



**FAIRMODE**

Forum for air quality modelling in Europe



## WG3 Source Apportionment

19-21 June 2017

### Source Oriented Models - Performance Evaluation

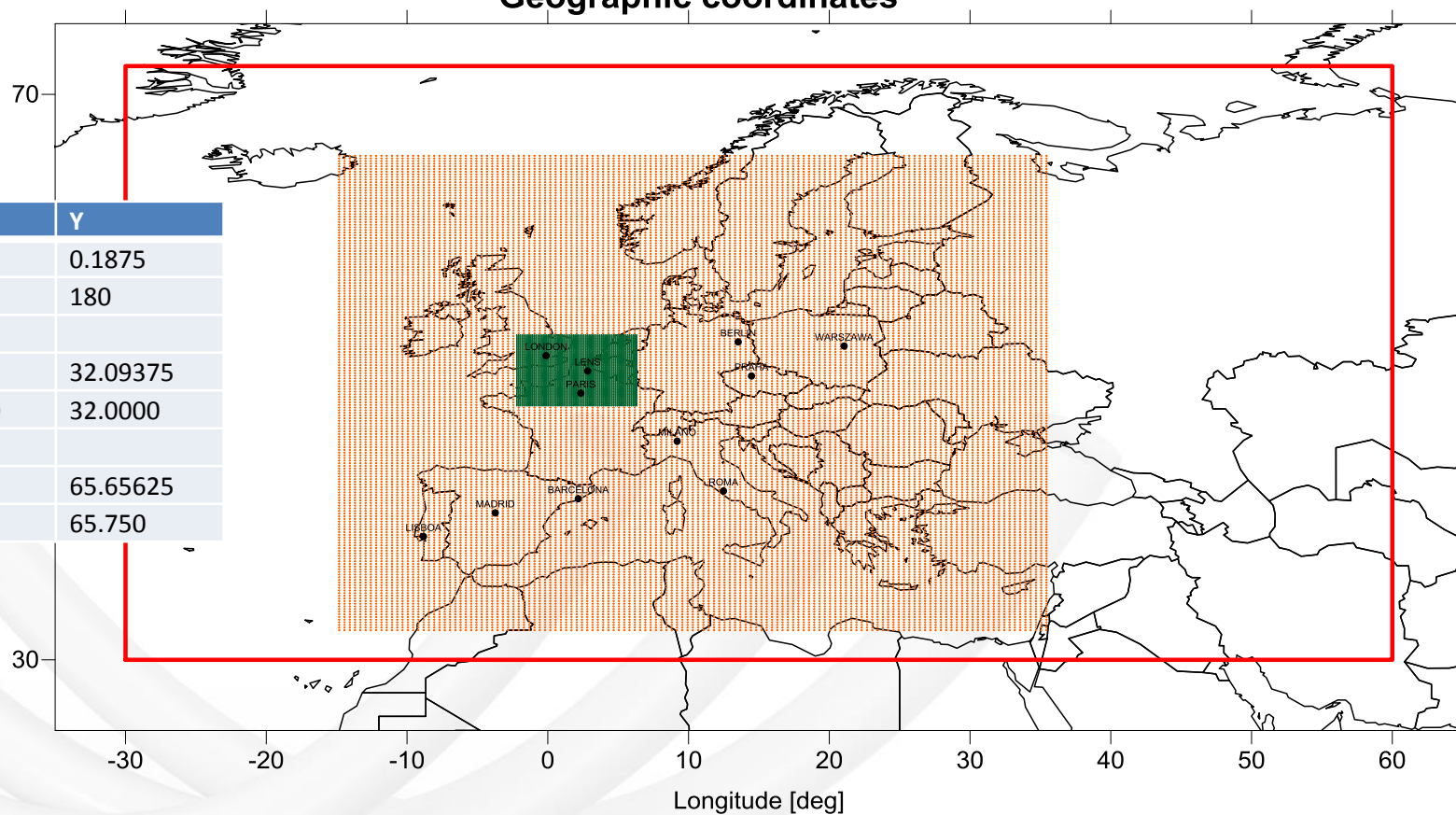
G. Pirovano, C. Belis, D. Pernigotti  
..and all SMs teams



# FAIRMODE Domains

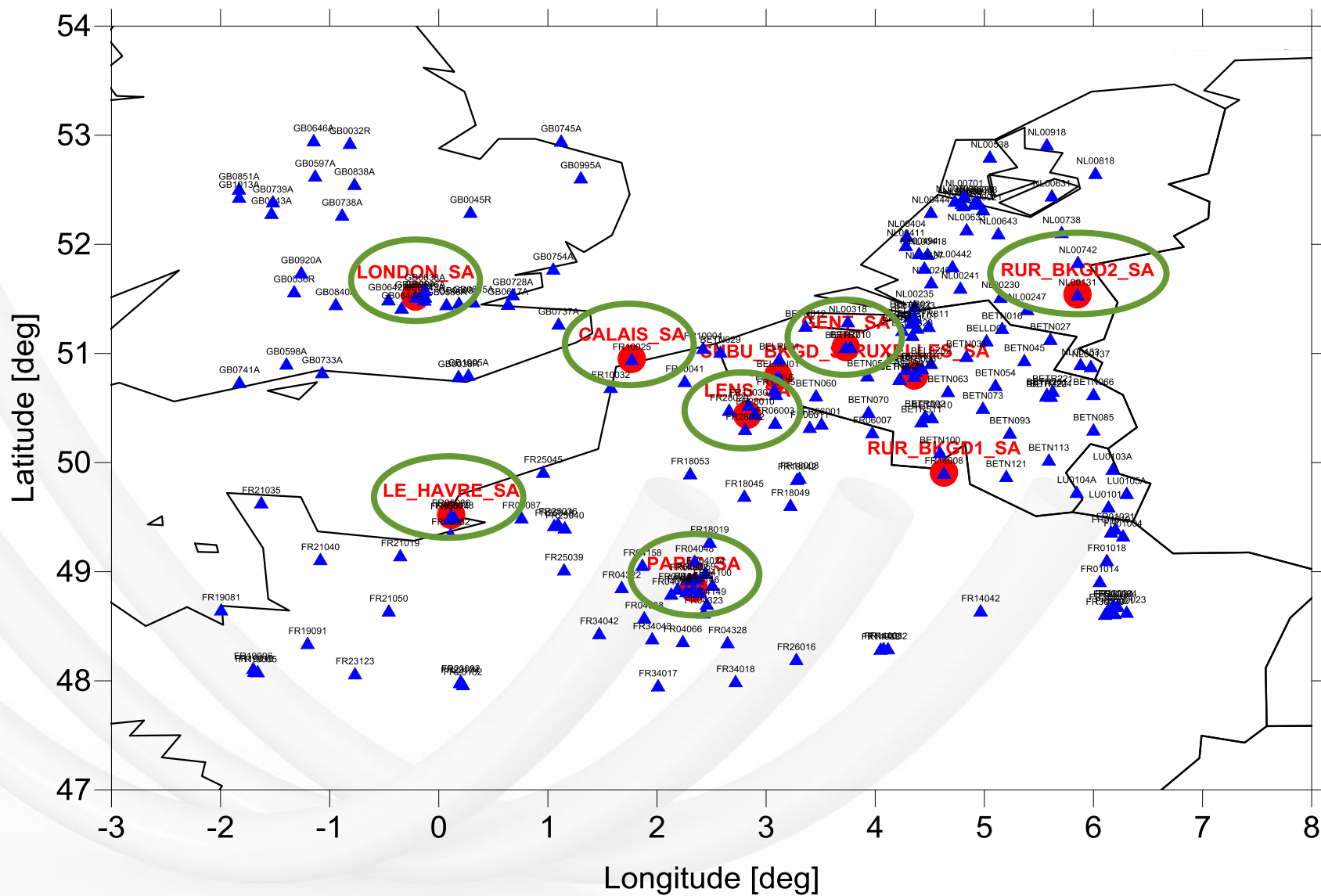
## FAIRMODE - Domains

Grid centers  
Geographic coordinates



	X	Y
D	0.375	0.1875
N	135	180
SW_centre	-14.8125	32.09375
SW_corner	-15.0000	32.0000
NE_centre	35.4375	65.65625
NE_corner	35.625	65.750

