NEW ASPECTS ON PARTICULATE MATTER MODELLING

Ana Miranda (University of Aveiro)
Wilfried Winiwarter (IIASA, Laxenburg and Austrian Research Centers, Vienna)

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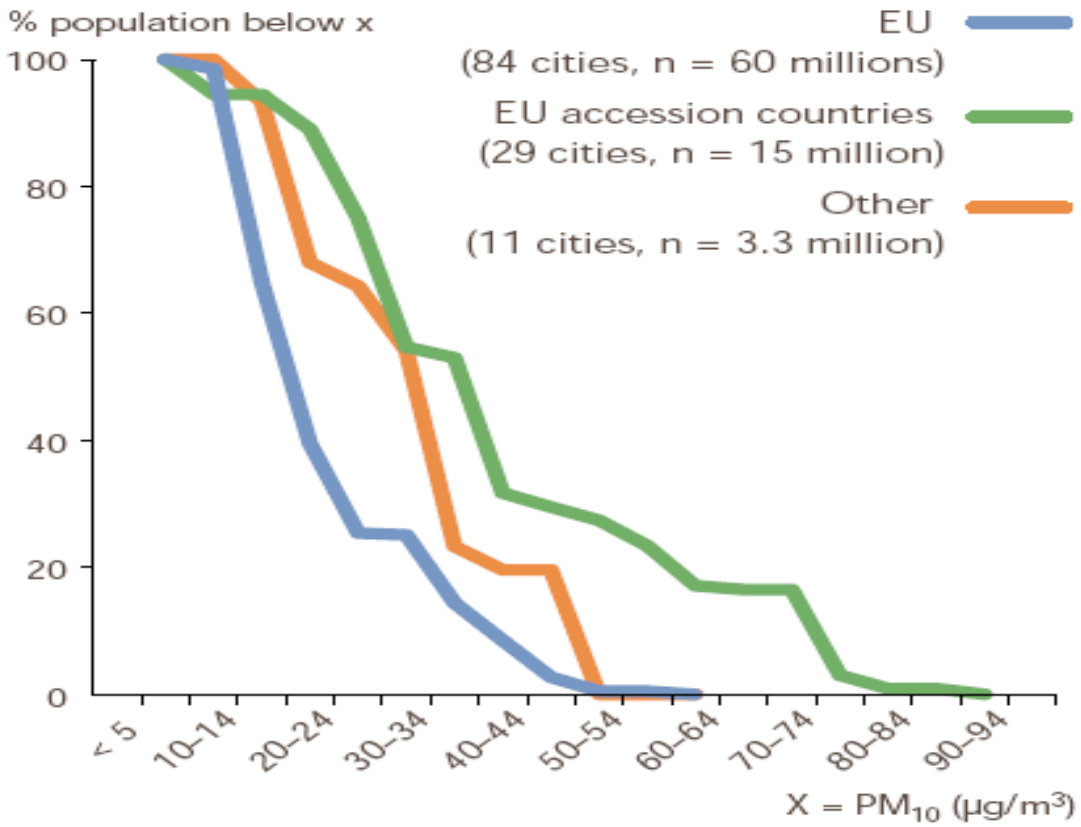
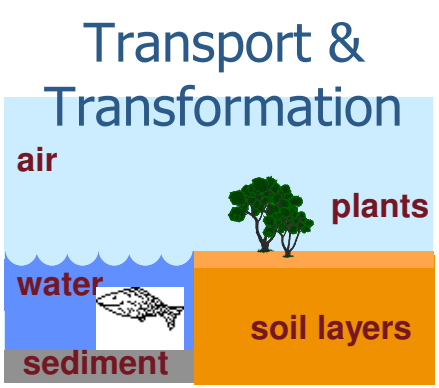
Scope

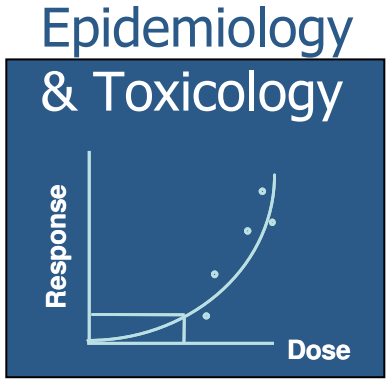
Air pollution is a major environmental health problem causing approximately three million deaths per year in the world, as result of exposure to particulate matter

Population exposure to estimated PM_{10} levels in 124 European cities

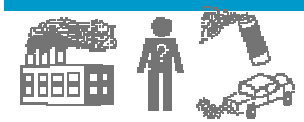


Source to dose assessment





Emission sources → Air quality concentrations → Exposure → Dose → Health effects



What goes out …

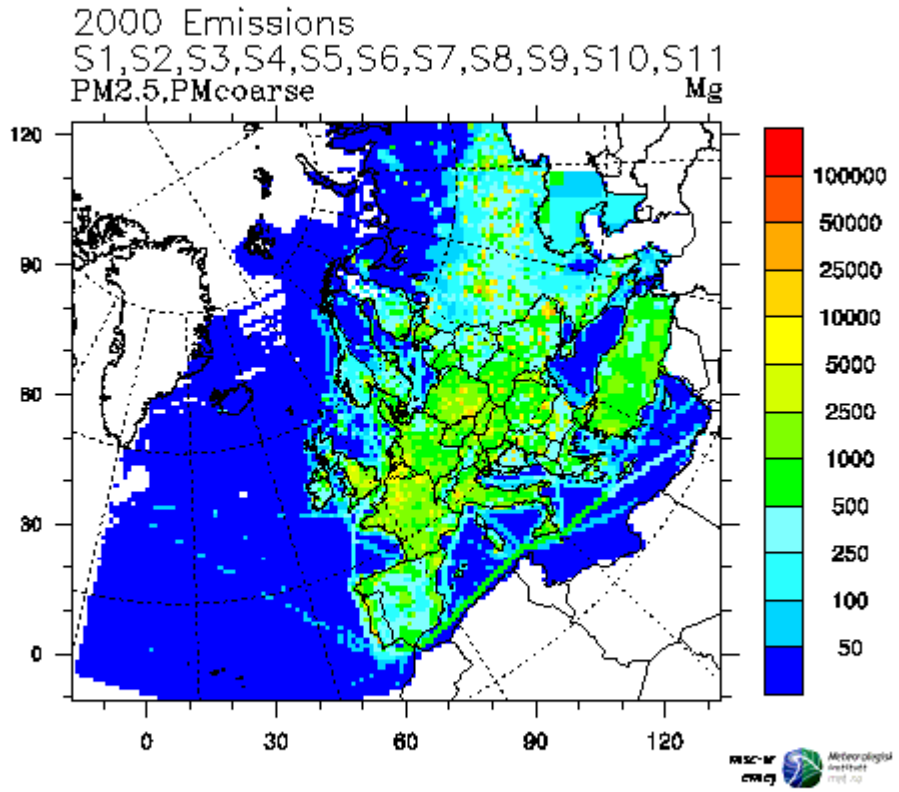
emission modeling

- Country emissions: obligatory submission to UNECE, EU
  → EMEP inventory

- Event specific (often science-driven) PM inventories for specific urban areas
  → e.g. „City delta“ project

