FMI Projects on PM_x modelling

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Source apportionment of urban airborne particles and polycyclic aromatic hydrocarbons in Europe – SAPPHIRE, 2002 – 2005. EU, City of Tomorrow. (**www.gees.bham.ac.uk/research/sapphire)**

Health Effects caused by Urban Air Pollution for the Transport System Plan Scenarios in Helsinki Area – HEAT, 2002 – 2004. Research programme TERVE (**www.fmi.fi/research_air/air_18.html)**

An integrated model for evaluating the emissions, atmospheric dispersion and risks caused by ambient air fine particulate matter - KOPRA. 2002 – 2005. Research programme FINE. (**www.fmi.fi/research_air/air_47.html**)

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SAPPHIRE –WP 3 (modelling)

Source apportionment of PM based on analysis of datasets produced in WP's 1 and 2.

Include:

- **seasonal and spatial variation,**
- **inter- and intra-city variation,**
- **chemical composition,**
- **in five European cities.**

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SAPPHIRE –WP 3

http://www.gees.bham.ac.uk/research/sapphire/

- Receptor modelling (resp. U. Hertfordshire)
  - Principal Component Analysis
  - Multiple Linear Regression Analysis
  - (supplemented by) e.g., cluster analysis
- Inverse modelling (resp. NERI)
  - Differential Mobility Analyser (DMA) data
  - Operational Street Pollution Model (OSPM)
- **Deterministic modelling (resp. FMI)**
  - **Emission inventories, modelling vehicular PM emissions**
  - **Dispersion + aerosol process modelling (in cooperation with U. Helsinki)**

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SAPPHIRE –WP 3 /deliverables

- **A readily transferable protocol for conducting data analysis of particle size distribution and its use in the determination of direct traffic emissions of particles of different sizes: yearly 2005**
- **A readily transferable protocol for conducting source apportionment of size-fractionated airborne particulate matter and its individual chemical constituents : late 2005**

Modelling/Aerosols

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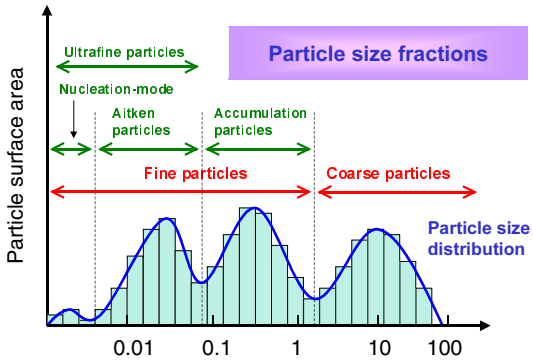
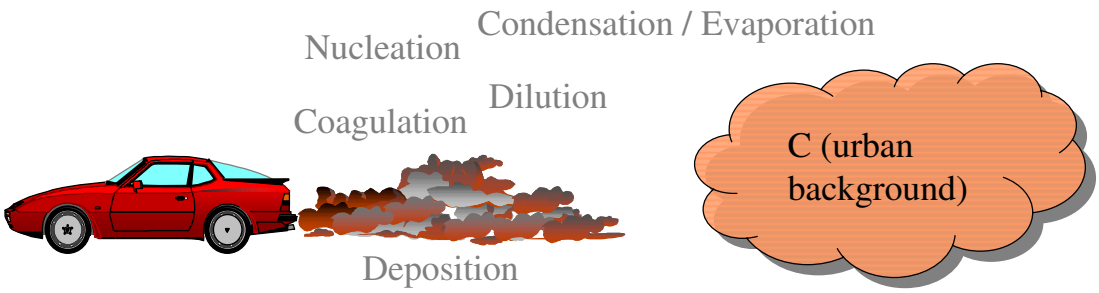
Modelling aerosol dynamics in the atmosphere – the MONO32 model

FMI, University of Helsinki and Helsinki Polytechnic





Aerosols /results

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M. Pohjola, L. Pirjola, J. Kukkonen and M. Kulmala (2003). Modelling of the influence of aerosol processes for the dispersion of vehicular exhaust plumes in street environment. Atmos. Environ. 37, pp. 339-351.

- simple plume model was combined with MONO32
- condensation of insoluble organic vapour is important if vapour concentration exceeds 1010 or 1011 cm-3
- coagulation important if dilution is neglected
- after 25 s and at 75 m distance from the plume source, the particle population has reached quasi-steady state

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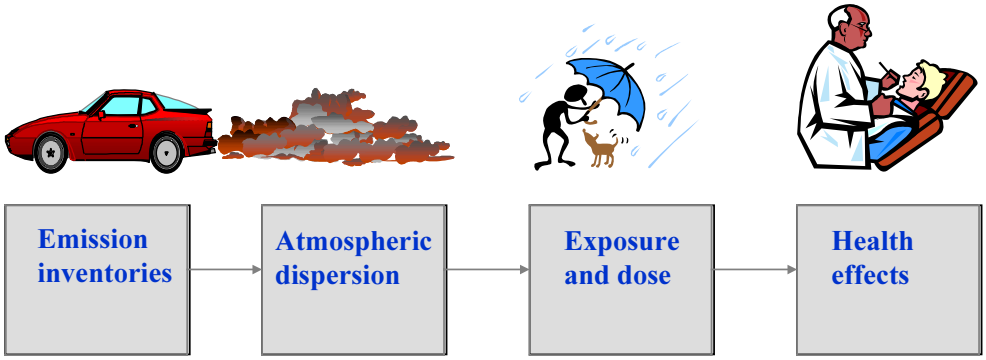
Health Effects caused by Urban Air Pollution for the Transport System Plan Scenarios in Helsinki area - HEAT (2002 - 2004)