# Measurement and SA sites



# Partecipating models & teams

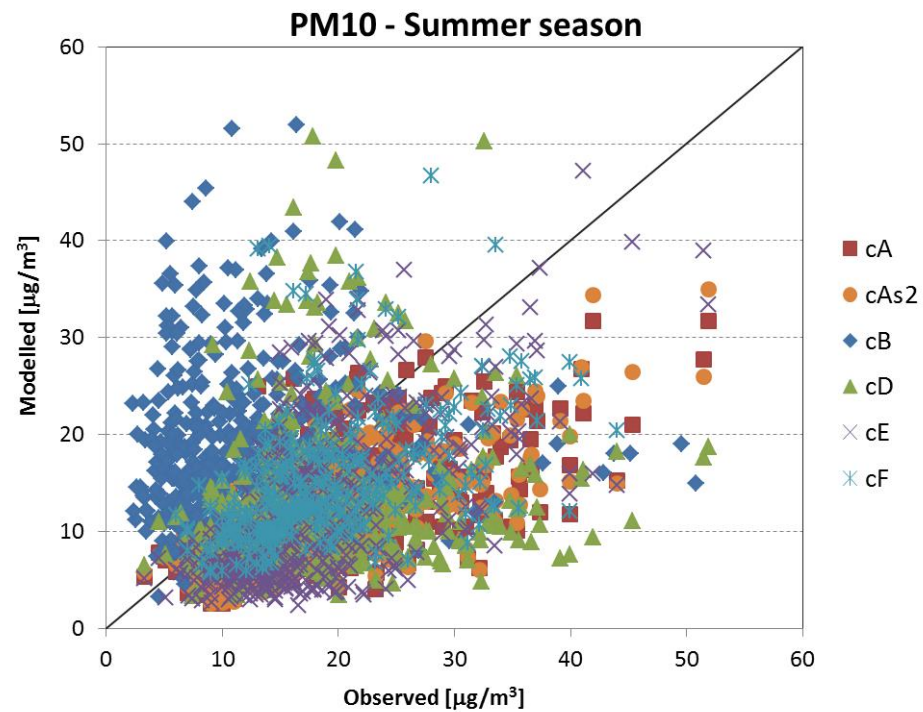
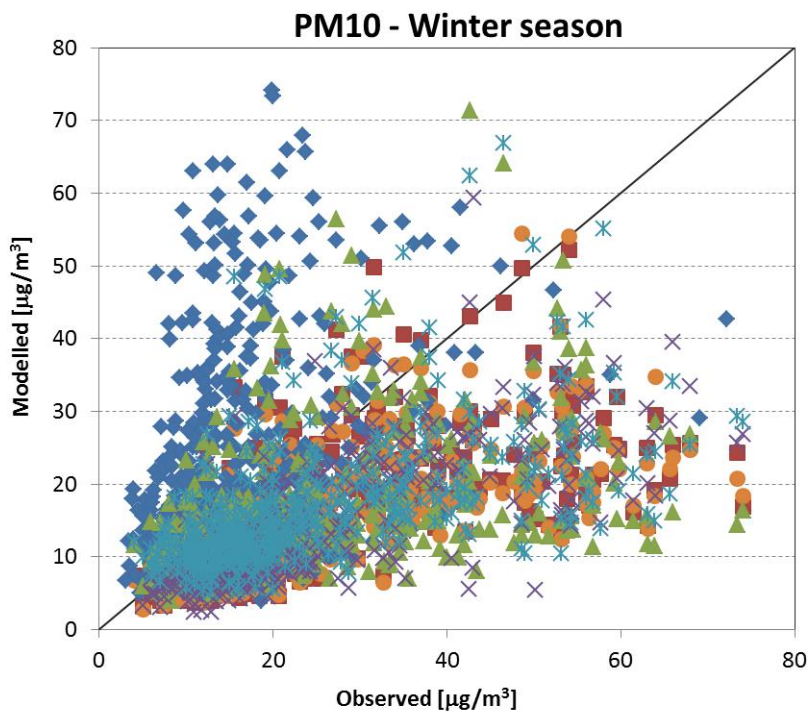
kind of collaboration	participant	code	model	mandatory set	optional set
coordinated results	RSE <sup>1</sup>	<b>cA</b>	CAMx	selected reference	for
		<b>cAo</b>	CAMx		selected for reference
	ARPAV	<b>cAs</b>	CAMx	sensitivity test	sensitivity test
		<b>cASO</b>	CAMx	sensitivity test	sensitivity test
UNIV AVEIRO	<b>cAs2</b>	CAMx	sensitivity test	sensitivity test	
joint result	ENEA /ARIANET/ARPA PIEMONTE	<b>cB</b>	FARM	selected reference (*)	for
		<b>cBo</b>	FARM		selected for reference (*)
independent result	TNO	<b>cD</b>	LOTOS	selected reference	for
		<b>cDo</b>	LOTOS		selected for reference
independent result	RIER- UNI KOLN	<b>cE</b>	EURAD	selected reference (*)	for
joint result	CIEMAT/LISA -CNRS	<b>cF</b>	CHIMERE	NH4 and NO3 not reported	NH4 and NO3 not reported

<sup>1</sup> with the contribution of: Aristotle University of Thessaloniki, Ramboll-Environ, University of Genova.

(\*) when both tagged species and brute force approaches are used for the reference

# MPE Summary

## PM<sub>10</sub> daily concentration



# MPE Summary

## PM<sub>10</sub> daily concentration

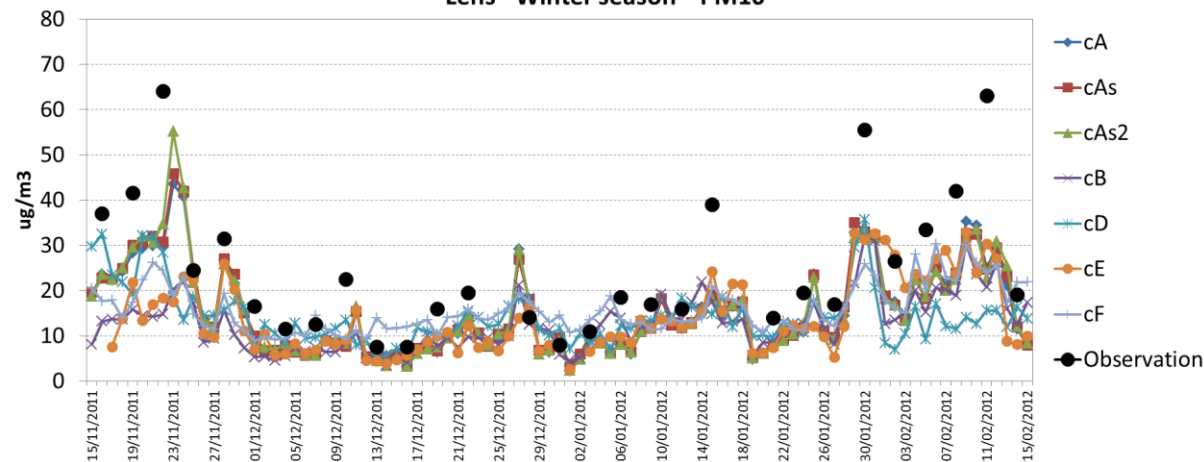
Winter	cA	cAs	cAs2	cB	cD	cE	cF	Obs
#	651	651	651	651	651	623	651	469
Mean	15.65	15.67	14.82	16.09	16.91	14.35	17.49	24.63
MB	-9.59	-9.60	-10.33	-8.19	-8.24	-11.08	-7.50	
NMB	-39%	-39%	-42%	-33%	-33%	-45%	-30%	
RMSE	14.35	14.41	14.78	16.73	15.85	15.28	14.44	
Correlation	0.69	0.68	0.70	0.32	0.43	0.76	0.55	

