Source contribution - an alternative metric?

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Outline

CSIC

Contract S-G D Air Quality and Industrial Environment

EVALUATION OF PM POLLUTION IN SPAIN

GOBIERNO DE ESPAÑA

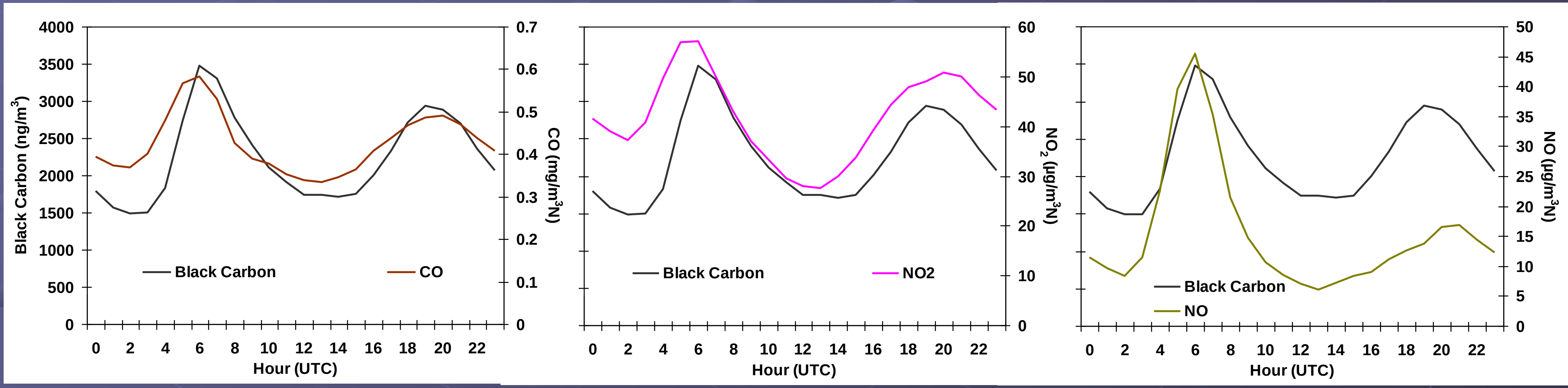
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

- Source apportionment possibilities
  1. Time variation
  2. Measuring tracers
  3. Spatial variation
  4. Receptor modelling
- Conclusions

1. Time variation and correlation with other components

A large proportion of PM exceedances occur in urban-traffic sites

The levels of a number of pollutants co-vary along the day with traffic

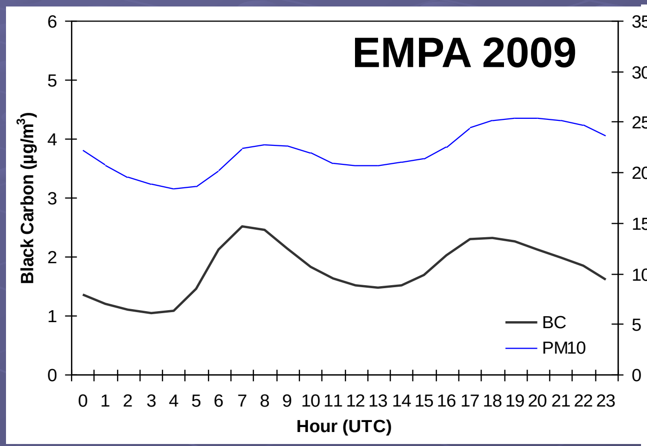


BARCELONA, urban background, mean values for 2009

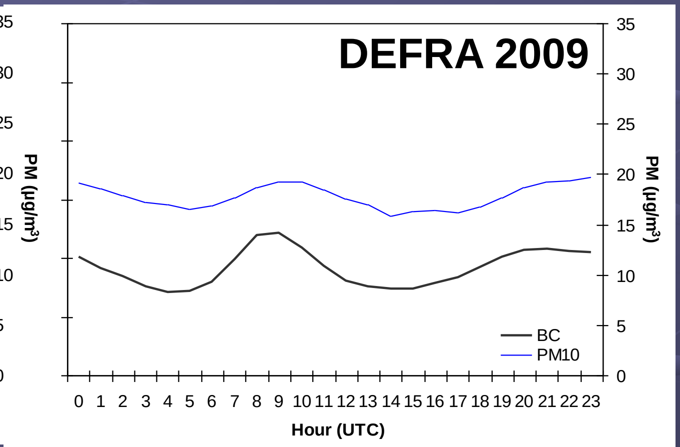
1. Time variation and correlation with other components

PM does not always co-vary with traffic

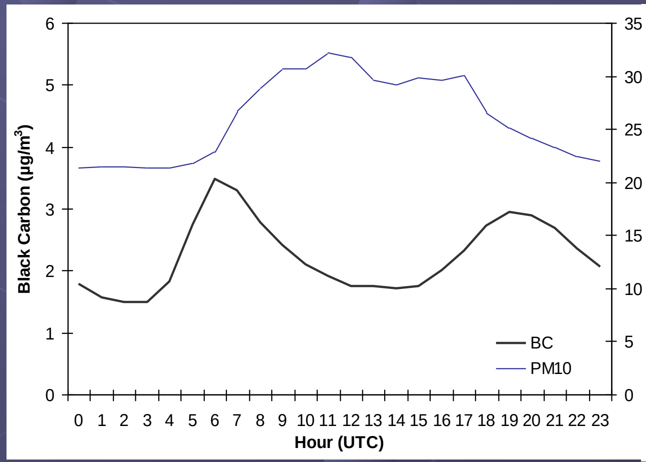
LUGANO URBAN SITE



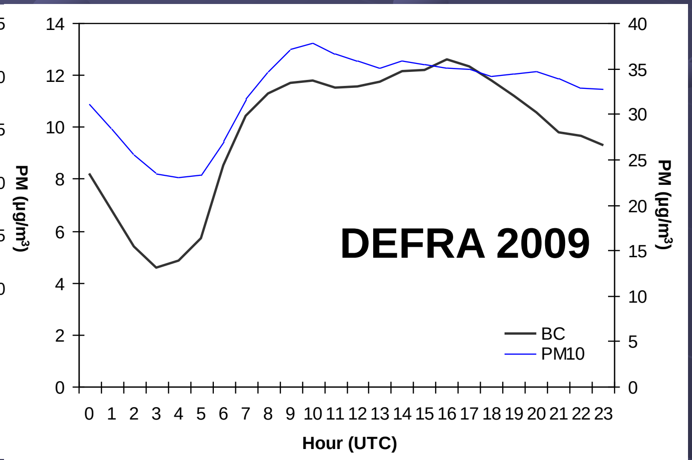
S. KENSINGTON URBAN SITE



BARCELONA URBAN SITE



MARYLEBONE KERBSIDE SITE (TRAFFIC)