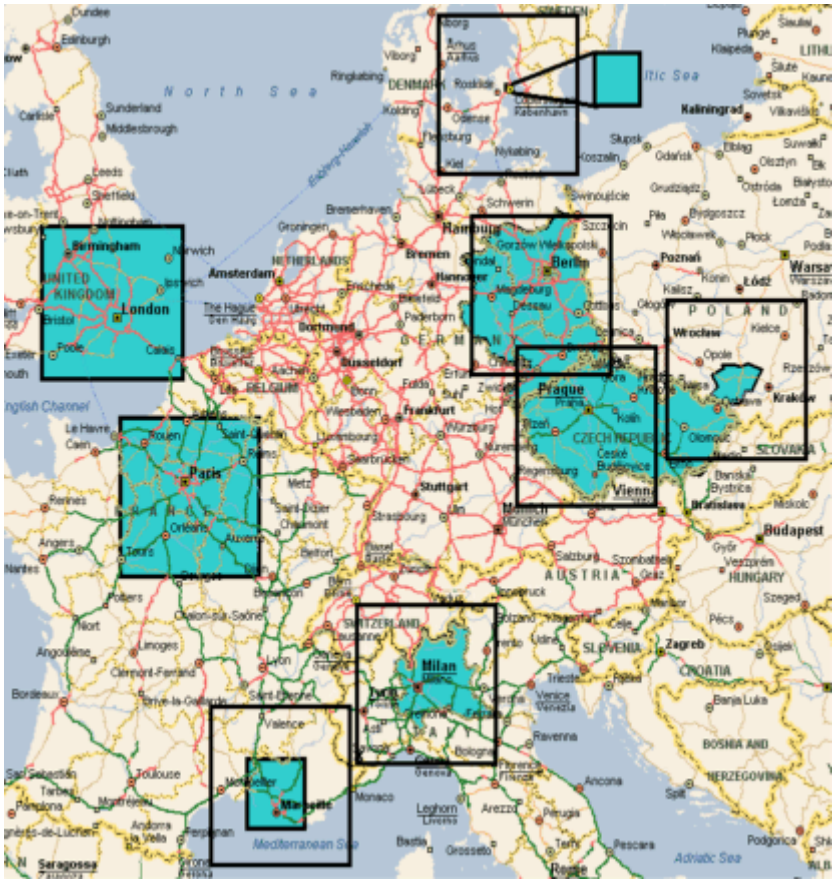
  inventories provide basis for abatement plans

