EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

COST 633
Particulate Matter: Properties Related to Health Effects

COST

PM over Europe

from measurement to modelling
from sources to exposure

T.A.J. Kuhlbusch, A. Miranda, M. Viana, J.-P. Putaud, W. Winiwarter, C. Borrego, M. Jicha, M. Ketzel, and COST 633 Members

Particulate matter and health in 2020: Are we on the right track?
Brussels, 13th-14th March 2008

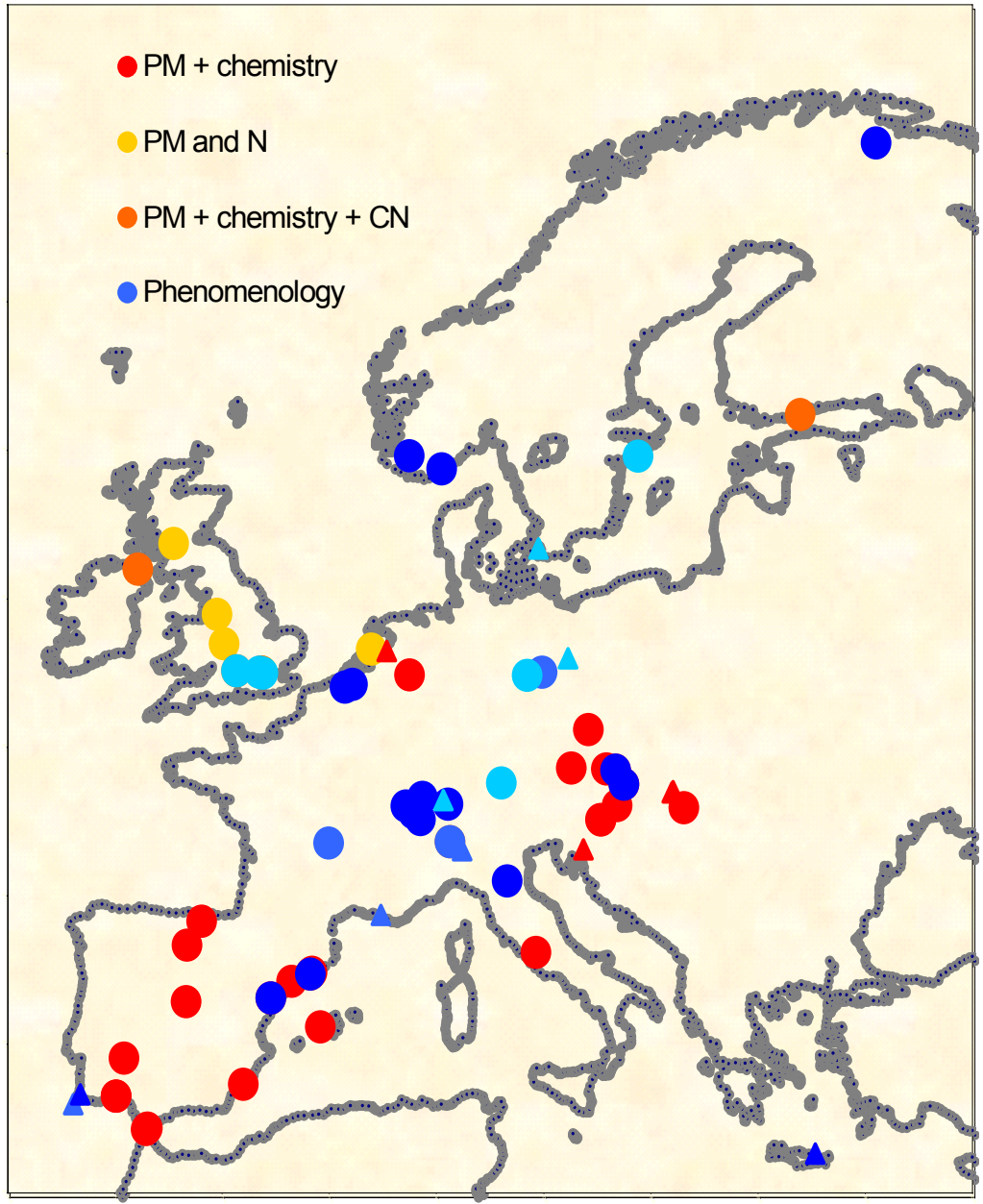
Content

1. Measurements over Europe – Mass concentrations, chemical composition, particle size distributions
2. What can be modeled? What is modeled?
3. Sources – Emission inventories and source apportionment
4. Measurement, modeling, and sources – linkage to exposure?
   (PM2.5 approach! Current Epi! New Epi! Tox!)
5. Is this all?
   Other stressors and
   Particle characteristics (ROS….)