Health Promotion Research Programme (TERVE)



http://www.fmi.fi/research_air/air_18.html

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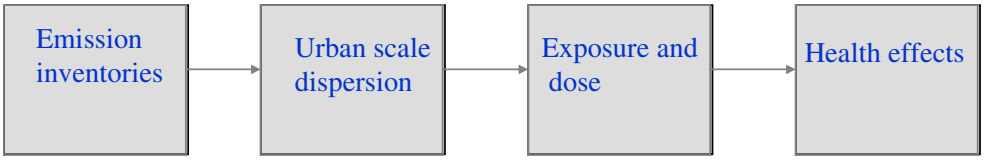
Responsible institutes

YTV FMI	FMI	KTL,YTV FMI, UKU	KTL



Models

Emission models for mobile and stationary sources	Urban and local scale dispersion models	Population exposure models, source apportionment models	Dose - response models

Datasets

Emission coefficients of VTT, YTV traffic network, FMI emission database	FMI meteorological database, YTV background concentrations	Datasets of EXPOLIS and ULTRA I, YTV population statistics dataset	Dose -response data, YTV population statistics database

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HEAT:
deteministic modelling system
for local/urban scale concentration & exposure calculations

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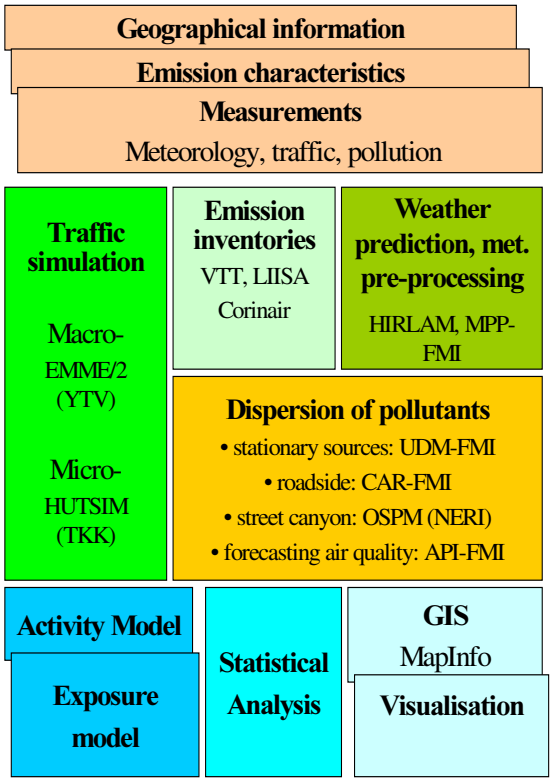
The integrated modelling system



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The aerosol process model includes:

- ☆ **chemical reactions** in the gas phase,
- ☆ **dry deposition** of particles and gases,
- ☆ homogenous binary H_2SO_4-H_2O - or ternary H_2SO_4-H_2O-NH_3 - **nucleation**,
- ☆ **condensation** of H_2SO_4, H_2O, HNO_3, NH_3 and organic vapors to particles,
- ☆ **coagulation** between and within the size classes and
- ☆ **dilution** of the gases by background air.

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Deterministic and statistical modelling of $PM_{2.5}$

Contributions to urban $PM_{2.5}$ concentration

$$PM_{2.5} = PM_{2.5}^{tr,e} + PM_{2.5}^{tr,n\text{-}e} + PM_{2.5}^{st} + PM_{2.5}^{bg,urb} + PM_{2.5}^{bg,lrt} + PM_{2.5}^{wind}$$

Primary traffic + non-exhaust traffic + stationary sources + urban BG + long-range BG + suspended material from other sources than traffic.

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Using the experimental relation

$$PM_{2.5}^{bg,lrt} = b\, C_{ion}$$

the above-mentioned equation can be written as

$$PM_{2.5} = (1 + a)\, PM_{2.5}^{tr,e} + b\, C_{ion} + PM_{2.5}^{st} + c$$

where C_{ion} is the so-called ion sum, a and b are constants and c the the contribution of other sources except for local traffic, LRT and stat. sources

