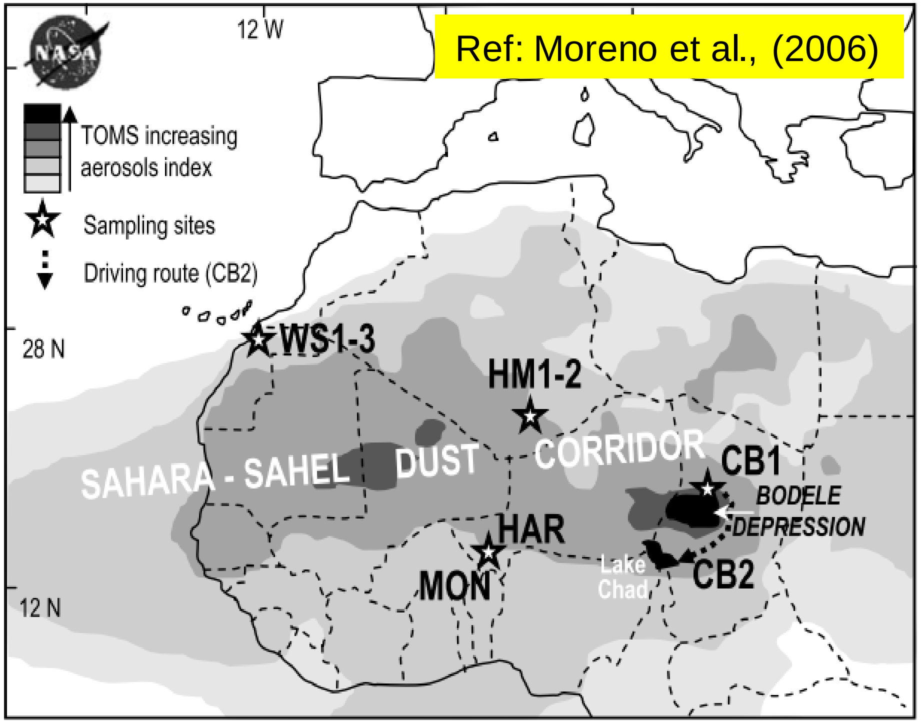
Carbonaceous (dry-haze)= 2.5 µg.m^{-3}
Carbonaceous (dust-free)= 2.1 µg.m^{-3}

OM=1.8*OC

Calculation of Soil Dust from elemental aerosol composition

MM82 - ref Manson and Moore (1982)

	MM(82)	Moreno et al., (2006)			
	Crustal Average	Algeria HM1-HM2	Chad CB1-CB2	Niger MON/HAR	WesSahara WS1-3
	(%)	(%)	(%)	(%)	(%)
SiO2	59.3	62.3	66.7	68.1	50.8
TiO2	0.7	1.3	1.1	1.3	0.7
Al2O3	15.4	14.2	12.8	11.9	7.0
Fe2O3	7.2	5.6	5.7	5.0	3.8
MnO	0.1	0.1	0.1	0.1	0.1
MgO	3.5	1.7	1.0	0.7	2.5
CaO	5.1				
Na2O	3.8	1.8	0.8	0.5	0.8
K2O	3.1	2.5	1.5	1.5	1.7
P2O5	0.2	0.3	0.2	0.1	0.3
SO3	0.1				
SO42-		0.2	0.3	0.1	0.1
CaCO3		3.3	2.1	1.5	21.1
SUM	98.5	93.1	92.2	90.7	88.8
SUM-P2O5	98.2	92.9	92.0	90.6	88.4
		AVERAGE=			**91.0**

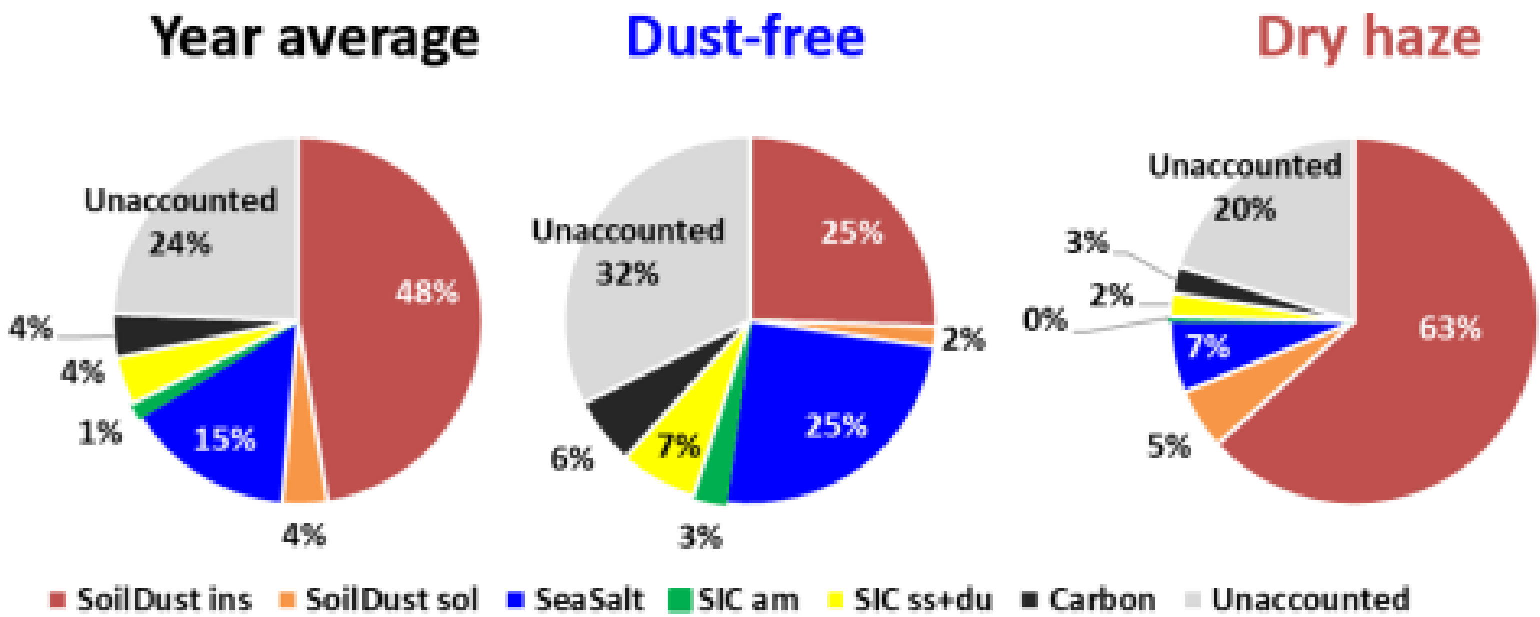


Soil Dust= $(SiO_2+TiO_2+Al_2O_3+Fe_2O_3+MnO+MgO_{ins}+CaO_{ins}+K_2O_{ins}+SO_{3ins}+\mathbf{Dust_{sol}-Dust_{SIC}})/\mathbf{0.91}$

Soil Dust (dry-haze)=83.3 µg.m^{-3} (71%)

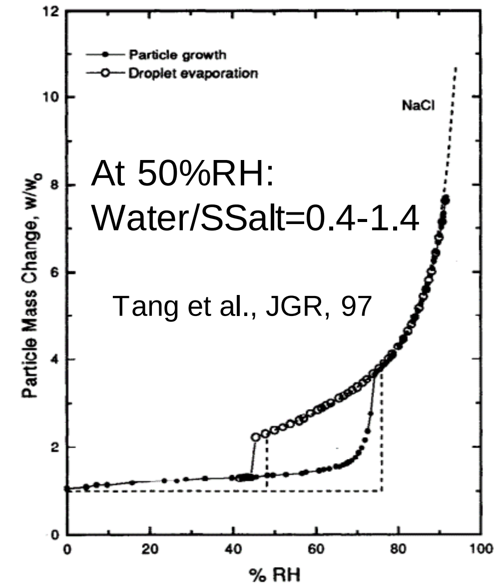
Soil Dust (dust-free)=12.7 µg.m^{-3} (33%)

Mass Balance accounts only for 76% of PM10 measured mass

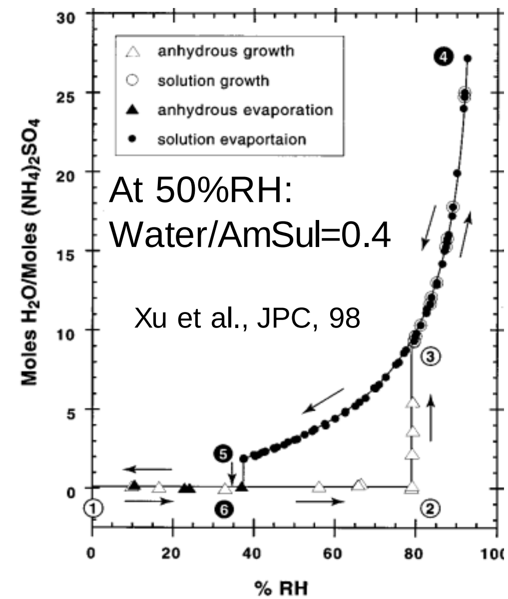


Aerosol Water

(Filters weighted
at 50% RH)