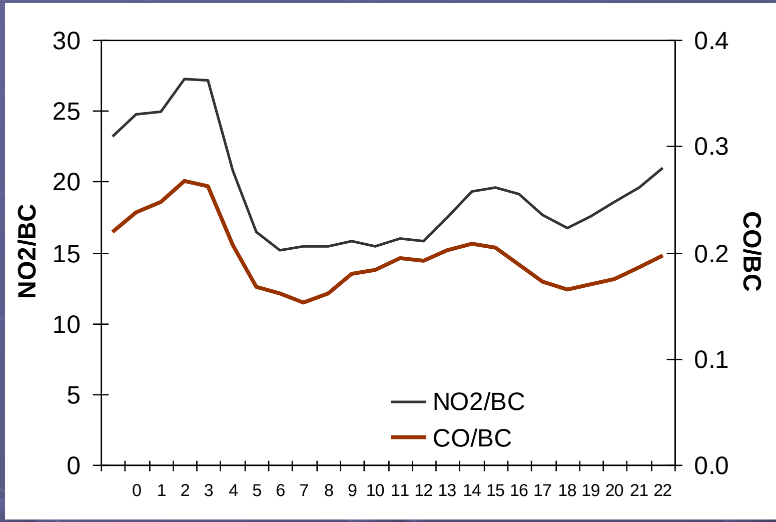
Mean values for 2009

1. Time variation and correlation with other components

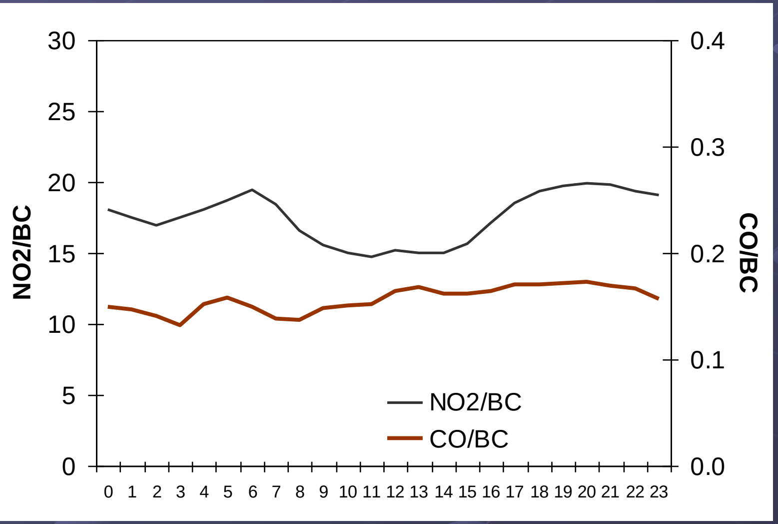
Are CO/BC, NO2/BC constant across Europe?

This would allow avoiding BC measurements, but this is not the case!

BARCELONA



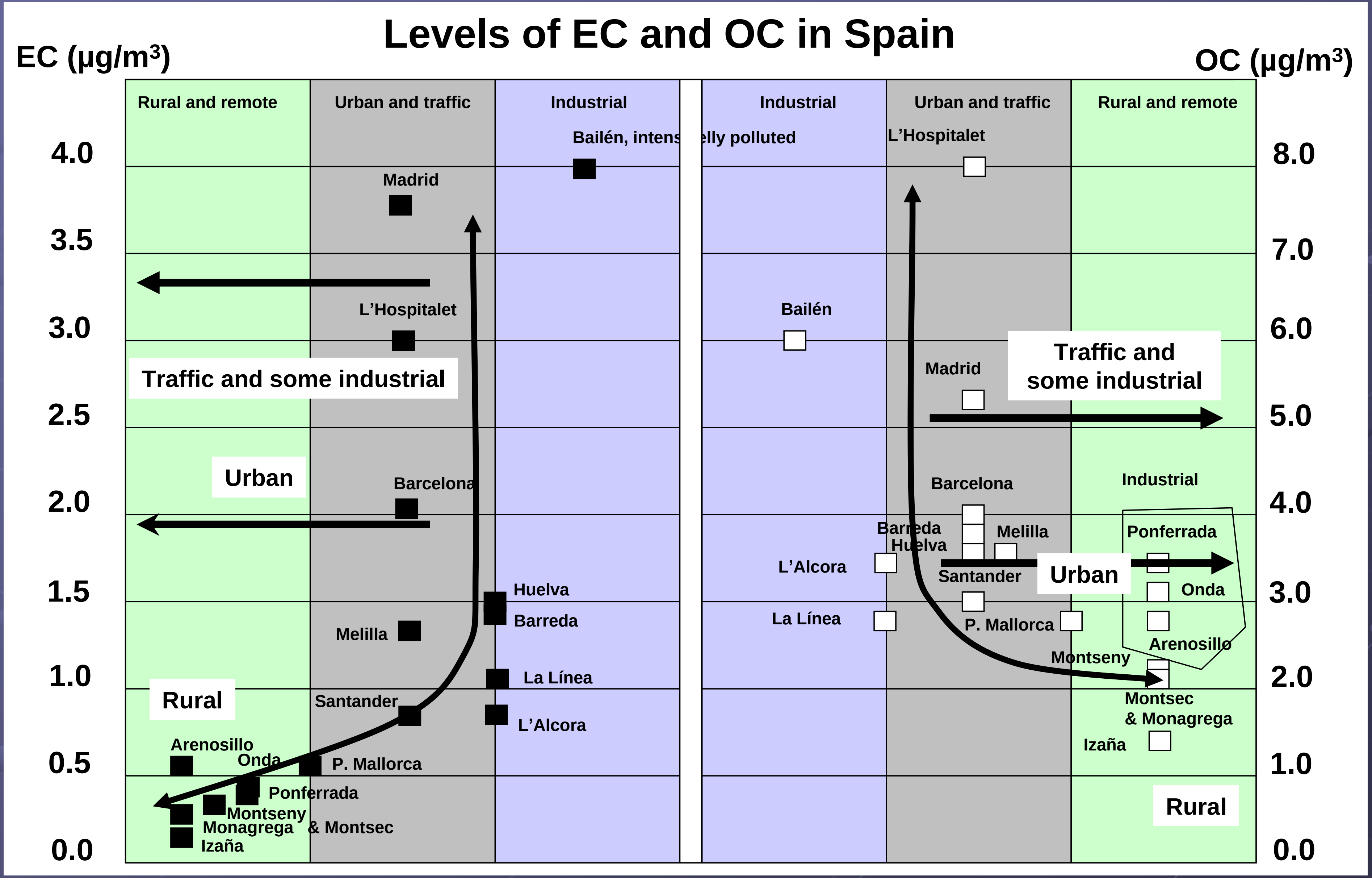
BERN_KERBSIDE SITE (TRAFFIC)



Probably due to different fleet composition and local sources (ex. BB)

2. Measuring levels of specific tracing parameters

BC may be proportional to contribution from traffic and BB and can be calibrated with EC



2. Measuring levels of specific tracing parameters

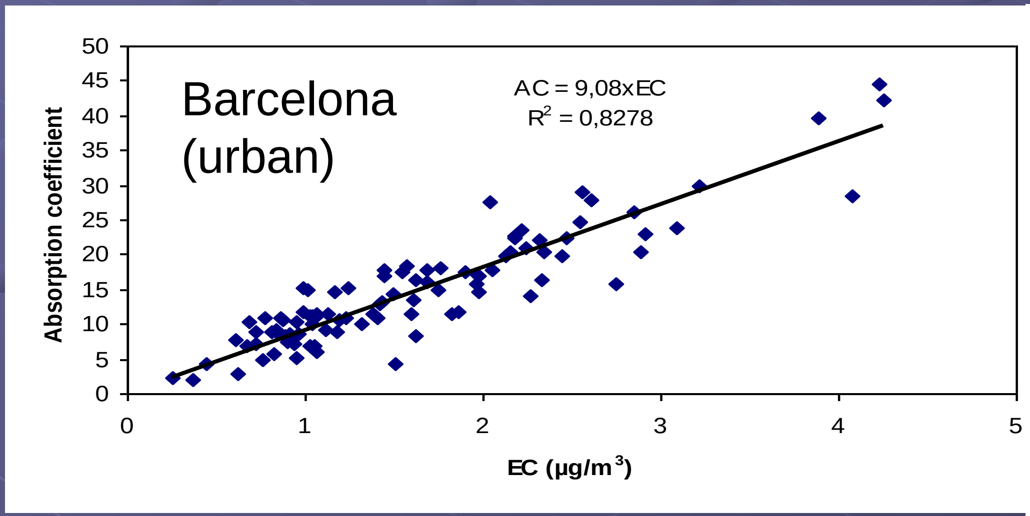
Example: EC or BC tracing road traffic and BB

Levels of BC compared with EC: MAAP and Sunset (EUSAAR-2)