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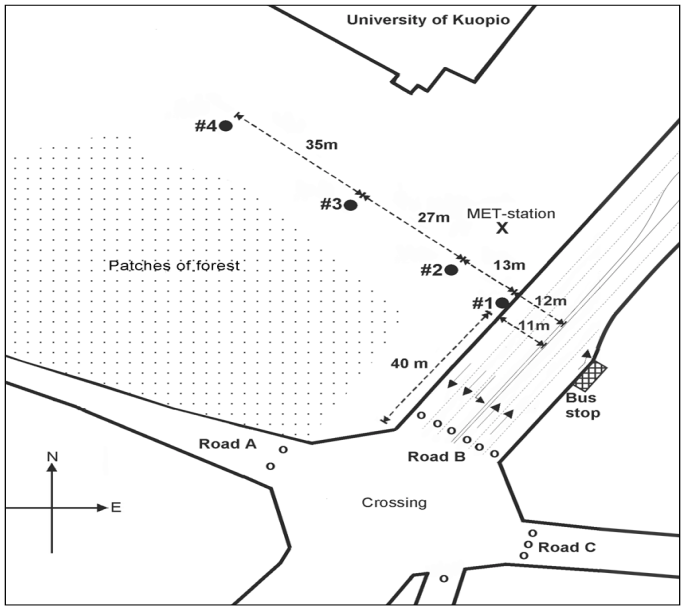
Evaluation of the $PM_{2.5}$ model : Kuopio, 1999 *(Tiitta et al, 2002)*



The measuring units and their environment.
The sampler locations = #1, #2, #3, #4.
The circles (o) denote traffic flow measurements.

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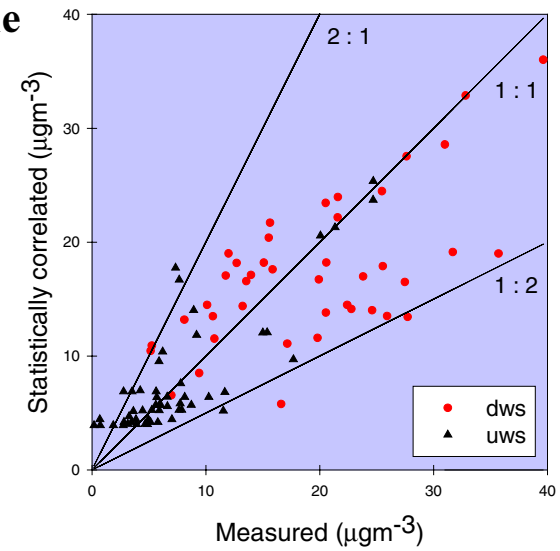
Evaluation of the $PM_{2.5}$ model : Kuopio, 1999 *(Tiitta et al, 2002)*

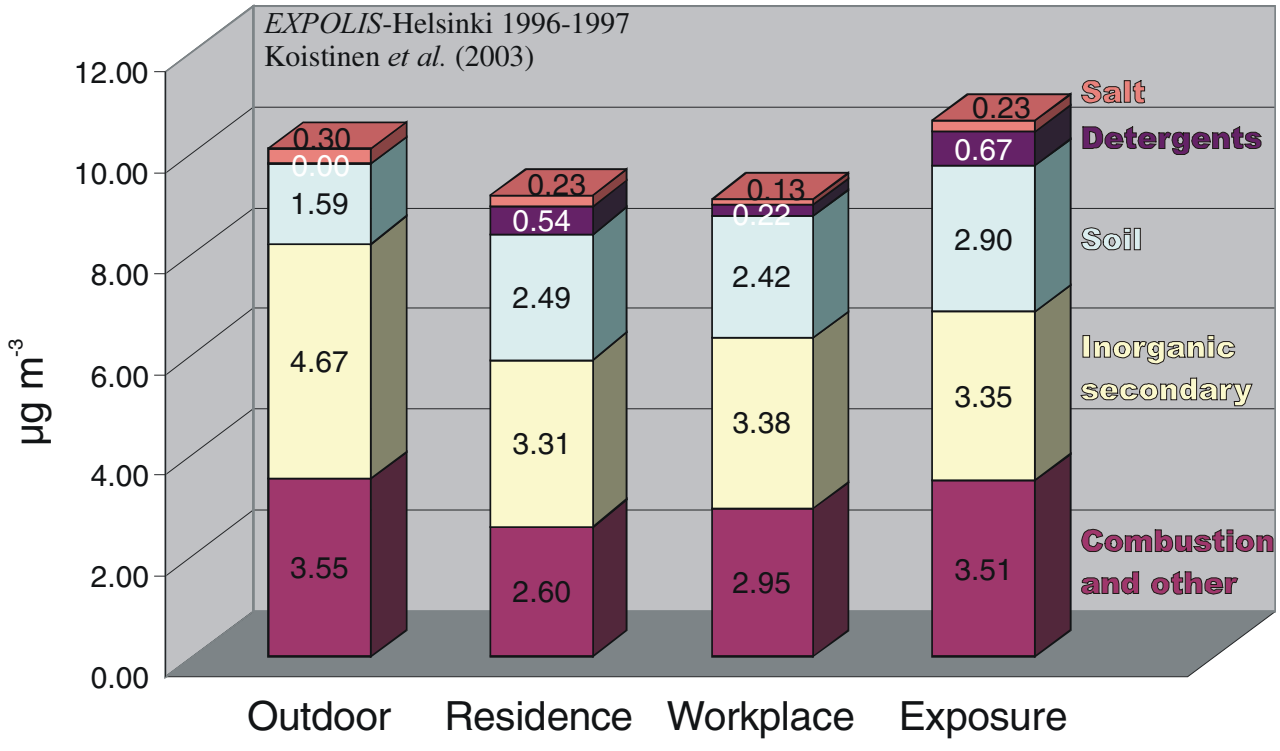


A scatter plot of the statistically correlated and measured concentrations of $PM_{2.5}$.
The figure also shows measurement locations downwind (dws) and upwind (uws) with respect to the road.

