Non-exhaust contributions to PM levels in 5 EU cities

39th PMP Meeting

9 - 10 March 2016

AIRUSE

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Testing and Development of air quality mitigation measures in Southern Europe

Duration: 2012- 2016

Coordinator

CSIC, Spanish Research Council

Associated beneficiaries

- DEMOKRITOS, Greece
- University of Aveiro, Portugal
- University of Florence, Italy
- Institute of Ceramic Technology, Spain
- ARPA Lombardia, Italy
- University of Birmingham, UK

OBJECTIVES http://airuse.eu/media/AIRUSE-EN.mp4

- Characterizing similarities & differences in PM sources & contributions across Southern EU **(Porto, Barcelona, Milan, Florence and Athens)**
- **Develop, test and propose specific and non specific measures** to abate urban ambient air PM in Southern EU, **to meet AQ standards & to approach WHO guidelines**.

Specific PM mitigation measures

- Street washing & dust suppressants for road dust
- Biomass burning
- Industrial emissions
- LEZ, eco-efficient vehicles, labelling, shipping, …

Methods

- ✓ Urban background sites : Barcelona, Porto, Florence, Athens

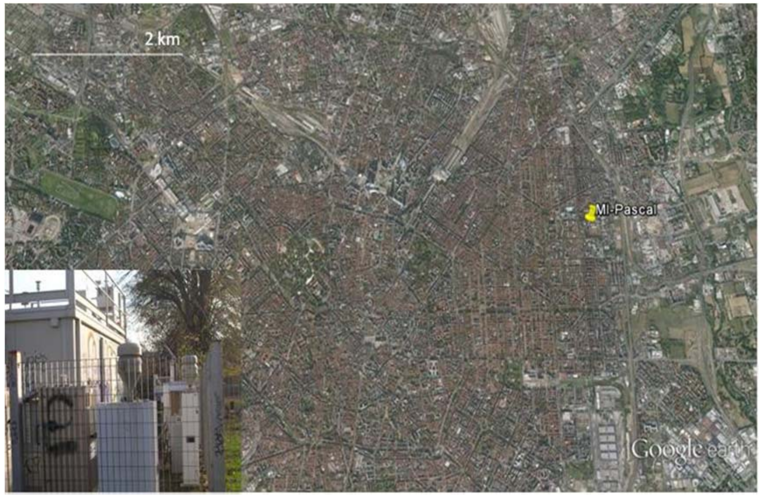
  January-December 2013 (1/3 days)

- ✓ Traffic sites: Barcelona, Porto, Florence, Athens

  Intensive campaigns

Barcelona (UB)

Milan (UB)

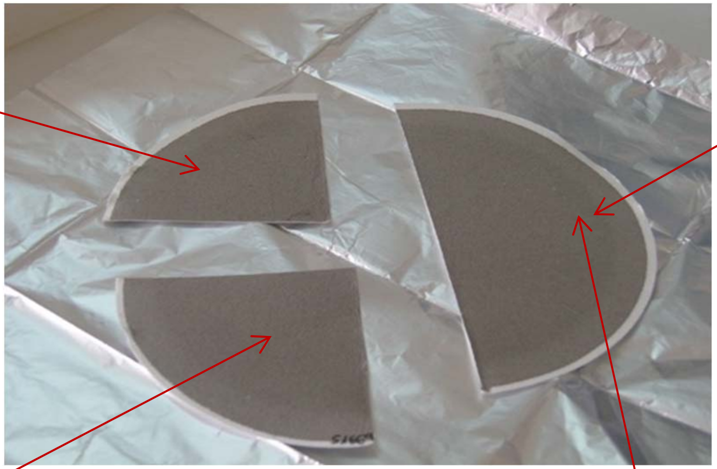


Athens (SUB)

Florence (UB)

Porto (TR)

Sample treatment



Thermal optical analysis: EC, OC

ICP-AES:

Al, Ca, K, Na, Mg, ..

Ion Chromatography:

NO_3^-, Cl^-, $SO_4^=$, NH_4^+

ICP-MS:

Li, Be, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Rb, ..

- Levoglucosan for biomass burning
- Inorganic tracers (carbonate) for African dust
- Intercomparison with XRF, PIXE

>2000 filters analyzed

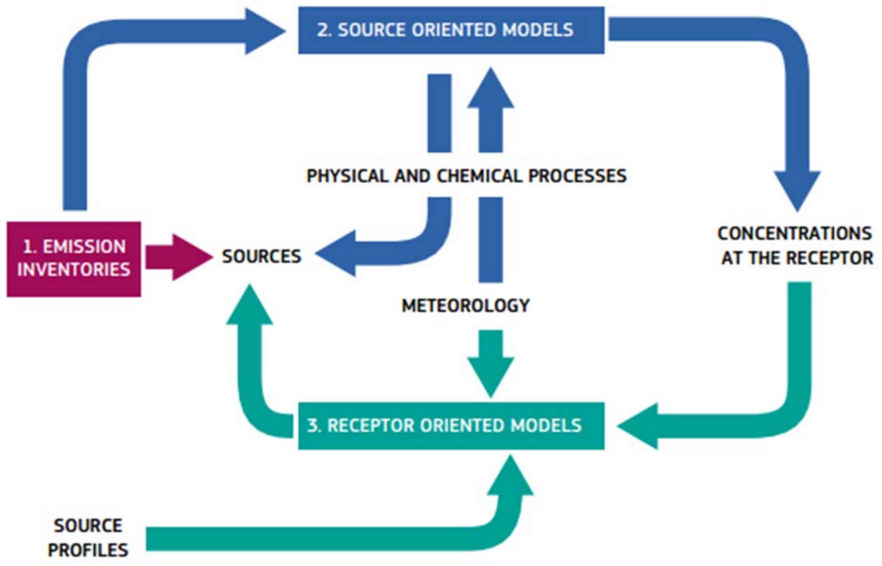
PMF: positive matrix factorization

$$x_{ij} = \sum_{k=1}^{p} g_{ik} f_{jk} + e_{ij} \qquad i=1,2,\dots,m \quad j=1,2,\dots,n$$

$$Q = \sum_{i=1}^{m}\sum_{j=1}^{n} \frac{\left(x_{ij} - \sum_{k=1}^{p} g_{ik} f_{jk}\right)^2}{\sigma_{ij}^2}$$

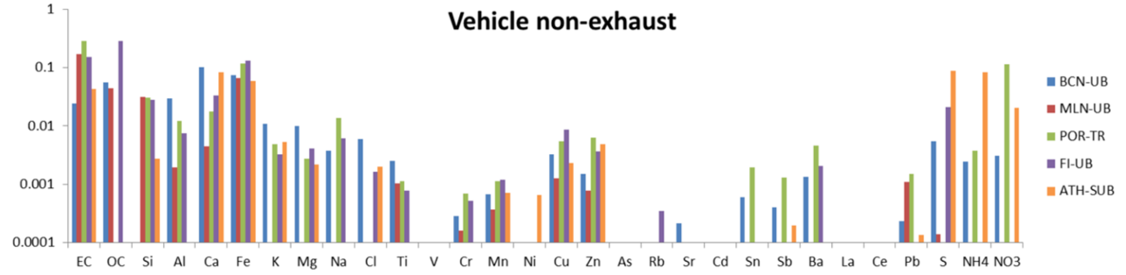
USEPA PMF v5

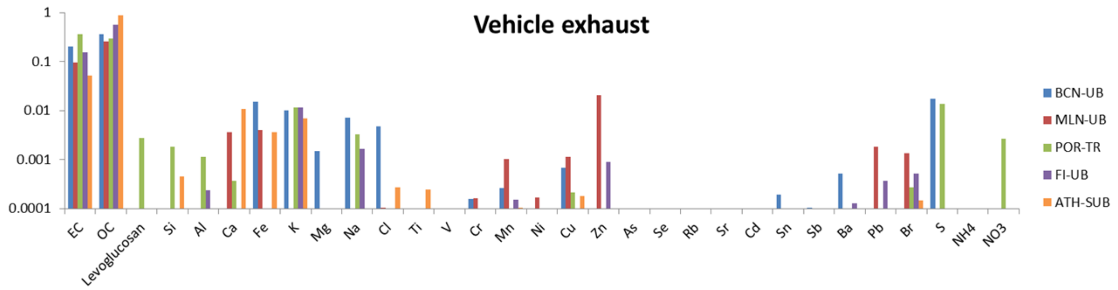
- No need of full source profiles
- Partial information about sources can be used