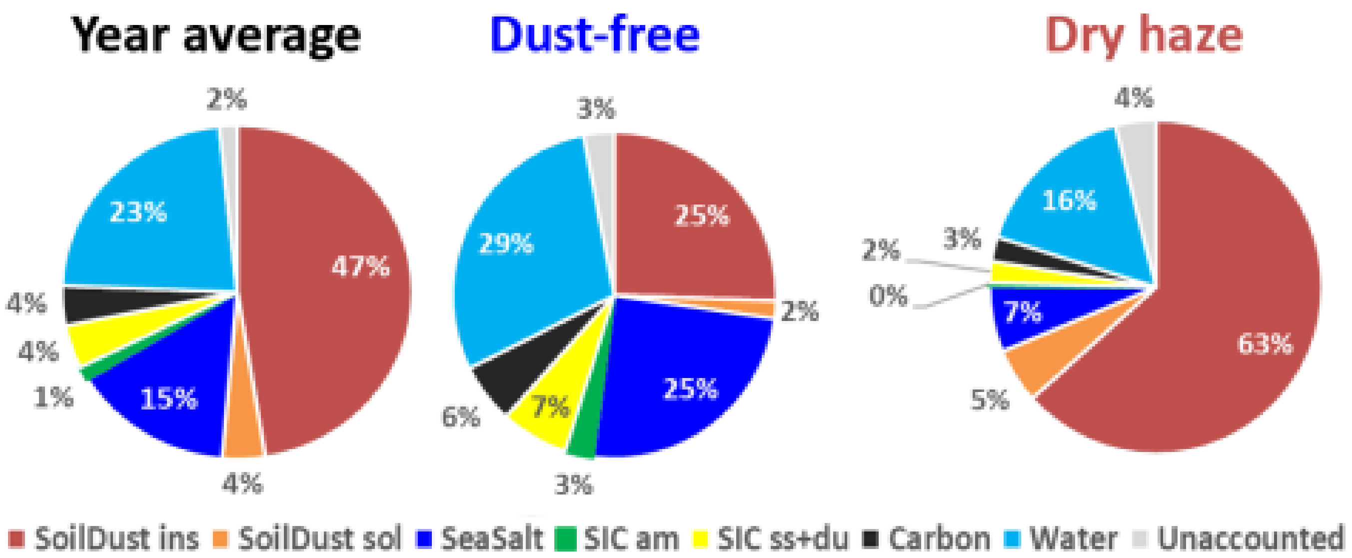
Water in Sea Salt =0.9*SS
Water in SIC AmSul=0.4*AmSul
Water in Organic Matter=0.2*OC
Water in Soluble Dust=0.4*SoilDu ws



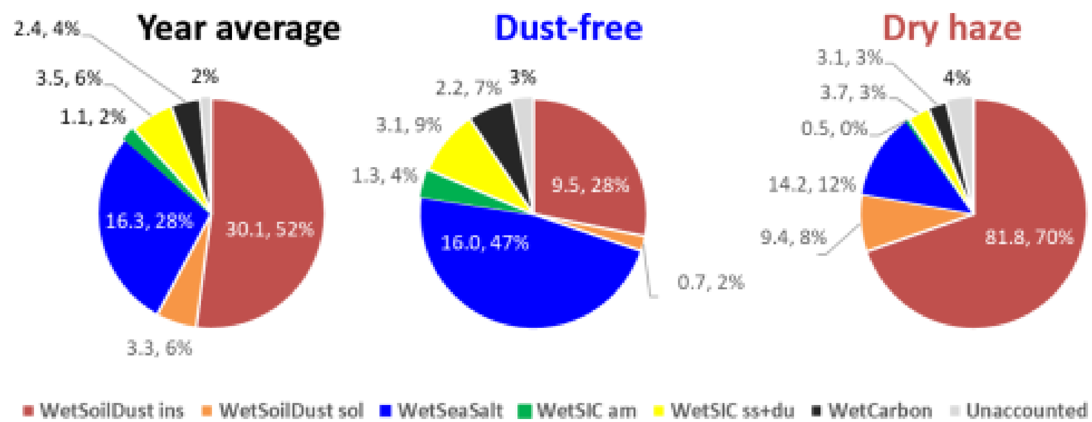
References:

(Harrison et al., 2003)	Water=0.29*AmSulphate
(Speer et al. (2003)	Water=0.45*AmSulphate
(Speer et al. (2003)	Water=0.20*OC
(Xu et al.)	Water=0.4*AmSulphate
(Tang et al.,	Water=1.4*SeaSalt (eflorescence)
	Water=0.4*SeaSalt (deliquescence)

Final Results of Material / Ionic Balance for dust-free and dry-fog periods

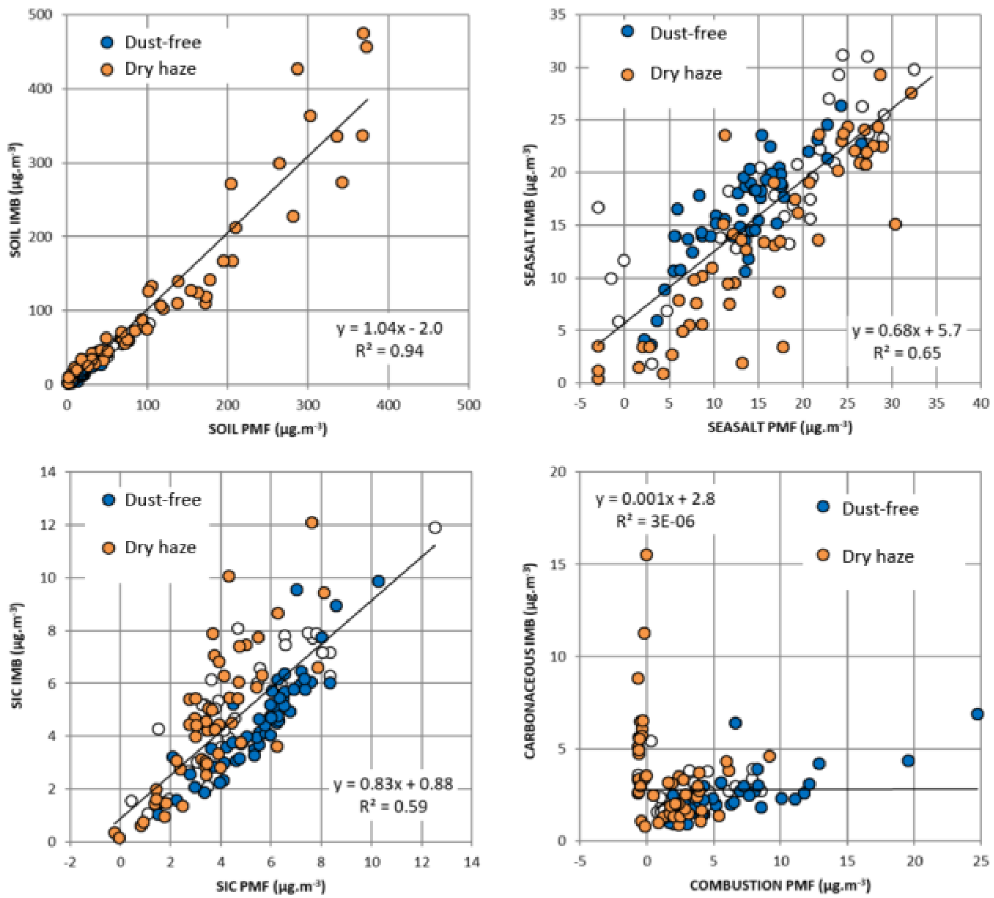


Comparison of Mass Balance and PMF Results



	Year Average		Dry-Haze		Dust-Free	
	PMF (µg/m3)	MassBal (µg/m3)	PMF (µg/m3)	MassBal (µg/m3)	PMF (µg/m3)	MassBal (µg/m3)
Soil	34.7	33.5	92.6	91.2	10.8	10.2
SeaSalt	15.1	16.3	15.9	14.2	12.9	16.0
SIC	4.8	4.6	3.5	4.2	5.4	4.4
Carbon	3.7	2.4	2.1	3.1	5.0	2.2
SUM	**58.3**	**56.8**	**114.1**	**112.7**	**34.1**	**32.8**
PM10	**57.7**		**117.3**		**33.9**	

Ref: Salvador et al., (2016)


Dust-free
Dry haze
y = 1.04x - 2.0
R² = 0.94
SOIL IMB (µg.m⁻³)
SOIL PMF (µg.m⁻³)
Dust-free
Dry haze
y = 0.68x + 5.7
R² = 0.65
SEASALT IMB (µg.m⁻³)
SEASALT PMF (µg.m⁻³)
Dust-free
Dry haze
y = 0.83x + 0.88
R² = 0.59
SIC IMB (µg.m⁻³)
SIC PMF (µg.m⁻³)
y = 0.001x + 2.8
R² = 3E-06
Dust-free
Dry haze
CARBONACEOUS IMB (µg.m⁻³)
COMBUSTION PMF (µg.m⁻³)

Thanks for your attention!

