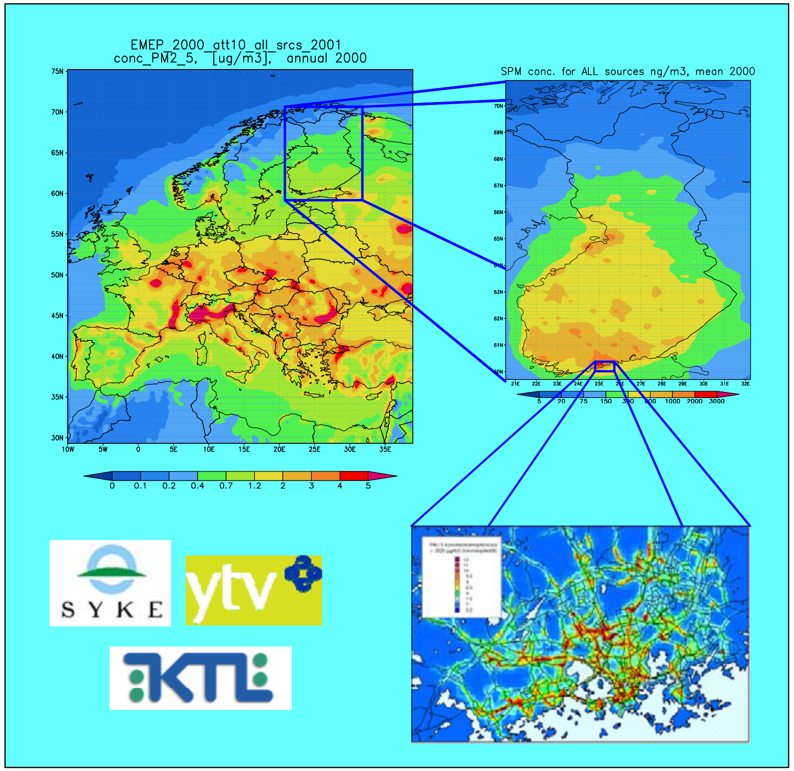
Dispersion modelling

- ✓ Development and evaluation of air quality models
- ✓ Combination of meteorological models and dispersion models
- ✓ Application of models and dissemination of information



Focus areas in modelling

1. Integrated modelling systems (from emissions to impacts, from street canyon to global scale)

2. Combined utilisation of meteorological models and dispersion models

3. Health effects of air pollution, especially modelling of the concentrations of and exposure to particulate matter

Modelling system - FMI

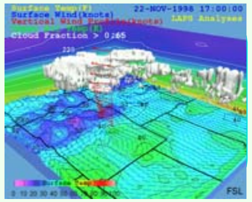
Weather prediction models

ECMWF

HIRLAM RCR

HIRLAM MBE

AROME, LAPS



Dispersion models - long-range, regional

SILAM LRT, meso, radioactivity

HILATAR LRT, meso

Aerosol process models:
UHMA (U Helsinki, FMI)
MONO32 (U Helsinki, Stadia)

Dispersion and effects models – urban, local

- CAR-FMI, roadside
- UDM-FMI, urban
- OSPM (NERI), street canyon
- BUOYANT, fires
- ESCAPE, chemical accidents
- FLUENT, CFD code
- EXPAND (FMI, YTV) population exposure
- MPP-FMI, Meteorological pre-processing model