3 traffic sources identified

- Fe at all sites
- Ca in BCN
- EC in POR, MLN and FI
- S in ATH

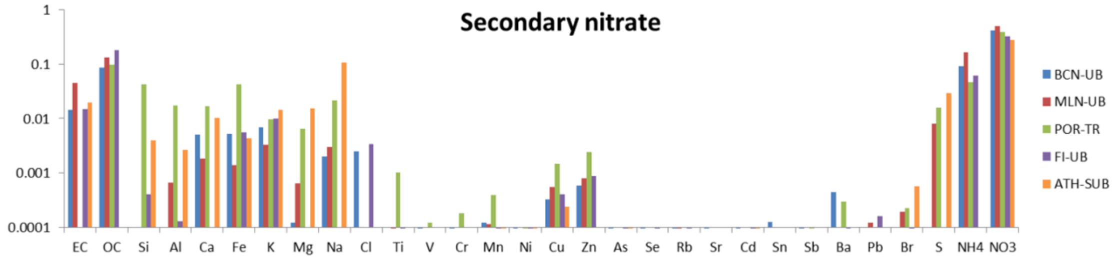




OC/EC:

- <1 at POR-TR
- 1.8-3.7 at UB sites
- 16.4 at ATH-SUB (low diesel)

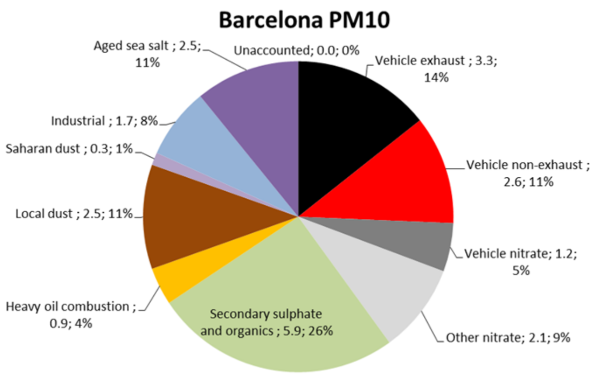
Mainly NH_4NO_3 and OC
$NaNO_3$ in ATH-SUB

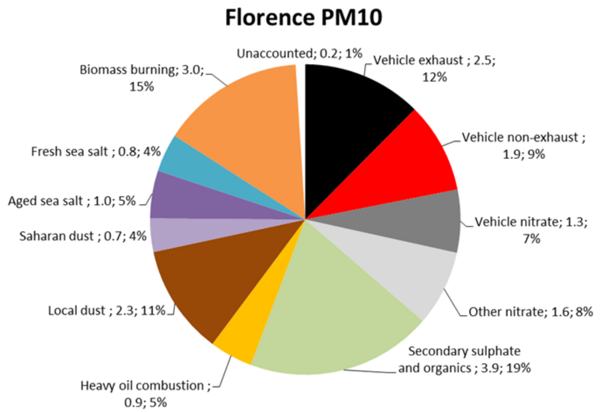


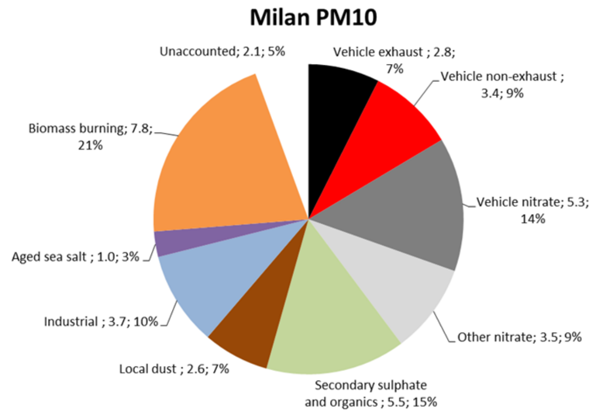
PM10: Annual mean

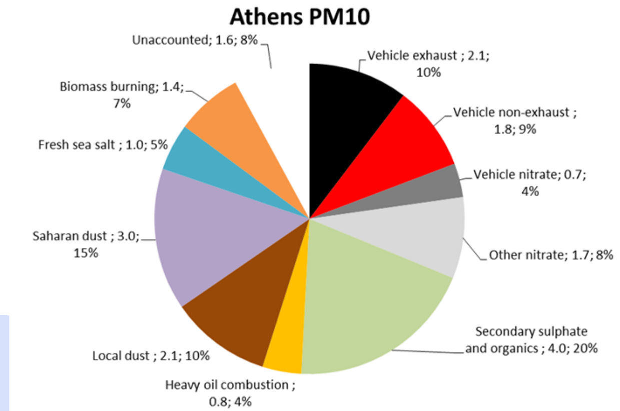
Total traffic: 1st source at all sites
22-36% of PM10

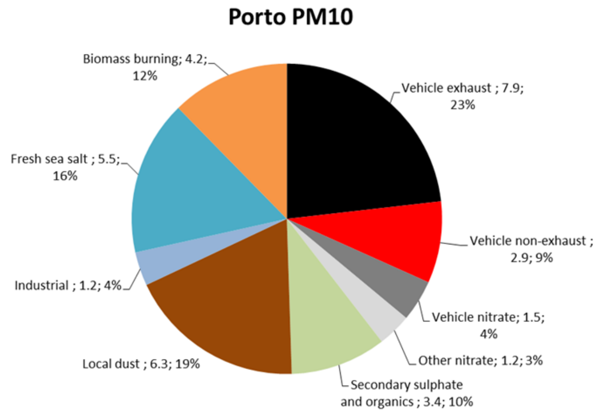
Non-exhaust: 1.8-3.4 $\mu g/m^3$
9-11% of PM10