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CVDUST
Measurements with the GRIMM Spectrometer

Evaluation of GRIMM measurements and size distributions

Grimm is Optical Aerosol Spectrometer based on light scattering by particles

(0.25->32µm)
31 channels

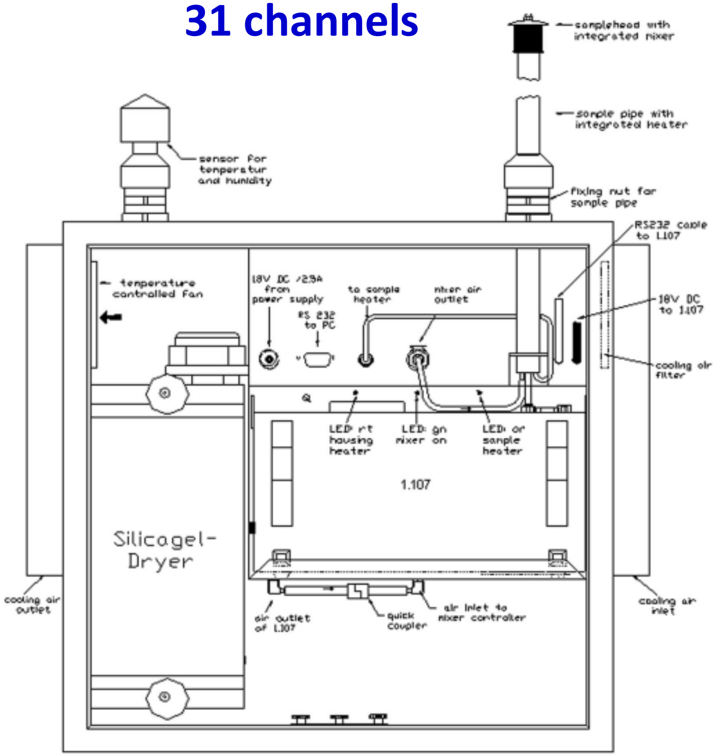
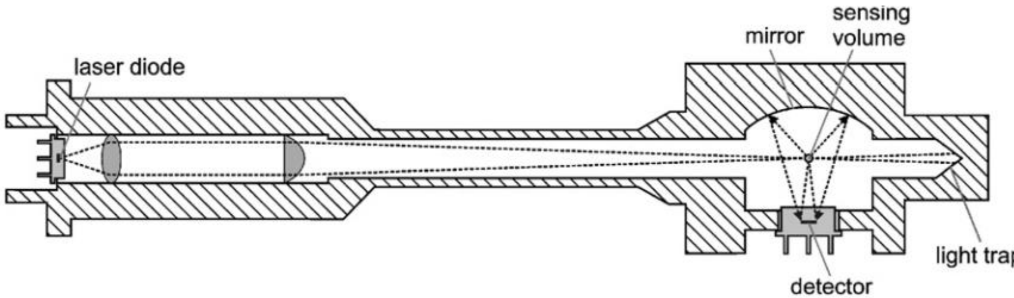
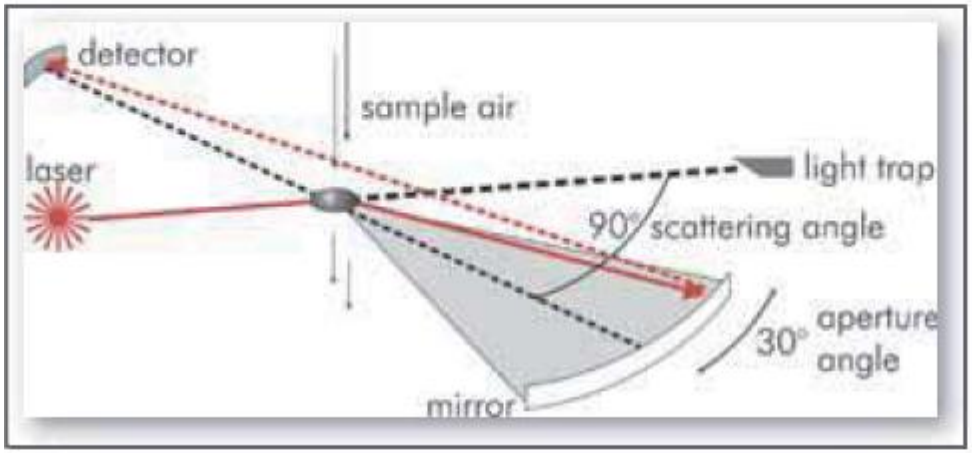


Figure 1. Details of the GRIMM model 1.107 monitor.





Light Scattering is described by Maxwell's Equations.

For aerosol:

- The intensity scattering function can be calculated for spherical particles by Mie theory
- For non-spherical particles by DDA (Discrete Dipole Approximation)

$$I(d,m) = k \cdot \int_{\theta_{start}}^{\theta_{stop}} d^2 \cdot f(\theta,d,m) \cdot \sin(\theta)\, d\theta$$

I – scattering intensity
Θ - angle
d- diameter (form)
m – refractive index

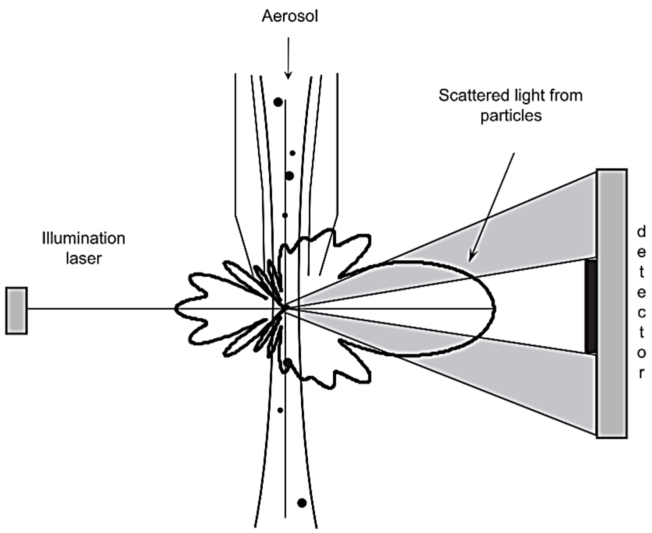
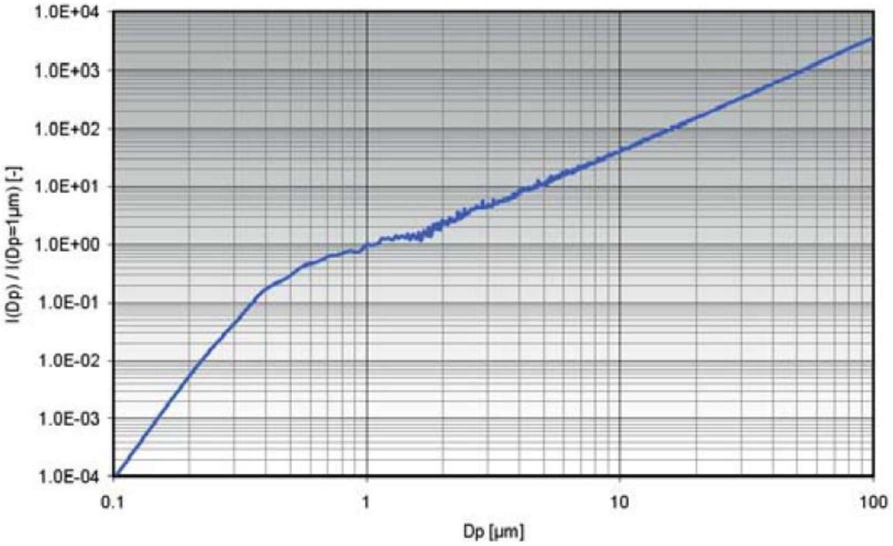


Fig. 1. Schematic diagram of a conventional optical particle spectrometer.

Calibration

All GRIMM Aerosol Spectrometers are calibrated with polystyrene latex (PSL). The calibration curve of the spectrometer illustrates correlation between the particle size and the scattered light system - the basis for a precise particle detection and calculation of masses.