emep pm inventories



www.emep.int

“city delta” pm inventories

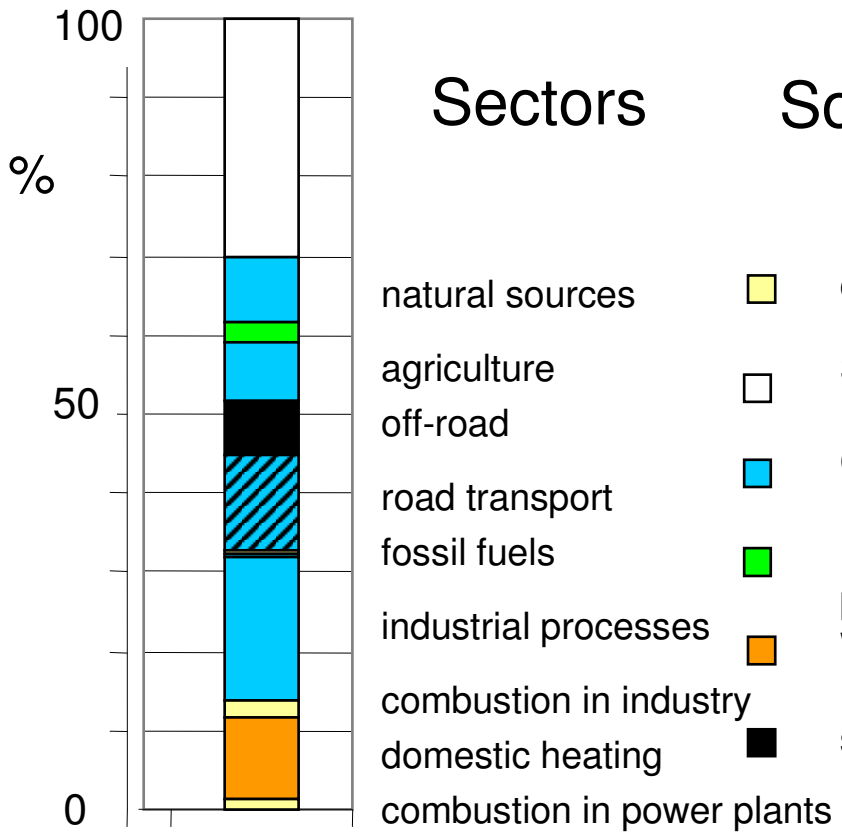


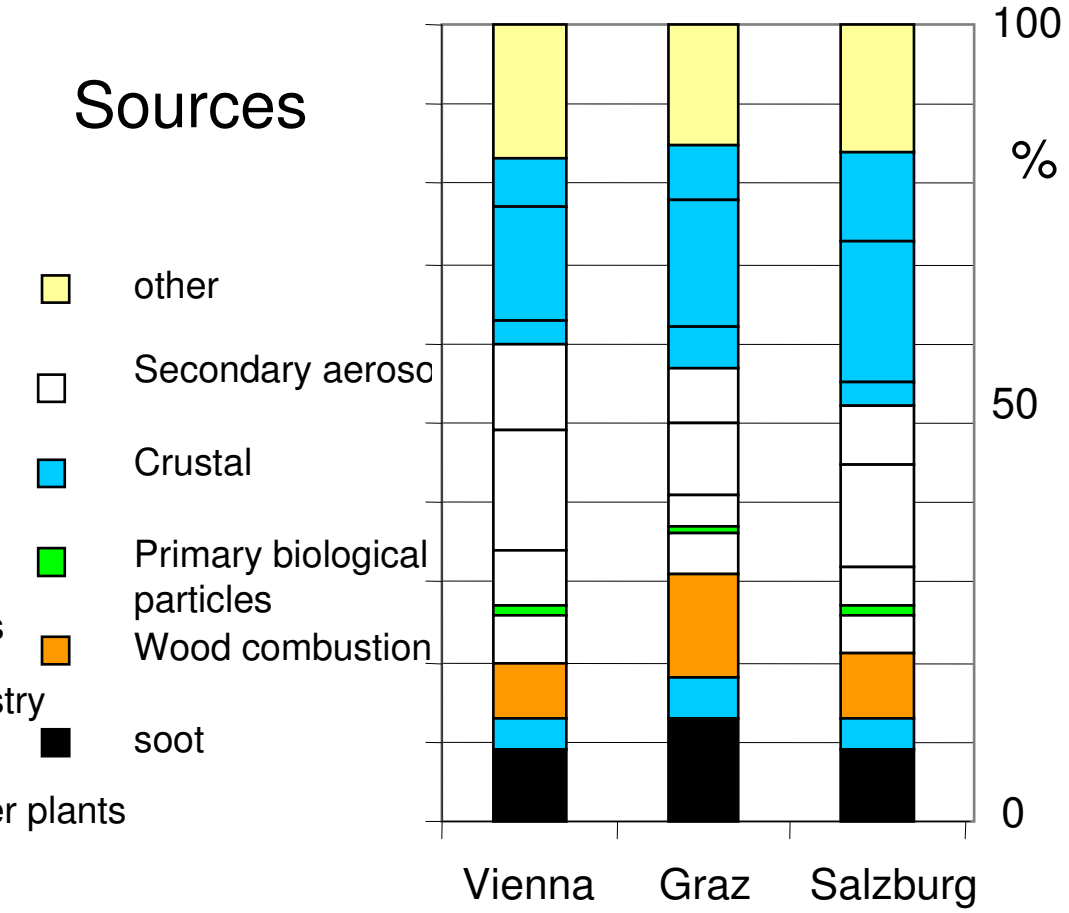
http://aqm.jrc.it/citydelta/ -- inventories are partly openly available

issues in pm emission modelling

- PM size, speciation affects emissions, properties, and effects
- Well-defined primary (combustion) emissions, ill-defined fugitive emissions
- Emission reductions decrease data availability and quality
- Emissions from natural sources

emission vs. Source apportionment modelling

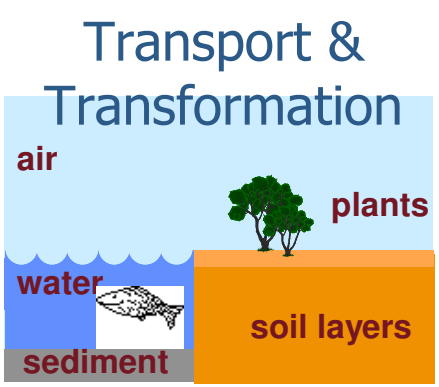


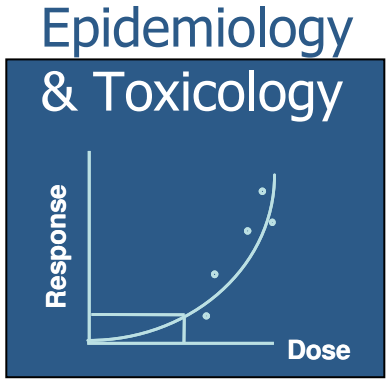


Austrian PM 10 emissions:
Winiwarter et al., 2007

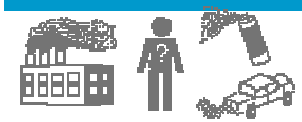
Source apportionment data
(AQUELLA, Bauer et al, 2007)

Source to dose assessment





Emission sources → Air quality concentrations → Exposure → Dose → Health effects



How to get them?

air (PM) **q**uality

how to get data

Air Quality monitoring networks…

- ✓ measuring ambient air pollutants concentrations in time