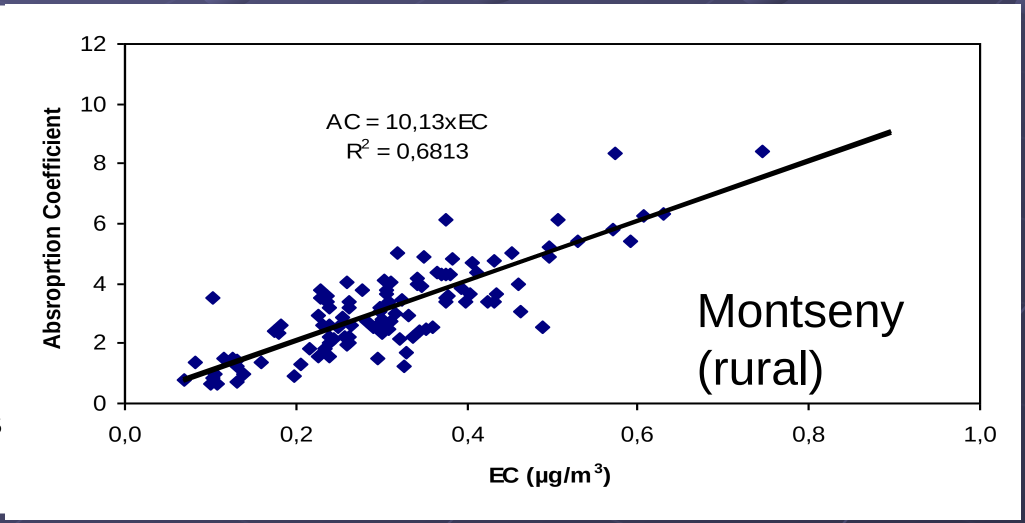
Absorption Coefficient (Mm^{-1}) and Black Carbon (BC)

$$BC\ (\mu g \cdot m^{-3}) = \frac{s_{ap}\ (Mm^{-1})}{\sigma\ (m^2 \cdot g^{-1})}$$

EC=AC/9



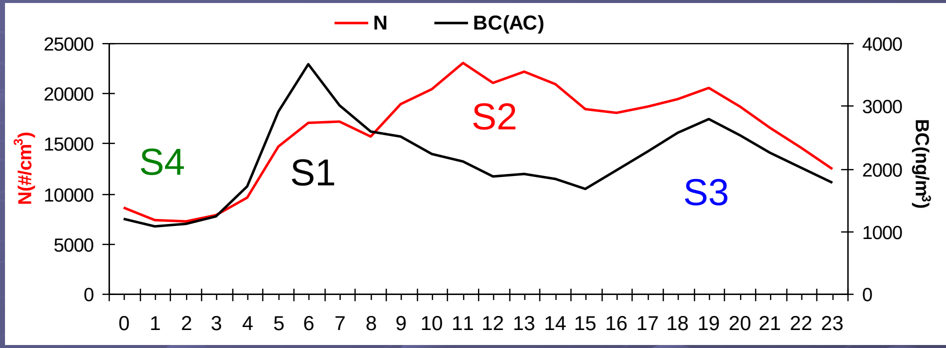
EC=AC/10

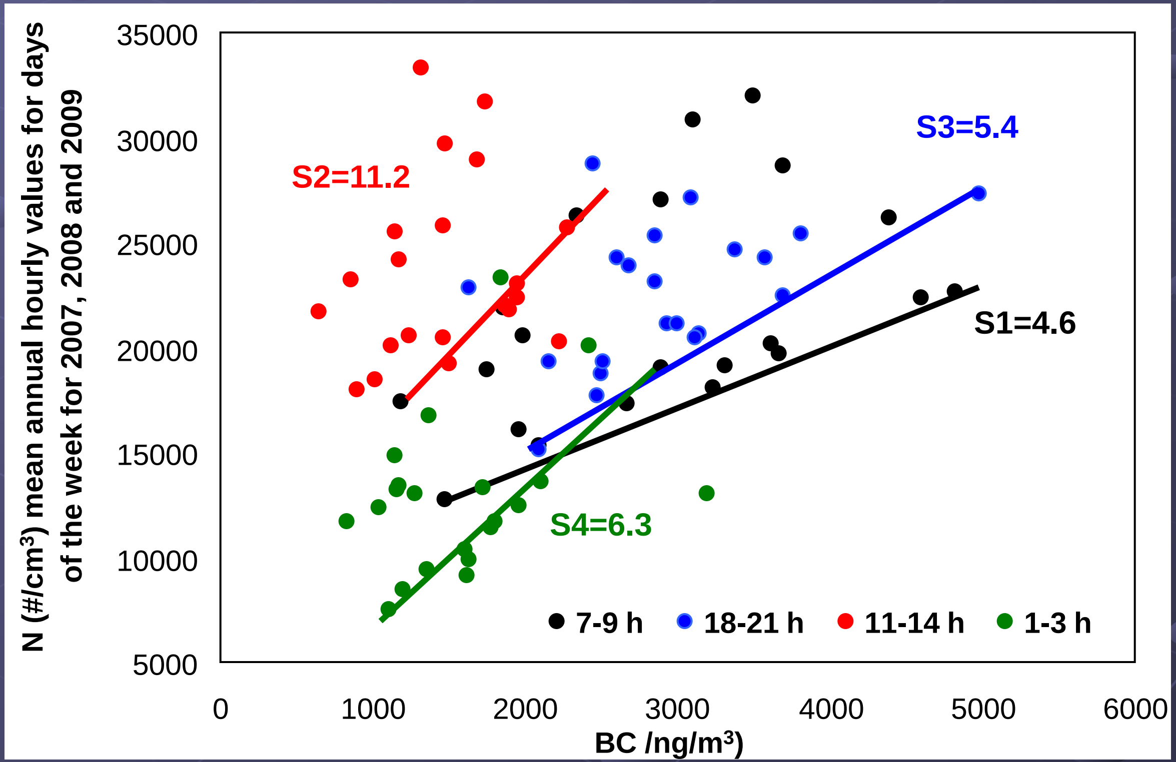


2. Measuring levels of specific tracing parameters

Are UFP tracing also road traffic?

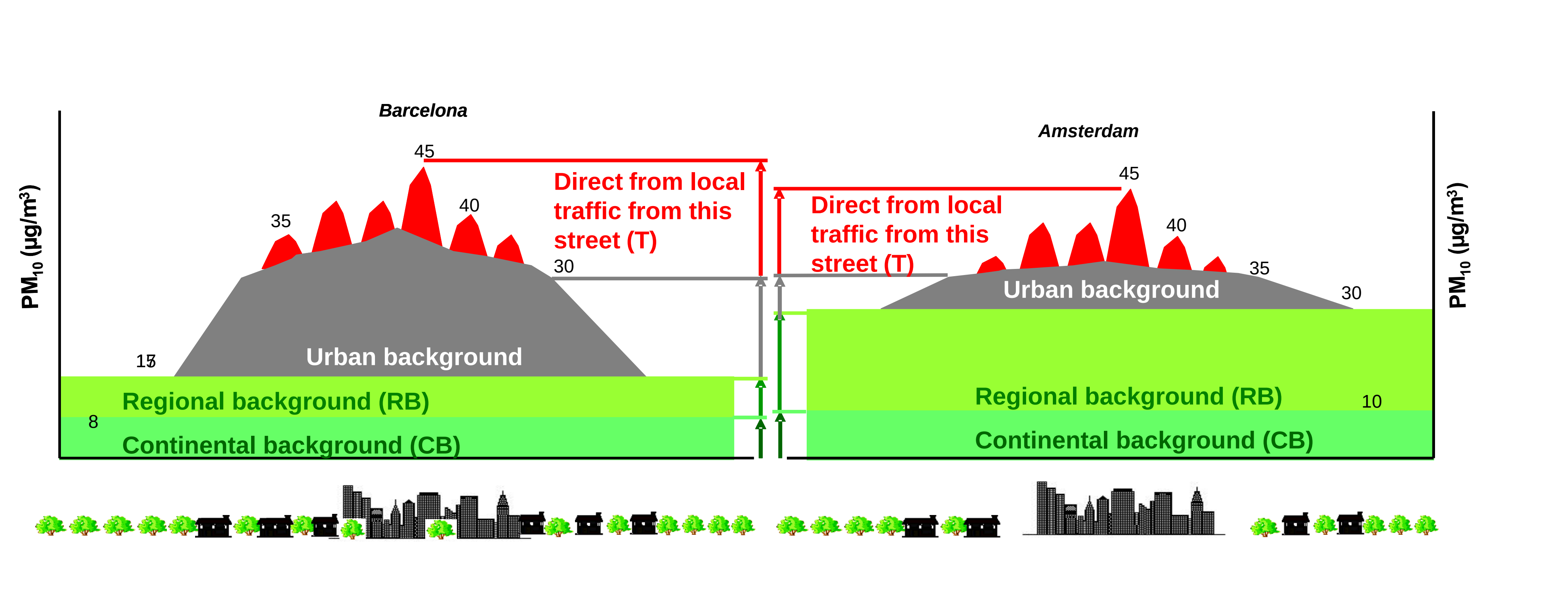
This is not always the case!
Example: BCN 2007-2009