PSL refractive Index – 1.59



Response function for PSL

Characteristics of aerosol dust and particles

aerosol type	density in g/cm^3	dynamic shape factor (>1μm)	refractive index at λ=780 nm	intensity scattering function
PSL	1.06 to 1.12	1.0	1.586	exact solution from Mie theory
sea salt	2.2	1.06	1.51	good solution from Mie theory
dust	2.0 to 2.7	1.2 to 1.3	1.53-i 0.001 to 1.53-i 0.005	'highly uncertainty' using DDA
marine (no sea salt)	1.49	1 to 1.06	1.5-i 0.001	good solution from Mie theory

For our studies we used:

- **Density- 2.5**
- **Dyn. Shape factor – 1.25**

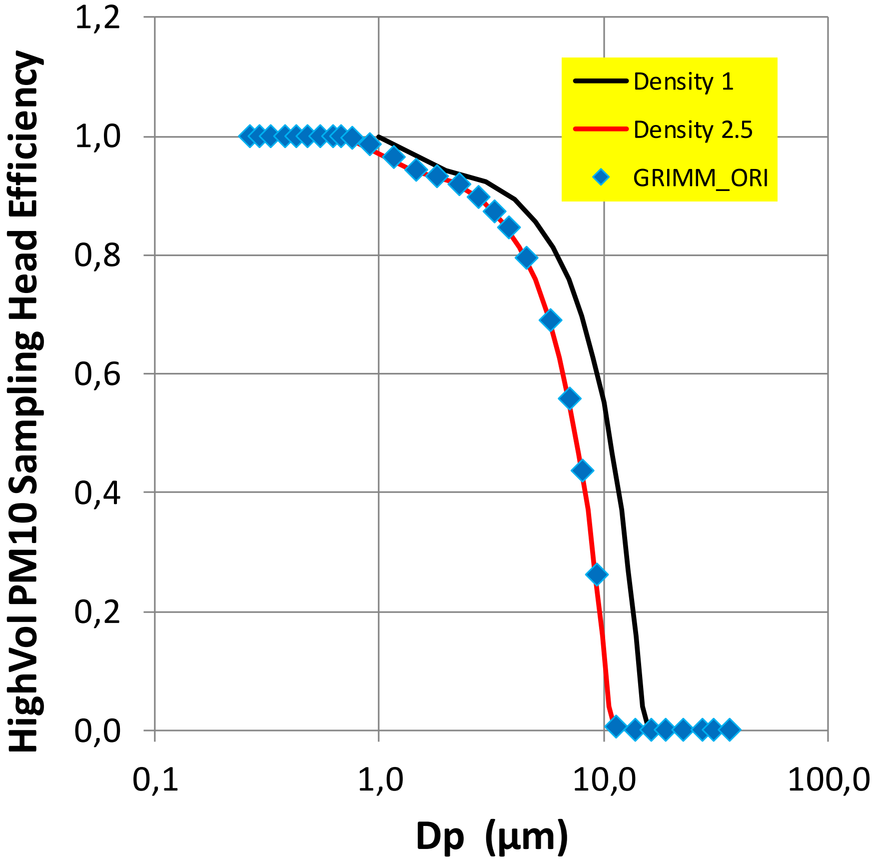
Intercomparison with PM10 weighted filter data

Stokes Law approximation:

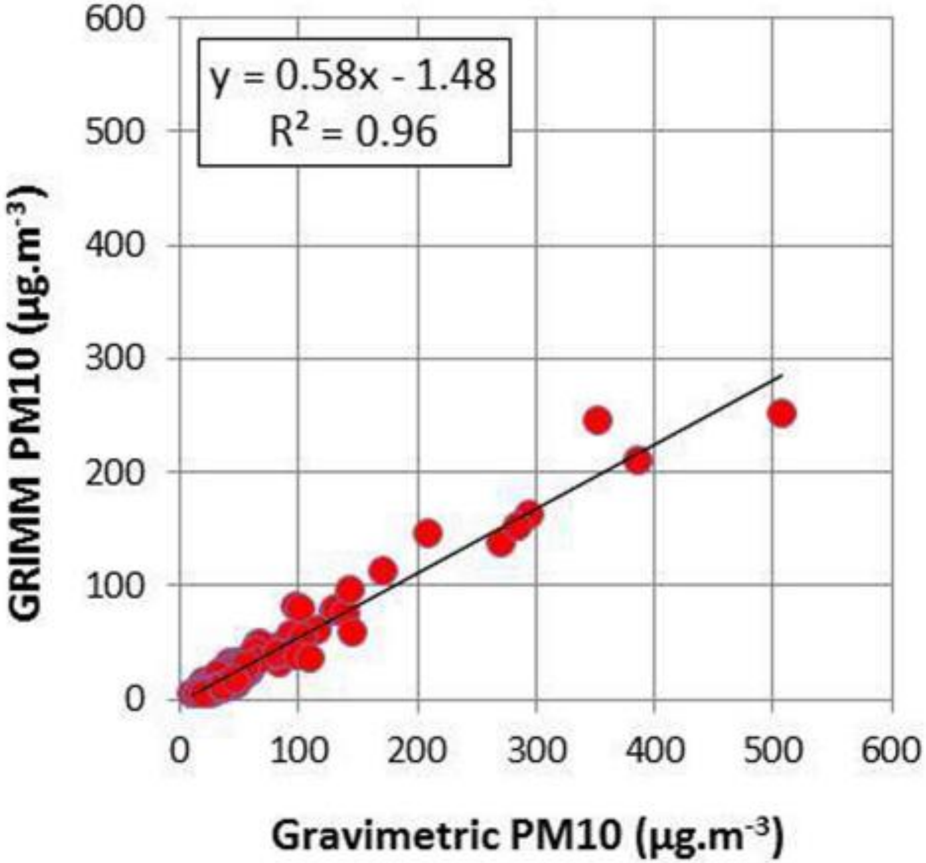
$$d_{vol} = d_{aer} \sqrt{\frac{\chi}{\rho / \rho_0}}$$

χ – dynamic shape factor

Inlet efficiency of PM10 sampling head



Results of Grimm/PM10 filters intercomparison with GRIMM original calibration



Re-calculation of GRIMM optical diameters based on different refractive index

Gently provided by T. Muller

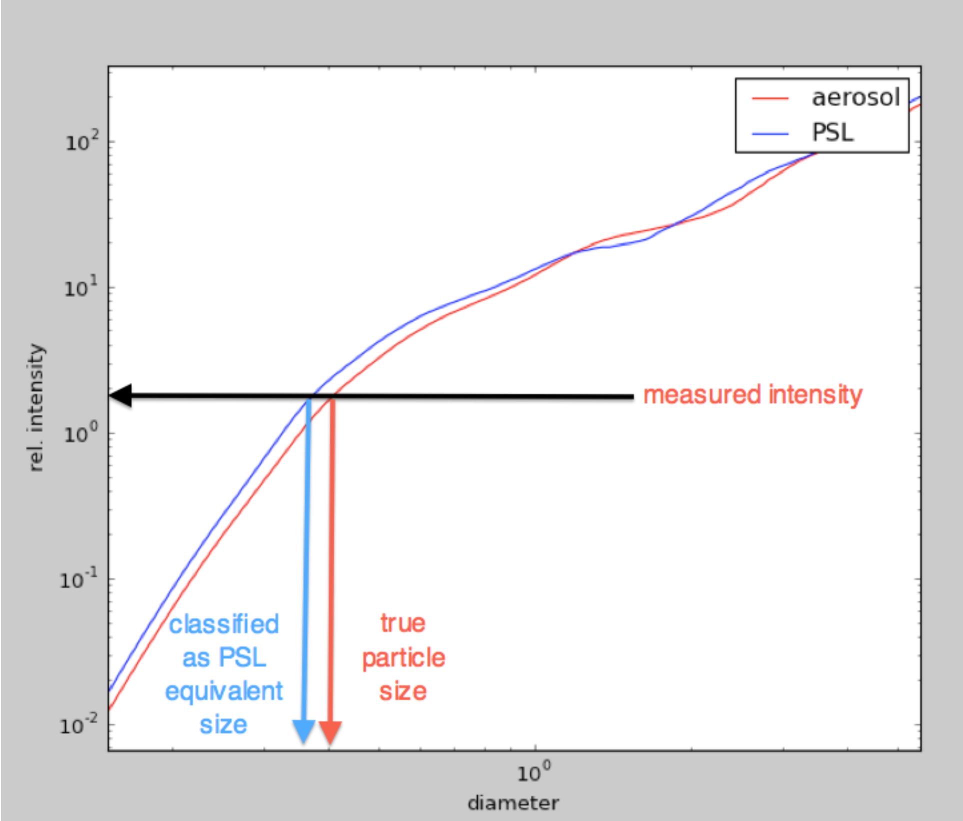
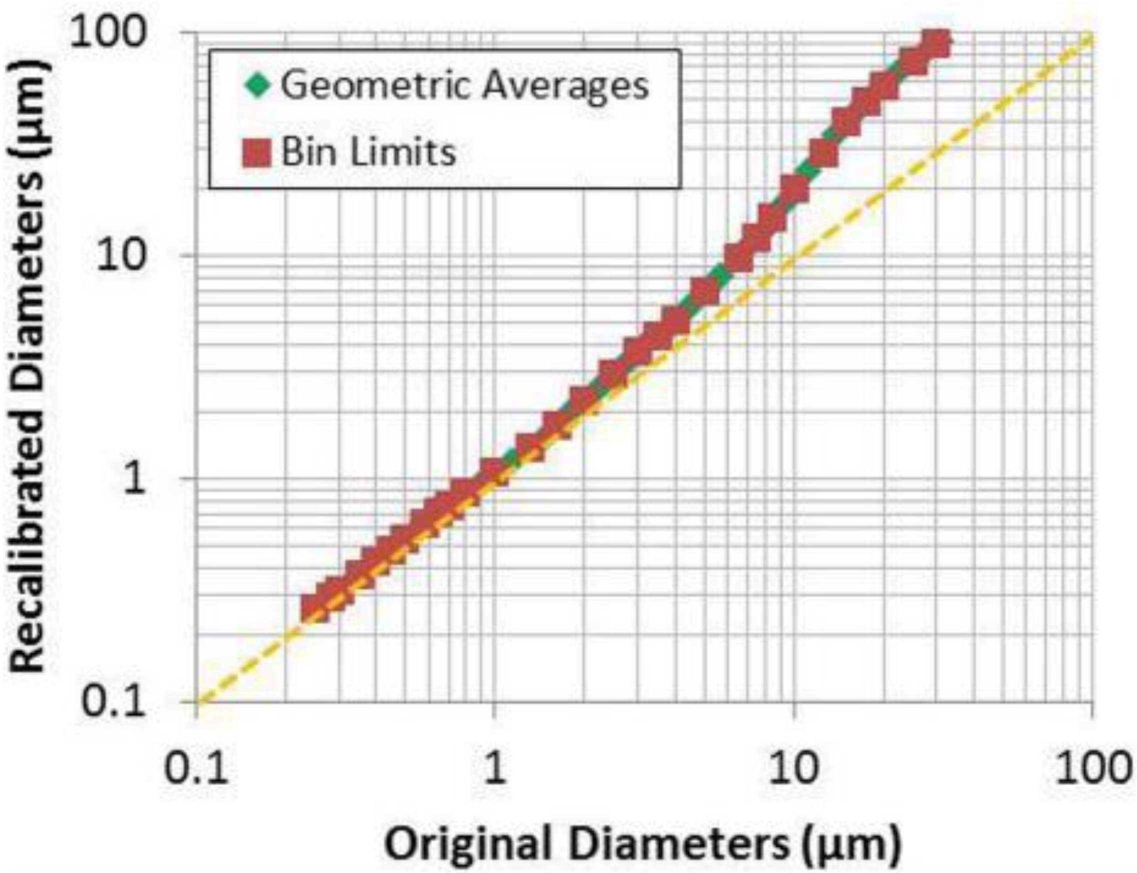