PM source apportionment & probabilistic exposure modelling in the HEAT project

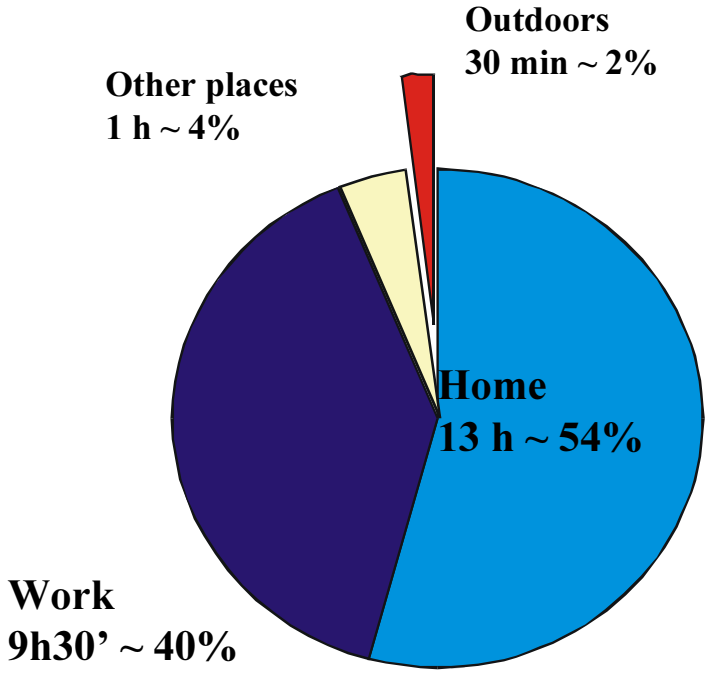
KTL, Kuopio

$PM_{2.5}$ microenvironment concentrations and exposure by source categories

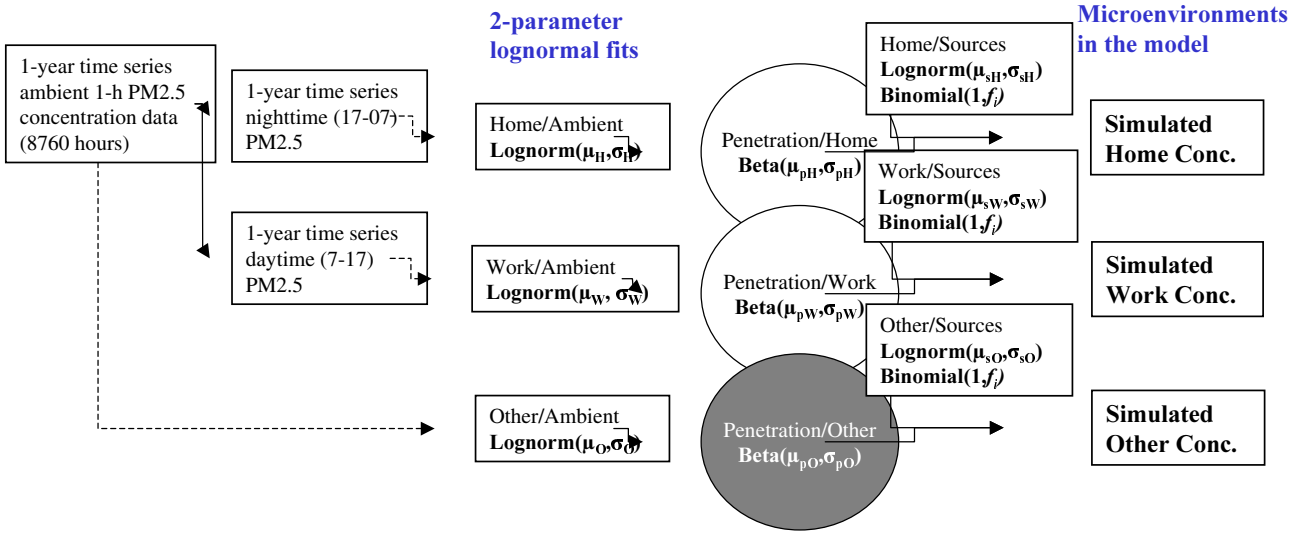


Microenvironment model

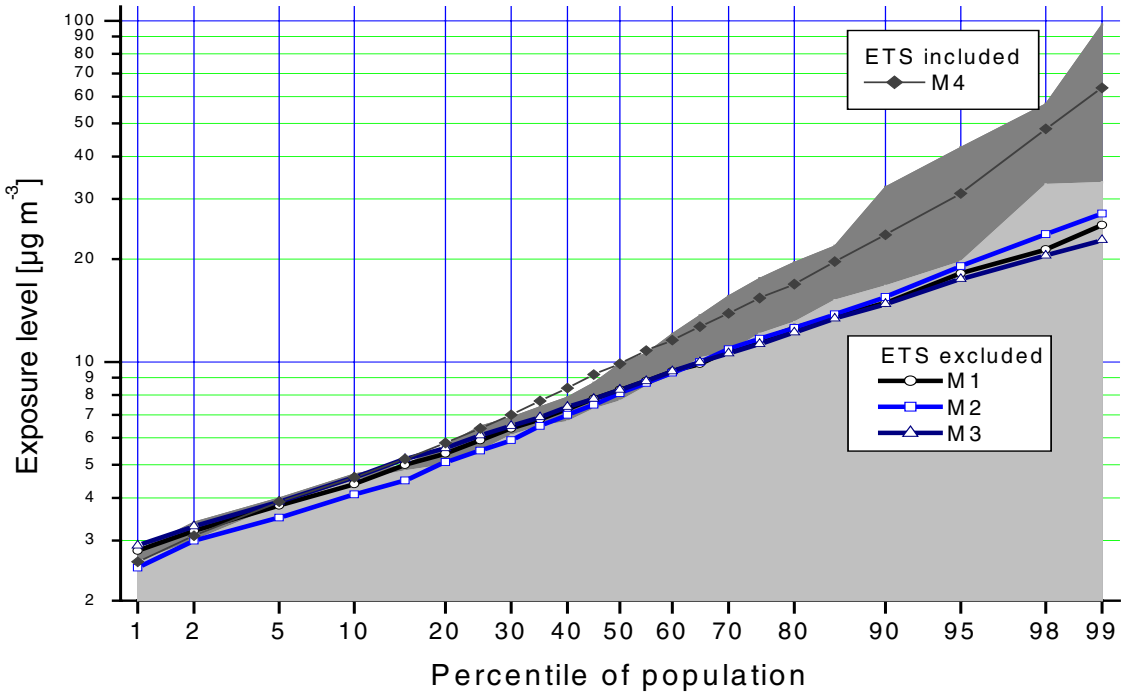
Classification of locations into 'microenvironments'