3. Spatial variation: local-regional scale

The Lenschow et al. (2001) approach



Δ PM regional

Limit values for
Δ urban

Δ hotspot

4. Receptor modelling

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Large data set on PM speciation needed (t & $)
(at least 100 days/year for annual representativity, all days for daily control)

Ex. Off-line inorganics, IDAEA-CSIC

Crustal-mineral

Al_2O_3	ICP-AES
Ca	ICP-AES
K	ICP-AES
Mg	ICP-AES
Fe	ICP-AES
Ti	ICP-AES
P	ICP-AES
CO_3^{2-}	ind. Ca
SiO_2	ind. 3*Al_2O_3

Marine aerosol

Na^+	ICP-AES
Cl^-	Ion Cromat.
SO_4^{2-}	ind. Na

Anthropogenic

Cnm A. Elemental

OC & EC Thermo-optical

Inorganic Secondary Species

NH_4^+	C.FIA
SO_4^{2-}	Ion Cromat.
NO_3^-	Ion Cromat.

40 Metals (ICP-MS)

As, Ba, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er,Ga, Gd, Ge, Hf, La, Li, Mn, Mo, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Sm, Sn, Sr, Ta, Th, Ti, Tl, U, V,W, Yb, Zn, Zr

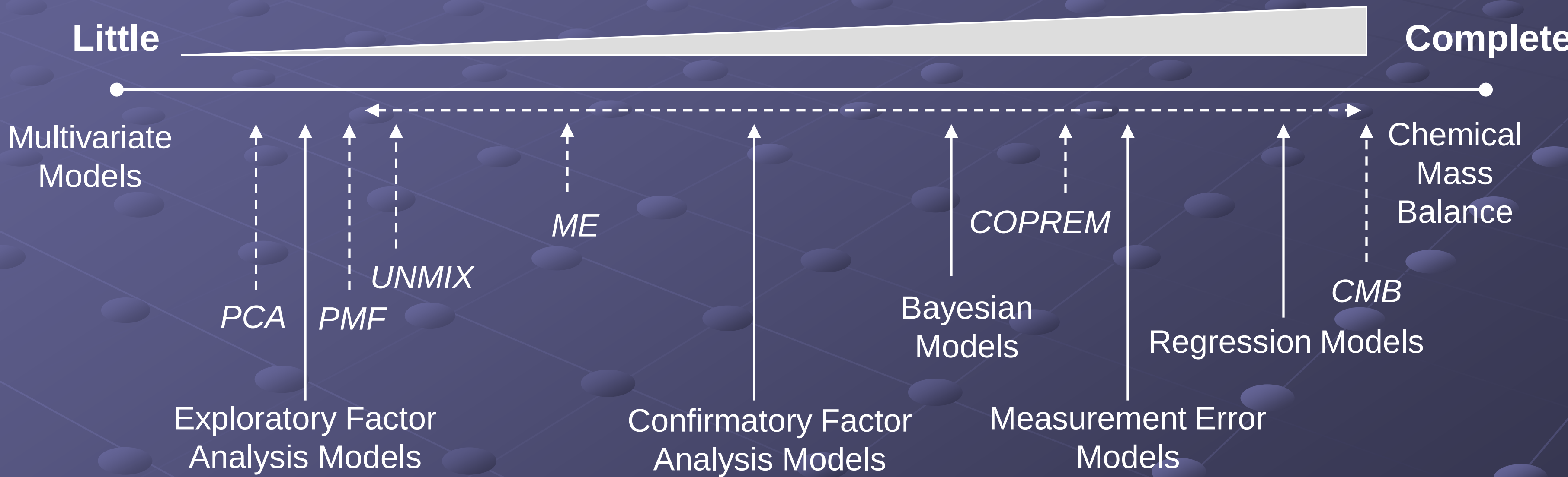
Accounted

75-85 % mass PM

4. Receptor modelling

$$\underset{p \times 1}{X_t} = \underset{p \times k}{\Lambda} \; \underset{k \times 1}{f_t} + \underset{p \times 1}{e_t}$$

Knowledge required about pollution sources prior to receptor modelling



Modified from Schauer et al. (2006)

4. Receptor modelling

Expl.1: ME2: Annual source contributions in Barcelona

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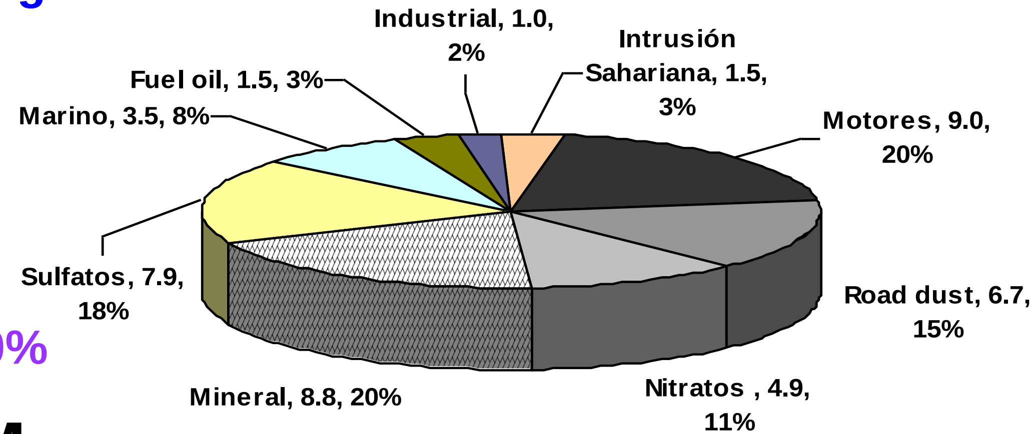
PM_{10}