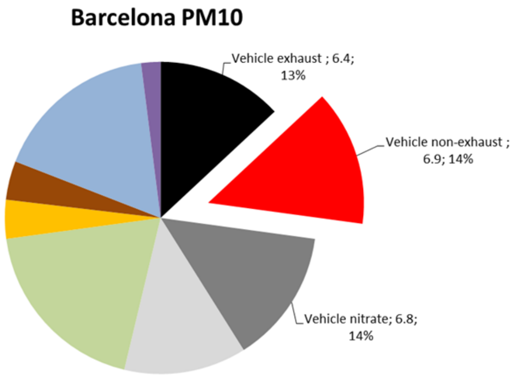


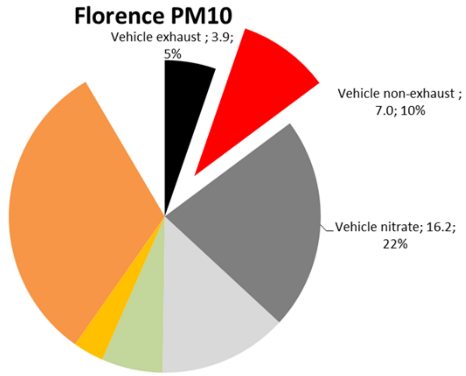


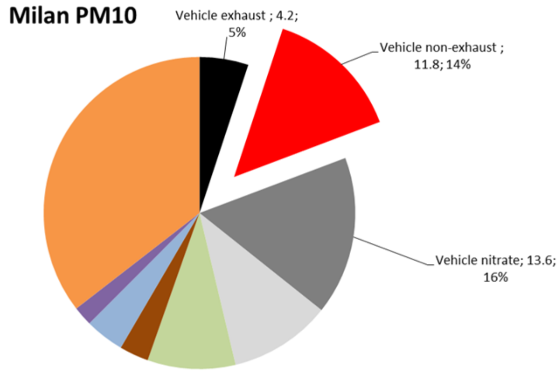


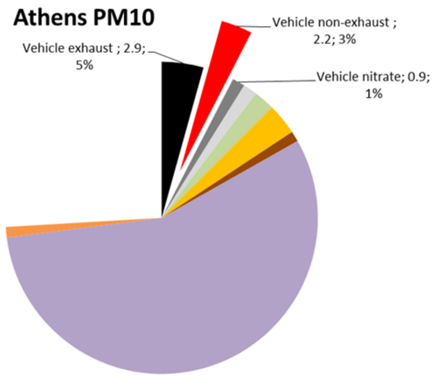


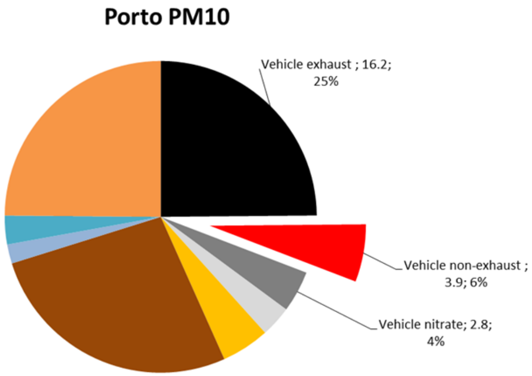
Days with >50 µgPM10/m^3











Non-exhaust: 2.2-11.8 µg/m^3
3-14% of PM10

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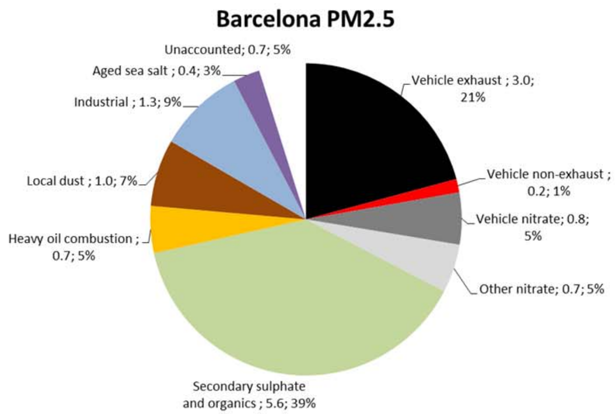
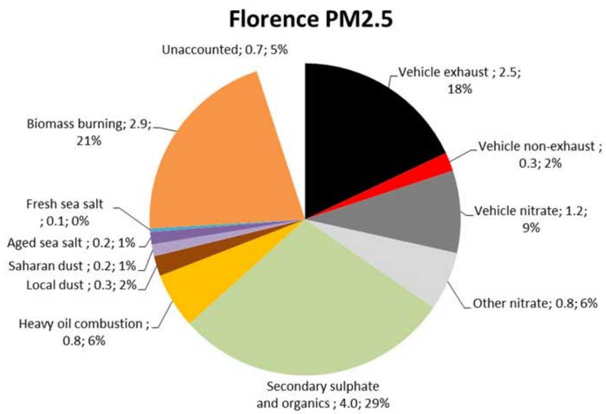
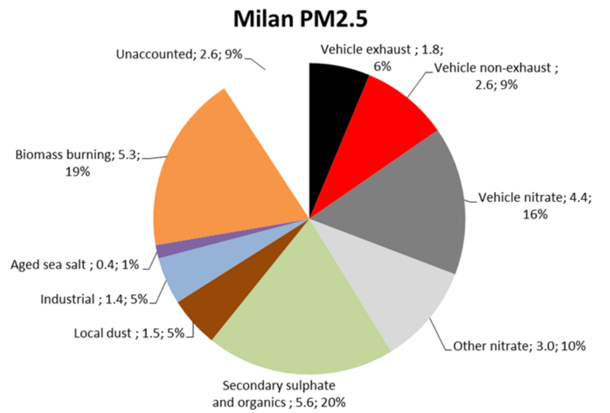
PM2.5: Annual mean

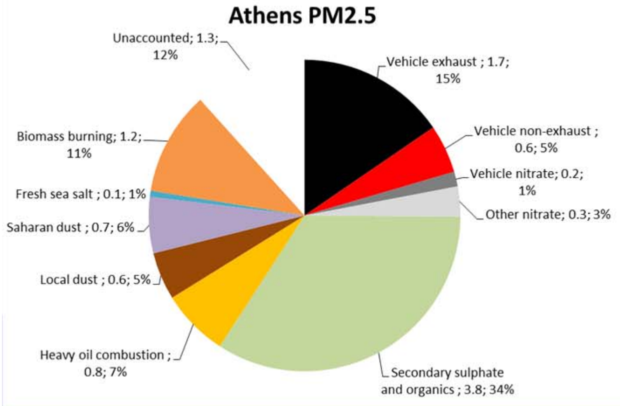
Total traffic: 1st source at MLN, POR and FI
2nd source, at BCN and ATH
26-39% of PM2.5 (22% ATH)

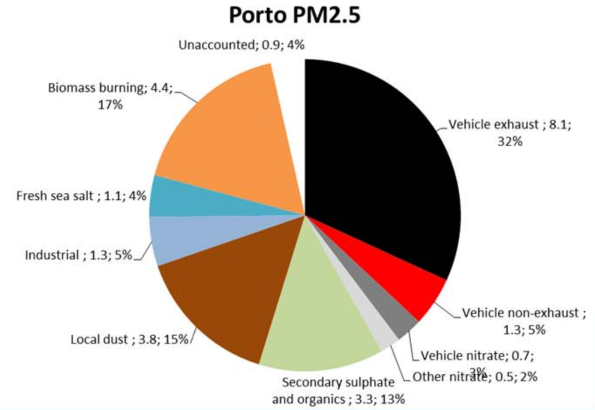
Non-exhaust: 0.2-2.6 μg/m^3
1-9% of PM2.5











