atmosphere

MDPI

Supplementary Materials:

Source Apportionment of Ambient Particulate Matter (PM) in Two Western African Urban Sites (Dakar in Senegal and Bamako in Mali)

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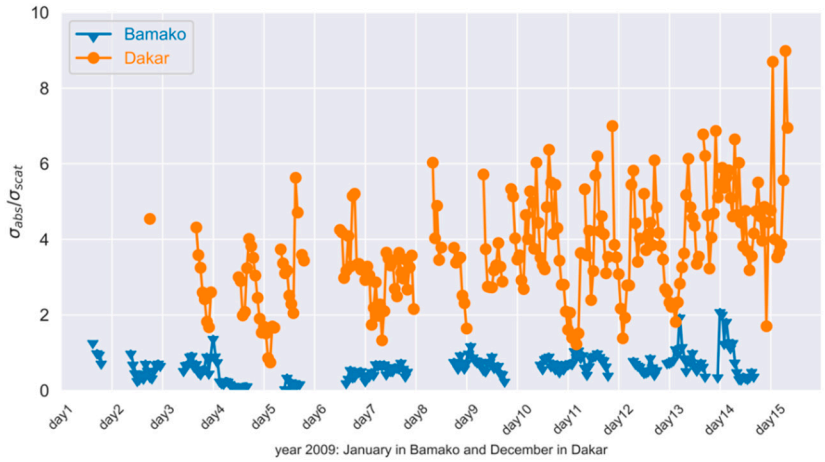


Figure S1. Daily evolution of σ_{abs} / σ_{scat} ratio in Bamako and Dakar.

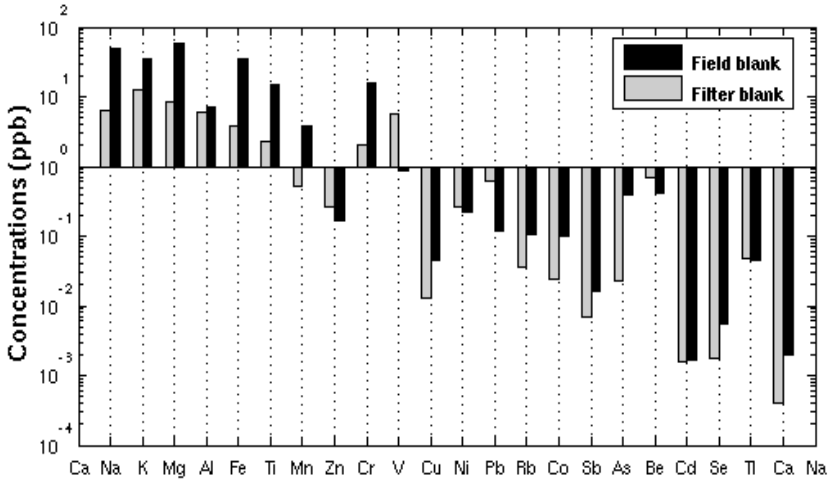


Figure S2. Comparison between average concentration of field blanks and filter blanks.