Summer	cA	cAs	cAs2	cB	cD	cE	cF	Obs
#	644	0	644	644	644	637	427	483
Mean	12.00		11.62	11.65	12.43	12.69	14.88	18.26
MB	-6.42		-6.75	-5.95	-5.59	-5.67	-8.52	
NMB	-35%		-37%	-33%	-31%	-31%	-47%	
RMSE	8.93		8.83	11.90	11.00	9.15	13.15	
Correlation	0.59		0.67	0.02	0.18	0.62	0.44	

# PM<sub>10</sub> Daily time series

Lens - Winter season PM10

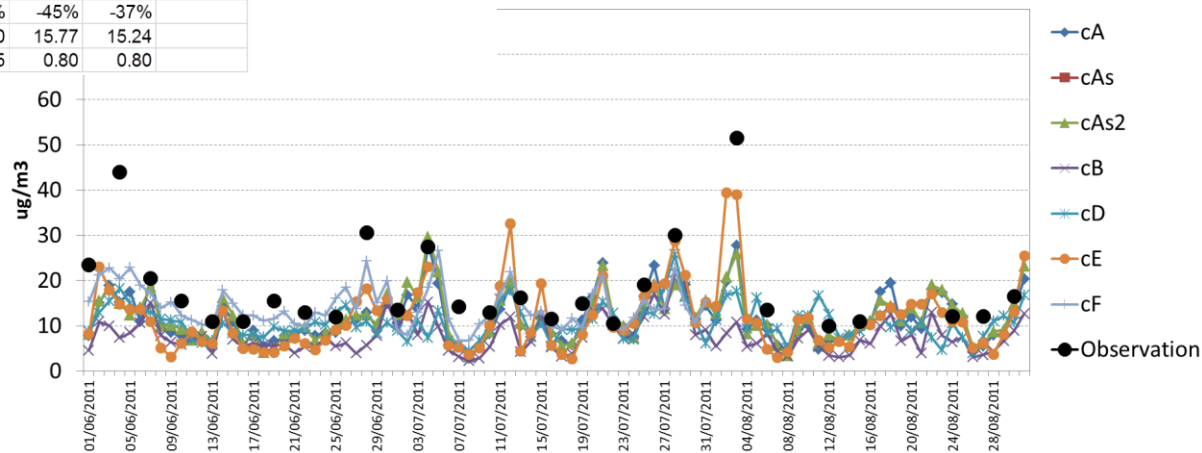


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	15.23	15.49	15.49	12.74	14.34	13.90	15.92	25.02
MB	-10.05	-9.74	-9.94	-12.71	-10.61	-11.29	-9.17	
NMB	-40%	-39%	-40%	-51%	-42%	-45%	-37%	
RMSE	13.73	13.53	13.50	17.23	16.20	15.77	15.24	
corr	0.87	0.87	0.88	0.79	0.65	0.80	0.80	

Lens - Winter

Lens - Summer

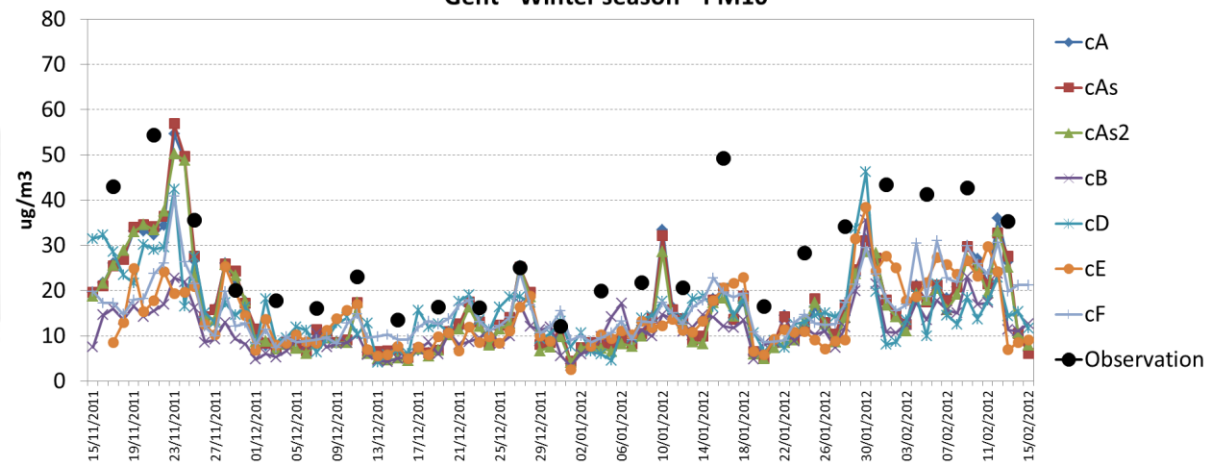
Summer season PM10



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	61	27
mean	11.62		11.86	7.88	10.71	11.65	14.37	18.29
MB	-6.58		-6.44	-10.61	-7.27	-7.06	-7.97	
NMB	-36%		-35%	-58%	-40%	-39%	-44%	
RMSE	9.71		9.92	14.04	11.05	9.24	13.07	
corr	0.72		0.67	0.42	0.60	0.81	0.81	

# PM<sub>10</sub> Daily time series

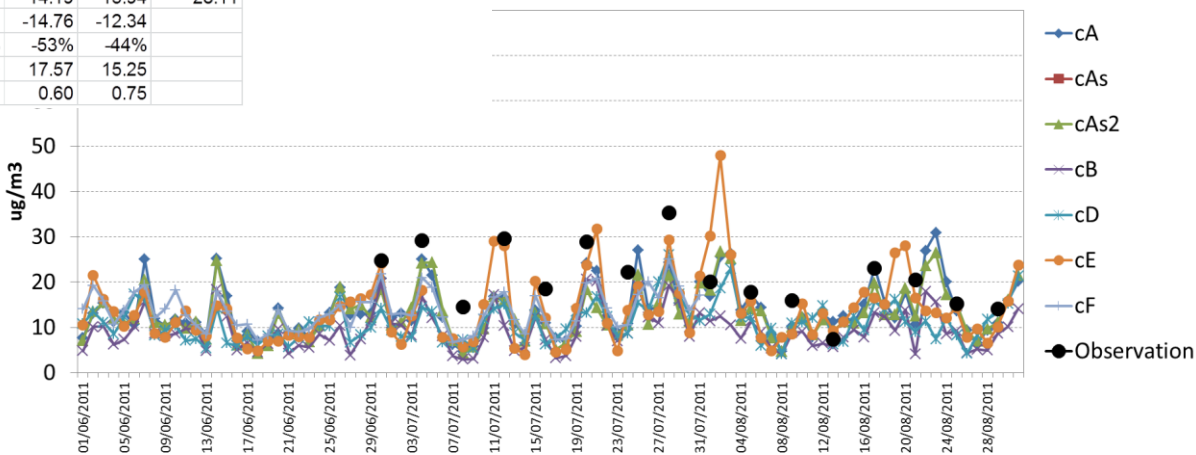
Gent - Winter season PM10



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	23
mean	15.94	16.22	15.30	11.71	15.49	14.19	15.94	28.11
MB	-11.62	-11.09	-12.23	-16.75	-13.71	-14.76	-12.34	
NMB	-41%	-39%	-43%	-60%	-49%	-53%	-44%	
RMSE	14.20	13.81	14.70	19.47	16.70	17.57	15.25	
corr	0.76	0.75	0.76	0.69	0.64	0.60	0.75	