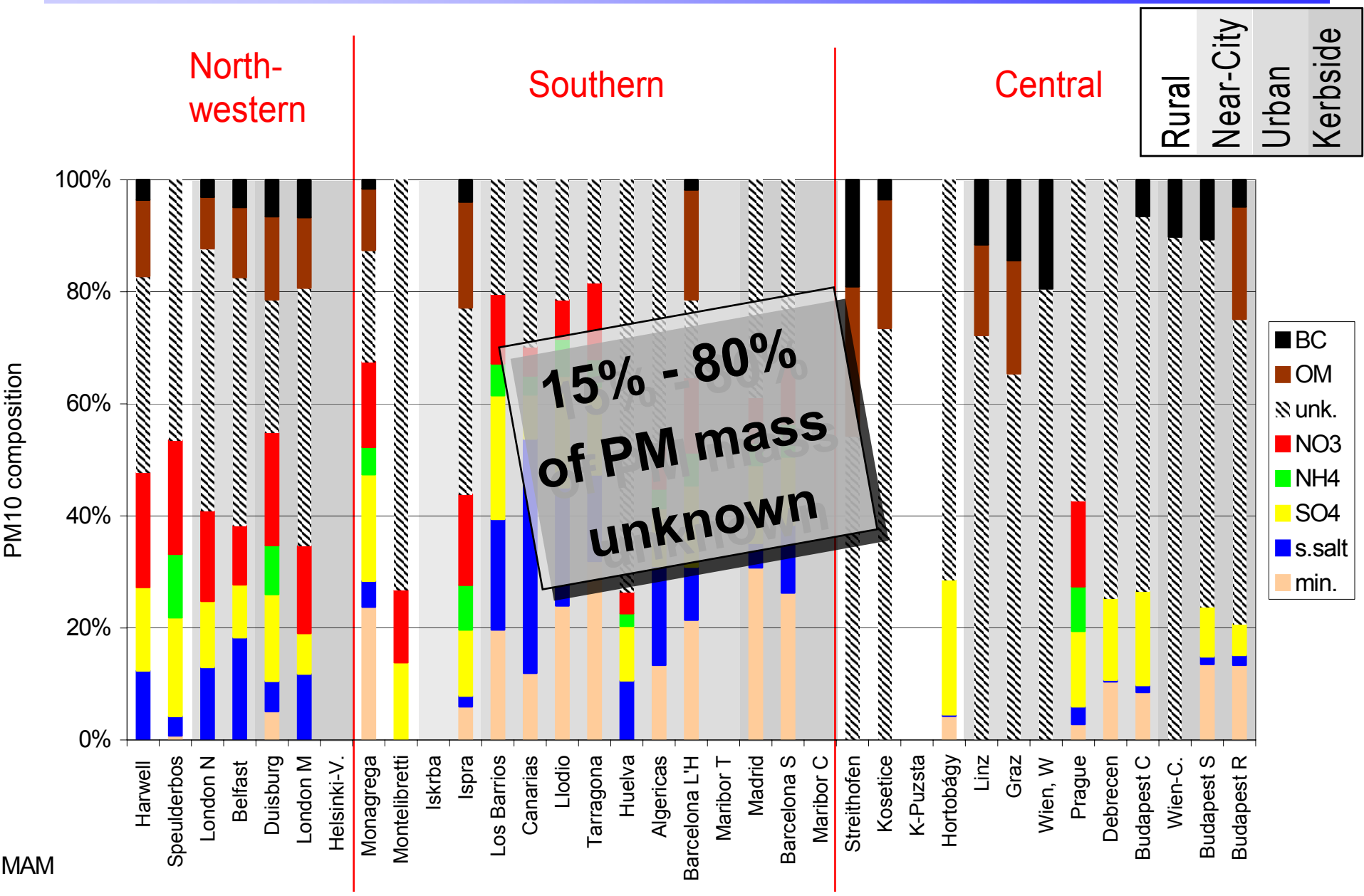
PM – Homogeneity and Heterogeneity

- 1st *Phenomenology*: 34 sites

- COST633: 50 original data sets
  - 35 with PM and chemistry
  - 15 with PM and CN number

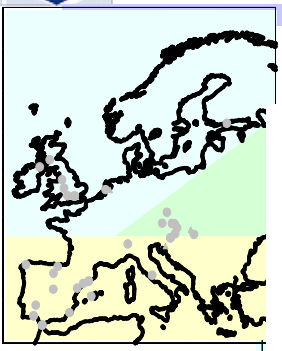


PM 10 – Composition over Europe



MAM

PM – Number concentrations and siting



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PM – Number concentrations over Europe