- ✓ obtaining data at discrete sites (different types of stations)

depending on the location and dimensions of the region to be studied, monitoring data could not be sufficient to characterize PM values of the area or to estimate human exposure.

numerical modelling → a complementary tool

air **q**uality (PM) **m**odelling

numerical models

… are useful tools for mapping air pollutants along the time (spatial and temporal distribution of PM)

… simulate the

- transport
- chemical transformation
- deposition of air pollutants

… more recently
formation of secondary particles from gaseous precursors and particles dynamics

air quality (PM) modelling

There are different models for different applications !!!

According to air pollution problem

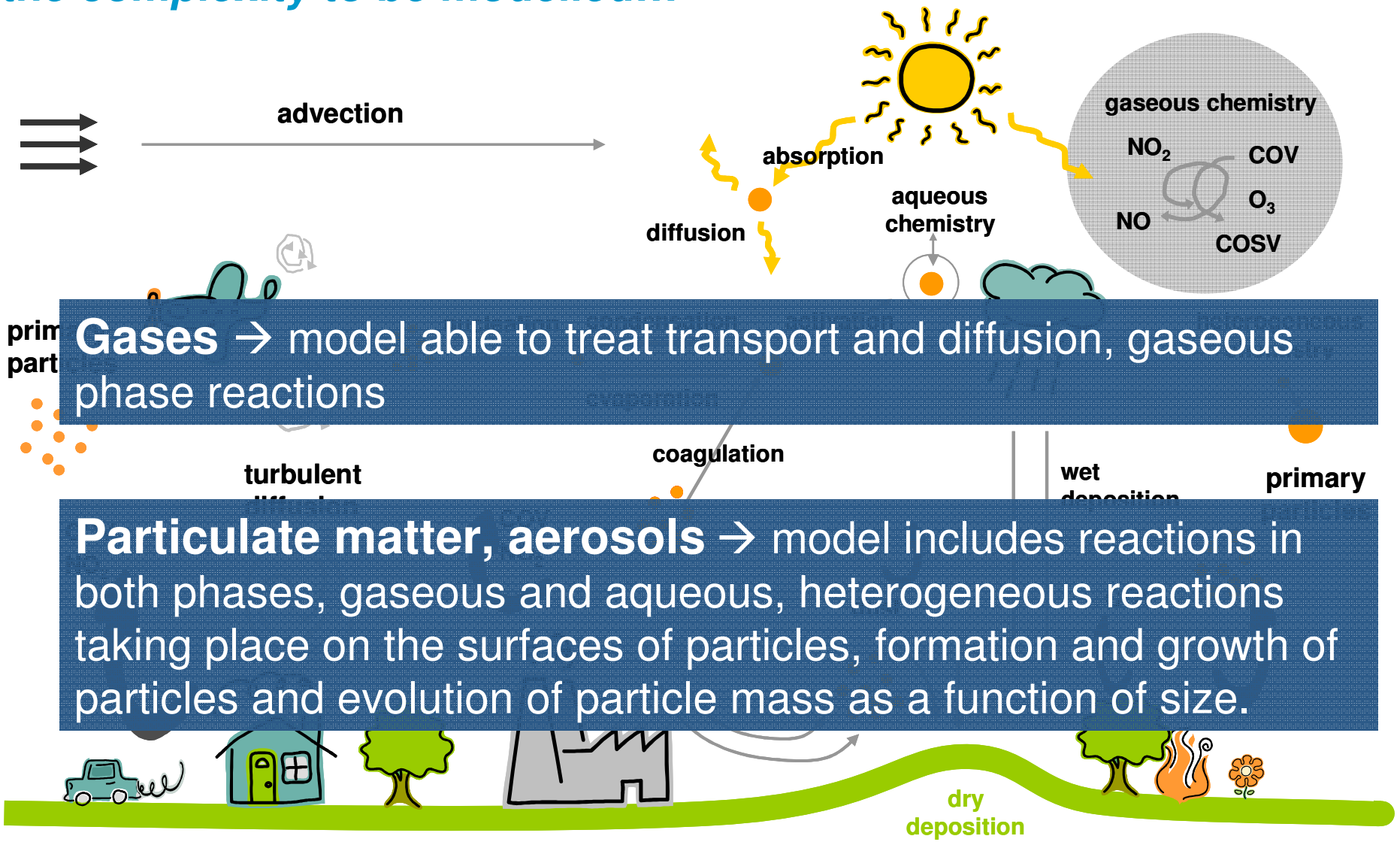
- **spatial scale**: global, regional, mesoscale, urban, local, microscale
- **temporal scale**: short-term, seasonal, long-term
- **chemical reactions**: passive dispersion, photochemical, **...**