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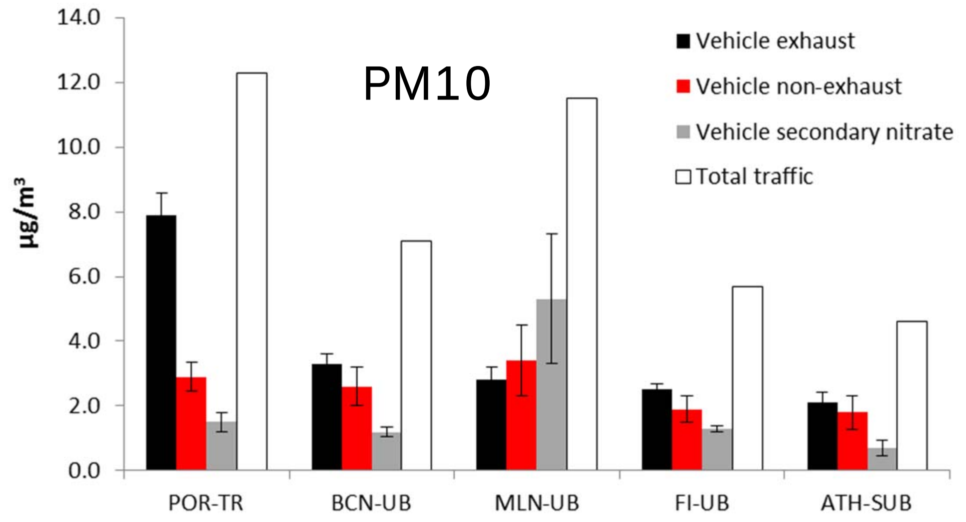
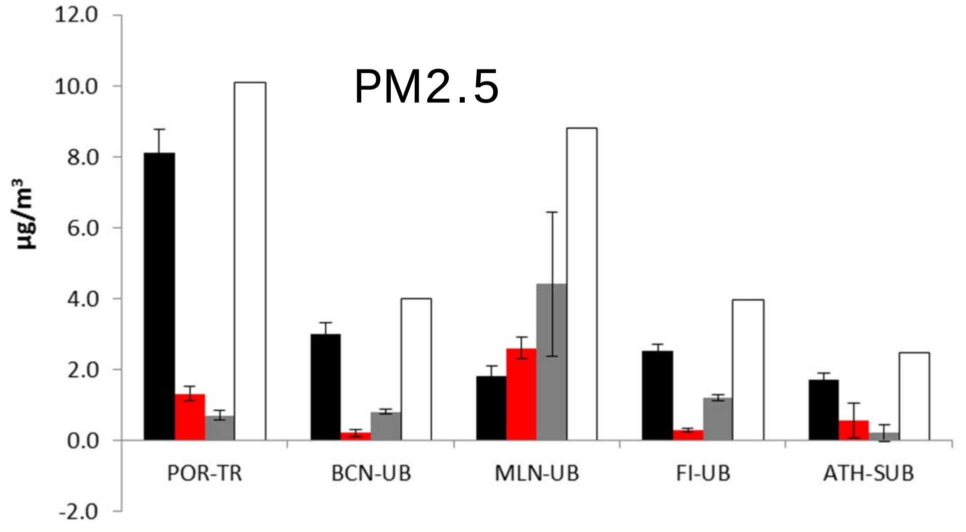


At background PM10, Exhaust and Non-exhaust contributions are nowadays similar



In PM2.5 Exhaust generally dominates

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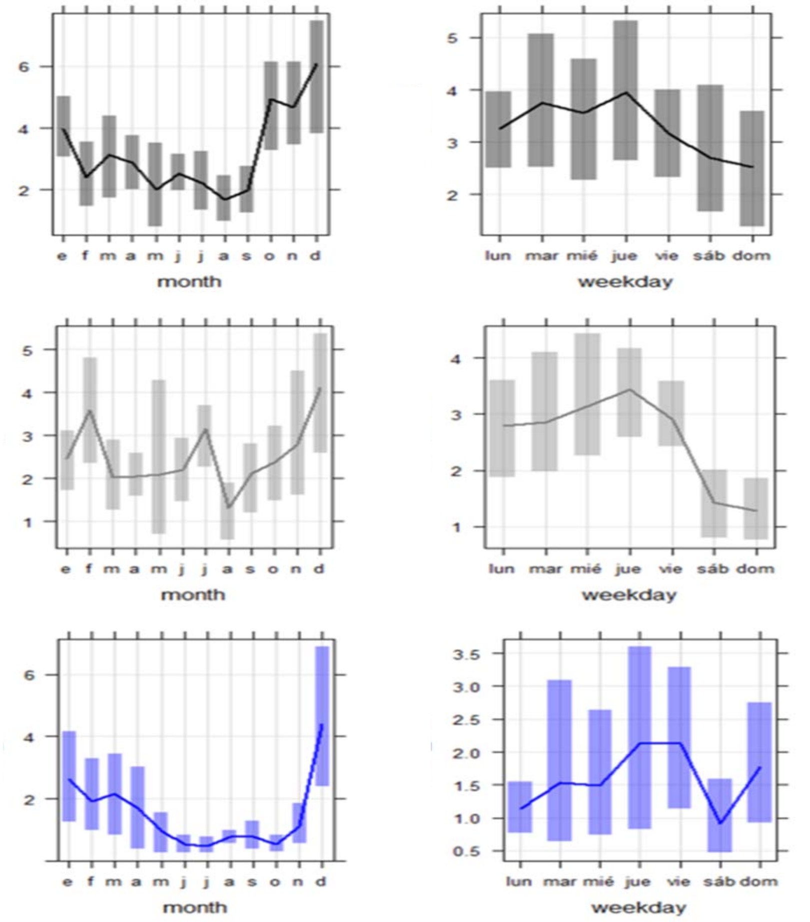
Time variability