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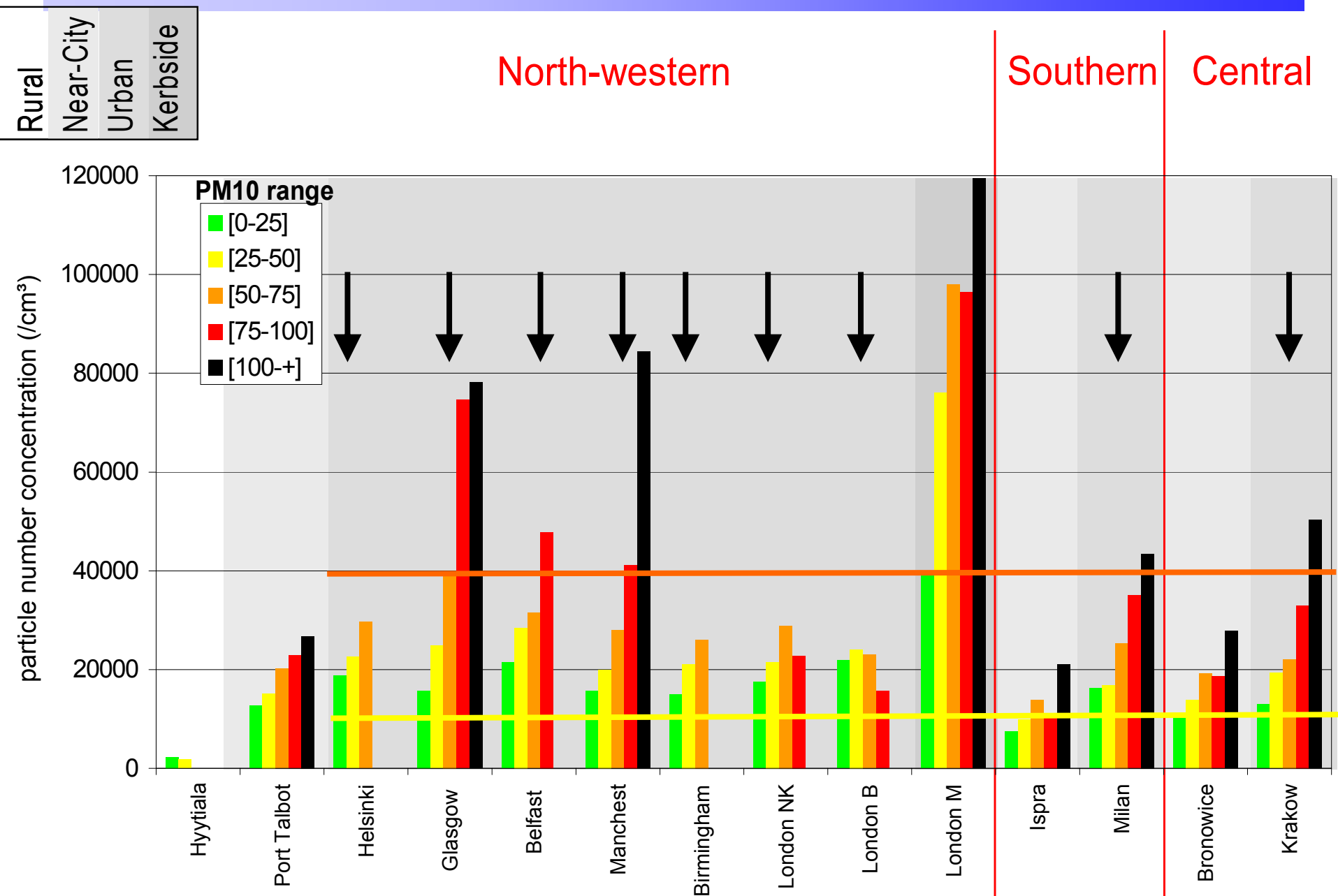

PM 10 – Average of main aerosol constituents

		rural	near-city	urban	kerbside
North Western Europe	min. dust	1%			
	sea salt	8%		15%	6%
	SO4	13%		9%	8%
	NO3	15%		11%	12%
	OM	15%		14%	14%
	EC	4%		5%	8%
	TC	*14%*		*15%*	*18%*
Southern Europe	min. dust	19%	9%	16%	19%
	sea salt	5%	10%	14%	6%
	SO4	16%	14%	12%	10%
	NO3	13%	10%	8%	6%
	OM	12%	32%	22%	
	EC	1%	5%	2%	
	TC	*13%*	*21%*	*19%*	*27%*
Central Europe	min. dust	4%		8%	
	sea salt	0.2%		0.3%	
	SO4	24%		15%	
	NO3				
	OM	28%		21%	
	EC	12%		16%	11%
	TC	*27%*		*30%*	

PM – Measurements

- Routine mass concentration data (PM10 and PM2.5) good and improving
- Information on main components of particles over Europe slowly become available. Efforts combining data and using this knowledge are scarce
- Data on important, possibly health relevant particle compounds and characteristics is still scarce