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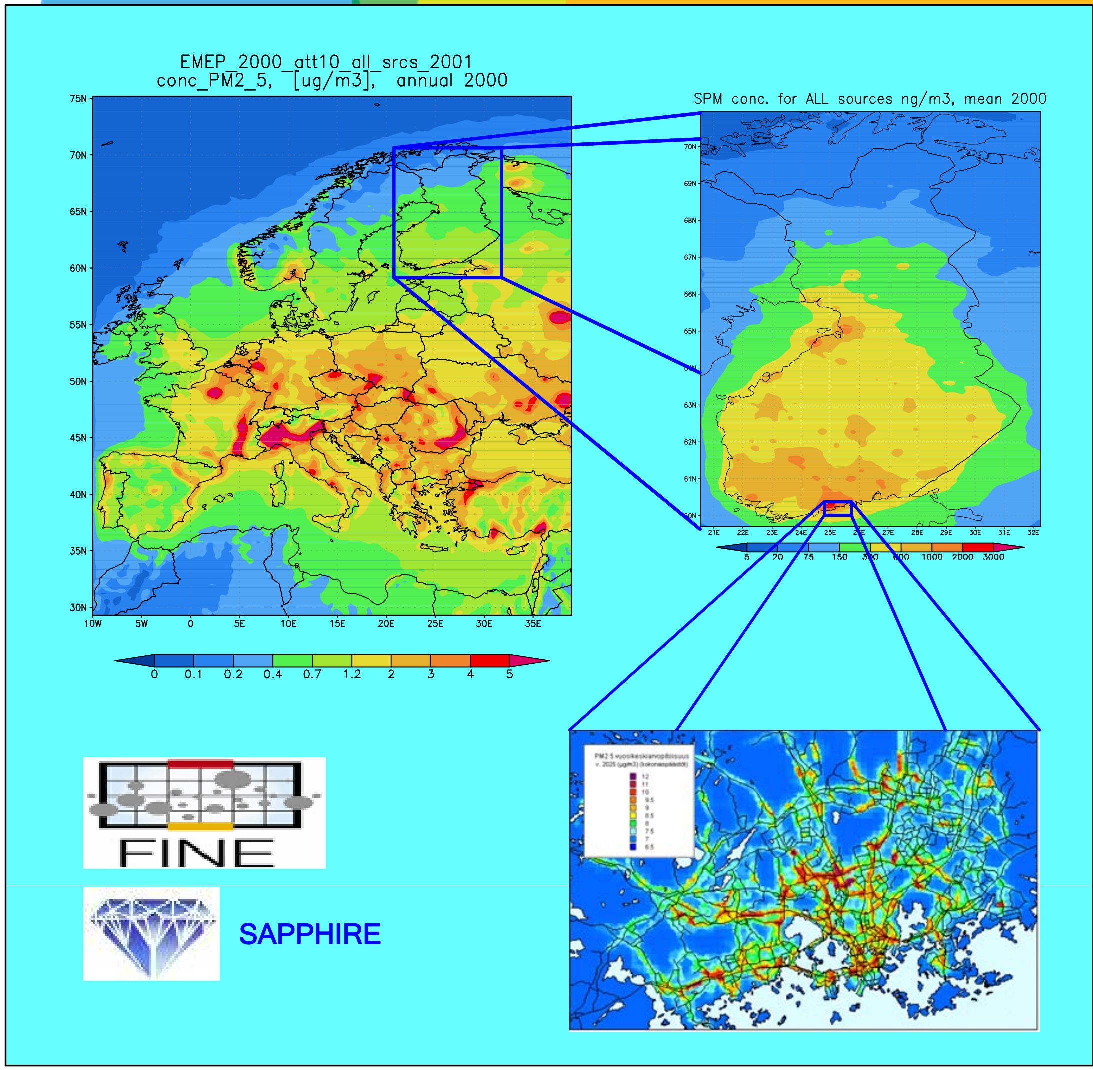
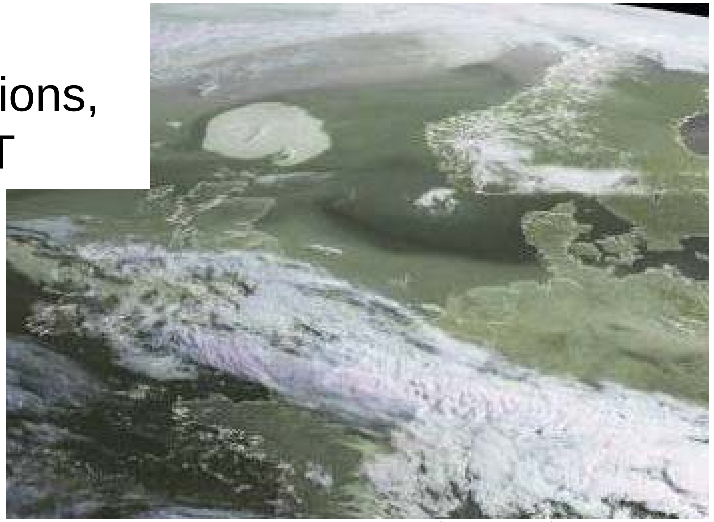
Multiscale modelling