Gent - Winter

Summer season PM10



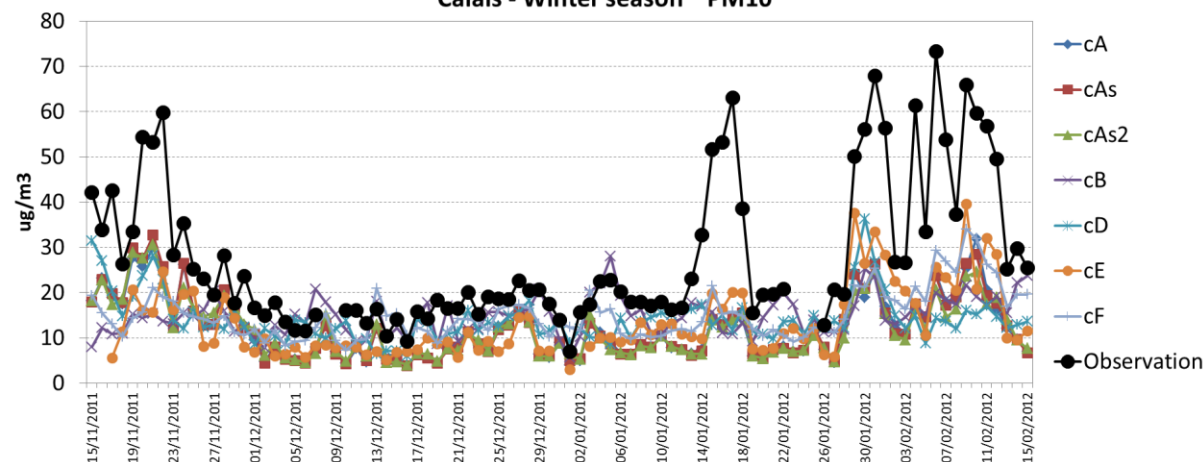
	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	61	16
mean	13.79		13.00	9.44	11.10	13.81	13.76	21.08
MB	-5.36		-6.44	-9.95	-8.96	-3.81	-12.66	
NMB	-25%		-31%	-47%	-43%	-18%	-60%	
RMSE	7.07		7.89	10.97	10.02	6.20	13.82	
corr	0.76		0.76	0.75	0.77	0.77	0.90	

Gent - Summer



# PM<sub>10</sub> Daily time series

Calais - Winter season PM10

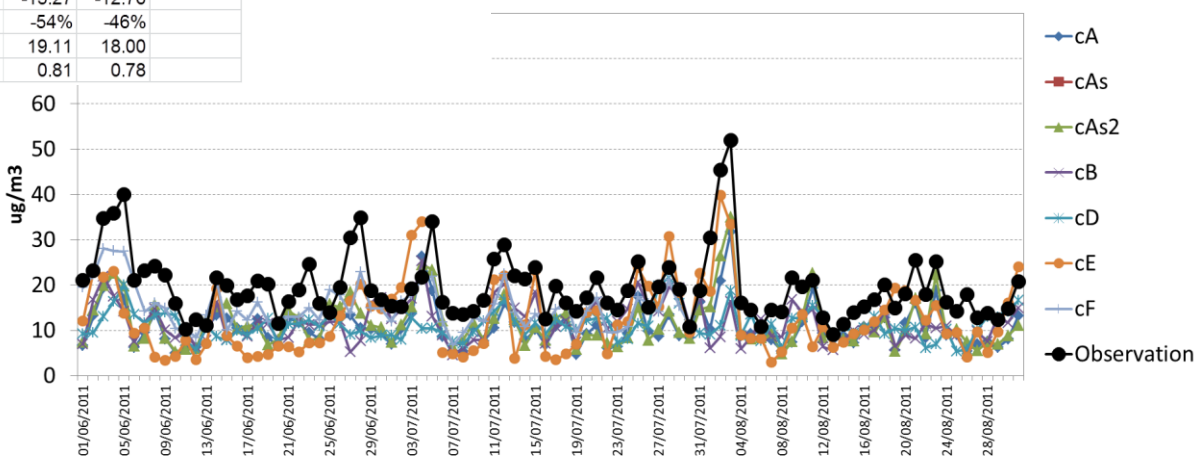


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	88
mean	12.20	12.23	11.87	14.85	14.15	13.19	15.06	28.04
MB	-15.67	-15.62	-16.02	-13.20	-13.78	-15.27	-12.76	
NMB	-56%	-56%	-57%	-47%	-49%	-54%	-46%	
RMSE	19.59	19.53	20.23	20.34	19.68	19.11	18.00	
corr	0.79	0.79	0.75	0.34	0.58	0.81	0.78	

Calais - Winter

Calais - Summer

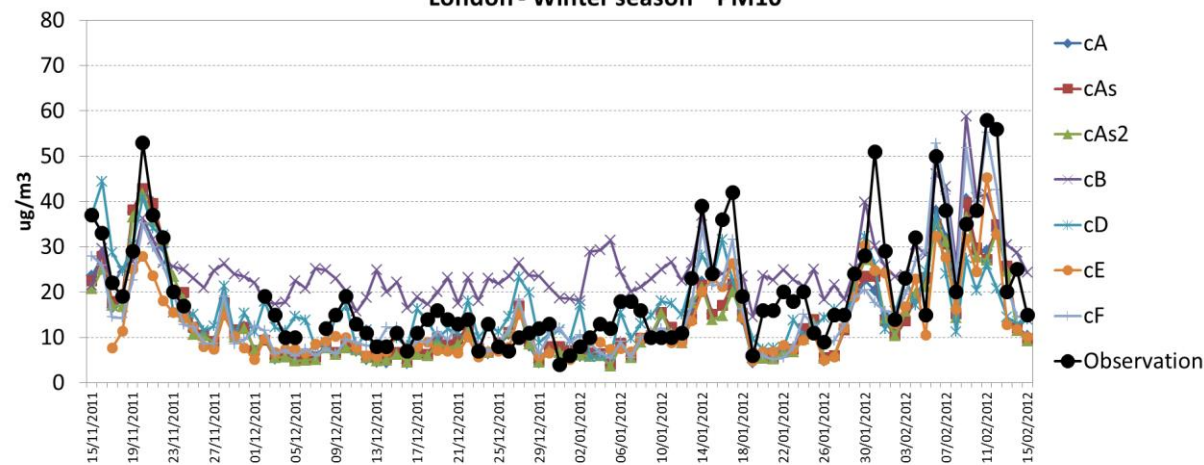
- Summer season PM10



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	61	92
mean	10.86		11.59	11.72	11.12	12.47	15.30	19.60
MB	-8.73		-8.01	-7.87	-8.48	-7.26	-9.45	
NMB	-45%		-41%	-40%	-43%	-37%	-48%	
RMSE	10.14		9.30	10.63	10.85	10.27	13.16	
corr	0.73		0.77	0.36	0.42	0.61	0.77	