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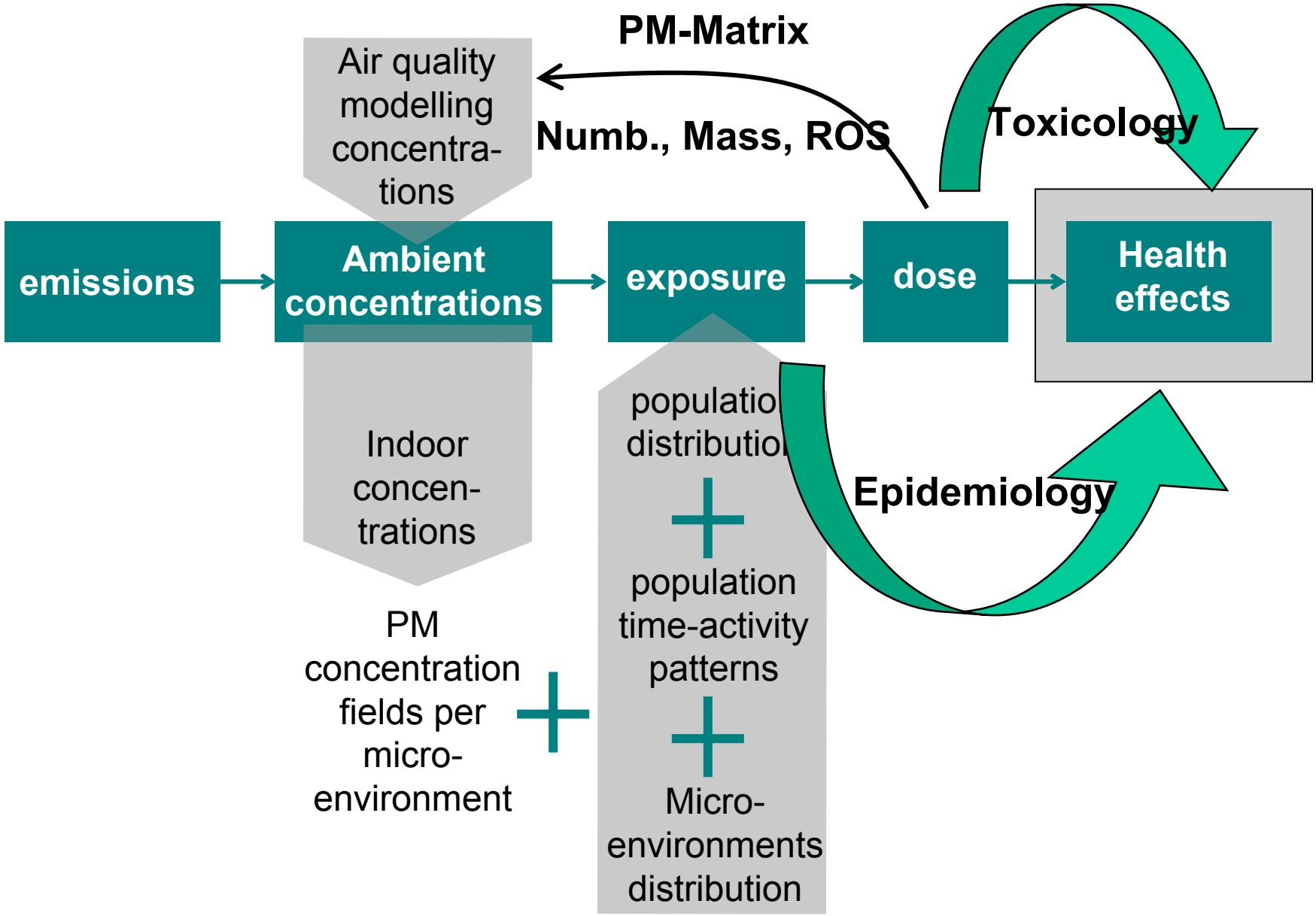
2. What can be modeled? What is modeled?

PM – Emission / Modelling / Exposure



PM –Modelling in Europe

Overview of the application of PM models in European COST633 Action member countries –

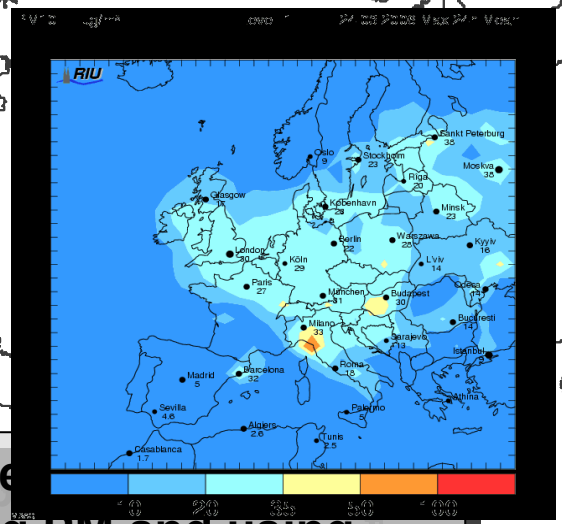
Aim case-study oriented summary

Answer Country	Case Study	Model used + web page	PM modelling		Time resolution	Spatial resolution	Domain	Validation	Contact Person	Available documents (papers, reports,…)	Other Info
			Primary	Secondary							
Austria…	✓										

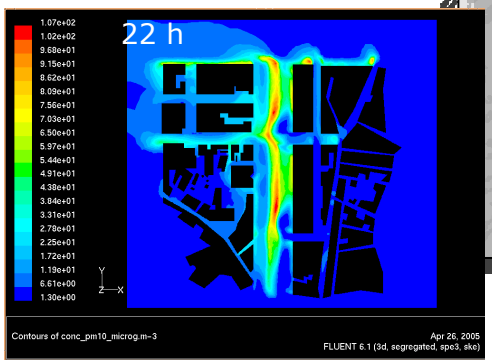
- 10 member countries replied reporting a total of 30 case studie applications.
- Primary aerosols simulated in all the cases, secondary aerosols included in 50% of the cases, estimating not only PM10, but also PM2.5 and SOA.
- Several models were applied, in a total of 20, with different scopes and covering different modelling scales, from the local (only simulating primary PM) to the regional scale.
- Validation work is associated to each reported case study.