but computer capacity and experts are also important

As much complex is the model better results could provide, however more resources are needed!!!

air quality (PM) modelling

the complexity to be modelled…



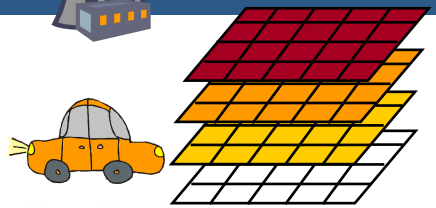
Gases → model able to treat transport and diffusion, gaseous phase reactions

Particulate matter, aerosols → model includes reactions in both phases, gaseous and aqueous, heterogeneous reactions taking place on the surfaces of particles, formation and growth of particles and evolution of particle mass as a function of size.

air quality (PM) modelling

Gridded **emissions**

Point sources



Traffic, industrial and biogenic emissions

inputs and outputs

Air quality data as initial and boundary conditions

inputs

Emissions
Meteorology
Topography and Landuse
...

Air quality model

air quality

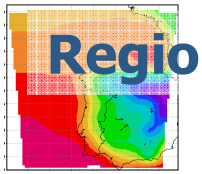
air pollutants concentrations

EFFECTS

Human health
Buildings, Biota, Climate

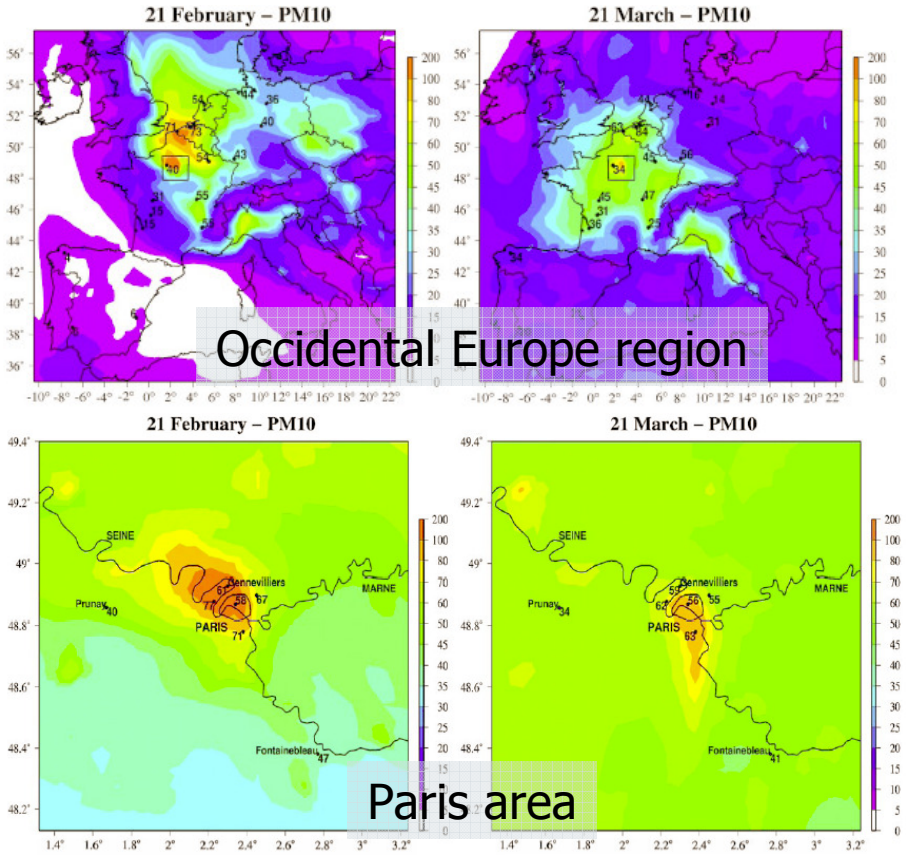
air quality (PM) modelling

applications



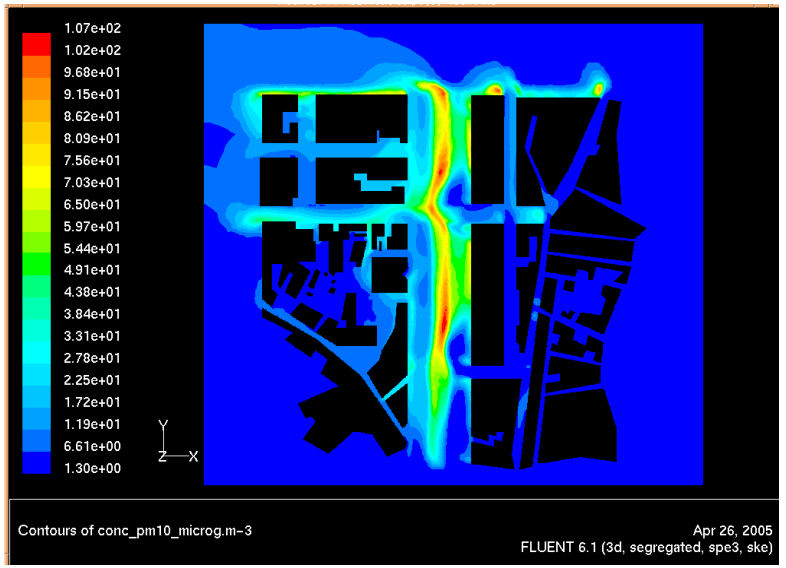
Regional/ Mesoscale models

CHIMERE application



Urban/ Local models

FLUENT aplication



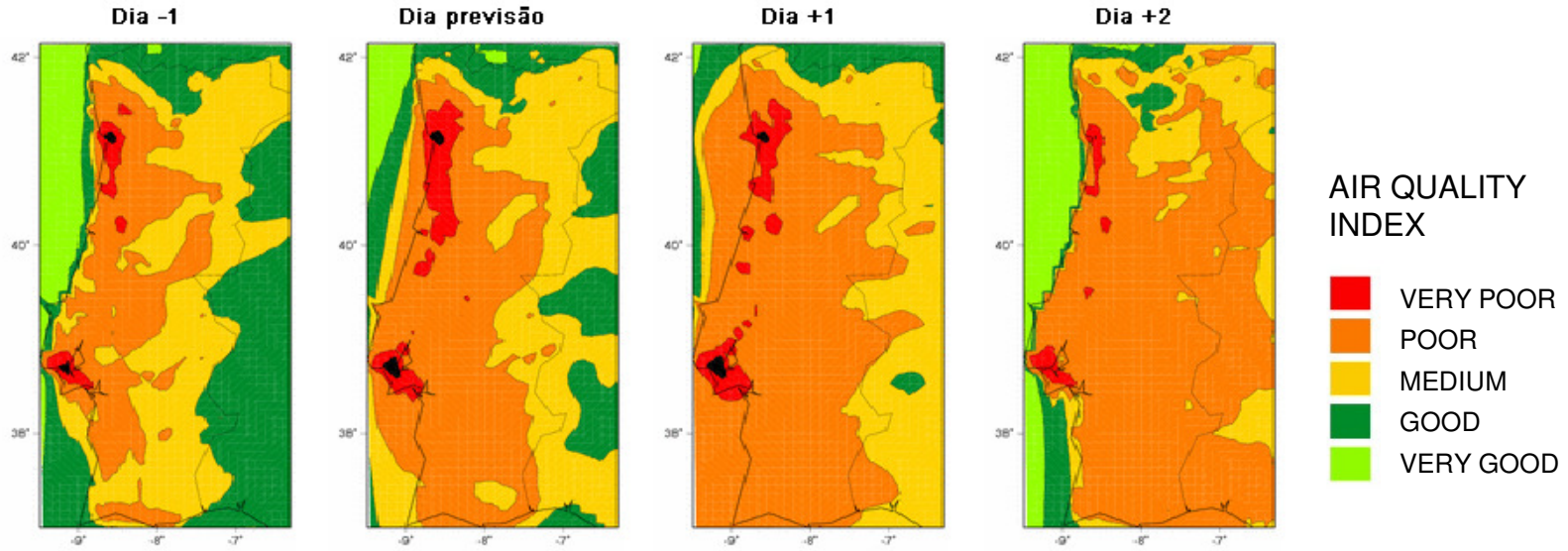
PM_{10} simulated results for a main avenue in Lisbon city centre