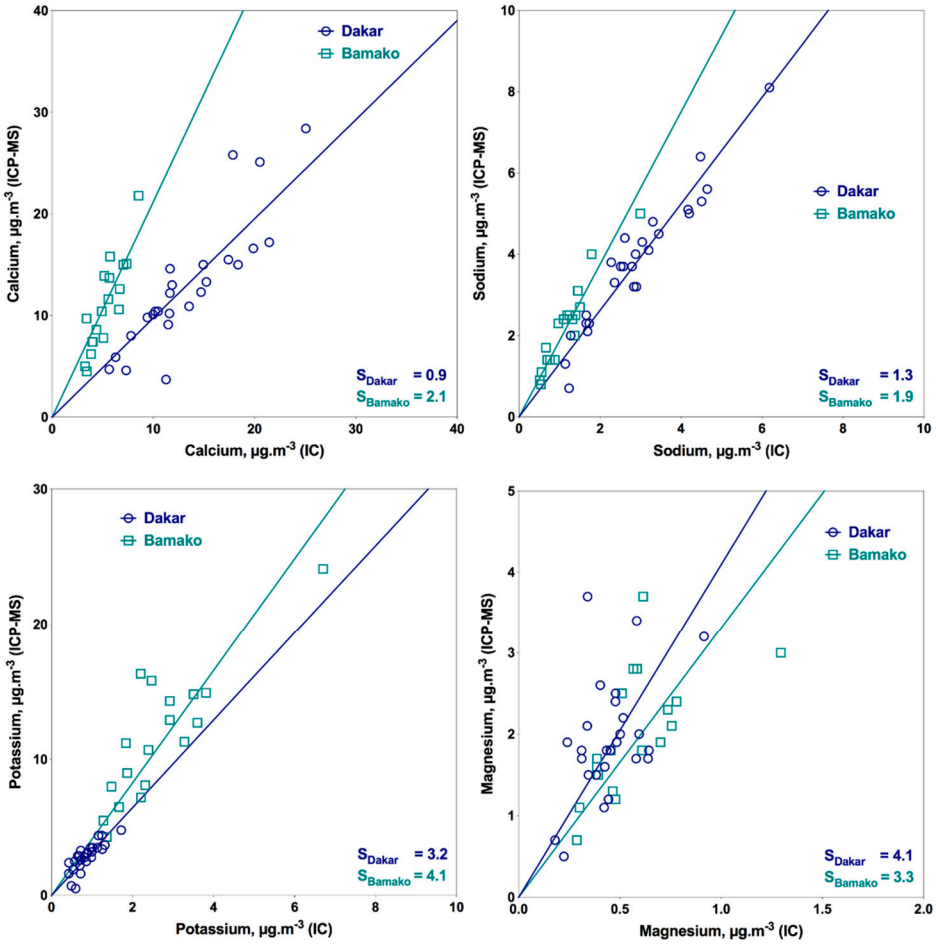


Figure S3. Comparison of calcium, sodium, potassium and magnesium elements measured