PM – Examples

EURAD application for Europe – PM_{10} forecast
(http://www.eurad.uni-koeln.de)



FLUENT application to Av. Liberdade, Lisboa, Portugal – PM_{10} conc at 22h
(Martins *et al.*, 2005)



In general, membe
already simulating PM and using models as useful tools to air quality management, nam
the Air Quality Fr

MM5-CMAQ application to Barcelona coast – $PM_{2.5}$ conc at 6h
(http://www.bsc.es/)

1 mesoscale model with Primary PM
1 mesoscale model with Primary and Secondary PM

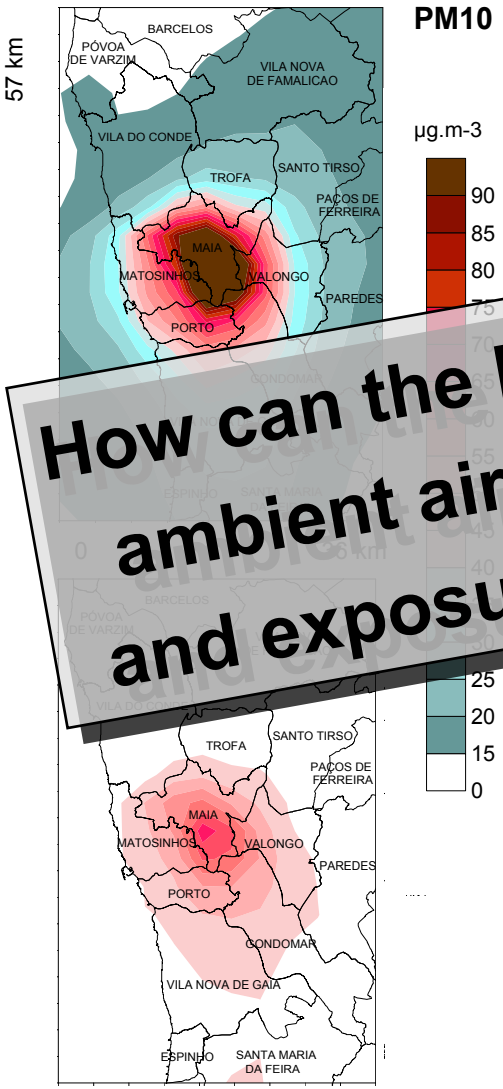
PM – Example of population exposure modelling

Porto Metropolitan Area – regional scale modelling of populational exposure

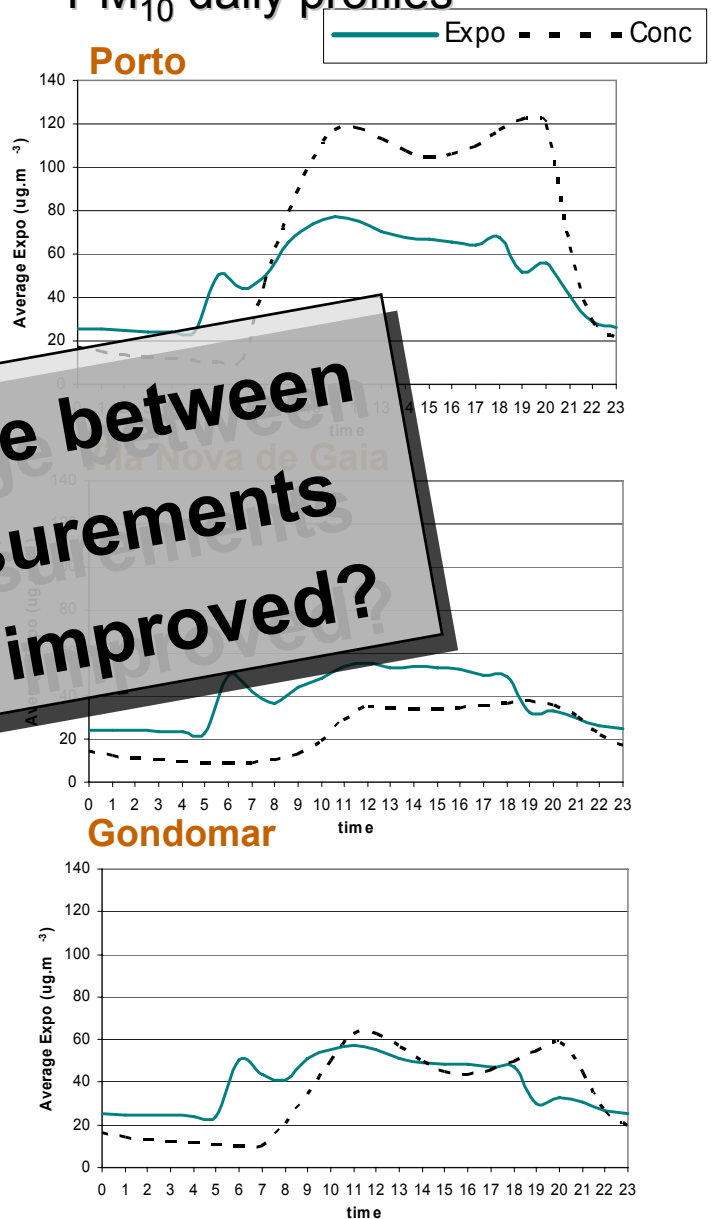
Annual average concentration

conc.and exposure fields

Annual average personal exposure



PM_{10} daily profiles



How can the linkage between ambient air measurements and exposure be improved?