Max. Shipping: 3%

Traffic: 43%

Amato, et al., 2009. Atmospheric Environment

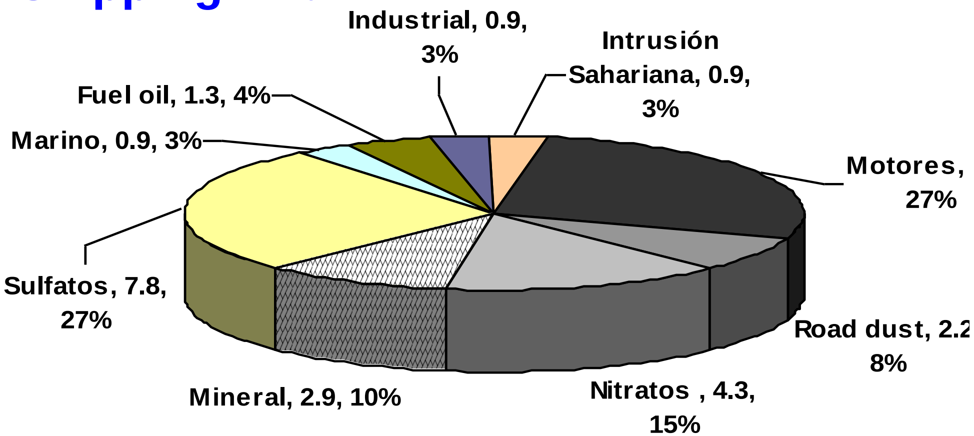


Dem.-res. (reg.): 20%

$PM_{2.5}$

Max. Shipping: 4%

Traffic: 46%

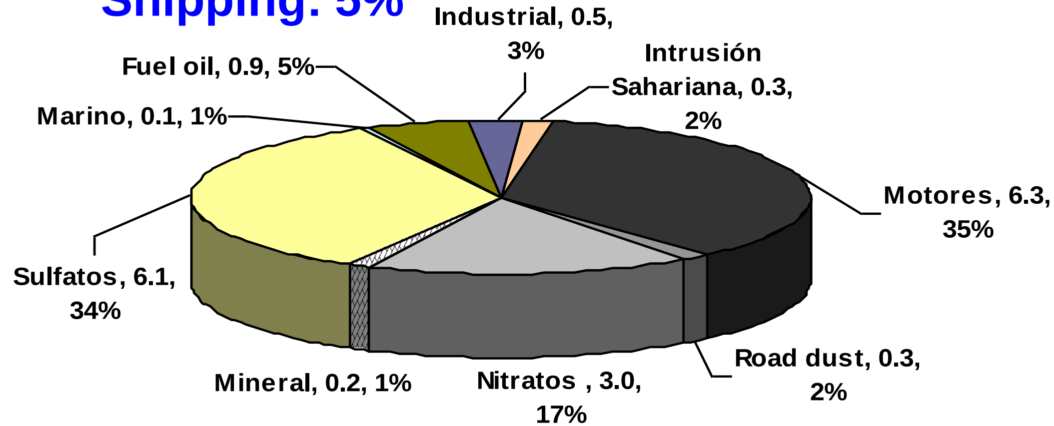


Demolition-resuspension (reg.): 10%

PM_1

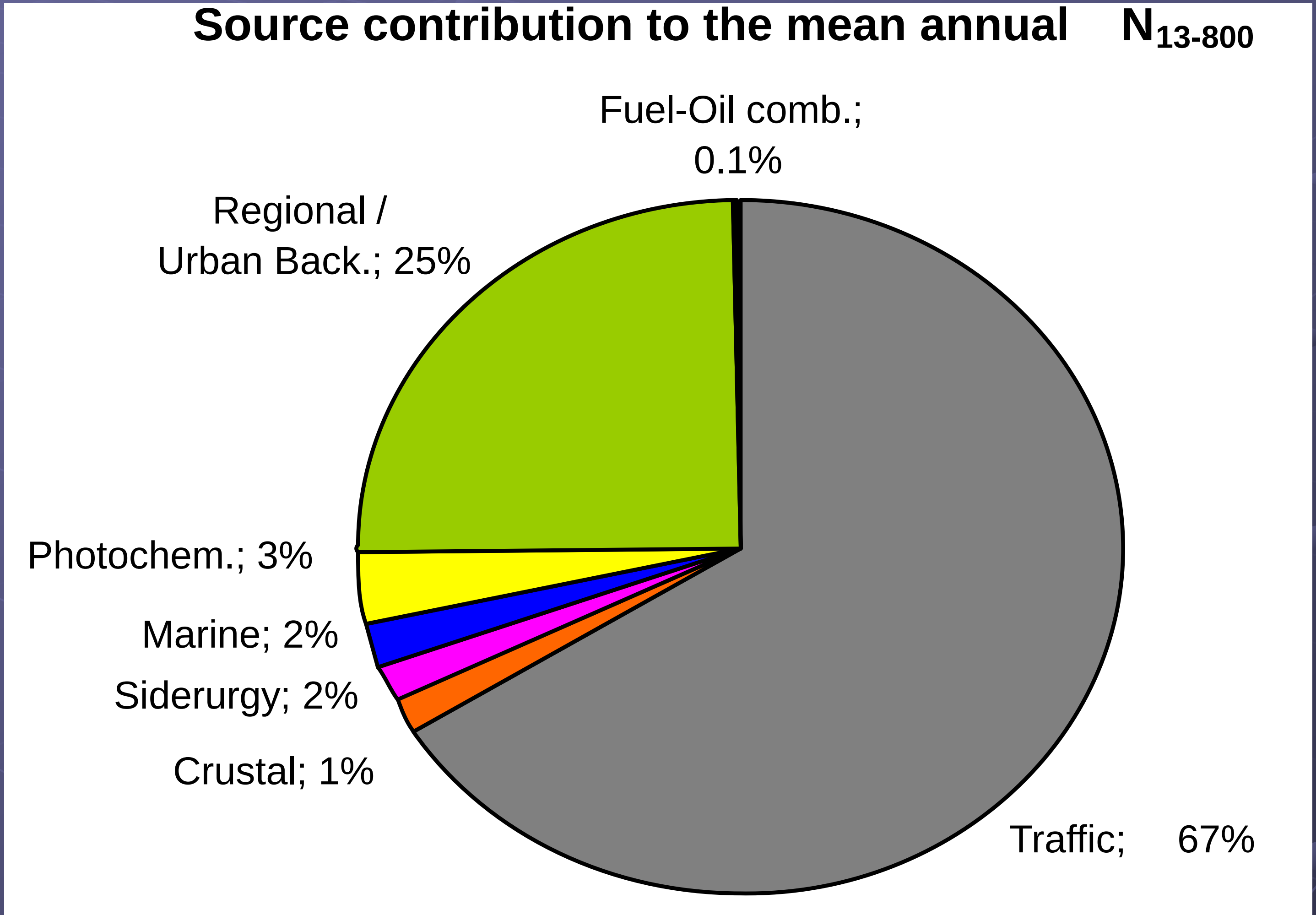
Max. Shipping: 5%

Traffic: 50%



Demolition-resuspension (reg.): 1%

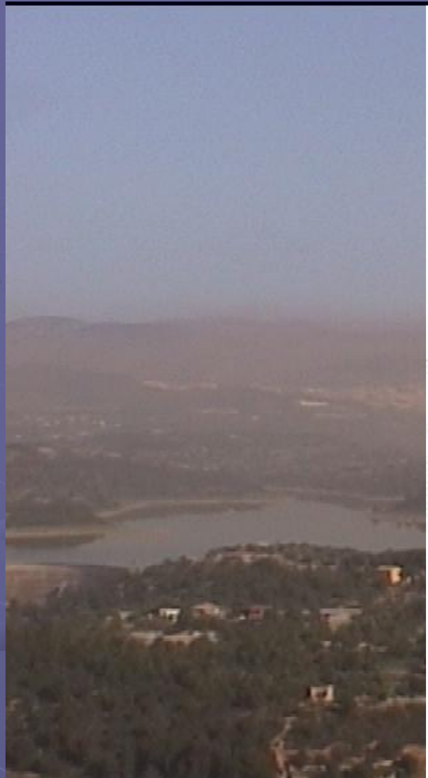
Expl.2: PCA Source apportionment in Barcelona: Number of sub-micronic PM