air quality (PM) modelling

applications

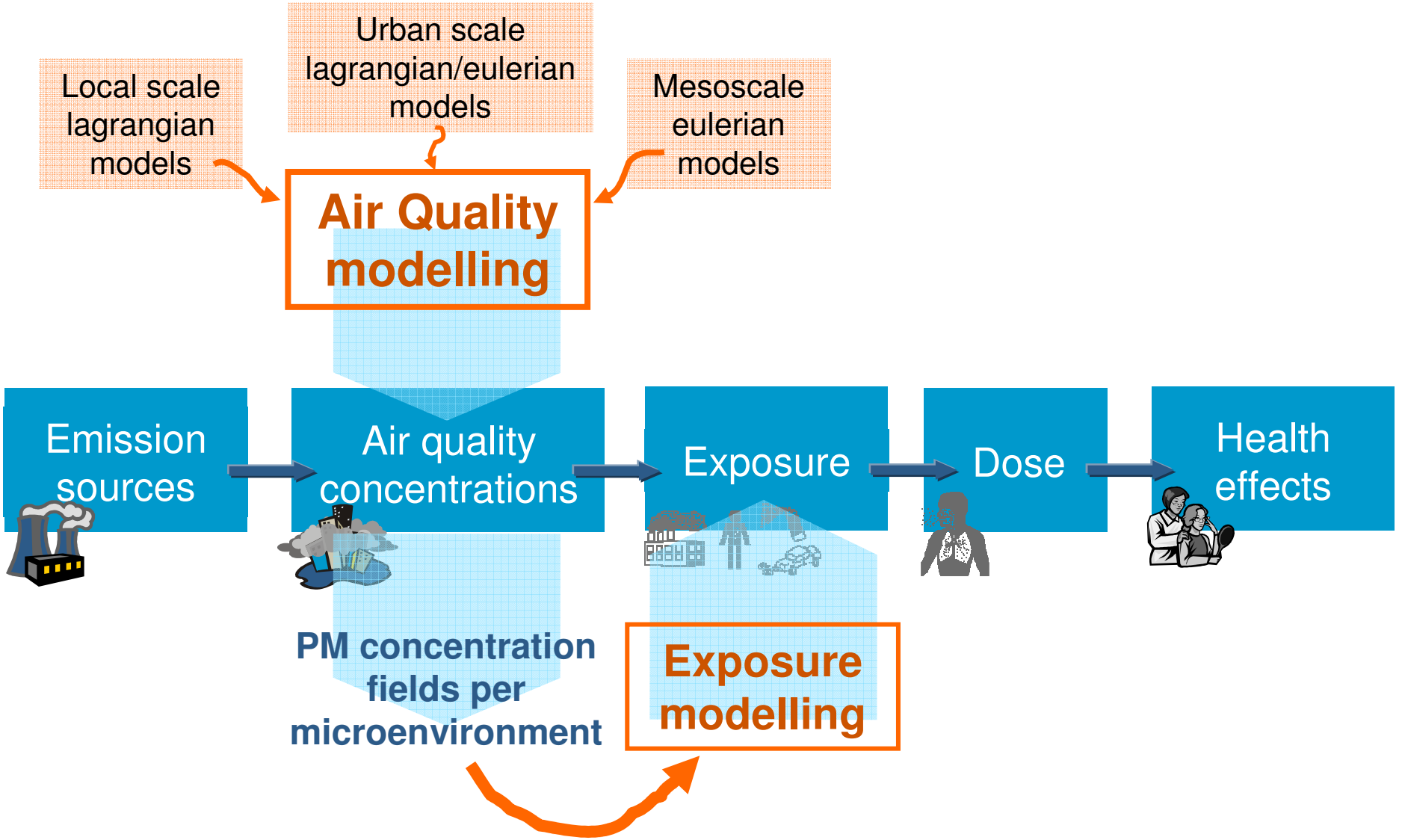
Forecasting PM

PM_{10} forecast → **Prevention of population health problems**



PM_{10} 3-day forecast for Portugal

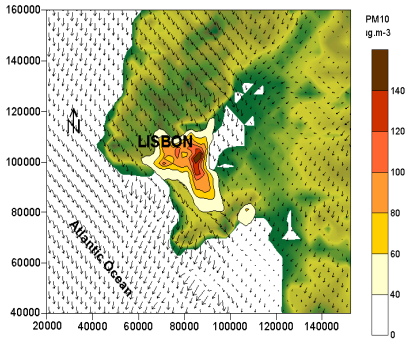
exposure modelling



exposure modelling

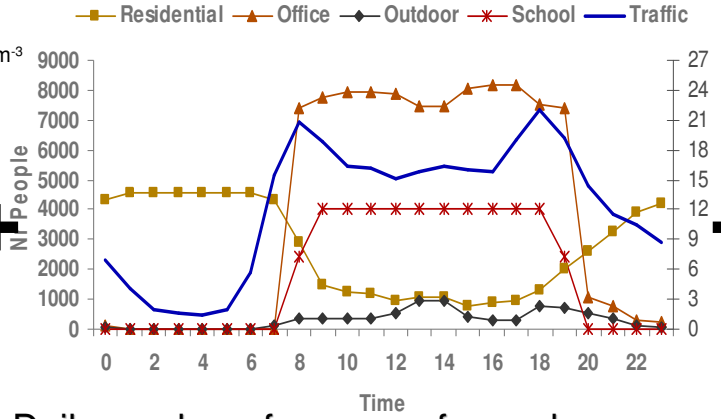
applications

From mesoscale to local scale

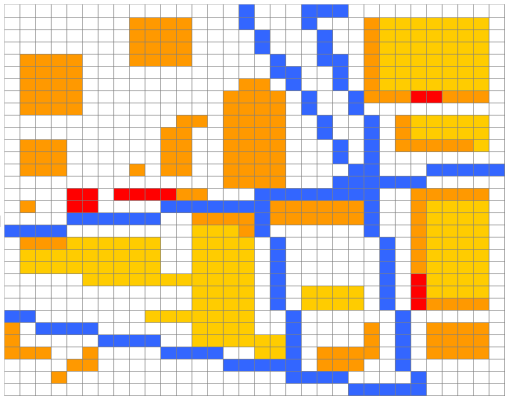


Boundary conditions to VADIS given by a mesoscale simulation with MEMO-PM
28th Feb 2000, 9:00

VADIS results - Wind and PM_{10} concentration fields at 9:00



Daily number of persons, for each microenvironment and time-activity pattern of the population



Microenvironments distribution:

Residence
Office
School
Outdoors
Traffic

PM_{10} concentration values inside the domain are above the daily limit value of 50 µg.m^{-3}

exposure modelling

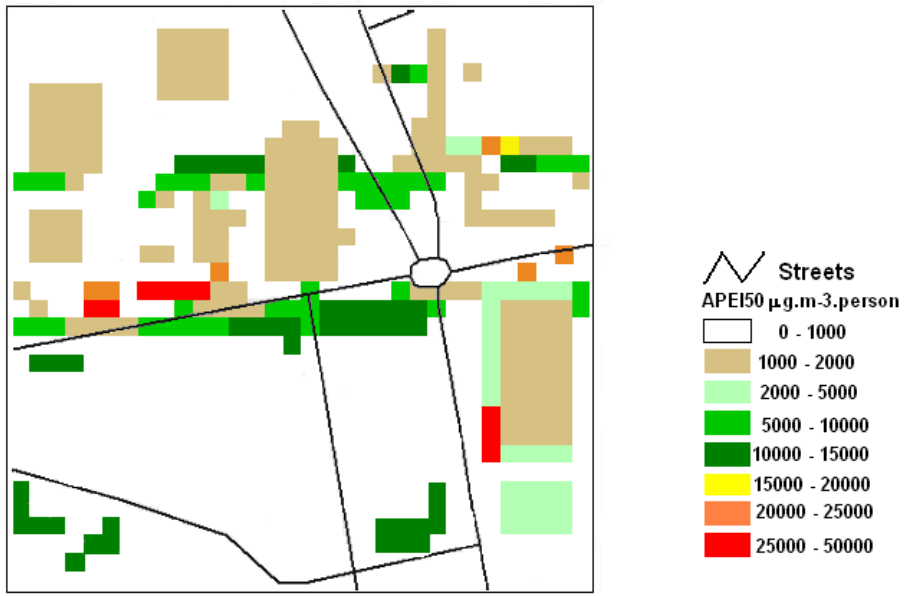
applications

Lisboa city centre – local scale modelling

Population exposure results

APEI50 obtained field with microenvironments distribution

28th Feb 2000, 9:00



APEI50 is the accumulated population exposure index for the population exposed above the concentration of 50 µg.m^{-3}

The importance of the calculation of exposure is justified by 2 main reasons:

- Areas of higher concentrations are not always areas of higher exposure (and vice-versa)

- Two persons living in the same area (similar ambient air quality) may have quite different exposures according to their activity patterns.

exposure modelling

applications

Helsinki Metropolitan Area – urban scale modelling

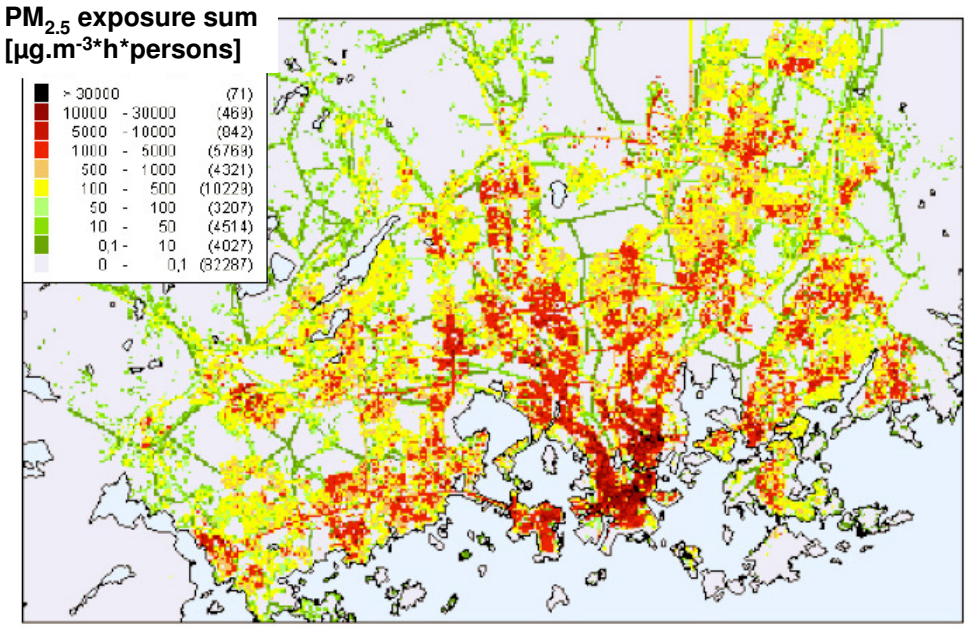
FUMAPEX Project

Urban Dispersion Modelling system (UDM-FMI) + Operational Street Pollution Model (OSPM)

road network dispersion model (CAR-FMI)