by ICP-MS and IC, excluded the dust episode.

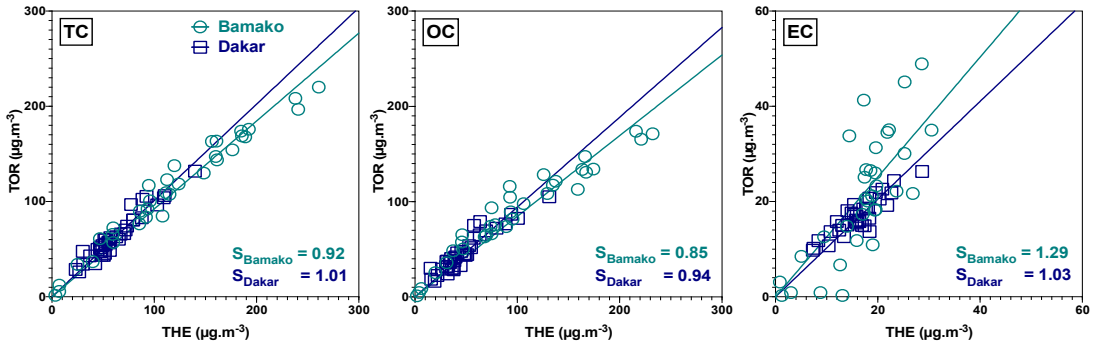
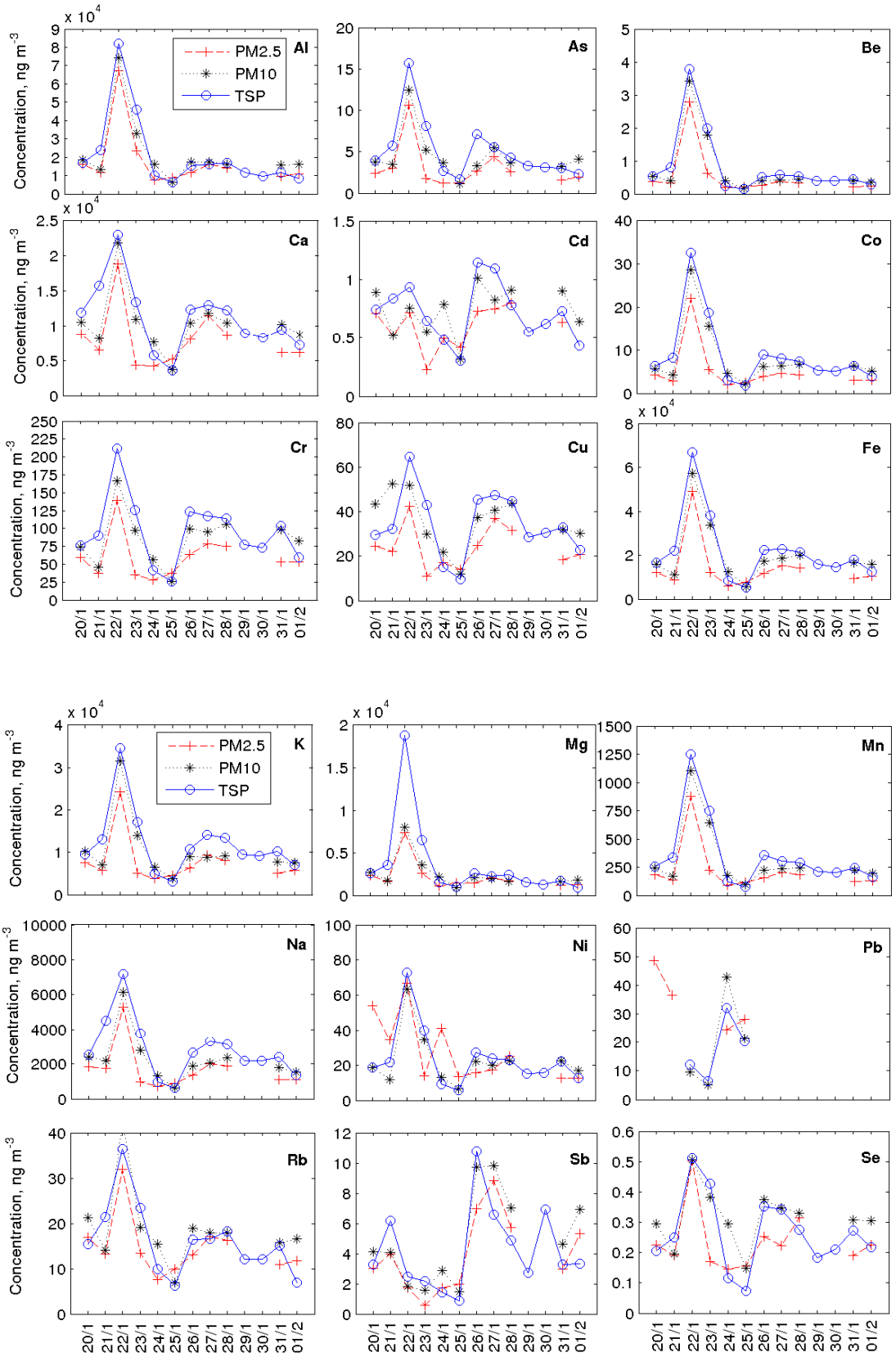