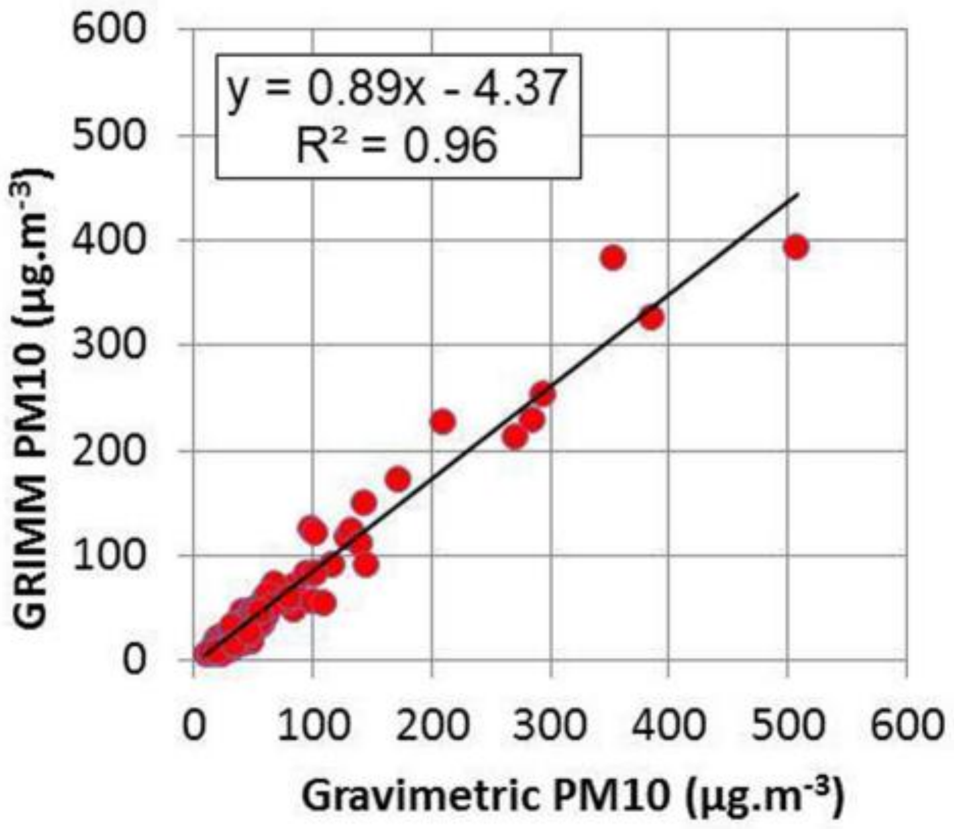
Figure: intensity curves for particles of refractive index m=1.58-0i (PSL) and m=1.53-i0

Recalibration curve using Mie equation applied to the instrument geometry, for particles with a RI=1.53-0.005i



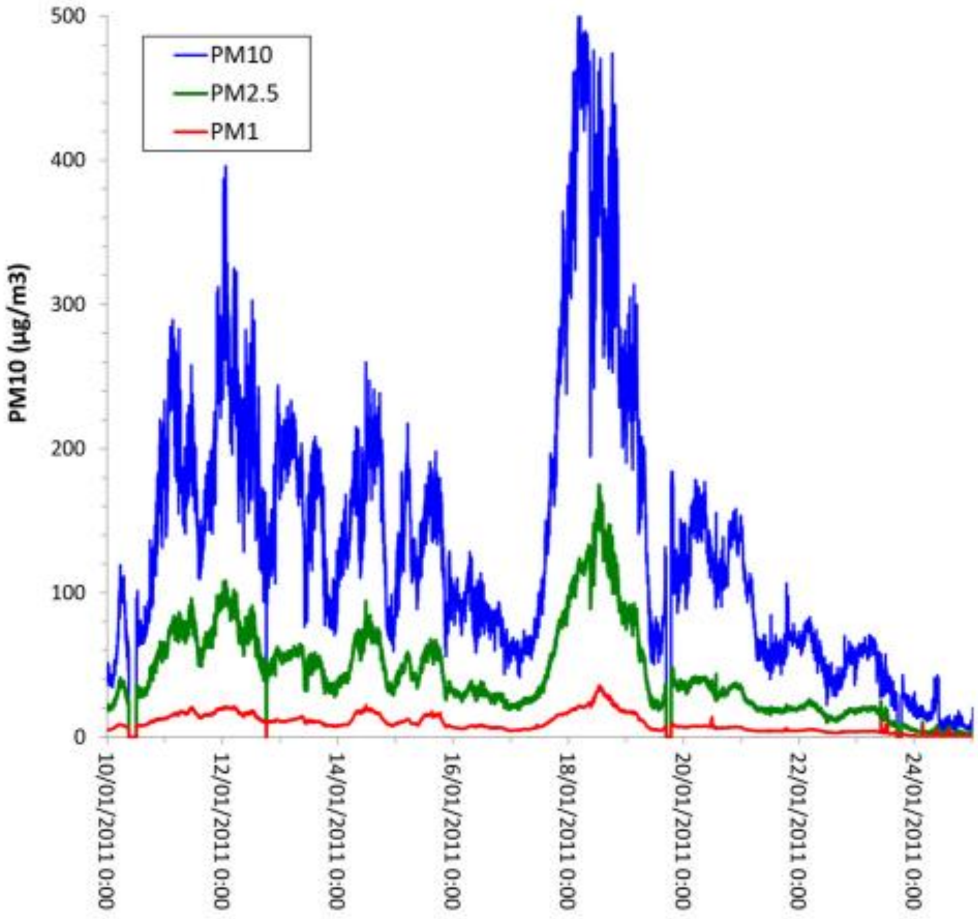
ref: Pio et al., (2014)

Results of Grimm/PM10 filters intercomparison with GRIMM new re-calculated diameters