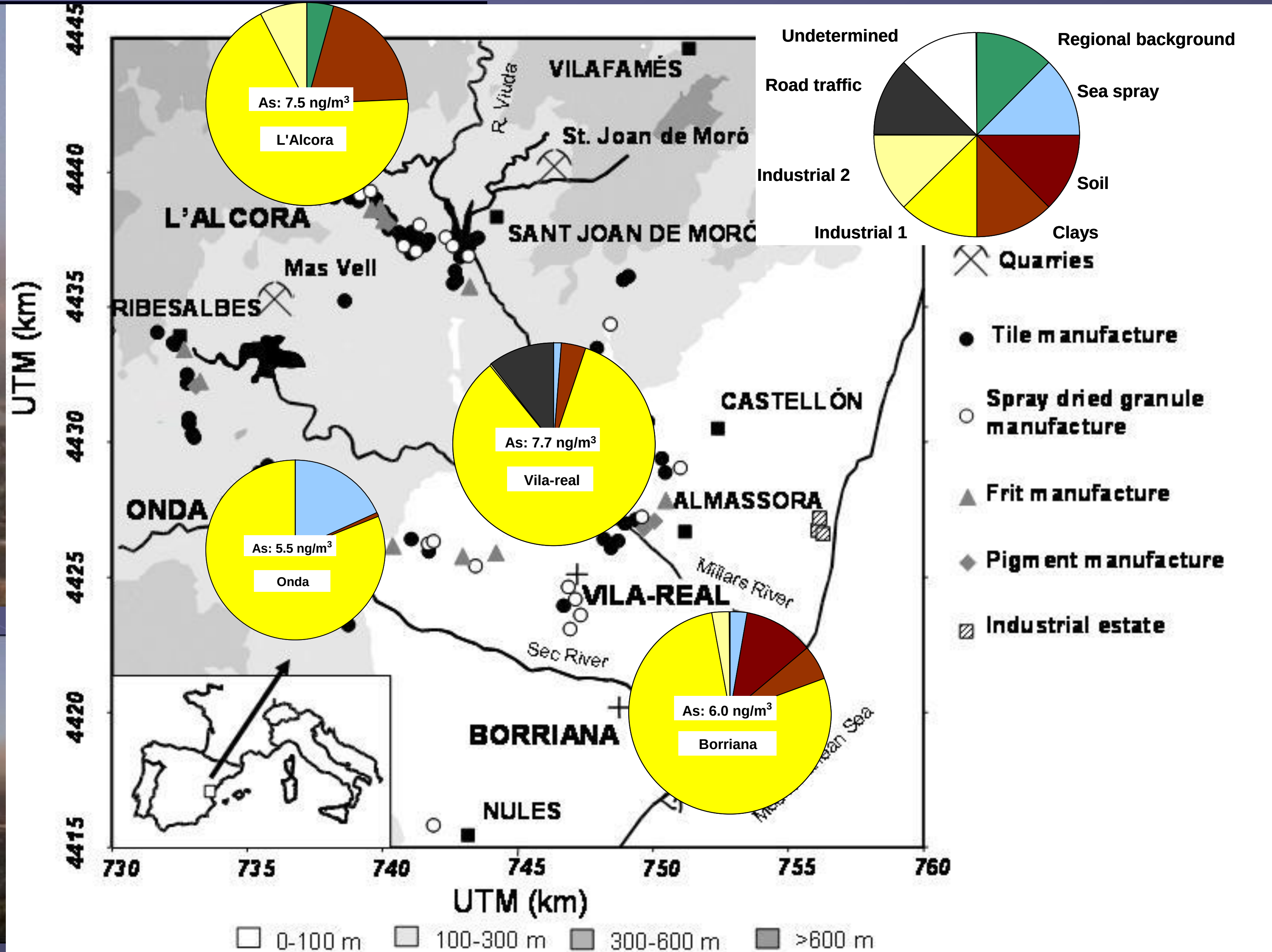


Pey J., et al. 2009. Atmospheric Environment

4. Receptor modelling

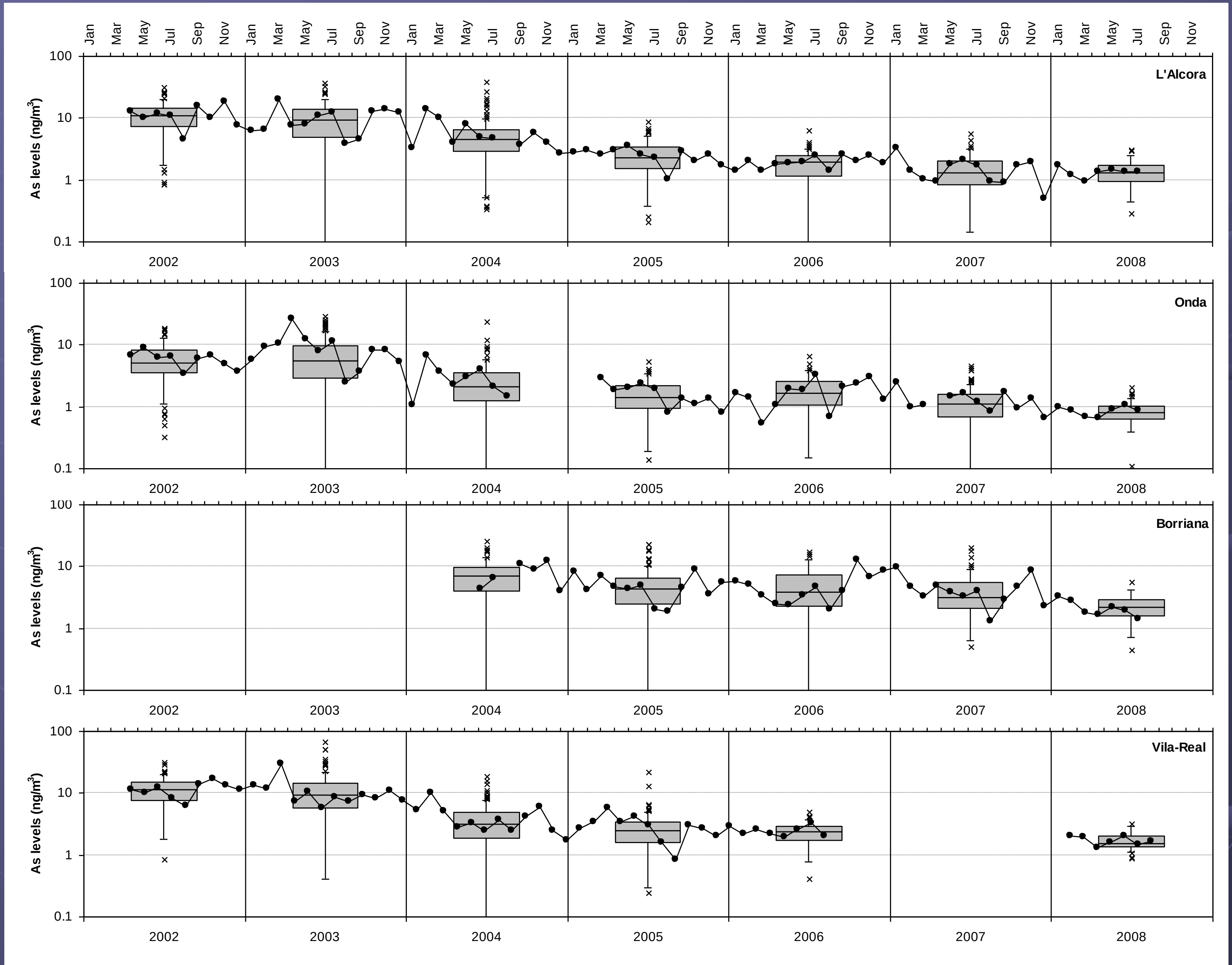
Expl.3.: Arsenic in an industrial area: a valuable tool for policy assessment!