Figure S4. Comparison between the Thermal-Optical Reflectance (TOR) and the THERMAL (THE) methods at the two sites for TC, OC and EC. The linear regression results are displayed, S being the slope for Dakar (S_{Dakar}) and Bamako (S_{Bamako}) with zero intercept.


PM2.5
PM10
TSP
Al
As
Be
Ca
Cd
Co
Cr
Cu
Fe
K
Mg
Mn
Na
Ni
Pb
Rb
Sb
Se
Concentration, ng m-3
x 10^4
20/1
21/1
22/1
23/1
24/1
25/1
26/1
27/1
28/1
29/1
30/1
31/1
01/2

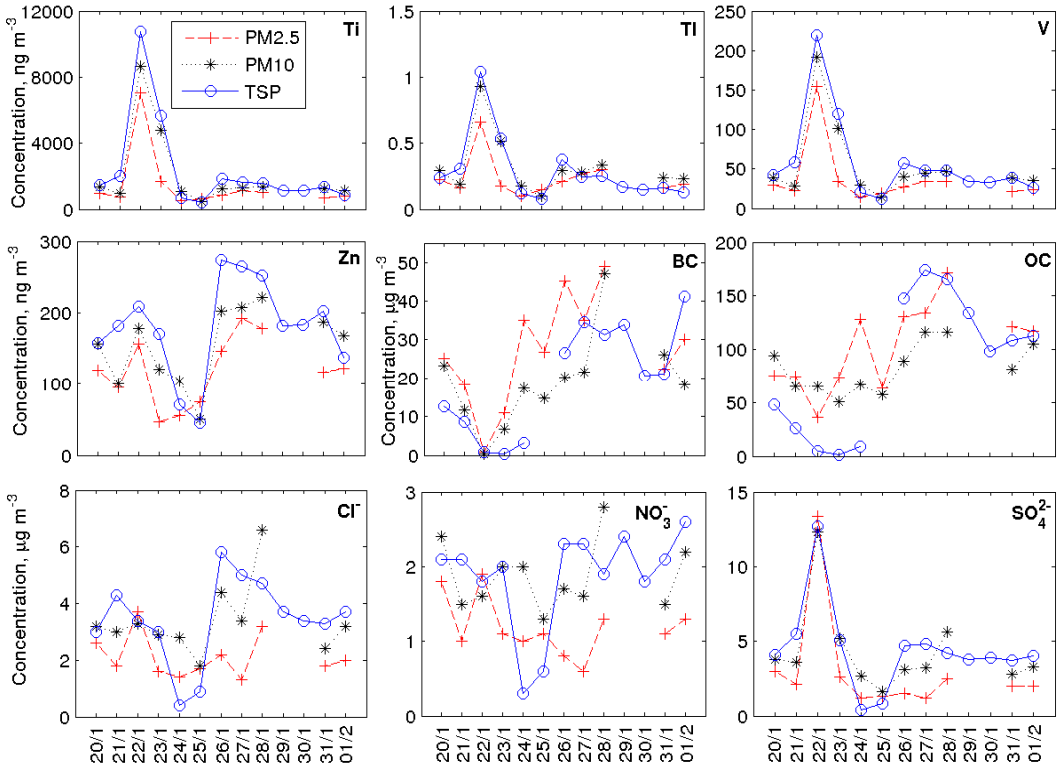
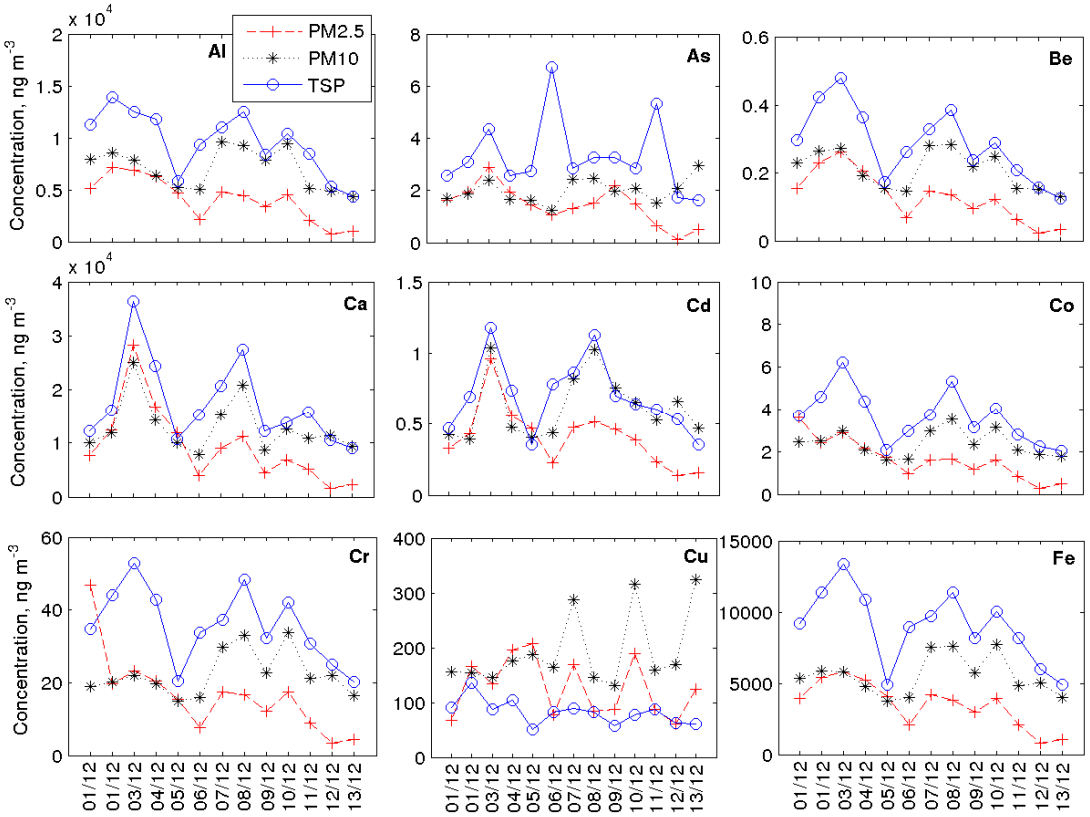


Figure S5. Time variations of $PM_{2.5}$, PM_{10} and TSP components concentrations measured at Bamako between 20 January and 1 February 2009.