Year Week

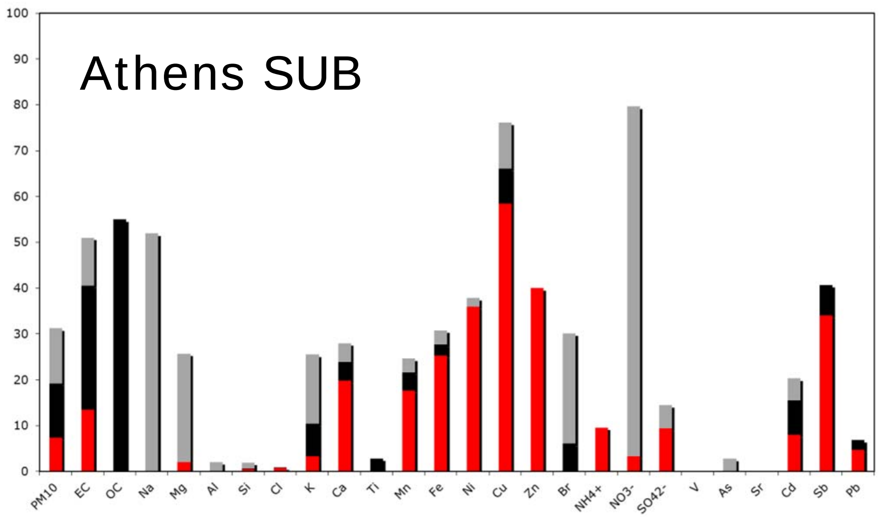
Exhaust

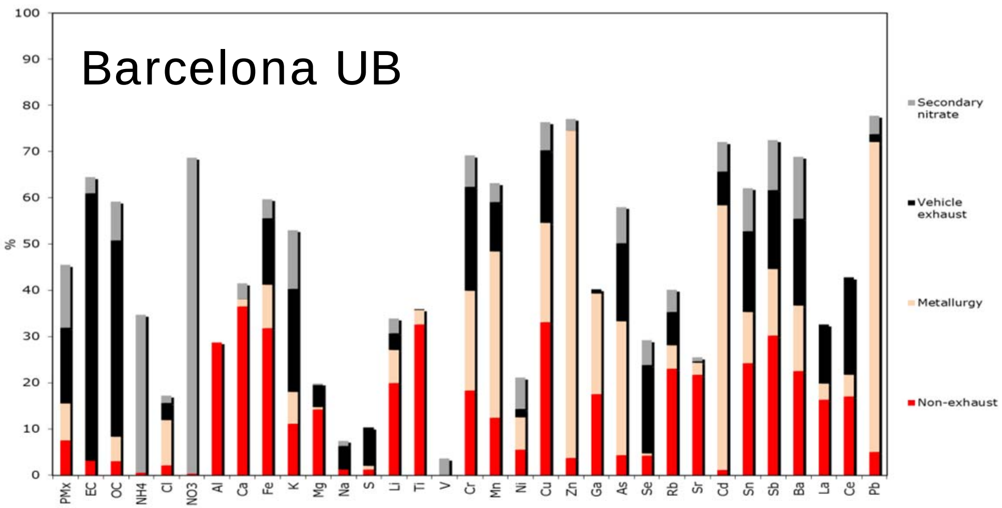
Non-exhaust

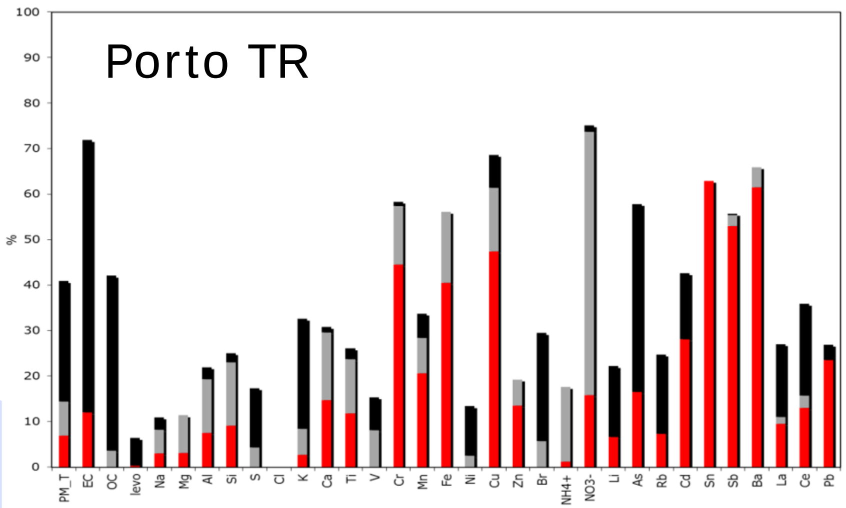
Nitrate



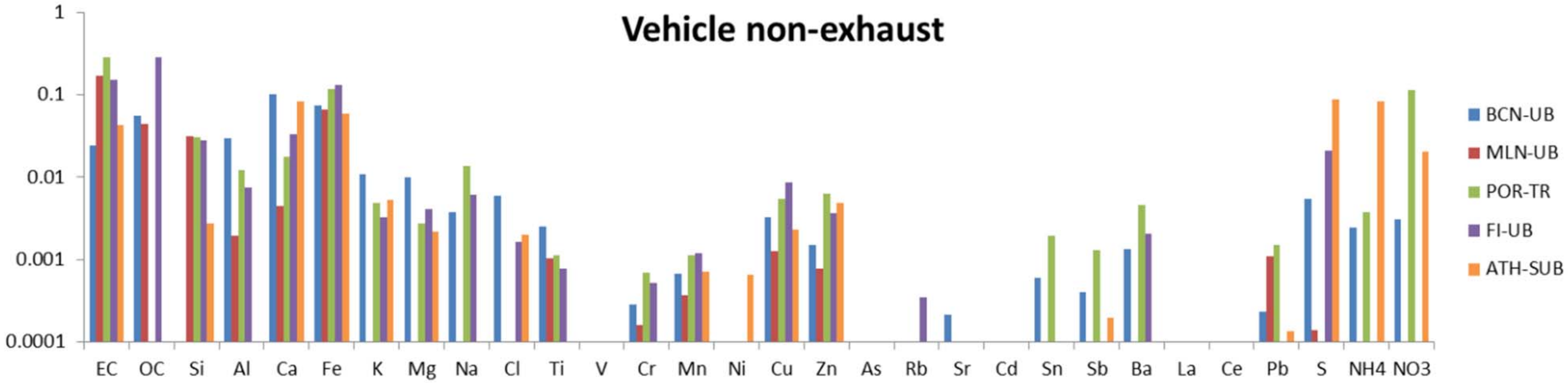
Contribution to elements/compounds







Can we separate better?