PM 10 – Modelling

- quite a few models are in use over Europe covering different scales from local to global scale

- models used for assessing exposure to the various modeled parameters

➔future improvements and research should hence focus on

a) validation of the models for areas over Europe (➔ measurements)

b) studies of comparability of models at various scales for different regions in Europe (example City Delta Project)

c) including models for exposure assessments in epidemiological studies (short- and long- term ➔ next presentation)

d) linking / improving source apportionment and model results for cross validation (➔ SoAp, assessment of abatement strategies)

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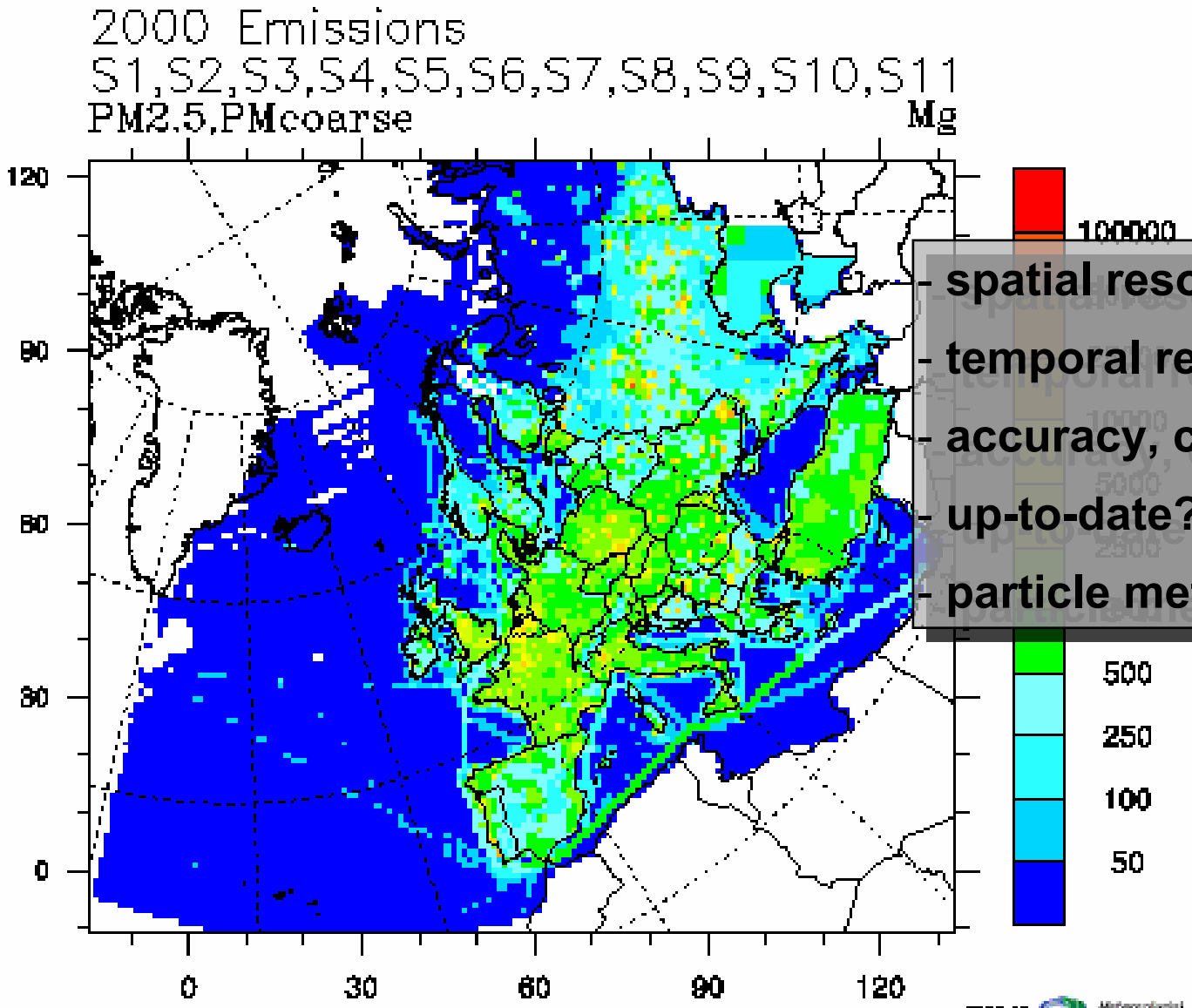
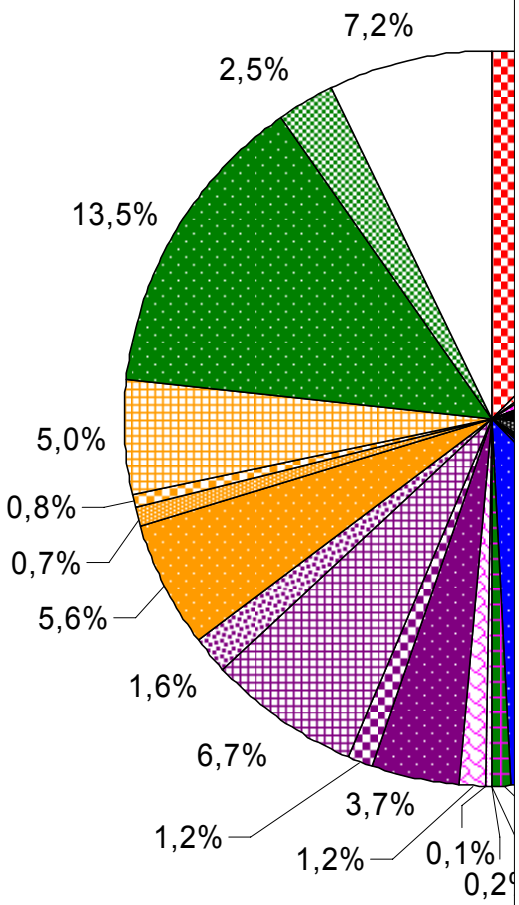
PM – Emission inventories for modelling & source apportionment