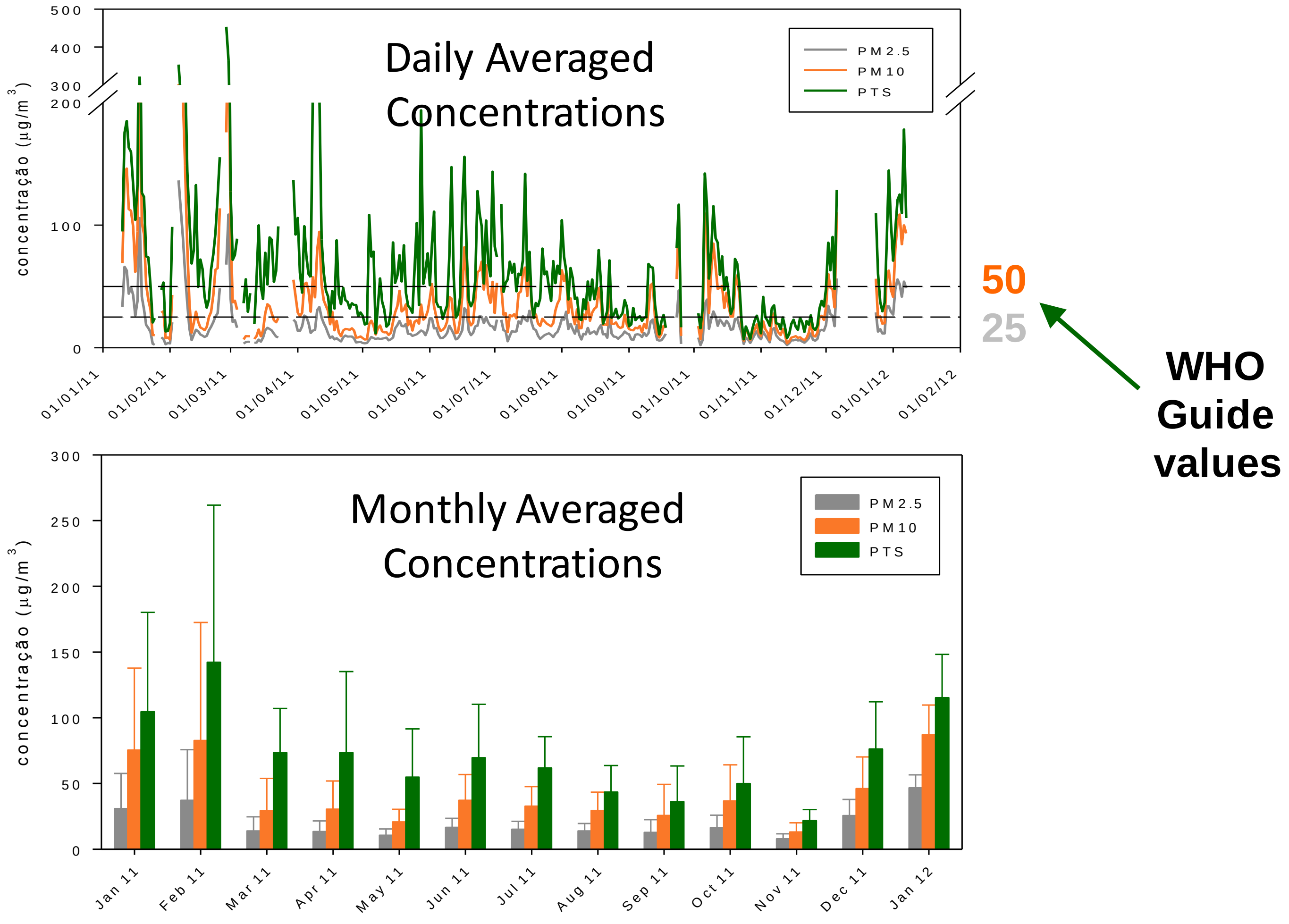


ref: Pio et al., (2014)

GRIMM 5 Minutes PM averages during the month of January



Daily and Monthly Averaged PM concentrations from GRIMM



Dust Size Distribution from GRIMM measurements

Monthly Averages

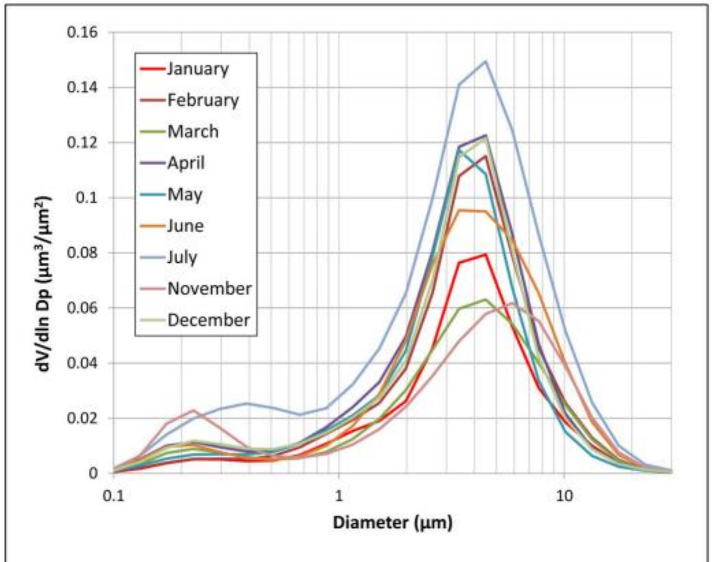


FIGURE 13 | Monthly averaged, column integrated, volumetric size distributions retrieved from AOD measurements in AERONET station at Sal Island, Cape Verde. No data is available for August-October.

AERONET column integrated data from Sal island

Ref: Pio et al., FES (2014)

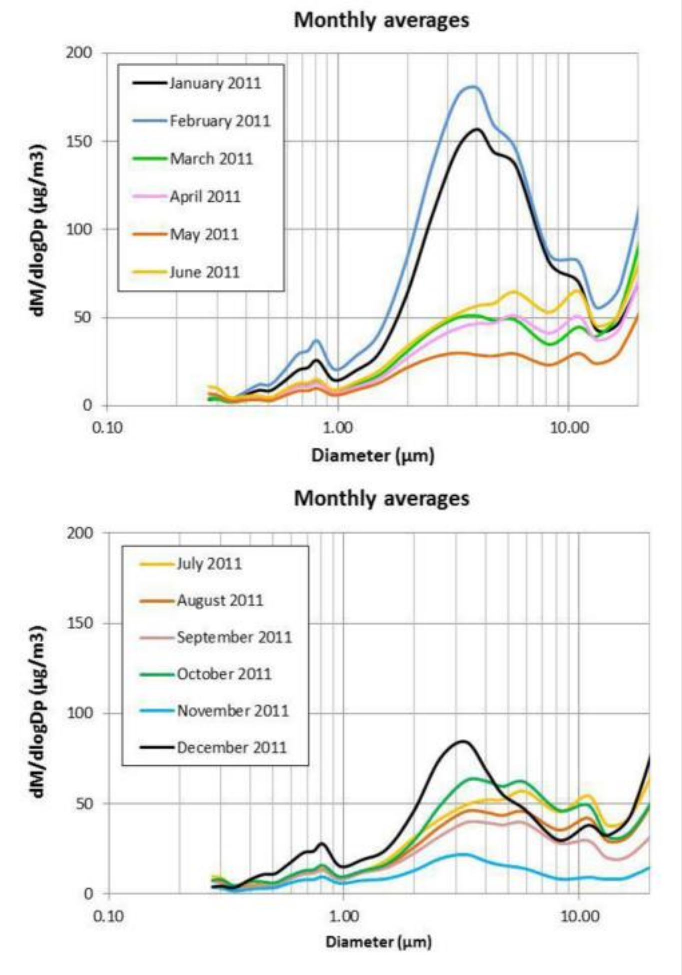


FIGURE 11 | Monthly averaged mass concentration size distributions of the Praia atmospheric aerosol, for every 2011 month.

Dust Size Distribution from GRIMM

- **Dust mass mainly in size range 1-10 µm, but much less is known for Giant Particles**

Yearly Average dust size profile

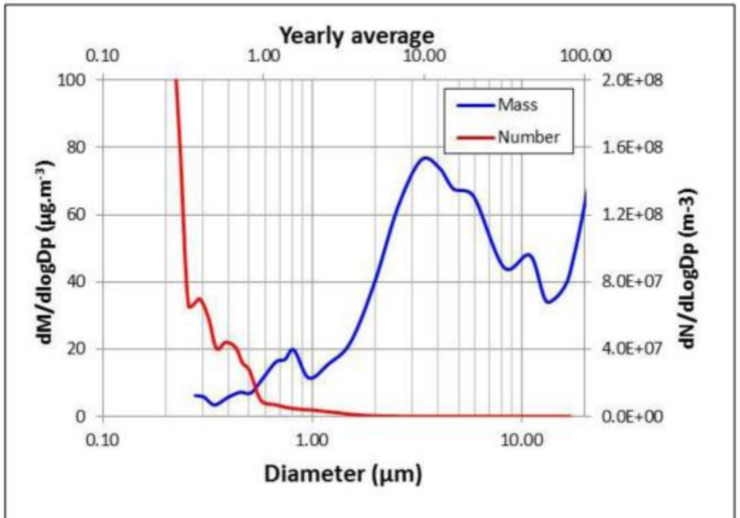


FIGURE 10 | Yearly averaged mass and number concentration size distributions for the Praia atmospheric aerosol during 2011.