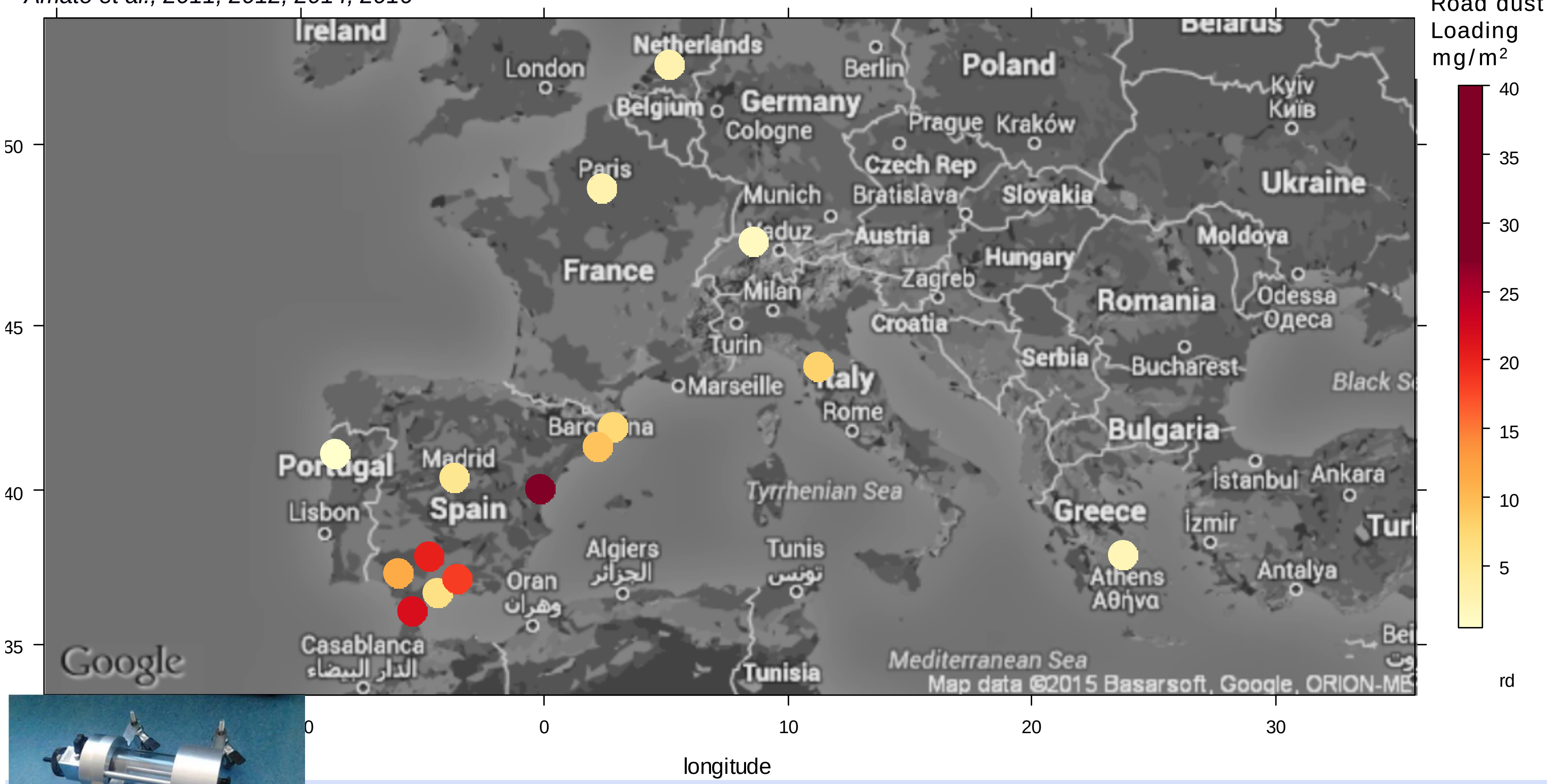


Comparison with experimental profiles

1-hour resolved measurements

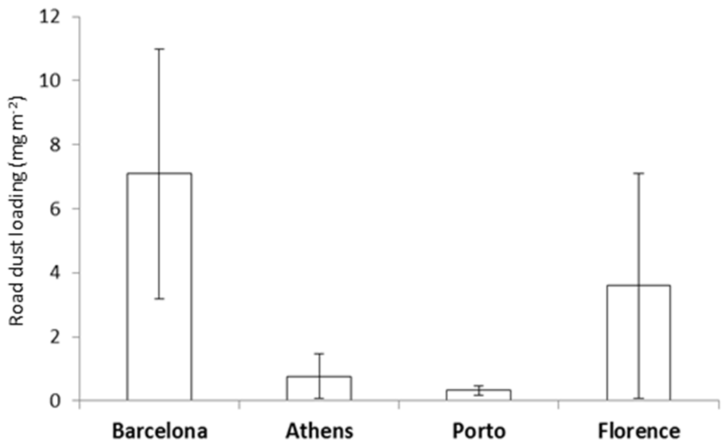
Experimental profiles: Road dust

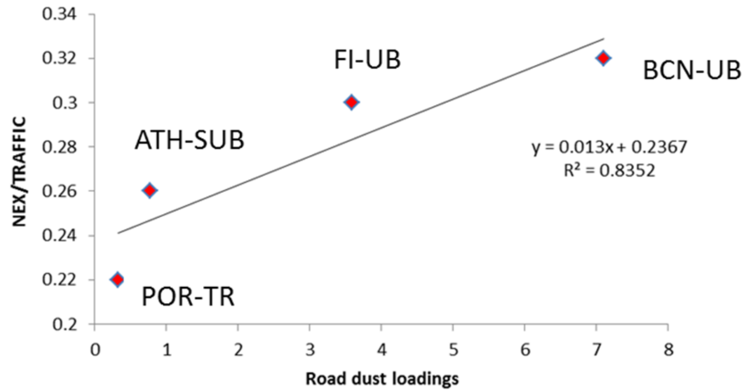
Amato et al., 2011, 2012, 2014, 2016

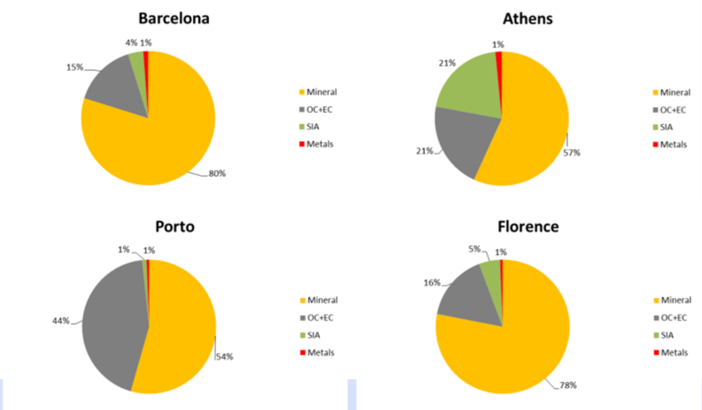


IDPS: Inhalable Deposited Particle Sampler (CSIC patent)

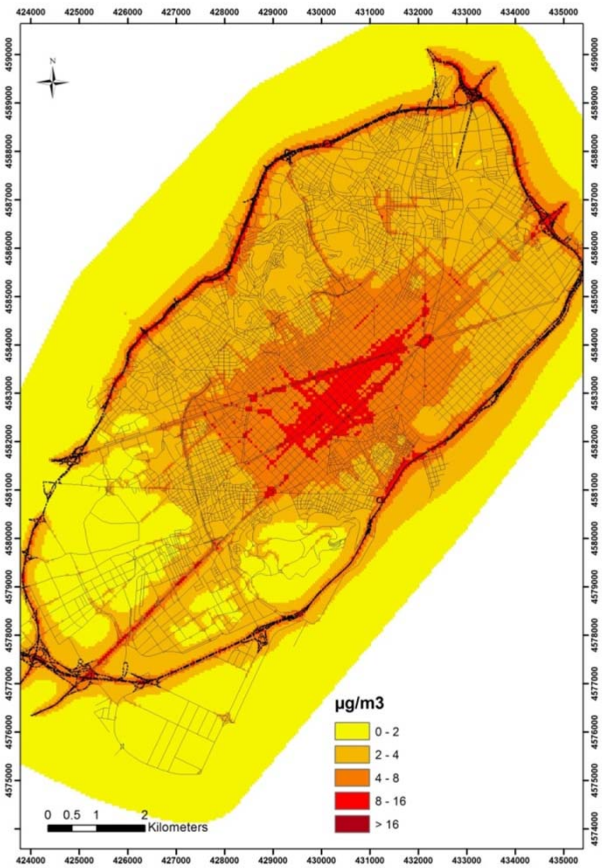
Experimental profiles: Road dust

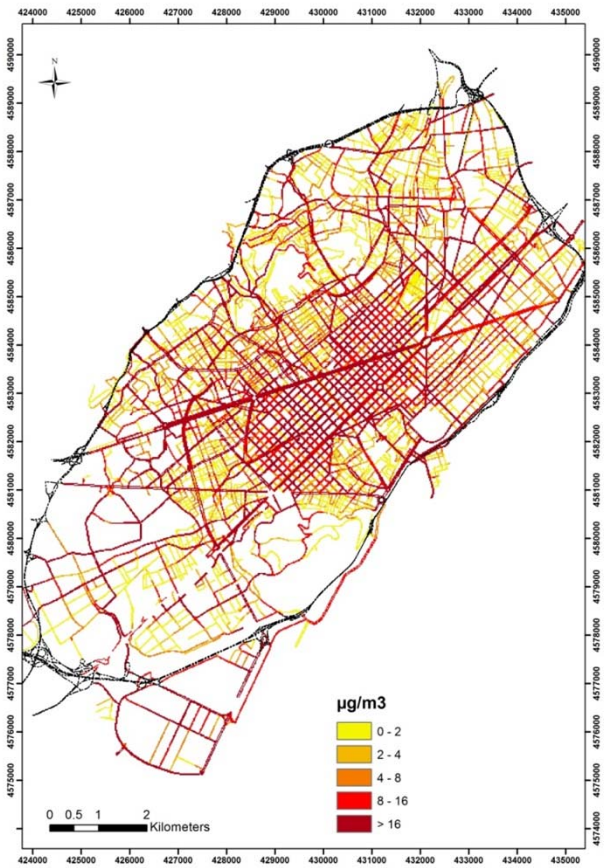






Urban and street level modelling





URBIS model (Amato F., Zandveld P. et al., 2016)