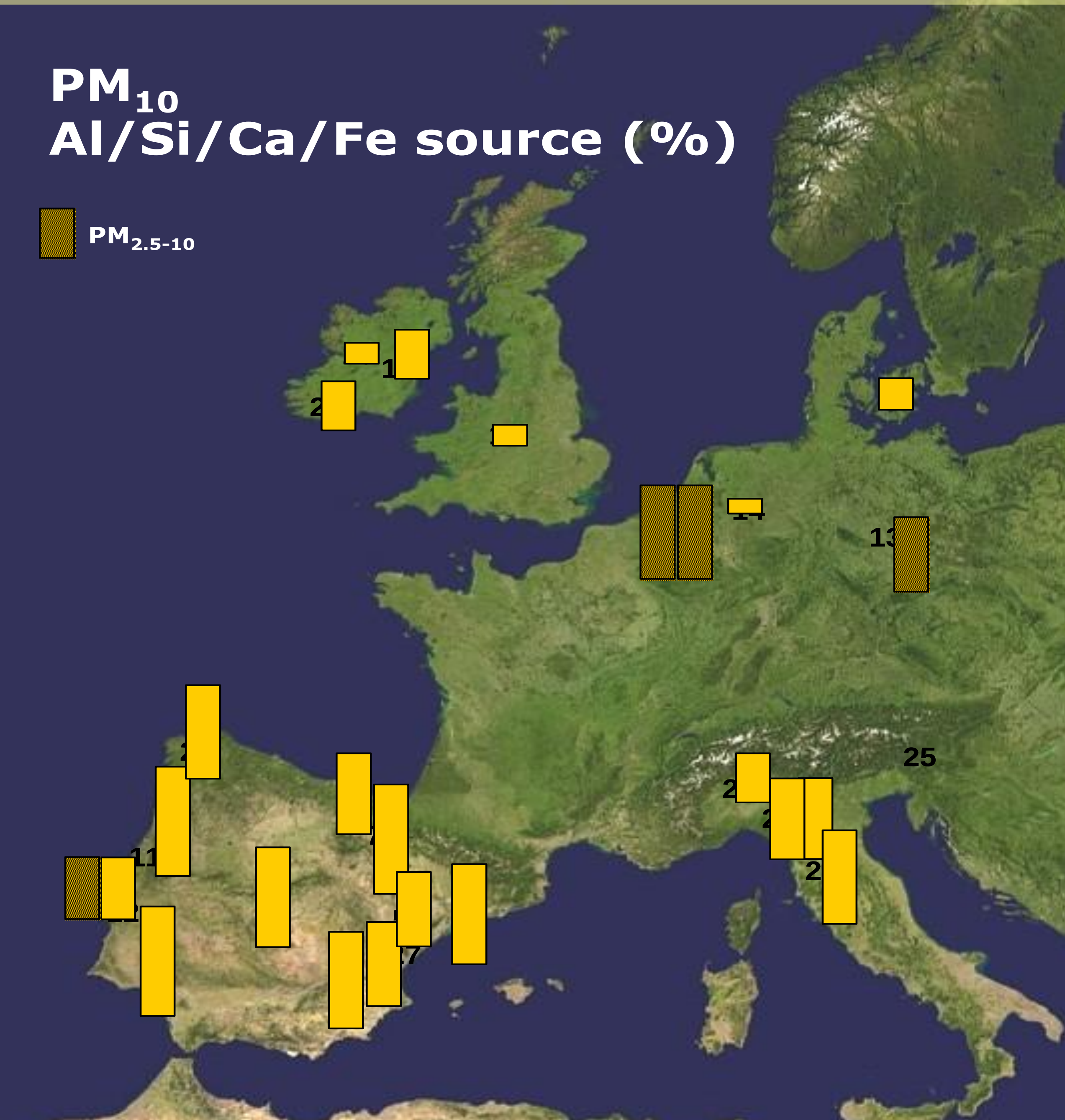


4. Receptor modelling

PMF and PCA: Source apportionment of Arsenic in an industrial area



4. Receptor modelling



Major COMMON sources identified in EU

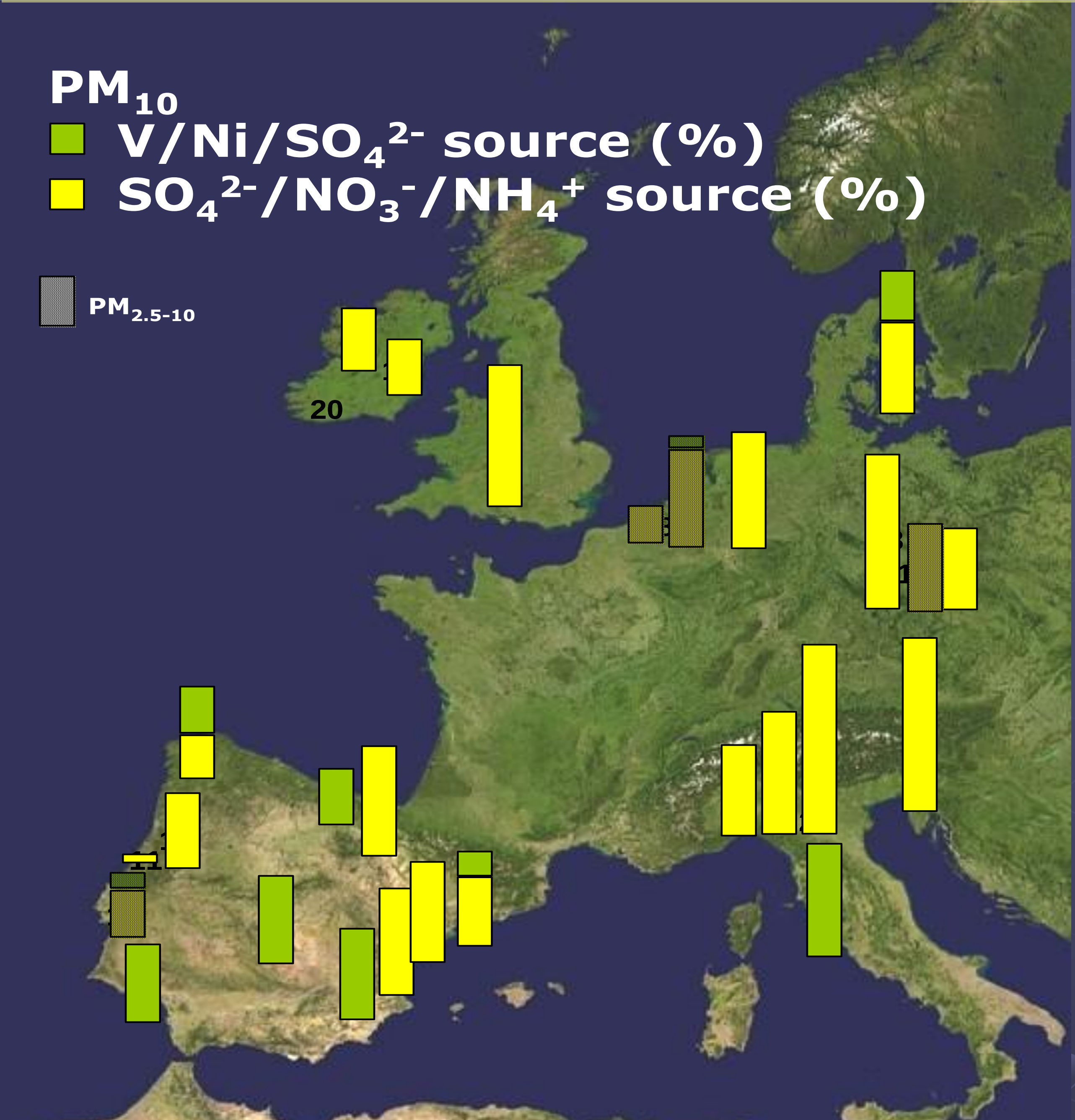
Contributions to be controlled with limit values?

MINERAL

- Local or Regional re-suspension, City dust, Crustal material, Road dust, etc.

Viana et al. (2008). J. Aerosol Science
COST 633

4. Receptor modelling



Major COMMON sources identified in EU

Contributions to be controlled with limit values?