Simulation of indoor concentrations



Comparison of observed and simulated exposures. The filled grey areas represent the observed exposure distributions.



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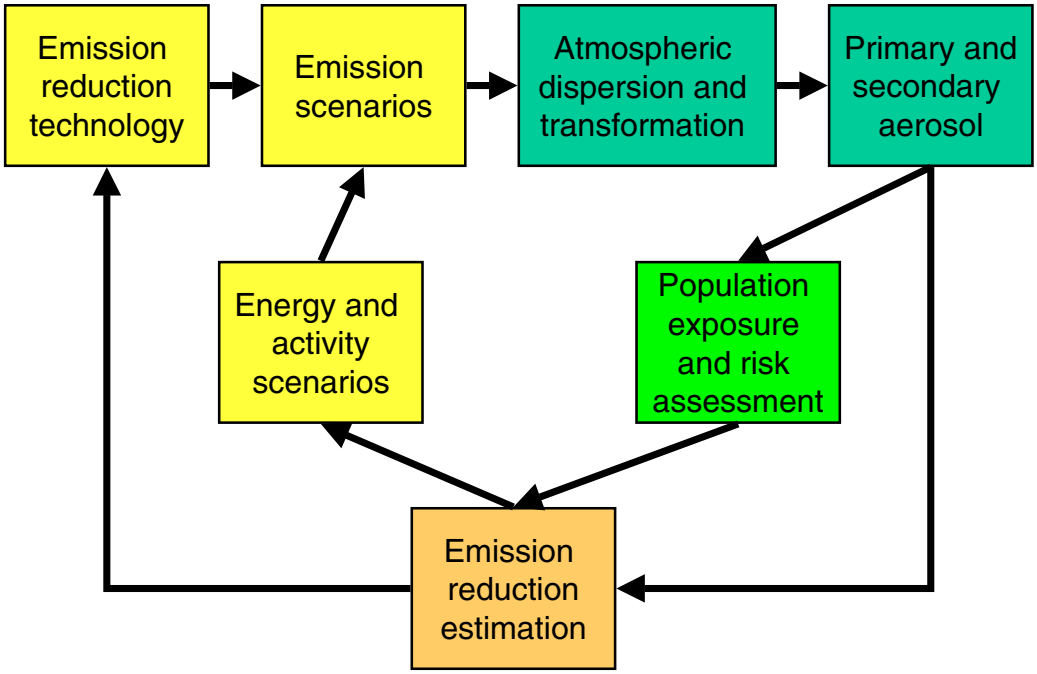
An integrated model for evaluating the emissions, atmospheric dispersion and risks caused by ambient air fine particulate matter – KOPRA