- spatial resolution
- temporal resolution
- accuracy, comparability?
- up-to-date?
- particle metric?

PM10 Emission – source contributions

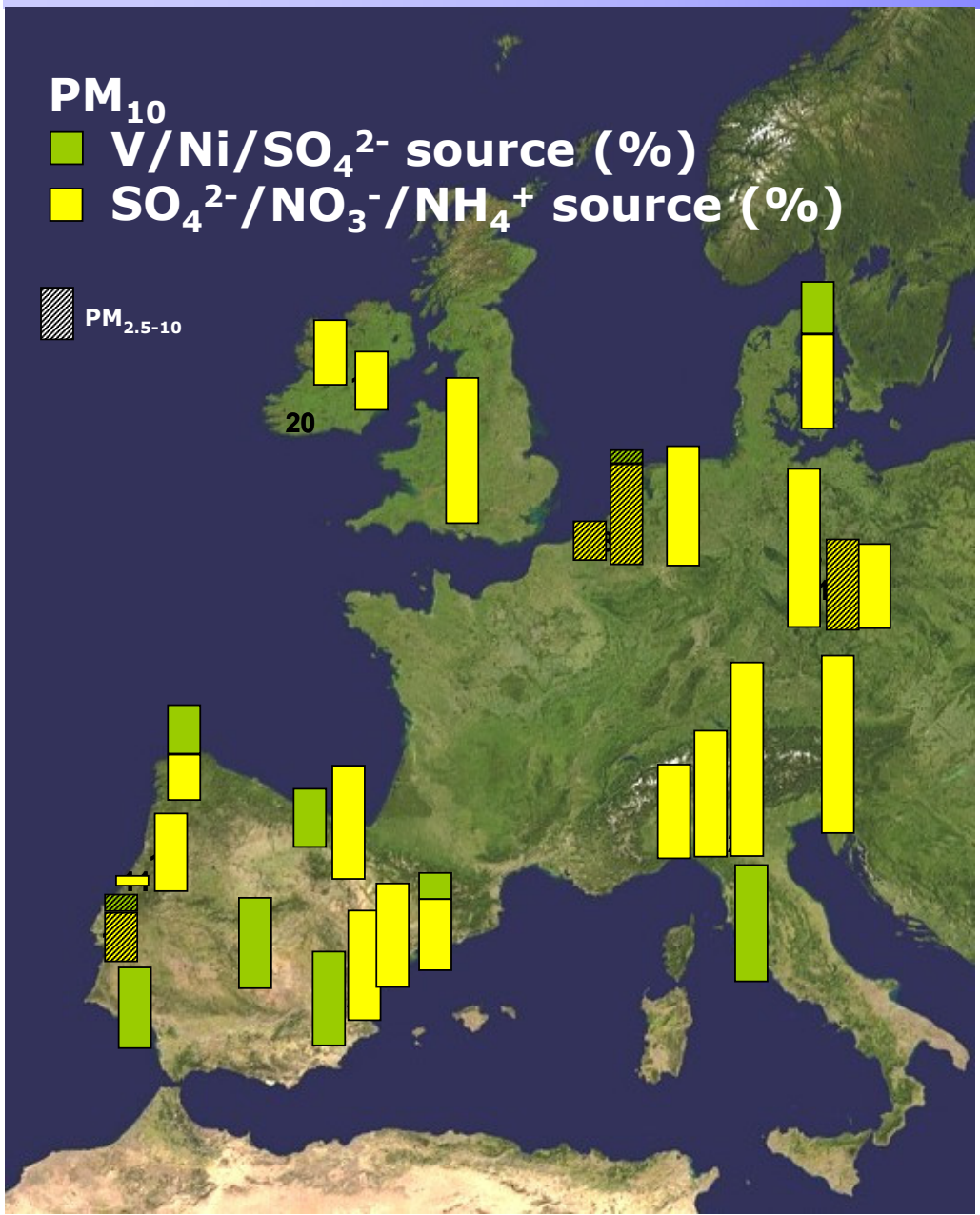
PM10 – background concent
9.4 µg/m³



- 1 A 1 a Public Electricity and Heat Production
- 1 A 1 b Petroleum refining
- 1 A 1 c Manufacture of Solid Fuels and Other Energy Industries
- 1 A 2 Manufacturing Industries and Construction
- 1 A 3 a ii (i) Civil Aviation (Domestic, LTO)
- 1 A 3 a ii (ii) Civil Aviation (Domestic, Cruise)
- 1 A 3 b Road Transportation
- 1 A 3 b i R.T., Passenger cars
- 1 A 3 b ii R.T., Light duty vehicles
- 1 A 3 b iii R.T., Heavy duty vehicles
- 1 A 3 b iv R.T., Mopeds & Motorcycles
- 1 A 3 b v R.T., Gasoline evaporation
- 1 A 3 b vi R.T., Automobile tyre and brake wear
- 1 A 3 b vii R.T., Automobile road abrasion
- 1 A 3 c Railways
- 1 A 3 d ii National Navigation
- 1 A 3 e Other (Please specify in a covering note)
- 1 A 4 a Commercial / Institutional
- 1 A 4 b Residential
- 1 A 4 c Agriculture / Forestry / Fishing
- 1 A 5 a Other, Stationary (including Military)
- 1 A 5 b Other, Mobile (Including military)
- 1B1 Fugitive Emissions from Solid Fuels
- 1 B 2 Oil and natural gas
- 2 A MINERAL PRODUCTS
- 2 B CHEMICAL INDUSTRY
- 2 C METAL PRODUCTION
- 2 D OTHER PRODUCTION
- 2 G OTHER (Please specify in a covering note)
- 3 A PAINT APPLICATION
- 3 B DEGREASING AND DRY CLEANING
- 3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING
- 3 D OTHER including products containing HMs and POPs (Please specify in a covering note)
- 4 B MANURE MANAGEMENT
- 4 C RICE CULTIVATION
- 4 D 1 Direct Soil Emission
- 4 F FIELD BURNING OF AGRICULTURAL WASTES
- 4 G OTHER
- 5 B FOREST AND GRASSLAND CONVERSION
- 6 A SOLID WASTE DISPOSAL ON LAND
- 6 B WASTE-WATER HANDLING
- 6 C WASTE INCINERATION
- 6 D OTHER WASTE
- 7 OTHER

Quass et al. 2007, UBA Kataster

PM – Source contributions and definitions



Regional-scale, Transport, 2ary part., 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

- PM_{10}: no clear spatial pattern
  - 15-40% $SO_4^{2-}/NO_3^-/NH_4^+$
  - 10-30% $V/Ni/SO_4^{2-}$

- $PM_{2.5}$: no clear spatial pattern
  - 20-60% $SO_4^{2-}/NO_3^-/NH_4^+$
  - 10-30% $V/Ni/SO_4^{2-}$

Viana et al., submitted, 2008

PM SoAp – Current research trends

1. Inter-comparison of source apportionment methods