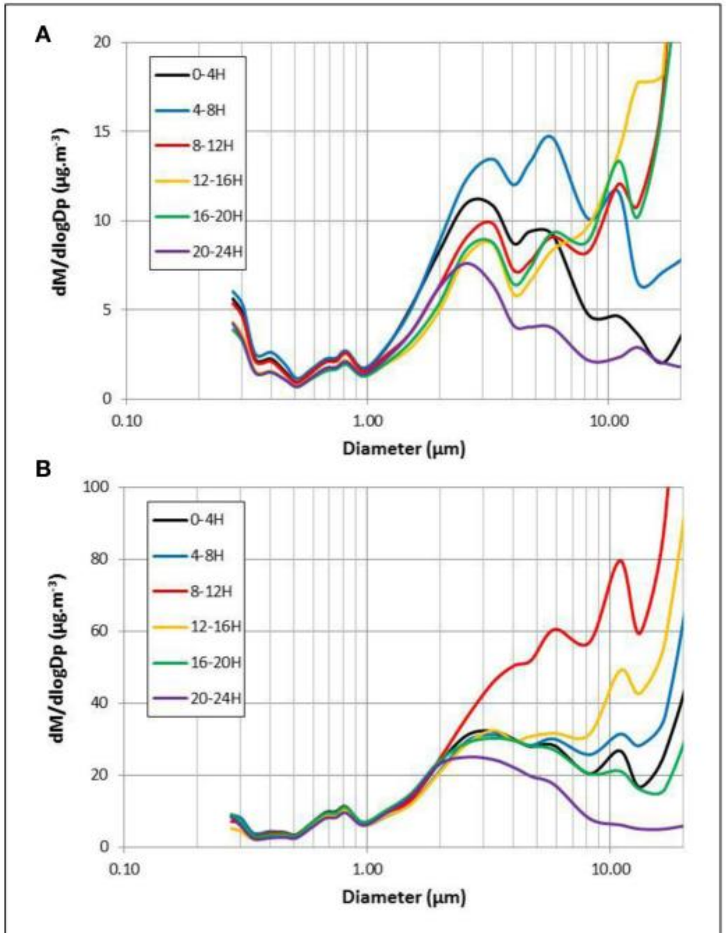
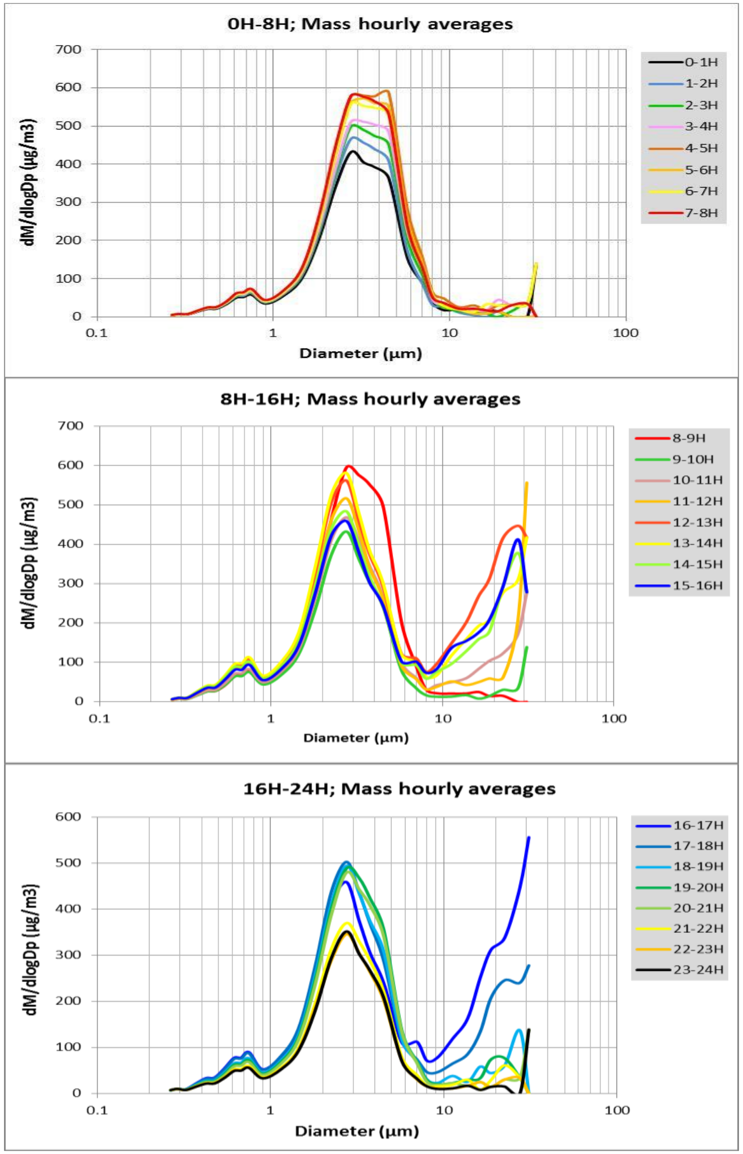


FIGURE 12 | Four hours average mass concentration size distributions during 2 days without direct Saharan dust intrusions. (A) 2nd May, 2011; **(B)** 12th June, 2011.

- **Local suspension processes probably responsible for dust particles outside "Bruma Seca"**

Hourly averaged dust size distribution variability along a dust episode day (18/01/2011)



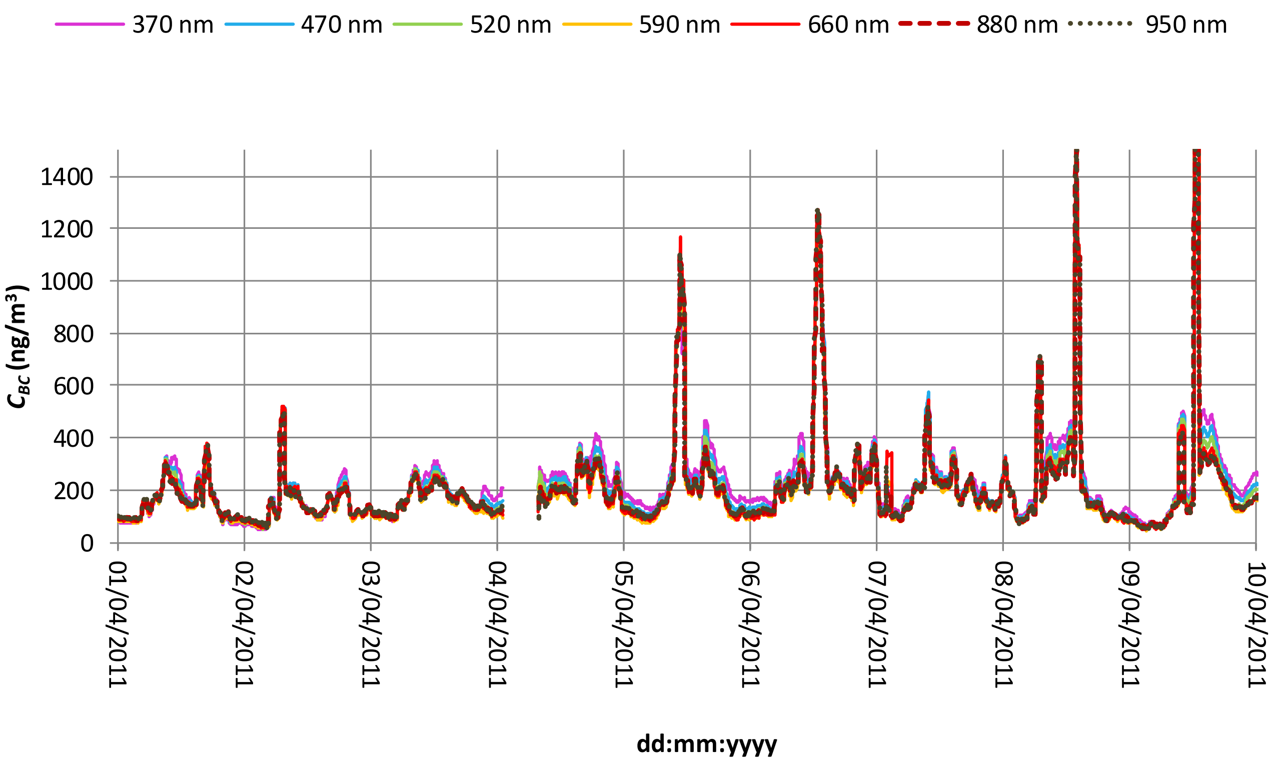
- ❖ Local re-suspension processes probably responsible for dust particles above 10 µm, even during "Bruma Seca"