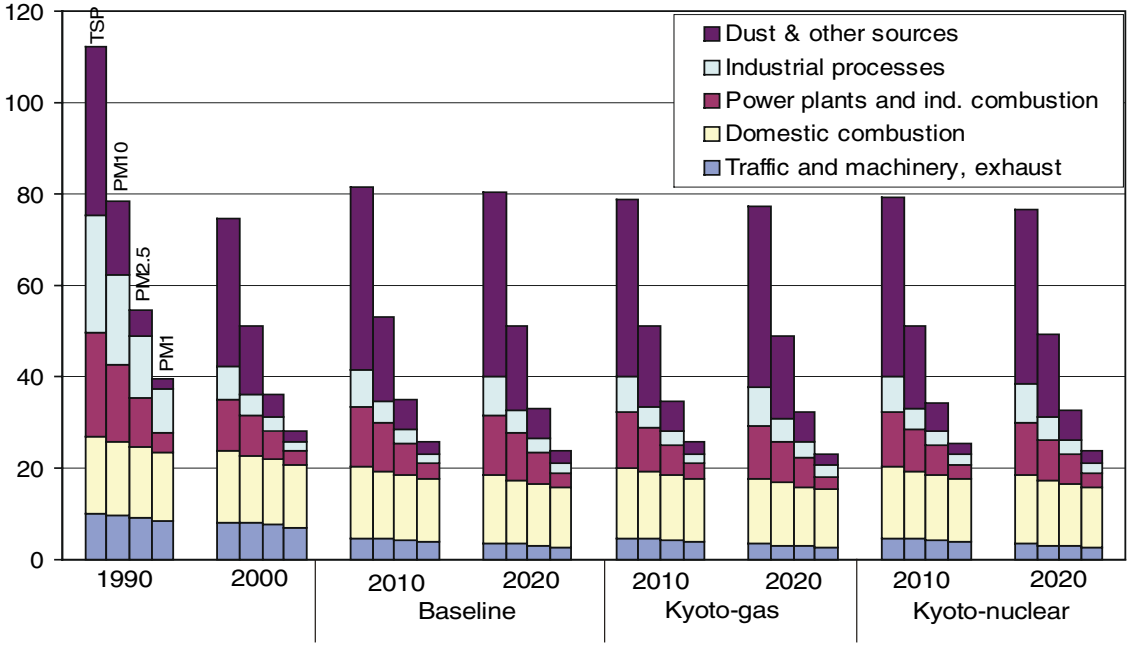
http://www.fmi.fi/research_air/air_47.html

The processes evaluated in KOPRA

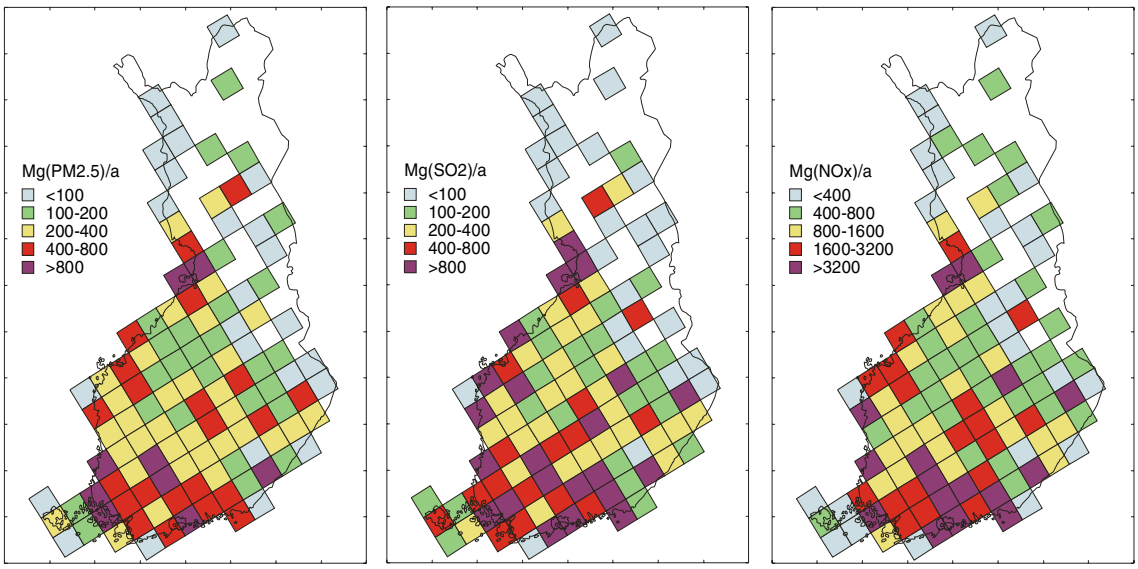


Source: Matti Johansson, SYKE

Emission scenarios: primary PM



Spatial distribution of emissions



PM2.5 SO_2 NO_x

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The dispersion and transformation of fine particles

Urban scale modelling

- urban dispersion modelling system extended to mass fractions of PM
- PM computations have been performed for the Helsinki Area in 2002.

Regional scale modelling

- MATCH testing continued
  - An interface to Finnish meteo input data completed and tested.
  - An interface to emission data is under development.
  - A MATCH version implementation at CSC is in progress.
- Input meteorological data generation for 2000
- Chemistry + aerosol dynamics module
  - A gas phase chemistry module from SMHI was extended to aqueous phase by internal MATCH routines. Preliminarily tested.
  - A chemistry pre-processor KPP code has been downloaded.