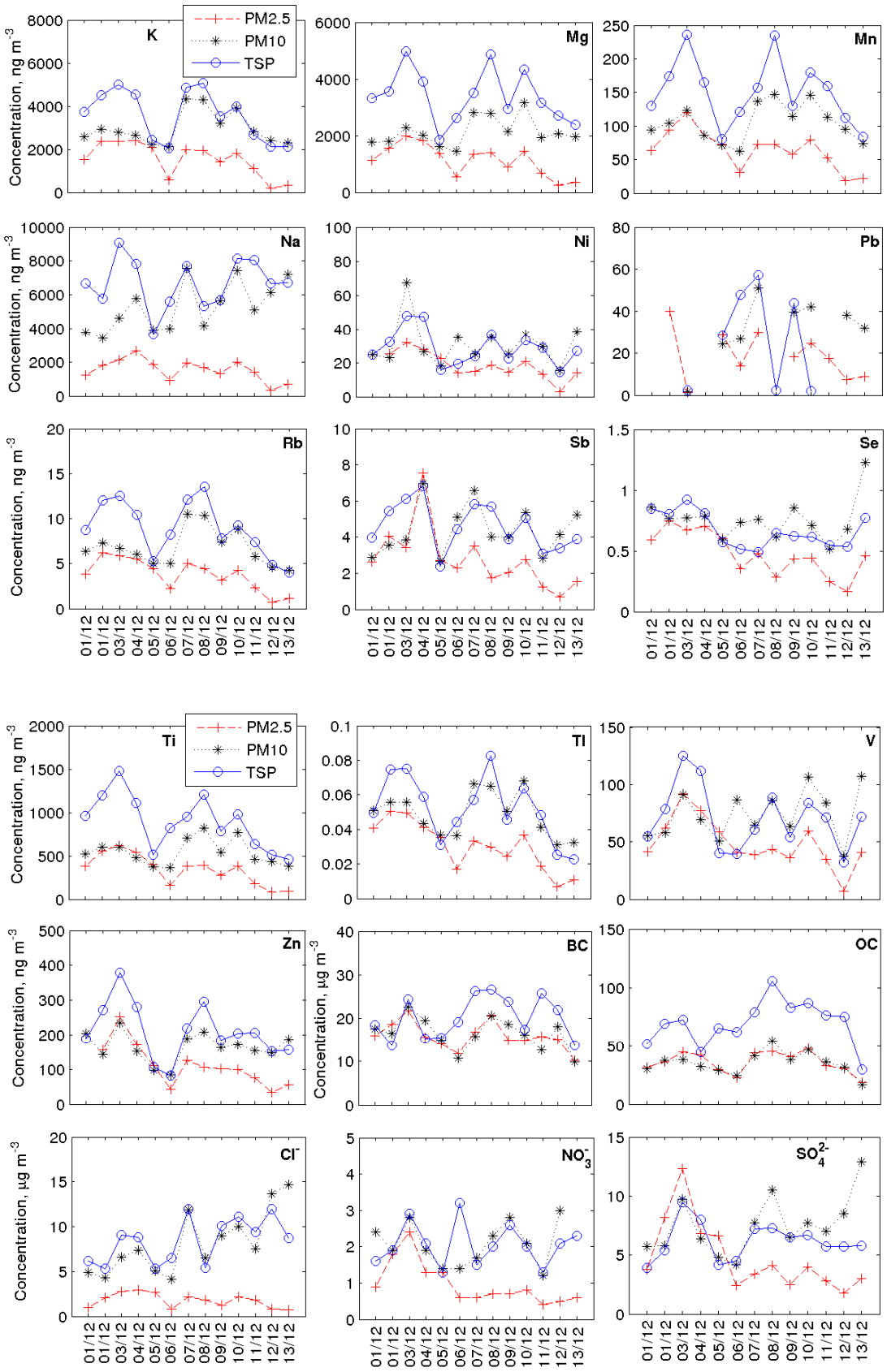


Figure S6. Time variations of components in $PM_{2.5}$, PM_{10} and TSP concentrations measured at Daker between 1 and 13 December 2009.

Table S1. Detection limits and blank values for water soluble species. The analysis was performed on 24 filter blanks and all values are in ppb.

	Cl^-	NO_3^-	SO_4^{2-}	Na^+	NH_4^+	K^+	Mg^{2+}	Ca^{2+}
Filter blank	13	24	4	8	9	2	0.3	25
DL	3	6	3	3	4	1	1	4

Table S2. Detection limits, vessel blank (VB) and filter blank (FB) in a matrix of 10 ml HNO_3 and 0.5 ml HF.

Metals	Vessel blank (VB) ($\mu g.l^{-1}$)	Field blank (FB) ($\mu g.l^{-1}$)	DL_{VB} ($\mu g.l^{-1}$)	DL_{FB} ($\mu g.l^{-1}$)
Ag	0.07	0.02	0.20	0.10
Al	0.84	34	1.07	60
As	0.09	0.41	0.65	0.61
Ba	0.05	0.70	0.17	1.89
Ca	3	49	5	221
Cd	0.0005	0.006	0.0006	0.015
Ce	0.001	0.03	0.004	0.13
Co	0.001	0.02	0.001	0.07
Cr	0.03	0.9	0.20	3.2
Cs	0.0002	0.001	0.0002	0.002
Cu	0.038	0.2	0.036	0.7
Eu	0.001	0.002	0.003	0.008
Fe	0.7	15	4.2	86
Hf	0.0009	0.007	0.003	0.017
K	3	57	6	102
La	0.0009	0.01	0.0022	0.06
Mg	0.3	7	0.8	34
Mn	0.03	0.2	0.06	0.7
Mo	0.004	0.07	0.011	0.24
Na	3	34	6	132
Ni	0.04	0.12	0.05	0.19
Pb	0.006	0.11	0.018	0.38
Rb	0.01	0.10	0.01	0.16
Sb	0.002	0.39	0.004	3.03
Se	0.07	0.05	0.48	0.03
Sm	0.0002	0.003	0.0003	0.012
Sn	0.03	11	0.08	20
Sr	0.02	0.2	0.07	1.2
Th	0.0002	0.002	0.0006	0.006
Ti	0.07	4	0.29	10
U	0.001	0.006	0.005	0.025
V	0.01	0.05	0.03	0.17
W	0.002	0.03	0.005	0.09
Zn	0.5	15	4	120
Zr	0.01	0.2	0.05	0.5
Be	0.001	0.002	0.001	0.002
Tl	0.0001	0.002	0.0001	0.008

Table S3. Certified/non certified and resulting concentration for elements in SRM 1648.