# PM<sub>10</sub> Daily time series

London - Winter season PM10

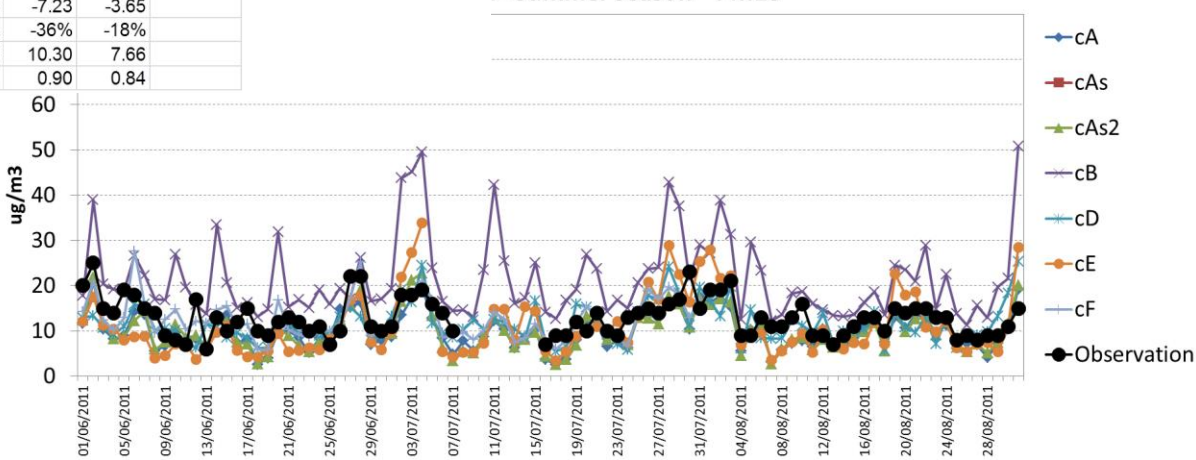


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	84
mean	13.54	13.81	13.36	25.03	16.77	12.80	15.61	19.83
MB	-5.90	-5.63	-6.07	5.37	-2.68	-7.23	-3.65	
NMB	-30%	-28%	-31%	27%	-14%	-36%	-18%	
RMSE	9.23	9.17	9.36	10.51	9.08	10.30	7.66	
corr	0.82	0.81	0.82	0.69	0.71	0.90	0.84	

London - Winter

London - Summer

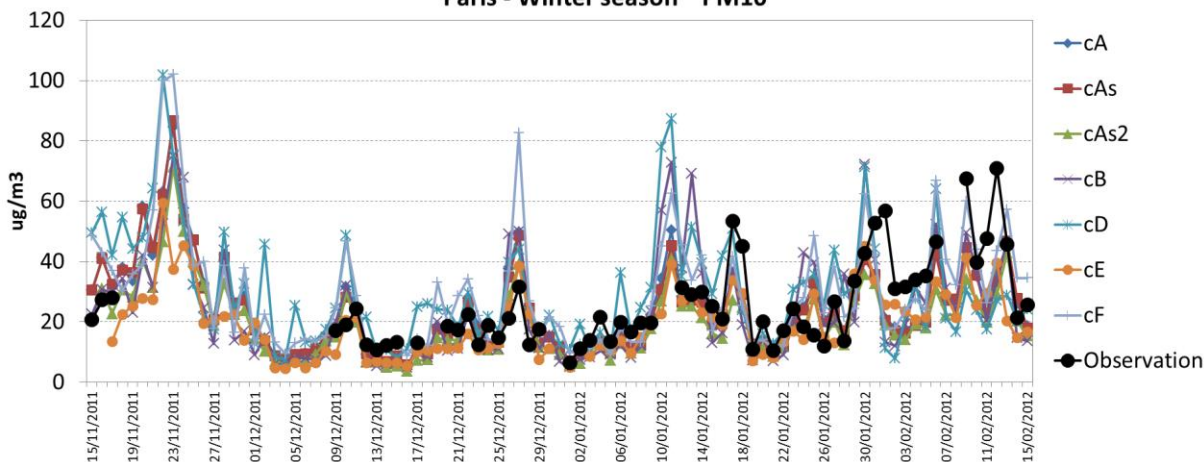
London - Summer season PM10



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	61	84
mean	9.90		10.03	21.44	11.71	11.02	12.71	12.92
MB	-2.90		-2.73	8.46	-1.20	-1.99	-4.67	
NMB	-22%		-21%	65%	-9%	-15%	-36%	
RMSE	4.29		4.29	11.24	4.36	5.95	8.24	
corr	0.71		0.71	0.56	0.51	0.63	0.66	

# PM<sub>10</sub> Daily time series

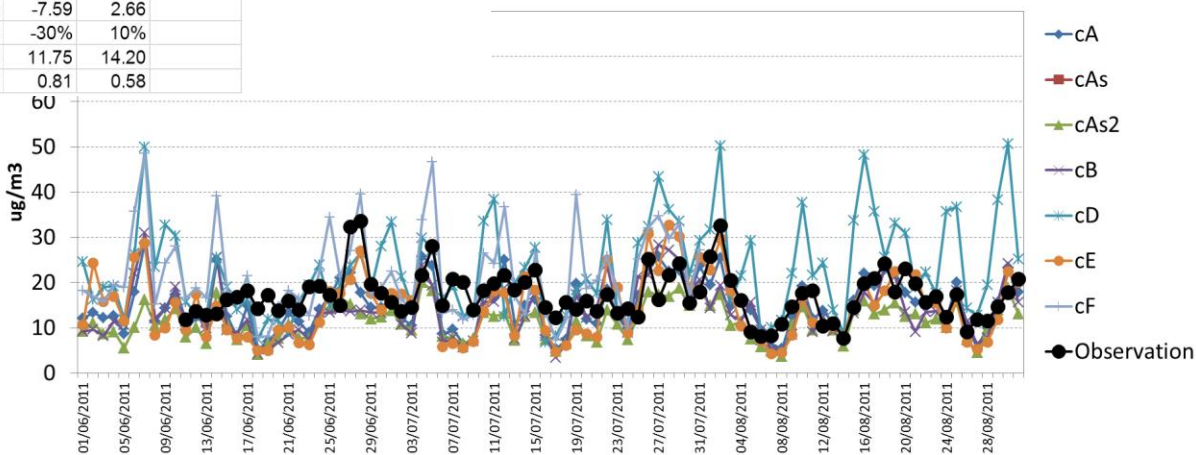
Paris - Winter season PM10



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	63
mean	24.64	24.14	19.98	23.88	30.23	19.52	29.98	25.60
MB	-2.94	-3.53	-7.22	-2.71	2.14	-7.59	2.66	
NMB	-11%	-14%	-28%	-11%	8%	-30%	10%	
RMSE	10.94	11.16	12.53	14.49	16.05	11.75	14.20	
corr	0.68	0.67	0.70	0.55	0.37	0.81	0.58	

Paris - Winter

Summer season PM10

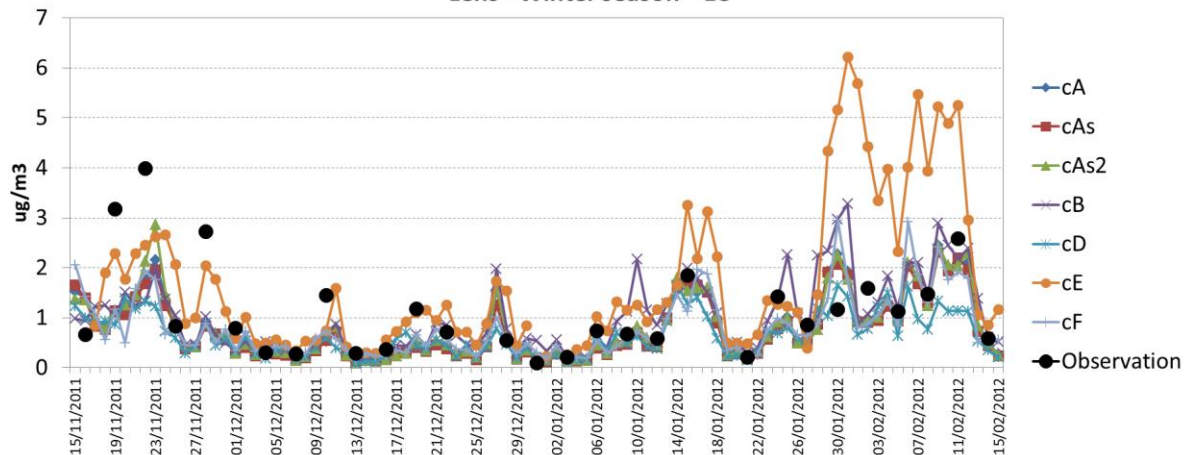


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	61	82
mean	14.86		11.31	13.63	23.06	14.50	21.96	17.05
MB	-2.20		-5.67	-3.56	5.72	-3.01	-3.66	
NMB	-13%		-33%	-21%	34%	-18%	-21%	
RMSE	5.44		7.15	7.03	10.85	6.71	12.65	
corr	0.59		0.58	0.39	0.45	0.66	0.51	