CVDUST
Measurements with the Aethalometer

BC measurements with the Aethalometer

❖ **Daily Cycles show an important local influence on BC levels, principally in periods outside the "Bruma Seca" season**

10 minutes
BC Concentration
averages

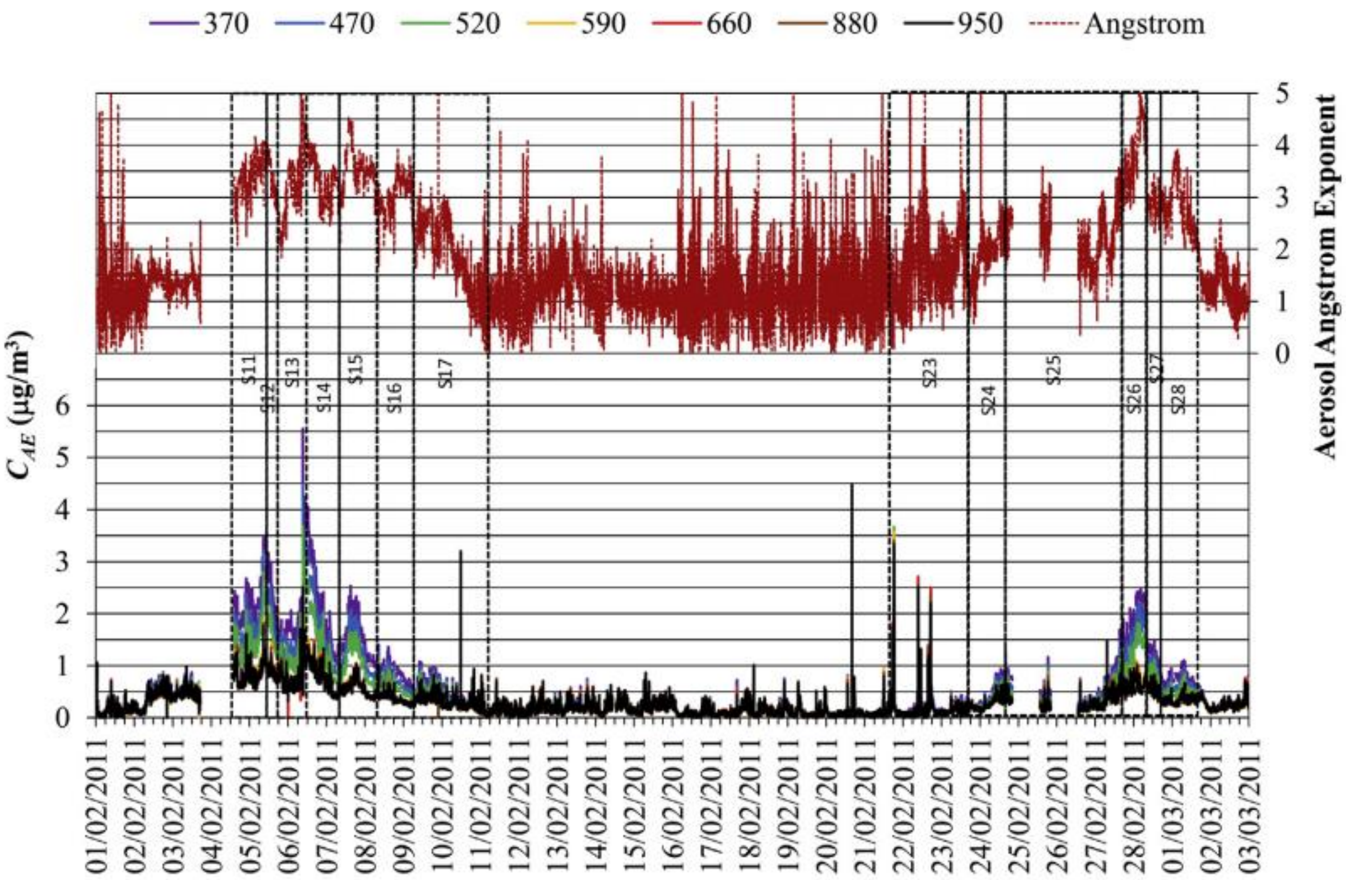


BC seasonal data with the Aethalometer

ref: Fialho et al., (2014)

- **Intensity peaks during dust episodes; effect of coloured dust / iron oxides**

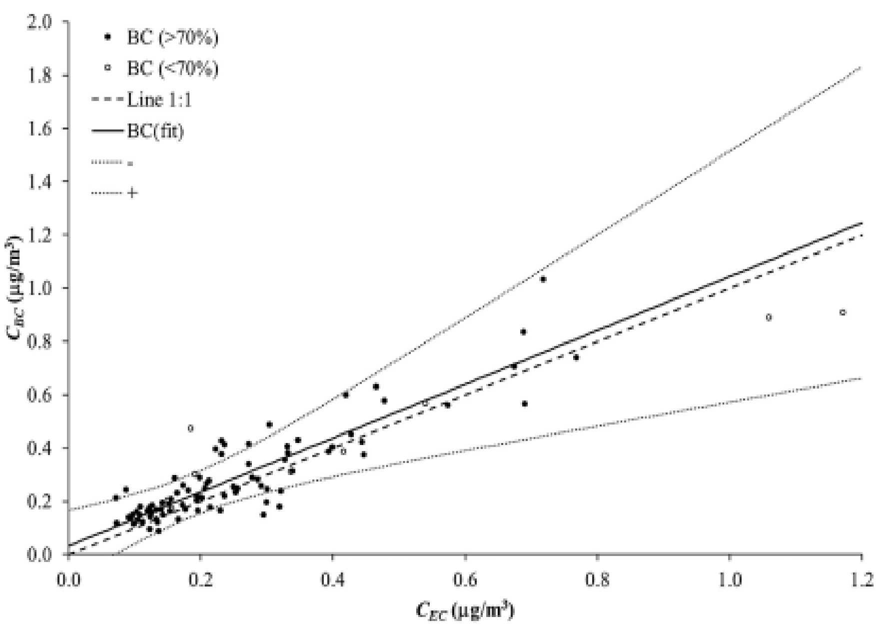
10 minutes BC/AE Concentration averages

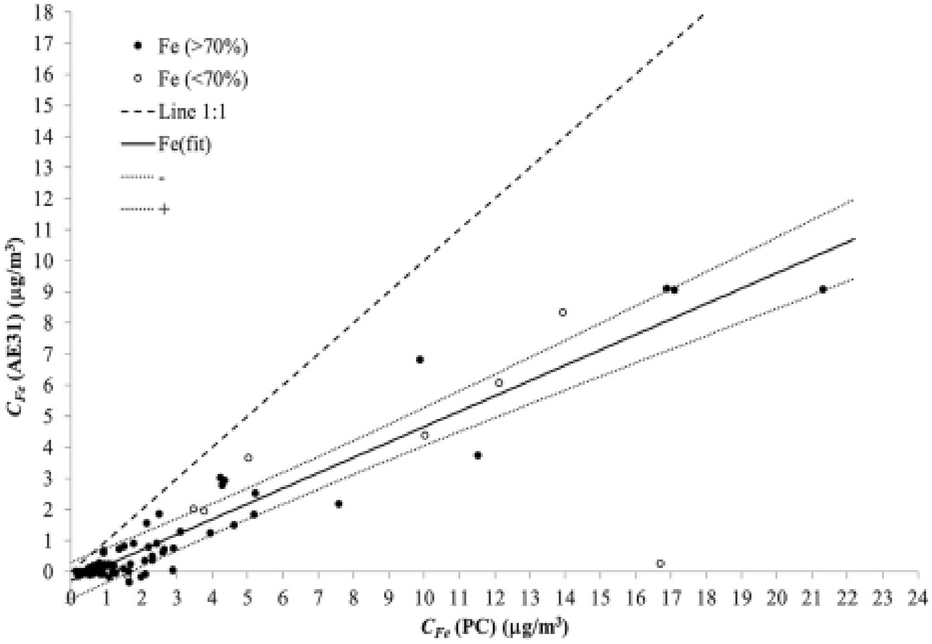


Using the aethalometer to measure Fe and BC

$$\sigma_{\mathrm{ATN-aerosol}}(\lambda,t) = \sigma_{\mathrm{BC}}(\lambda,t) + \sigma_{\mathrm{dust}}(\lambda,t)$$

$$\sigma_{\mathrm{ATN-aerosol}}(\lambda,t) = 14.625 \times \lambda^{-1} \times C_{\mathrm{BC}}(t) + 0.234 \times \lambda^{-4} \times C_{\mathrm{Fe}}(t)$$





Aethalometer deconvolution process to differentiate between BC (Black Carbon) and Iron Oxide dust. Results for February 2011

- Iron oxide dust and BC concentrations, recalculated with the deconvolution algorithm