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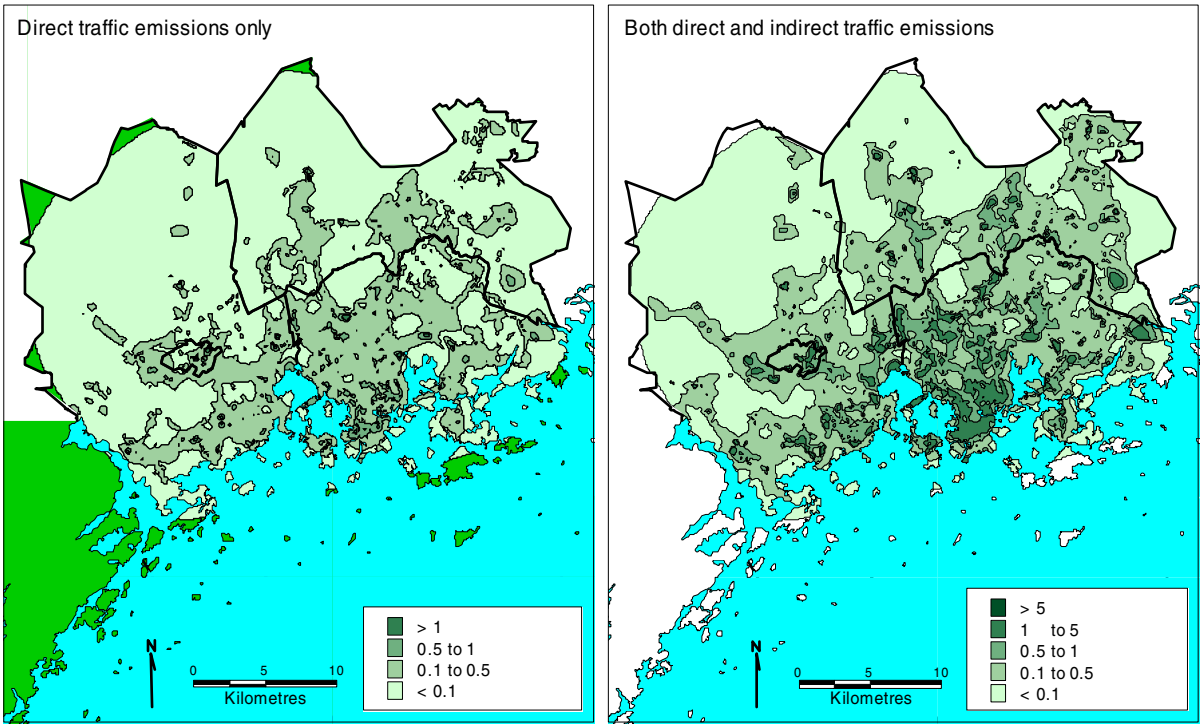
Average annual $PM_{2.5}$ concentrations [µg/m^3] in the Helsinki Metropoilitan Area 2002



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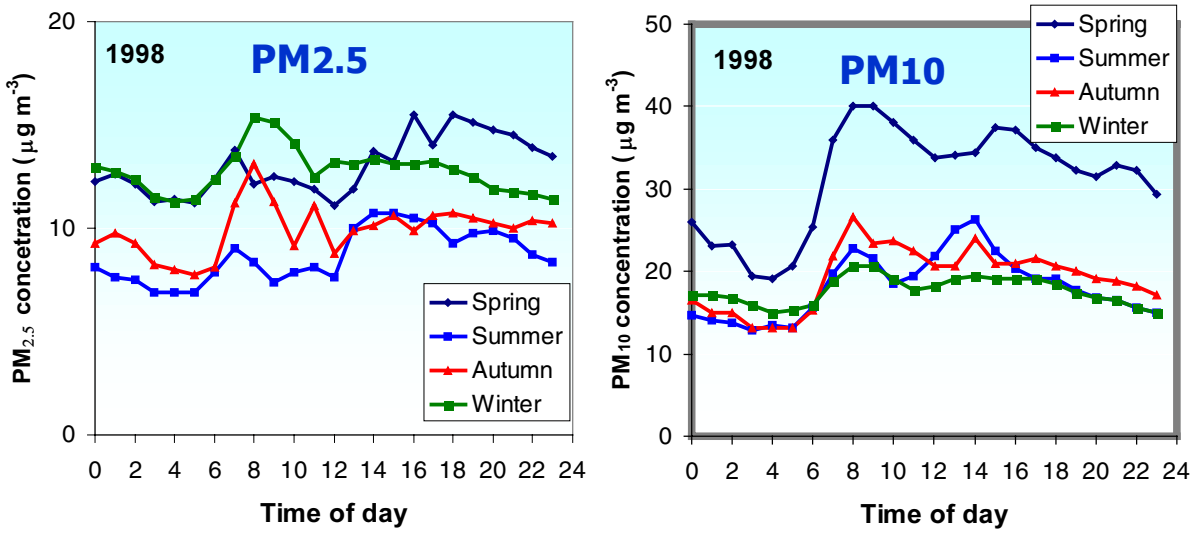
The diurnal variation of PM_{10} & $PM_{2.5}$ in Vallila in 1998, working days