Paris - Summer

# Lens - PM Composition - Daily time series

Lens - Winter season EC

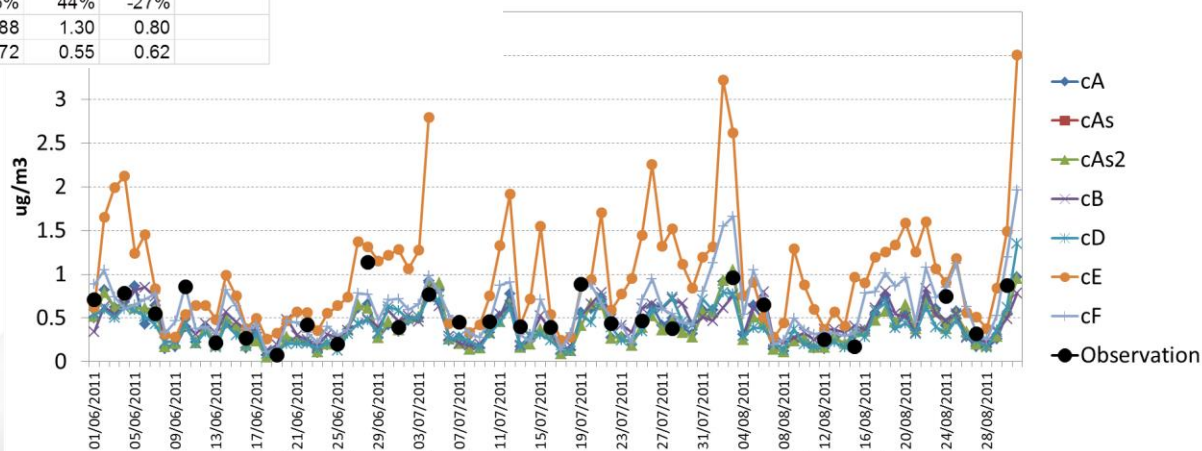


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	0.79	0.76	0.81	1.01	0.65	1.69	0.82	1.12
MB	-0.36	-0.38	-0.34	-0.20	-0.52	0.49	-0.31	
NMB	-32%	-34%	-30%	-17%	-46%	44%	-27%	
RMSE	0.78	0.78	0.73	0.84	0.88	1.30	0.80	
corr	0.68	0.69	0.73	0.52	0.72	0.55	0.62	

EC - Winter

EC - Summer

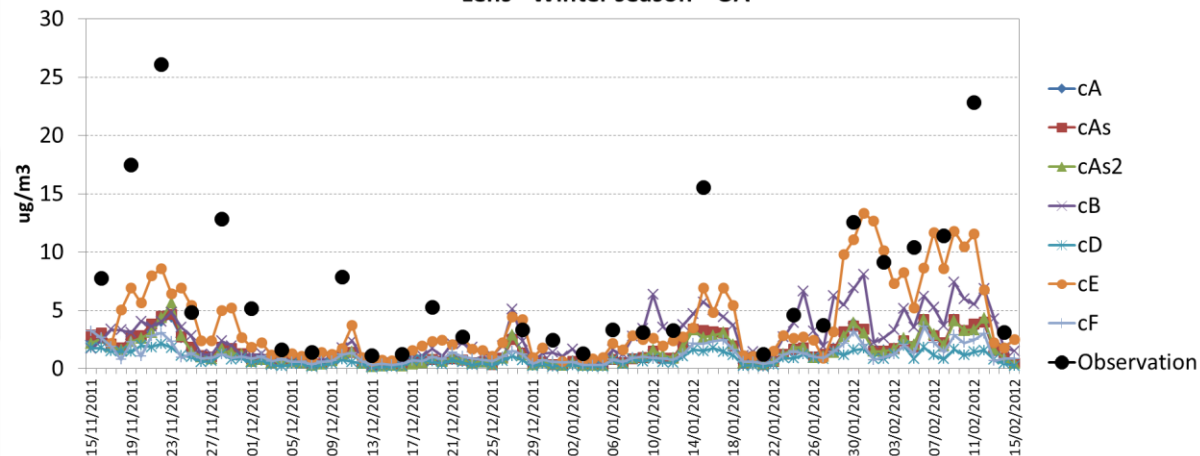
5 - Summer season EC



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	92	27
mean	0.41		0.40	0.45	0.39	1.00	0.62	0.53
MB	-0.12		-0.13	-0.07	-0.14	0.43	0.09	
NMB	-23%		-24%	-13%	-26%	82%	18%	
RMSE	0.21		0.22	0.24	0.24	0.71	0.21	
corr	0.79		0.76	0.53	0.68	0.54	0.82	

# Lens - PM Composition - Daily time series

Lens - Winter season OA

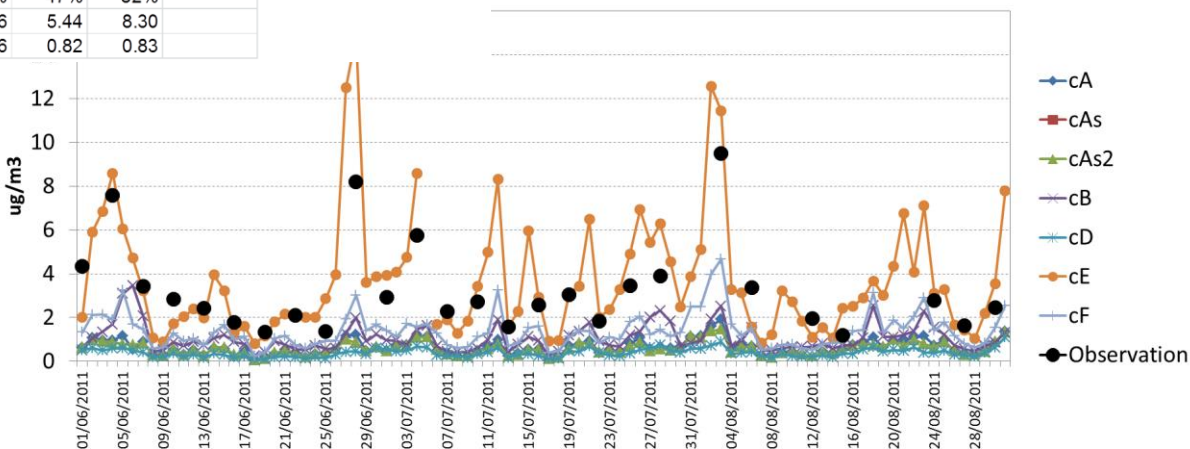


	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	1.49	1.55	1.50	2.75	0.86	3.92	1.24	7.13
MB	-5.68	-5.59	-5.68	-4.61	-6.32	-3.32	-5.86	
NMB	-80%	-78%	-80%	-65%	-89%	-47%	-82%	
RMSE	7.97	7.82	7.95	7.17	8.76	5.44	8.30	
corr	0.89	0.91	0.89	0.72	0.86	0.82	0.83	