Element	Concentration ($\mu g.g^{-1}$)	SD (%)	Certified SRM 1648 ($\mu g.g^{-1}$)	Recovery (%)
Na	4416 ± 1277	3.5	4250 ± 20	104
Mg	6732 ± 1723	3.9	(8000)	84
Al	30025 ± 7885	3.8	34200 ± 1100	88
K	10051 ± 2594	3.9	10500 ± 100	96
Cr	243 ± 73	3.3	403 ± 12	60
Mn	729 ± 188	3.9	786 ± 17	93
Fe	33207 ± 8425	3.9	39100 ± 1000	85
Co	16 ± 4	3.9	(18)	88
Ni	81 ± 24	3.4	82 ± 3	99
Cu	543 ± 135	4.0	609 ± 27	89
Zn	4489 ± 1222	3.7	4760 ± 140	94
As	115 ± 31	3.7	115 ± 10	100
Se	27 ± 10	2.7	27 ± 1	99
Be	3.2 ± 0.7	3.4	-	-
Cd	68 ± 19	3.6	75 ± 7	91
Sb	37 ± 9	4.1	(45)	83
Cs	3.2 ± 0.9	3.6	(3)	105
Ba	668 ± 167	4.0	(737)	91
Ce	46 ± 12	3.9	(55)	83
Ca	37781 ± 7883	3.9	58400 ± 1900	-
Rb	50 ± 13	3.2	(52)	69
Pb	6413 ± 1014	6.3	6550 ± 80	98
Th	7.3 ± 1.1	6.4	(7.4)	98
U	5.4 ± 0.8	6.5	5.5 ± 0.1	97
V	119 ± 30	3.9	127 ± 7	94
Ti	3332 ± 784	4.2	(4000)	83

SD, the relative standard deviation between replicates (n = 9). Values in parenthesis are non-certified and are given for information.

Table S4. Summary of the Thermal Optical Reflectance (TOR) and THERMAL (THE) protocols.

Protocol	TOR	Thermal
Combustion environment for OC	He	O_2
Combustion environment for BC	98%He, 2%O_2	O_2
Temperature plateau for OC (°C)	550	340
Residence time for OC (s)	580	7200
Temperature plateau for BC (°C)	800	1100
Residence time for EC (s)	580	600
Optical/charring correction	Reflectance	10% of OC; EC decomposition of 0.22% per min during OC analysis
Convert and detector	Methanator FID/CH_4	Coulometric titration/CO_2

Table S5. Comparison of no decarbonatation (noDC) and decarbonatation (DC) procedures on OC, EC and TC (OC + EC) measurements at Bamako.