	Brake pads					Tires	
%	UK BRAND A	UK BRAND B	US BRAND	ES BRAND	DE BRAND	JP BRAND	FR BRAND
TC	28	NA	26	28	32	83	79
Al	0.5	1	3.2	1.6	2.6	0.1	0.1
Ba	6.9	0.1	6.7	3.9	3.7	0.001	0.0015
Ca	0.5	0.3	1.7	4.3	2.1	1.3	0.5
Cu	0.003	11.8	2.6	0.02	1	0.0005	0.0007
Fe	45.6	26	13.2	23.6	27.4	<DL	<DL
K	0.1	<DL	0.4	0.1	0	<DL	0.1
Mg	1.3	0.8	3.8	0.6	0.6	<DL	<DL
Mn	0.2	<DL	0.1	1.5	0.1	0.0003	0.0003
Na	<DL	<DL	1	0.1	0.1	<DL	<DL
S	1	1.9	1.9	3.3	2.4	1.2	1.3
mg/kg							
Hg	<DL	0.1	0.1	2.1	0.2	NA	NA
Li	1.4	2	3.5	1.9	1.4	1	<DL
Ti	686	335	905	489	396	31	17
V	179	40	17	26	47	4	4
Cr	230	2834	185	1276	64	1	2
Co	24	10	11	13	20	80	94
Ni	47	33	50	72	69	<DL	<DL
Zn	36	14862	5717	1778	761	19849	15073
Ga	8	6	5	4	5	<DL	<DL
Ge	2	4	2	1	1	<DL	<DL
As	9	8	23	10	120	1	1
Se	<DL	7	12	<DL	12	<DL	<DL
Rb	31	5	29	16	1	1	3
Sr	696	26	719	763	1371	18	3
Y	1	16	16	7	2	<DL	<DL
Zr	13	950	2337	73	23	1	1
Nb	2	<DL	2	136	9	<DL	1
Mo	4	3093	86	13	167	<DL	1
Cd	<DL	23	2	<DL	2	3	2
Sn	1	10	342	41	148	3	2
Sb	12	6944	15916	30	64	12	2
Cs	1	1	1	<DL	<DL	<DL	<DL
La	3	<DL	8	41	2	2	4
Ce	5	<DL	14	56	5	<DL	1
Hf	<DL	<DL	45	1	<DL	<DL	<DL
Pb	159	7	175	39	261	20	26
Bi	<DL	<DL	36	<DL	9	<DL	1
Th	1	4	4	4	<DL	<DL	<DL
U	<DL	4	4	1	<DL	<DL	<DL
W	<DL	<DL	<DL	19	1	<DL	<DL

Experimental profiles: Brake pads and Tires

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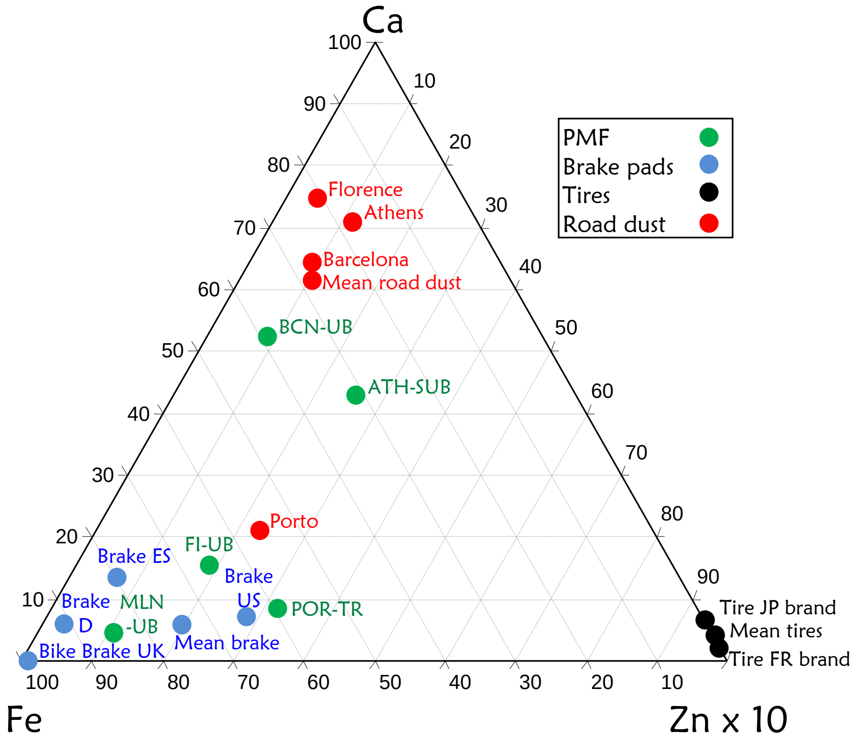
PMF profiles vs Experimental profiles



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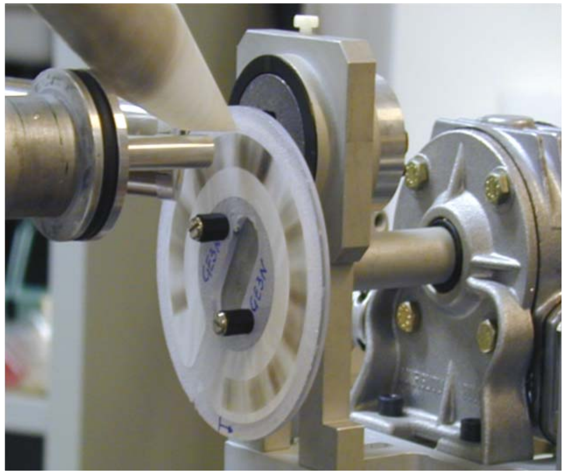
1-hour resolution measurements