OA - Winter

OA - Summer

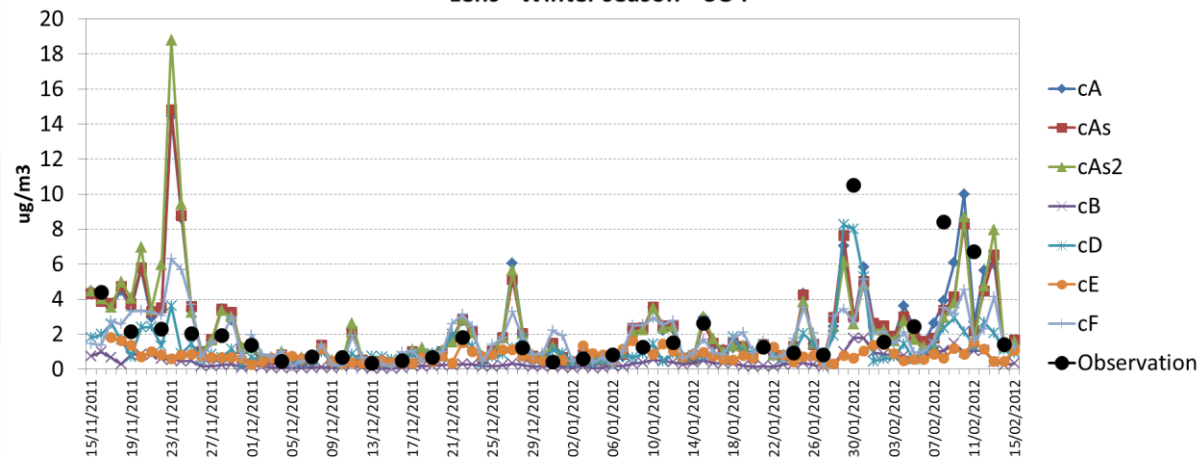
i - Summer season OA



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	92	27
mean	0.63		0.59	1.06	0.39	3.71	1.39	3.27
MB	-2.65		-2.70	-2.19	-2.88	0.54	-1.92	
NMB	-81%		-82%	-67%	-88%	17%	-59%	
RMSE	3.19		3.28	2.76	3.48	1.75	2.38	
corr	0.89		0.83	0.76	0.72	0.91	0.88	

# Lens - PM Composition - Daily time series

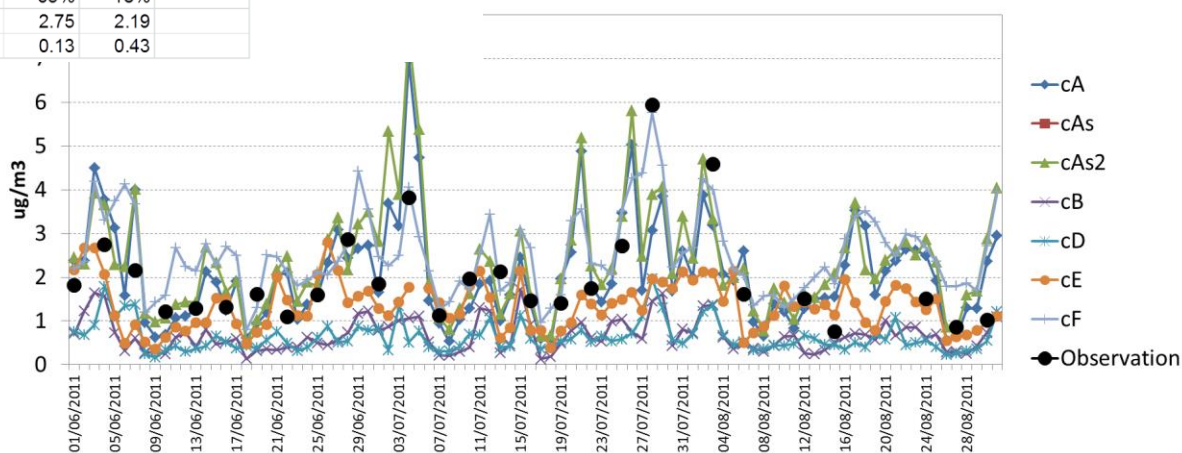
Lens - Winter season SO4=



SO<sub>4</sub><sup>=</sup> - Winter

	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	2.29	2.26	2.33	0.41	1.28	0.81	1.81	2.13
MB	-0.21	-0.21	-0.17	-1.69	-0.90	-1.38	-0.39	
NMB	-10%	-10%	-8%	-79%	-42%	-65%	-18%	
RMSE	1.92	2.01	2.23	2.65	1.79	2.75	2.19	
corr	0.61	0.55	0.39	0.91	0.79	0.13	0.43	

- Summer season SO4=

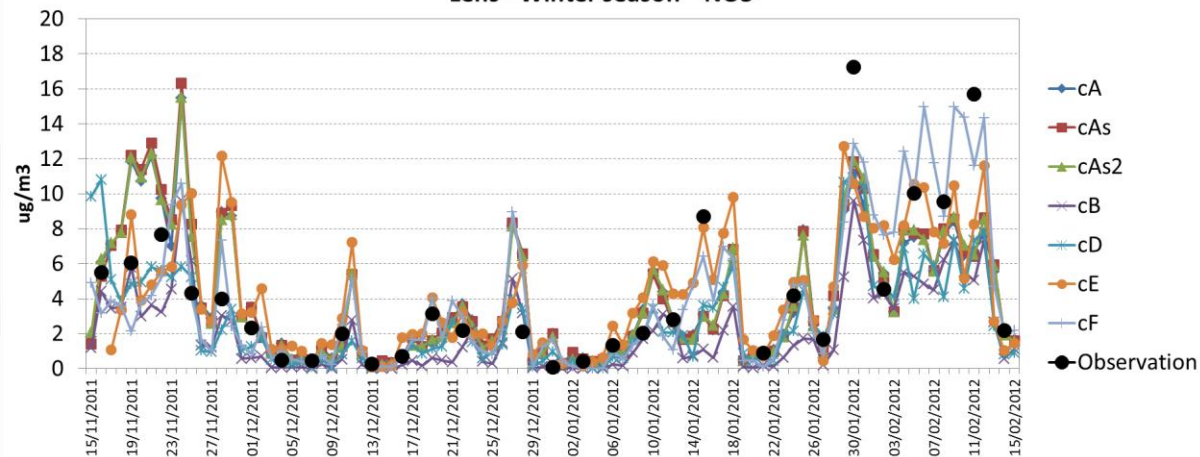


SO<sub>4</sub><sup>=</sup> - Summer

	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	92	27
mean	2.09		2.38	0.67	0.63	1.35	2.54	1.99
MB	0.16		0.41	-1.34	-1.30	-0.68	0.52	
NMB	8%		21%	-67%	-66%	-34%	26%	
RMSE	1.12		1.18	1.62	1.58	1.20	0.80	
corr	0.60		0.62	0.78	0.73	0.54	0.86	