Comparison		Filter	Mean ratio	Correlation	Mean values (μg.cm^{-2})			
noDC	**DC**	**n**	**DC/noDC**	r^2	noDC	DC	noDC - DC	Difference (%)
$PM_{2.5}$								
OC1	OC1	11	0.03 ± 0.05	-0.86	8.46	0.23	8.23	-97
OC2	OC2	11	0.11 ± 0.20	0.02	50.11	4.63	45.48	-91
OC3	OC3	11	0.40 ± 0.15	0.66	49.40	19.40	29.99	-61
OC4	OC4	11	0.72 ± 0.12	0.47	12.19	8.77	3.42	-28
EC1	EC1	11	1.33 ± 0.11	1.00	96.61	124.84	-28.24	29
EC2	EC2	11	0.15 ± 0.03	0.92	16.44	2.55	13.89	-84
EC3	EC3	11	1.02 ± 0.44	0.05	0.72	0.71	0.02	-2
OP	OP	11	0.90 ± 0.24	0.94	65.36	63.11	2.25	-3
TC	TC	11	0.70 ± 0.08	0.98	233.93	160.97	72.96	-31
OC	OC	11	0.51 ± 0.11	0.94	185.44	95.97	89.47	-48
EC	EC	11	1.42 ± 0.29	0.91	48.49	64.99	-16.51	34
PM_{10}								
OC1	OC1	11	0.01 ± 0.05	0.89	8.18	0.09	8.09	-99
OC2	OC2	11	0.08 ± 0.05	0.92	47.66	2.72	44.94	-94
OC3	OC3	11	0.48 ± 0.11	0.95	44.49	20.00	24.49	-55
OC4	OC4	11	0.83 ± 0.15	0.22	11.60	9.58	2.02	-17
EC1	EC1	11	1.29 ± 0.10	1.00	88.18	110.23	-22.05	25
EC2	EC2	11	0.18 ± 0.05	0.72	15.64	2.84	12.80	-82
EC3	EC3	11	1.27 ± 0.45	-0.24	0.73	0.88	-0.15	20
OP	OP	11	1.02 ± 0.35	0.84	63.65	68.03	-4.38	7
TC	TC	11	0.69 ± 0.05	1.00	216.48	146.27	70.21	-32
OC	OC	11	0.57 ± 0.10	0.94	175.58	100.36	75.23	-43
EC	EC	11	1.28 ± 0.37	0.77	40.90	45.91	-5.01	12
All								
OC1	OC1	22	0.02 ± 0.03	-0.29	8.32	0.15	8.17	-98
OC2	OC2	22	0.09 ± 0.15	0.11	48.89	3.68	45.21	-92
OC3	OC3	22	0.44 ± 0.13	0.74	46.94	19.70	27.24	-58
OC4	OC4	22	0.78 ± 0.15	0.27	11.90	9.17	2.72	-23
EC1	EC1	22	1.31 ± 0.10	1.00	92.39	117.54	-25.14	27
EC2	EC2	22	0.17 ± 0.04	0.79	16.04	2.70	13.35	-83
EC3	EC3	22	1.15 ± 0.45	-0.09	0.73	0.79	-0.07	9
OP	OP	22	0.96 ± 0.30	0.88	64.51	65.57	-1.06	2
TC	TC	22	0.70 ± 0.06	0.99	225.21	153.62	71.59	-32
OC	OC	22	0.54 ± 0.11	0.93	180.51	98.16	82.35	-46
EC	EC	22	1.35 ± 0.33	0.82	44.69	55.45	-10.76	24

Table S6. Comparison of no decarbonatation (noDC) and decarbonatation (DC) procedures on OC, EC and TC (OC + EC) measurements at Dakar.

Comparison		Filter	Mean ratio	Correlation	Mean values			
noDC	**DC**	**n**	**DC/noDC**	r^2	noDC	DC	noDC - DC	Difference (%)
$PM_{2.5}$								
OC1	OC1	13	1.08 ± 1.08	0.25	4.47	2.98	1.49	-33
OC2	OC2	13	0.99 ± 0.29	0.30	27.63	26.56	1.07	-4
OC3	OC3	13	0.97 ± 0.26	0.13	27.85	25.96	1.89	-7
OC4	OC4	13	0.46 ± 0.09	0.06	11.38	5.13	6.25	-55
EC1	EC1	13	1.21 ± 0.34	0.19	45.78	53.11	-7.33	16
EC2	EC2	13	0.17 ± 0.08	0.31	10.18	1.39	8.79	-86
EC3	EC3	13	1.23 ± 0.46	-0.21	0.54	0.63	-0.09	16
OP	OP	13	0.68 ± 0.39	0.23	17.66	9.93	7.72	-44
TC	TC	13	0.93 ± 0.23	0.37	127.82	115.75	12.07	-9
OC	OC	13	0.82 ± 0.24	0.22	88.98	69.67	19.31	-22
EC	EC	13	1.20 ± 0.21	0.51	38.84	46.08	-7.25	19
PM_{10}								
OC1	OC1	13	0.05 ± 0.05	0.35	3.95	0.06	3.89	-98
OC2	OC2	13	0.05 ± 0.01	0.29	28.80	1.27	27.53	-96
OC3	OC3	13	0.61 ± 0.19	0.11	25.79	14.86	10.93	-42
OC4	OC4	13	0.70 ± 0.22	-0.34	13.49	9.01	4.48	-33
EC1	EC1	13	1.05 ± 0.11	0.94	45.54	48.44	-2.91	6
EC2	EC2	13	0.27 ± 0.10	0.93	6.98	1.59	5.38	-77
EC3	EC3	13	1.61 ± 0.37	0.61	0.54	0.84	-0.30	56
OP	OP	13	0.82 ± 0.52	0.42	13.30	9.60	3.70	-28
TC	TC	13	0.62 ± 0.05	0.96	125.08	76.16	48.93	-39
OC	OC	13	0.41 ± 0.06	0.87	85.94	34.45	51.49	-60
EC	EC	13	1.08 ± 0.15	0.77	39.15	41.71	-2.56	7
All								
OC1	OC1	26	0.72 ± 1.00	0.15	4.21	1.52	2.69	-64
OC2	OC2	26	0.52 ± 0.52	-0.01	28.22	13.91	14.30	-51
OC3	OC3	26	0.79 ± 0.29	0.20	26.82	20.41	6.41	-24
OC4	OC4	26	0.58 ± 0.21	0.22	12.43	7.07	5.36	-43
EC1	EC1	26	1.13 ± 0.26	0.58	45.66	50.78	-5.12	11
EC2	EC2	26	0.22 ± 0.10	0.45	8.58	1.49	7.09	-83
EC3	EC3	26	1.42 ± 0.45	0.26	0.54	0.74	-0.20	36
OP	OP	26	0.75 ± 0.46	0.32	15.48	9.77	5.71	-37
TC	TC	26	0.78 ± 0.23	0.43	126.45	95.96	30.50	-24
OC	OC	26	0.62 ± 0.27	0.26	87.46	52.06	35.40	-40
EC	EC	26	1.14 ± 0.19	0.63	38.99	43.90	-4.90	13