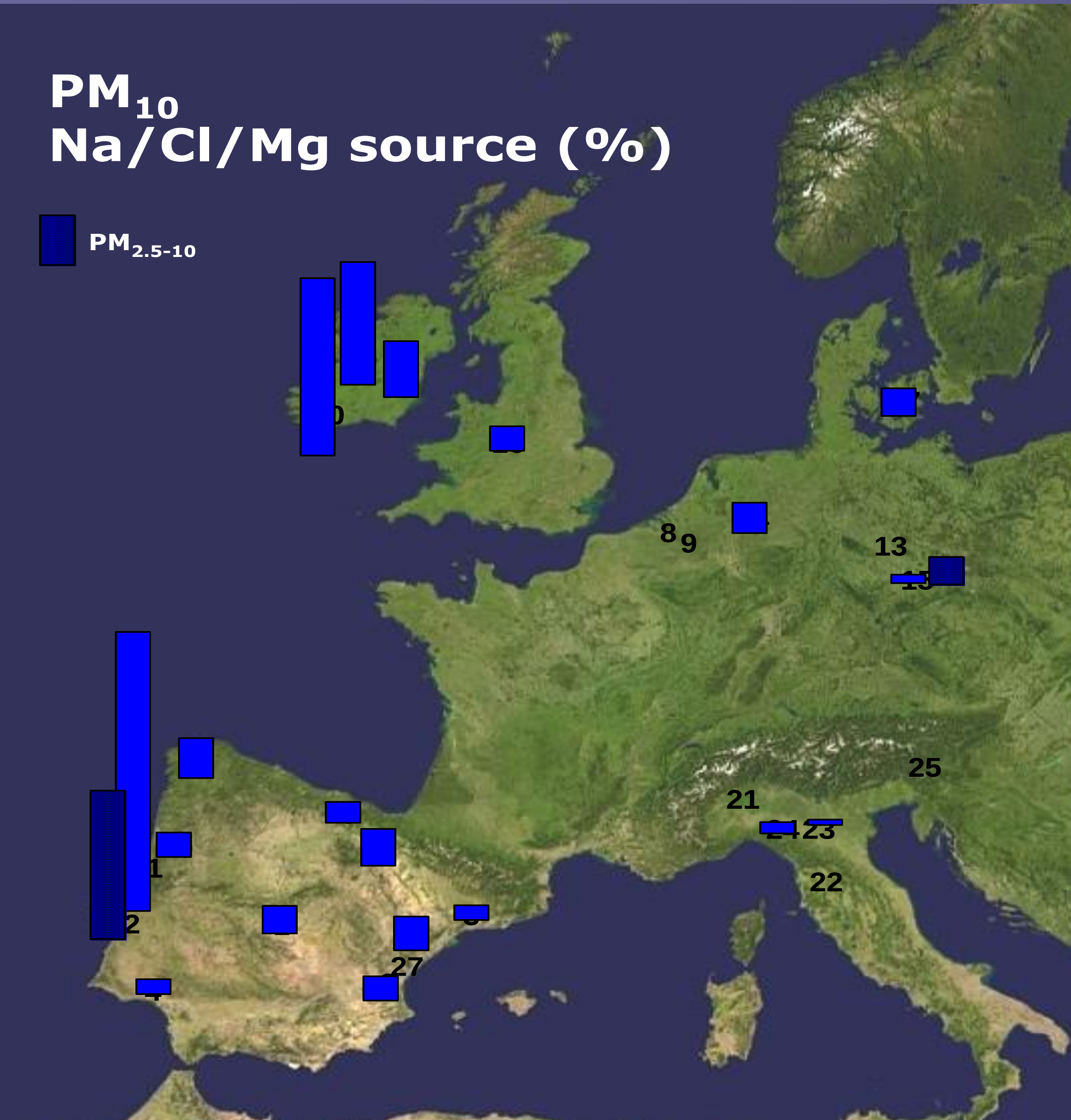
SULPHATE-NITRATE SOURCES

- Regional-scale poll., Long-range transport, 2ary aerosols, Oil comb., Industry, etc.

- Extremely difficult to discriminate between these two sources:
  - Secondary particles
  - Long residence time
  - Anthropogenic emissions
  - Large subjectivity in interpretation by authors

Viana et al. (2008). J. Aerosol Science
COST 633

4. Receptor modelling



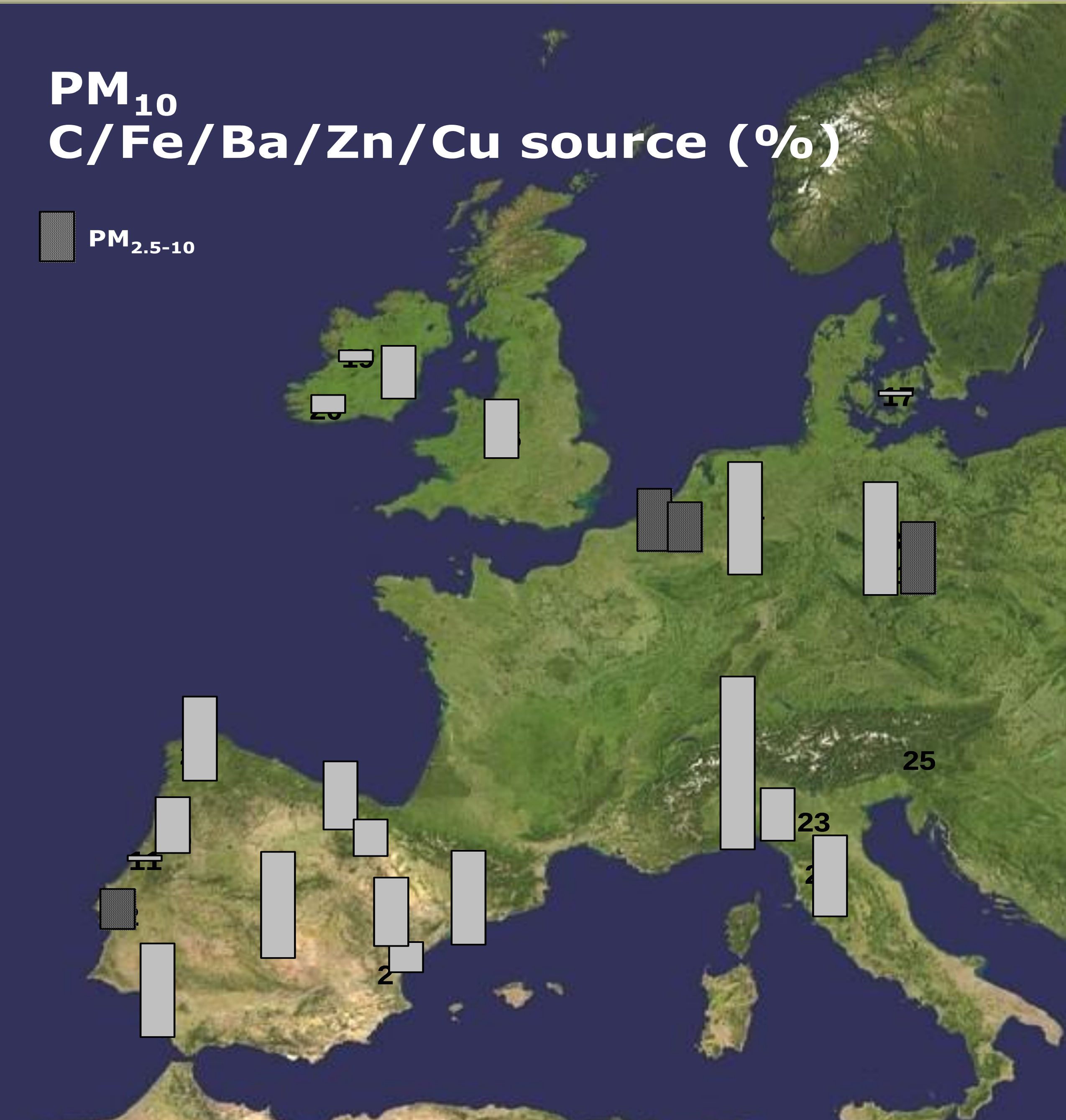
Major COMMON sources identified in EU

Natural source

SEA SALT
- Sea-salt, Sea-spray and Marine source

Viana et al. (2008). J. Aerosol Science
COST 633

4. Receptor modelling



Major <u>COMMON</u> sources identified in EU

Contributions to be controlled with limit values?

A similar profile for EU!!!!

PRIMARY TRAFFIC
- Vehicular source, Vehicle exhaust, Traffic, Industry/Traffic, abrasion

Viana et al. (2008). J. Aerosol Science
COST 633

Receptor modeling & standardization

- Key issues

- Ambient air PM contributions from traffic may be easily calculated across Europe for possible limit values using receptor modeling tools
- Harmonization of analytical procedures would be required
- CMB, PMF and hybrid PMF-CMB (ME-2) may be also harmonized for standardization

- Limitations

- Requires chemical speciation of PM, t & $ consuming
- CMB: lack of an European valid chemical source profiles database
- Multivariate (PMF) models may be a bit subjective
- A single industrial or mineral tracer may be emitted by different sources across Europe, and viceversa
- Secondary pollutants are grouped, and these may have local, regional and long range transport components

5. Concluding remarks

- PM10 (mixture of source contributions) and BC (as a source tracer for traffic and biomass burning) offer a good combination for air quality monitoring, specially because exceedances are registered in traffic hotspots
- The ratios NO/BC, NO_2/BC, CO/BC vary widely, thus NO_2 or CO cannot substitute BC to account for traffic PM
- Number concentration of ultrafine particles is influenced by several sources and processes and measurements are more complex than BC for standardization purposes
- The approach of 'delta' limit-target values for regional and urban backgrounds and traffic sites would allow better monitoring to identify the main causes (sources) of the problem (local, regional, transboundary)
- Receptor modeling is an excellent tool for policy and air quality abatement plans
- Quantitative receptor modeling applied to data sets of PM speciation may offer the possibility of setting limit values for PM contributions from road traffic (relatively homogeneous emission chemical profiles across Europe)
- However, BC measurements yield similar information, with real time infromation, low operational cost and easily to standardize method
- Coupling PM10 measurements with BC would provide a very good approach for air quality monitoring in urban environments

Thank you for your attention !

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Ministry of the Environment of Spain, Ministry of Sciences and Innovation of Spain

Regional AQ monitoring networks: Generalitat Valenciana, Generalitat de Catalunya Andalucía, Baleares, Canarias, Castilla-León, Castilla la Mancha, Euskadi, Extremadura, Galicia, Madrid, Murcia; EMPA and DEFRA for data LG, BN, MLY, SK