# Lens - PM Composition - Daily time series

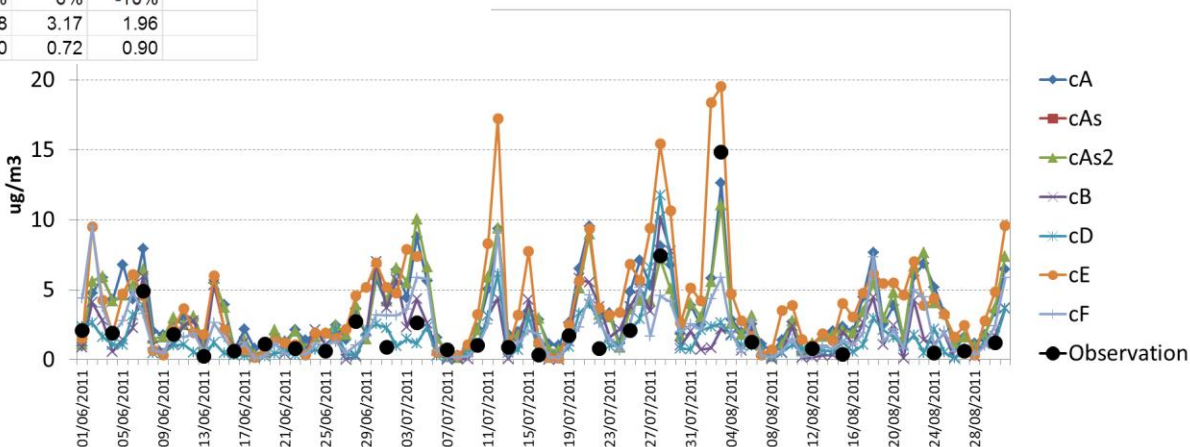
Lens - Winter season NO<sub>3</sub><sup>-</sup>



NO<sub>3</sub><sup>-</sup> - Winter

	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	3.99	4.07	4.00	2.12	2.85	4.30	3.95	4.23
MB	0.02	0.02	-0.04	-1.89	-1.30	0.25	-0.42	
NMB	0%	1%	-1%	-45%	-31%	6%	-10%	
RMSE	3.06	3.06	2.96	3.31	2.98	3.17	1.96	
corr	0.71	0.71	0.73	0.81	0.80	0.72	0.90	

- Summer season NO<sub>3</sub><sup>-</sup>

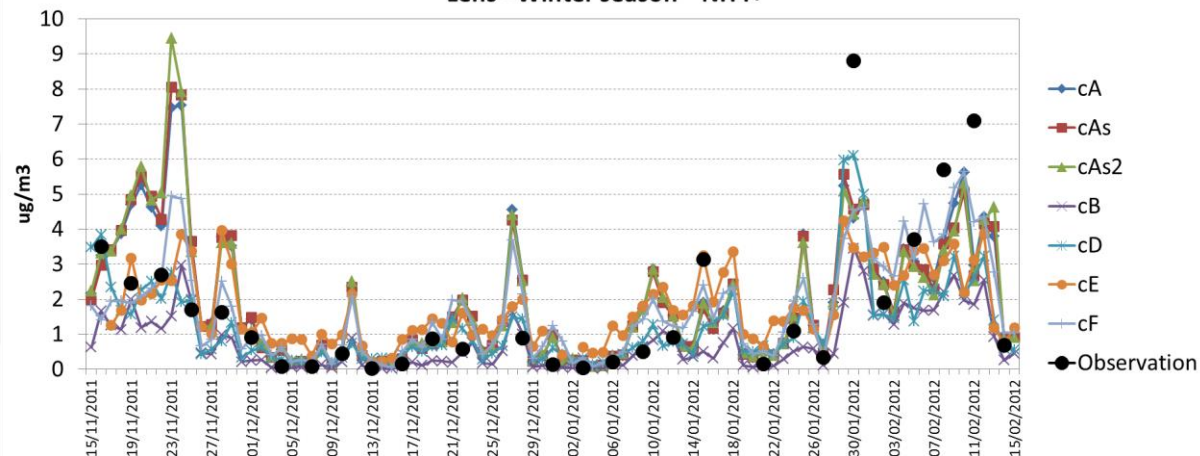


NO<sub>3</sub><sup>-</sup> - Summer

	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	92	27
mean	3.42		3.26	2.01	1.55	4.11	2.12	2.03
MB	1.47		1.27	-0.13	-0.41	1.87	-0.04	
NMB	72%		63%	-6%	-20%	92%	-2%	
RMSE	2.21		2.28	2.77	2.65	2.84	2.17	
corr	0.84		0.77	0.44	0.51	0.89	0.68	

# Lens - PM Composition - Daily time series

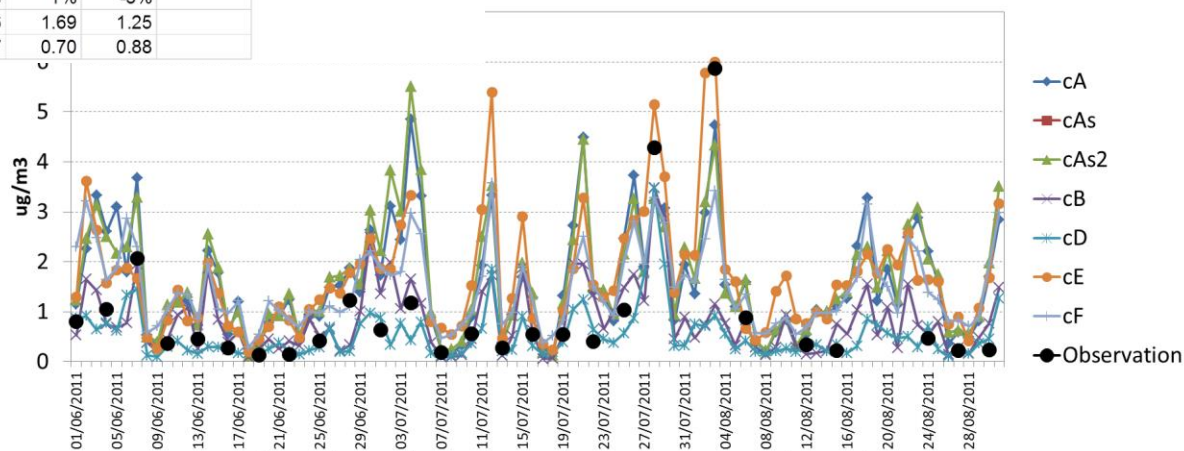
Lens - Winter season NH4+



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	93	93	93	93	93	89	93	29
mean	1.93	1.93	1.95	0.77	1.25	1.74	1.72	1.74
MB	0.13	0.12	0.13	-0.89	-0.49	0.02	-0.05	
NMB	8%	7%	7%	-51%	-28%	1%	-3%	
RMSE	1.52	1.55	1.60	1.73	1.36	1.69	1.25	
corr	0.72	0.70	0.68	0.87	0.87	0.70	0.88	

NH<sub>4</sub><sup>+</sup> - Winter

Summer season NH4+



	cA	cAs	cAs2	cB	cD	cE	cF	Observation
#	92	0	92	92	92	91	92	27
mean	1.60		1.67	0.83	0.53	1.68	1.49	0.92
MB	0.72		0.77	-0.13	-0.35	0.68	0.53	
NMB	78%		83%	-14%	-38%	74%	57%	
RMSE	1.15		1.26	0.99	1.02	0.87	0.96	
corr	0.74		0.68	0.64	0.68	0.91	0.80	

NH<sub>4</sub><sup>+</sup> - Summer





# Statistical indexes

$$MB = \frac{1}{N} \sum_{t=1}^N (C_{\text{mod}}(x, t) - C_{\text{obs}}(x, t)) = \bar{C}_{\text{mod}}(x) - \bar{C}_{\text{obs}}(x)$$

$$NMB = \frac{\frac{1}{N} \sum_{t=1}^N (C_{\text{mod}}(x, t) - C_{\text{obs}}(x, t))}{\frac{1}{N} \sum_{t=1}^N C_{\text{obs}}(x, t)}$$

$$RMSE = \sqrt{\frac{1}{N} \sum_{t=1}^N (C_{\text{mod}}(x, t) - C_{\text{obs}}(x, t))^2}$$