Exposure Model

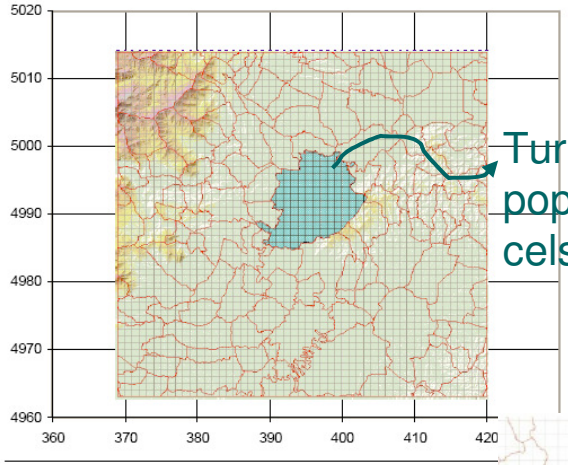
EXPAND



Spatial distribution of **population exposure** to **$PM_{2.5}$** in Helsinki metropolitan area for an inversion episode day.

exposure modelling

applications



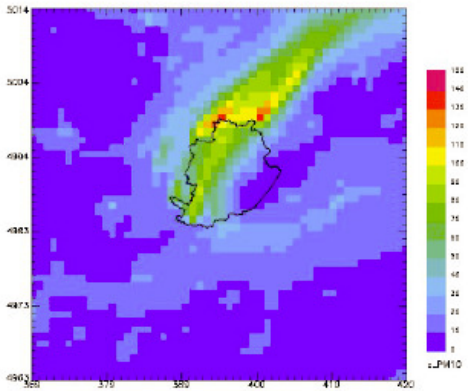
Turin city population cels

Turin city – mesoscale modelling

FUMAPEX Project

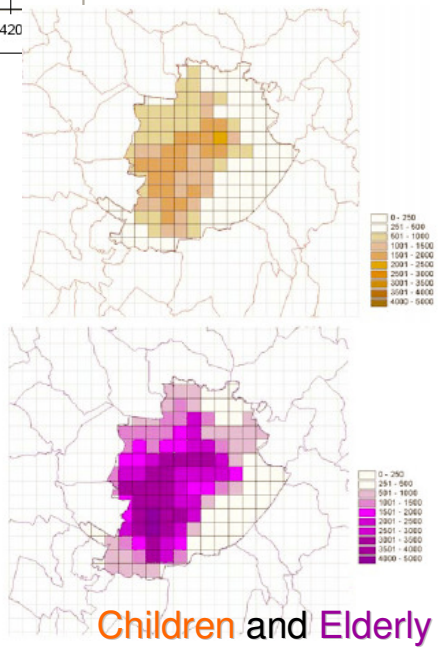
Air quality domain (RAMS-FARM modelling system): 51*51km^2, 1km resol

PM_{10} concentration [µg m^{-3}]



FARM results: PM_{10} 24-h concentration field

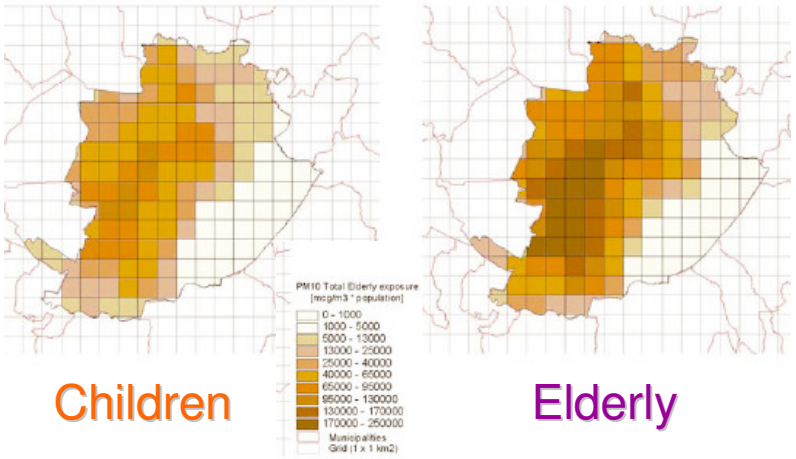
+



Children and Elderly living in each cell

=

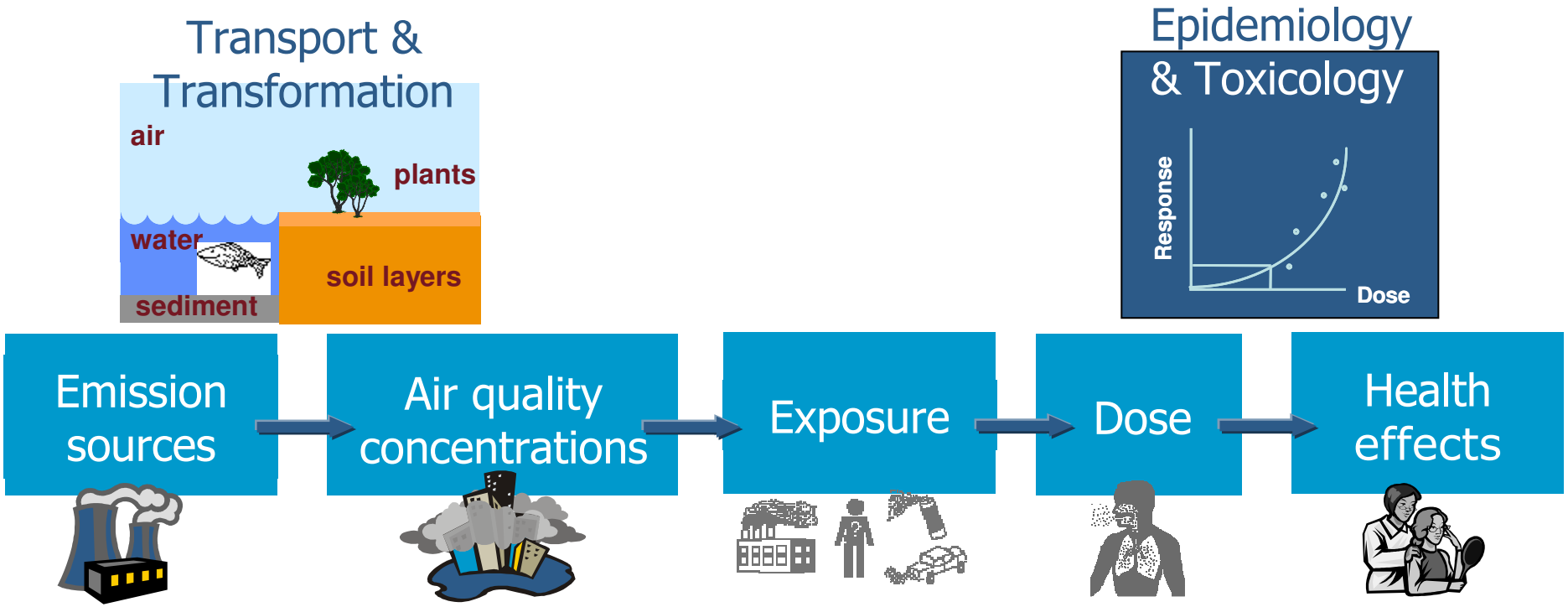
Total PM_{10} exposure [population*µg.m^{-3}]