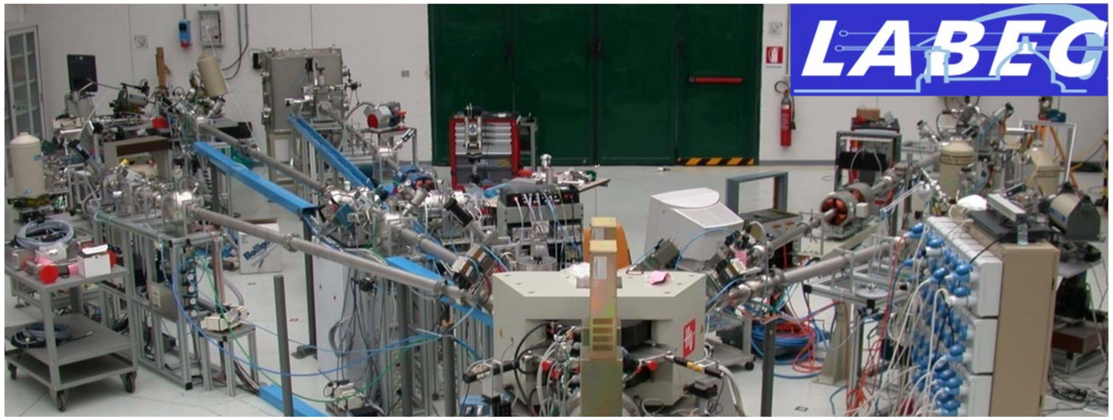
Streaker Sampler

PIXE analysis

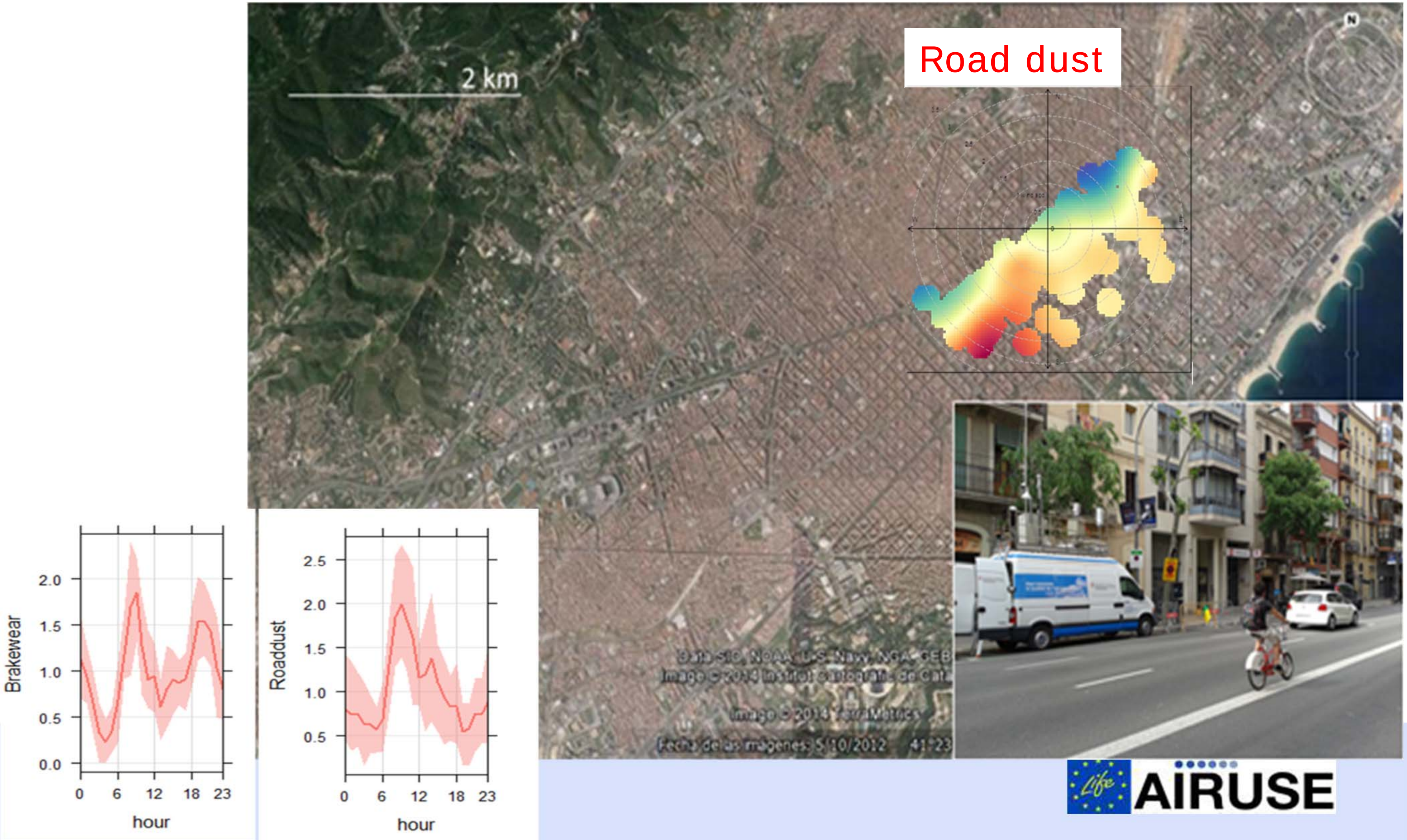


$PM_{2.5}$

$PM_{2.5-10}$



Hourly measurements



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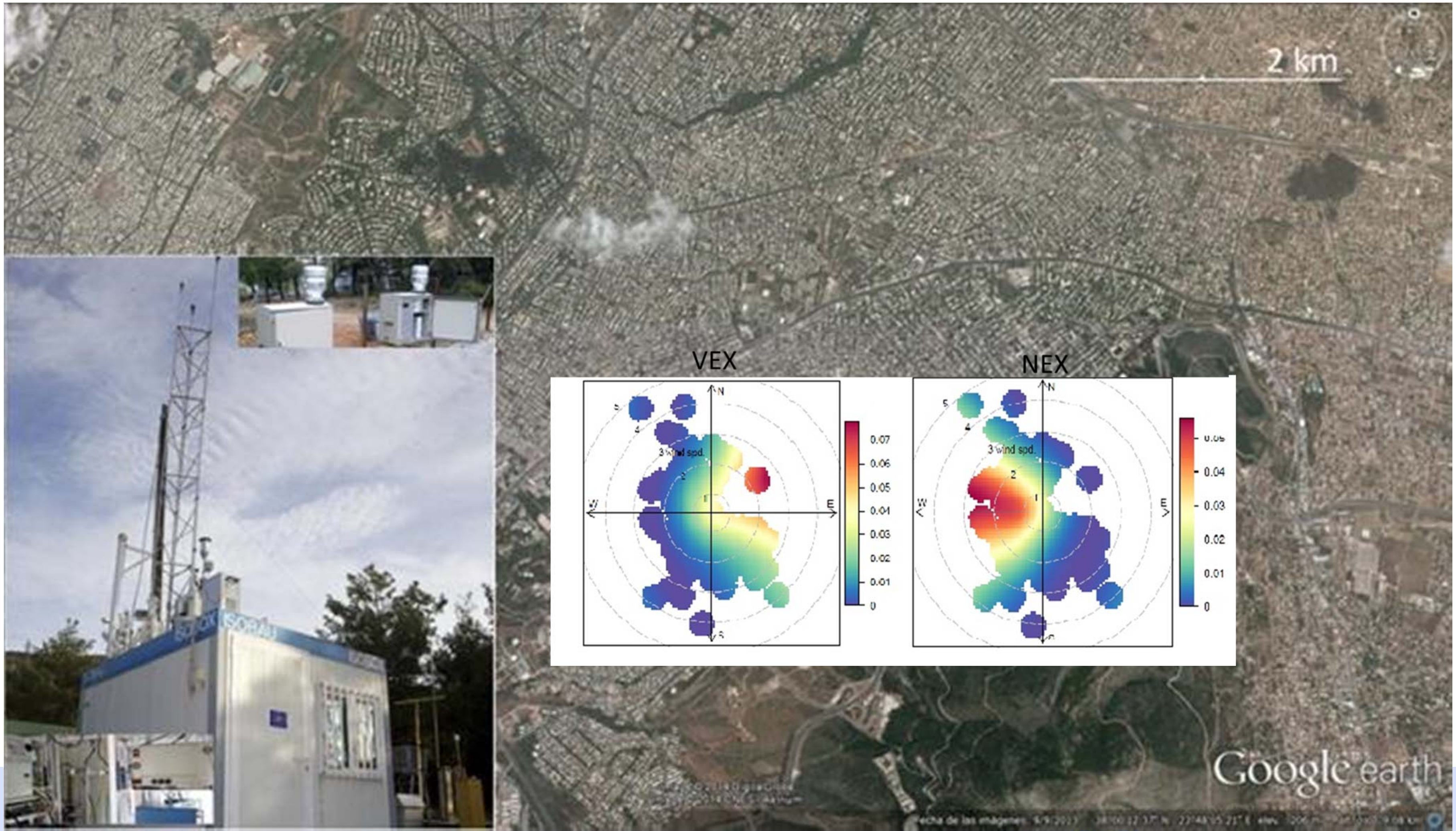
Athens ATH-SUB



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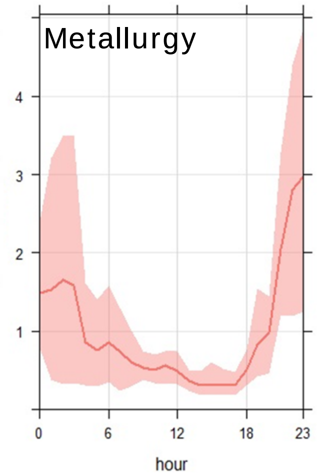
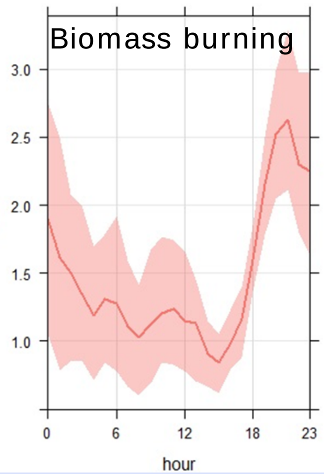
Hourly measurements





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Conclusions

1. Traffic is 29-36% of PM10 (22% ATH), 26-39% of PM2.5 (22% ATH)
2. Non-exhaust is 9-11% of PM10 (1.8-3.4 µg/m^3), comparable to exhaust
3. Non-exhaust is the main source of Cu, Fe, Sb, Zn, Cr, Ba, Sn, Ni…
4. In PM2.5, exhaust contribution generally dominates
5. Non-exhaust burden generally increases during PM10 exceedances
6. Non-exhaust contribution is more related to:
   - Resuspension (in Barcelona and Athens)
   - Brake wear (in Porto, Florence, and Milan)