2. Receptor modelling of particle size distribution data

3. Source apportionment analysis of specific PM fractions:
   a) C aerosols using ^{14}C
   b) Natural sources: mineral dust (windblown, African dust)
   c) Primary vs. secondary organic aerosols
   d) Anthropogenic sources (e.g. shipping emissions, diesel vs. gasoline)

4. Receptor modelling for epidemiological and health-related studies

5. Source apportionment of indoor air and relation to exposure

PM – Emission and sources

- Emission inventory for various particle parameters are needed
- Emission inventory (incl. chemistry) data and models needed to relate the source apportionment studies with model results
- Partially comparable, partially total different results of source apportionment studies over Europe
- Source factors as derived in the various studies are not directly comparable
- Source apportionment data coverage over Europe is sparse
- Source data coverage for different size fractions is even less

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PM and exposure

- exposure ➔ dose and investigating possible linkages to health 'end points' is the mayor approach used in epidemiology
- the more precise the exposure assessment
  the better the possible association to health effects
- current approaches based on mass of PM have shown their value but also their limitations in explaining effects, either by epidemiological or toxicological studies
- new approaches expressing exposure is needed
  (see also list of particle parameters next presentation)
- new approaches may be based on
  - particle sources
  - reactivity (ROS)
  - particle surface area / number concentration
  - ……

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5. Is this all?

- Several parameters linked to air quality and health effects have to be studied, e.g. ROS, UFP, source related effects…
- Effects can not be seen independently from other factors / stressors influencing human health,
  e.g. noise, climate, water quality….
- Nevertheless major effects (➔ efforts) are currently linked to air quality / PM and further improvements in scientific understanding and subsequent improved abatement strategies.
- Measurements, exposure research with tox and epi research taking into account the European heterogeneity is an activity urgently needed for Europe.
  ➔ Environment & Health Research Platforms