Source: Helsinki Metropolitan Area Council (YTV)

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Regional dispersion model MATCH

Eulerian 3D regional-scale dispersion model

S-N-O3 chemistry available

Developed at SMHI (Swedish Meteorological and Hydrological Institute)

Source: Mikhail Sofiev,
Leena Kangas

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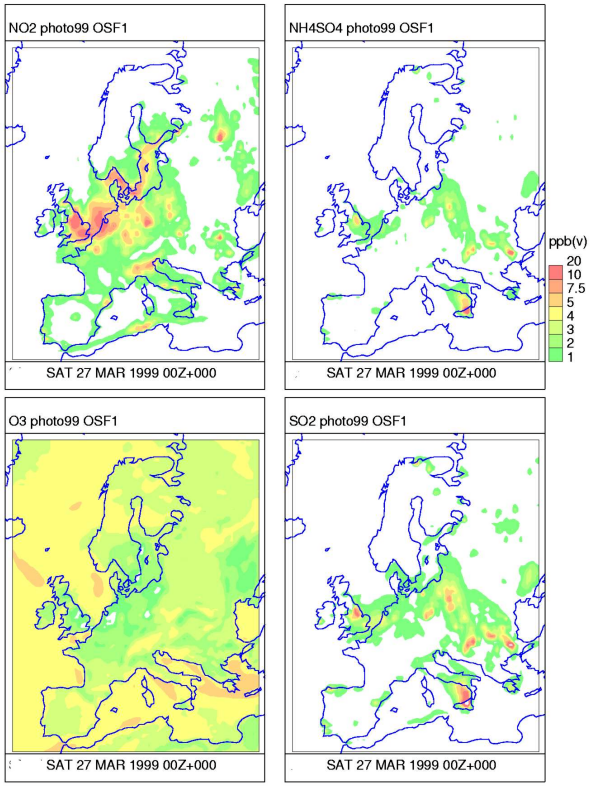
Numerical testing of the MATCH model at the FMI

Daily mean mixing ratios (ppbv) of

NO_2 NH_4SO_4
O_3 SO_2

during one selected day, 27 March 1999



Peer-reviewed publicatons

- Pohjola, M A, Pirjola, L, Kukkonen, J, Kulmala, M. 2003. Modelling of the influence of aerosol processes for the dispersion of vehicular exhaust plumes in street environment. Atmospheric Environment 37 (3), pp. 339-351.
- Kukkonen, J., Partanen, L., Karppinen, A., Walden, J., Kartastenpää, R., Aarnio, P., Koskentalo, T. and Berkowicz, R., 2003. Evaluation of the OSPM model combined with an urban background model against the data measured in 1997 in Runeberg Street, Helsinki. Atmospheric Environment 37 (8), pp. 1101-1112.
- Hänninen, O., Kruize, H., Lebret, E., Jantunen, M., 2003. EXPOLIS Simulation Model: PM2.5 Application and Comparison with Measurements in Helsinki. Journal of Exposure Analysis and Environmental Epidemiology 13: 74-85.
- Kruize, H., Hänninen, O., Breugelmans, O., Lebret, E., Jantunen, M., 2003. Description and Demonstration of the EXPOLIS Simulation Model: Two Examples of Modeling Population Exposures to Particulate Matter. Journal of Exposure Analysis and Environmental Epidemiology 13: 87-99.
- Koistinen K., Edwards R., Mathys P., Ruuskanen J., Künzli N., Jantunen M. ,2003. Sources of fine particulate matter in personal exposures and residential indoor, outdoor and workplace microenvironments in the Helsinki phase of the EXPOLIS study. Scand J Work Environ Health. (in press).

Peer-reviewed publications

- Karppinen, A., Härkönen, J., Kukkonen, J., Aarnio, P. and Koskentalo, T., 2004. Statistical model for assessing the portion of fine particulate matter transported regionally and long-range to urban air. Scandinavian Journal of Work, Environment & Health, (in press).
- Sofiev M., Kaasik M., Hongisto M. (2003). Model simulations of the alkaline dust distribution from Estonian sources over the Baltic Sea Basin. Water, Air and Soil pollution, 146, NN 1-4, 211-223.
- Kukkonen, J., Partanen, L., Karppinen, A., Ruuskanen, J., Junninen, H., Kolehmainen, M., Niska, H., Dorling, S., Chatterton, T., Foxall, R. and Cawley, G. (2003). Extensive evaluation of neural network models for the prediction of NO2 and PM10 concentrations, compared with a deterministic modelling system and measurements in central Helsinki. Atmospheric Environment 37(32), pp. 4539-4550.
- Tiitta, P., Raunemaa, T., Tissari, J., Yli-Tuomi, T., Leskinen, A., Kukkonen, J., Härkönen, J. and Karppinen, A., 2002. Measurements and Modelling of PM2.5 Concentrations Near a Major Road in Kuopio, Finland. Atmospheric Environment 36, pp. 4057-4068