BC components were assumed to consist of the sum of the three EC fractions obtained by TOR minus the pyrolysis correction (OP) so that EC = EC1 + EC2 + EC3 – OP. OC components were assumed to consist of the four fractions plus the pyrolysis correction obtained by TOR so that OC = OC1 + OC2 + OC3 + OC4 + OP.

Table S7. Quality control performance measures for carbonaceous analyses in Bamako and Dakar.

DRI instrument (TOR)			
Instrument blank ($\mu g.cm^{-2}$)	**TC**	**EC**	**OC**
Average	0.13	0.01	0.12
Standard deviation	0.15	0.04	0.11

Detection limit	0.45	0.13	0.33
Number of samples	16	16	16
Field blank (μg.cm^{-2})	**TC**	**EC**	**OC**
Average	4.29	0.63	3.66
Standard deviation	2.85	0.53	2.36
Detection limit	8.55	1.59	7.08
Number of samples	36	36	36
Carbon analyzer (Thermal)			
Calibration (sucrose)	low carbon (< 25μgC)	High carbon (> 25μgC)	
Ratio of sucrose to mass target	1.02	1.04	
Standard deviation	0.05	0.04	
Number of samples	23	22	
Field blank (μg.cm^{-2})	**TC**	**EC**	**OC**
Average	1.62	0.69	0.93
Standard deviation	0.74	0.63	0.68
Detection limit	2.22	1.89	2.04
Number of samples	22	15	15

Table S8. Comparison between measured and PMF calculated concentrations (in ng.m^{-3}) except for PM (in μg.m^{-3}) in Bamako for studied chemical species.

Species	Measured	PMF modeled	r^2	Uncertainty (%)
PM (μg.m^{-3})	430.01	380.67	0.25	11
OC	98295	84466	0.44	14
EC	24600	20765	0.35	16
Al	15457	15280	0.96	1
Fe	15423	15438	0.99	0
Ca^{2+}	5774	5775	0.98	0
SO_4^{2-}	3103	3078	0.97	1
K^+	2952	2934	0.99	1
Cl^-	2953	2902	0.94	2
NO_3^-	1649	1646	0.93	0
Na^+	1541	1542	0.99	0
Ti	1368	1335	1.00	2
Mg^{2+}	672	674	0.99	0
Mn	229	227	0.99	1
Zn	144	142	0.90	1
Cr	73	72	0.97	1
V	38	38	1.00	1
Cu	30	29	0.79	3
Ni	21	18	0.23	15
Rb	15	14	0.94	1
Co	6	6	0.99	1
Sb	4	4	0.67	3
As	3	3	0.85	3
Cd	1	1	0.26	1
Be	0.5	0.5	0.99	4
Se	0.3	0.3	0.94	0
Tl	0.2	0.2	0.92	4

Table S9: Comparison between measured and PMF calculated concentrations (in ng.m^{-3}) except for PM (in μg.m^{-3}) in Dakar for all chemical species.

Species	Measured	PMF modeled	r^2	Uncertainty (%)
PM (μg.m^{-3})	170.36	189.67	0.82	10
OC	46057	47941	0.96	4
EC	17131	17042	0.70	-1
Ca^{2+}	12038	12189	0.83	1
Al	6934	7142	0.96	3
Cl^-	6074	6190	0.97	2
SO_4^{2-}	6073	6038	0.98	-1
Fe	5975	5979	0.98	0
Na^+	3765	3785	0.98	1
NO_3^-	1662	1683	0.78	1
K^+	829	835	0.92	1
Ti	583	586	0.98	1
Mg^{2+}	549	553	0.99	1
Zn	160	160	0.93	0
Cu	130	129	0.93	0
Mn	105	108	0.96	3
V	62	61	0.86	-2
Ni	26	28	0.78	7
Cr	24	24	0.84	-1
Rb	6	6	0.97	-5
Sb	4	4	0.73	3
Co	3	3	0.95	2
As	2	2	0.70	-5
Cd	1	1	0.85	-2
Se	1	1	0.83	1
Be	0.2	0.2	0.98	0
Tl	0.04	0.05	0.93	4