Children

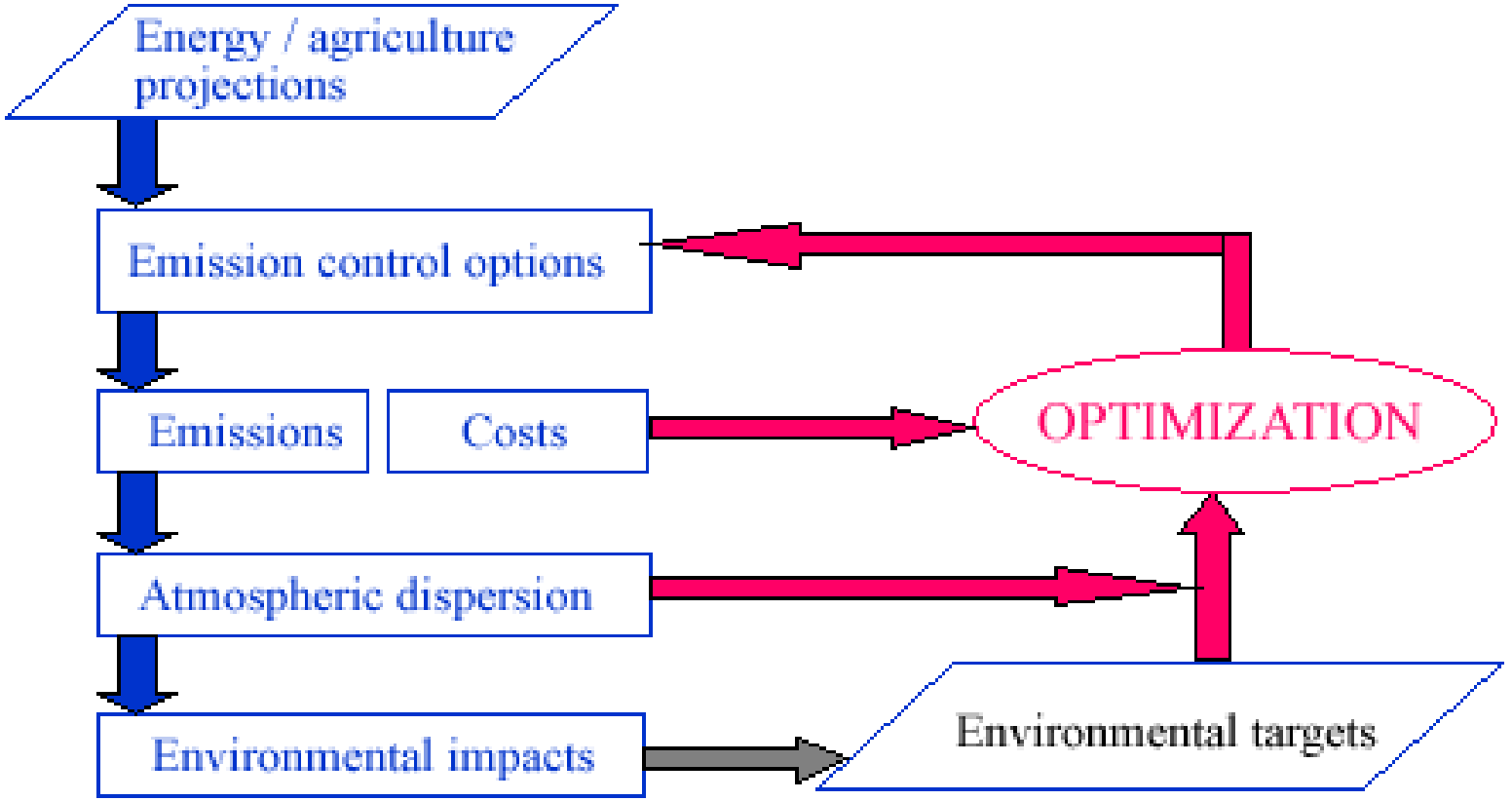
Elderly

Source to dose assessment



… all together now!

integrated **a**ssessment **m**odelling



GAINS model

how do iam's work?

- Integration: covers multiple aspects
- Assessment: includes optimization towards a (well-defined) target

- Models contain sub-models in a parameterized form

  (e.g. source-receptor matrix)

few Operative examples

- IIASA: GAINS
- Univ. Stuttgart: MERLIN
- RIVM: Image
- Imperial College London
- …

purpose

- Cost optimization for a given environmental target
- Target optimization at given costs
- Co-benefits
- …

→ IAM's provide answers to policy questions

final remarks

- Air quality models provide spatial distribution, where measurements assess the situation at specific points/areas only
- Emissions inventories provide limited information on PM size or chemical composition. Knowledge on emission processes is available – we need more interaction!
- All models are useful! Appropriate selection is required, such that model outcome reflects a model's abilities: air quality management, exposure and health estimations, …
- Legislation on air quality concerns ambient air quality while it is known that it can differ a lot and differently, from place to place, from real exposure to air pollutants, namely PM.
- **Air quality models are being applied for scientific purposes, BUT need extension into state-of-the-art 3rd generation models (Eulerian models with aerosol chemistry) on epidemiological studies – model coupling or integrated assessment?**

Thank You!!!!