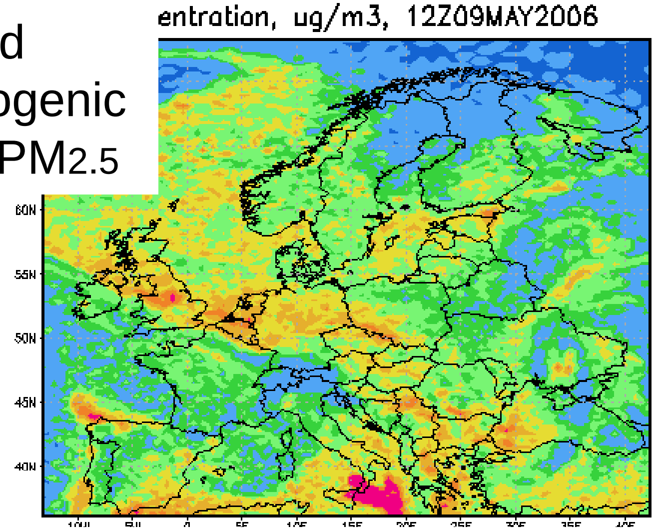
Predicted concentrations of primary $PM_{2.5}$ in Europe and in Finland in 2000, and $PM_{2.5}$ from all sources in the Helsinki metropolitan area in 2002 ($\mu g/m^3$). The results were computed using the emissions compiled by EMEP, SYKE and YTV, and the HIRLAM, SILAM, CAR-FMI and UDM-FMI models. The spatial resolution is 30 km for Europe, 5 km for Finland, and from 50 to 200 m in the Helsinki metropolitan area.

Multi-component modelling, SILAM, 9 May 2006

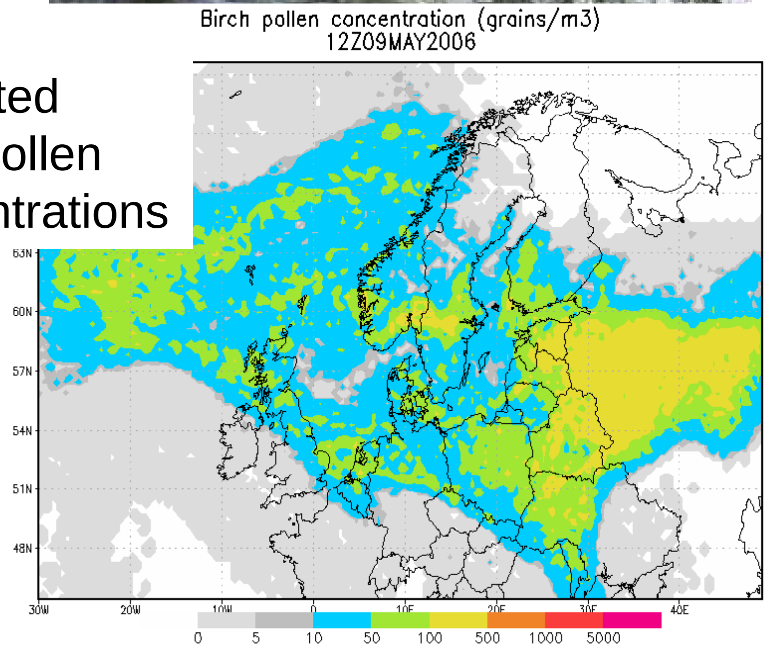
Satellite observations, ENVISAT



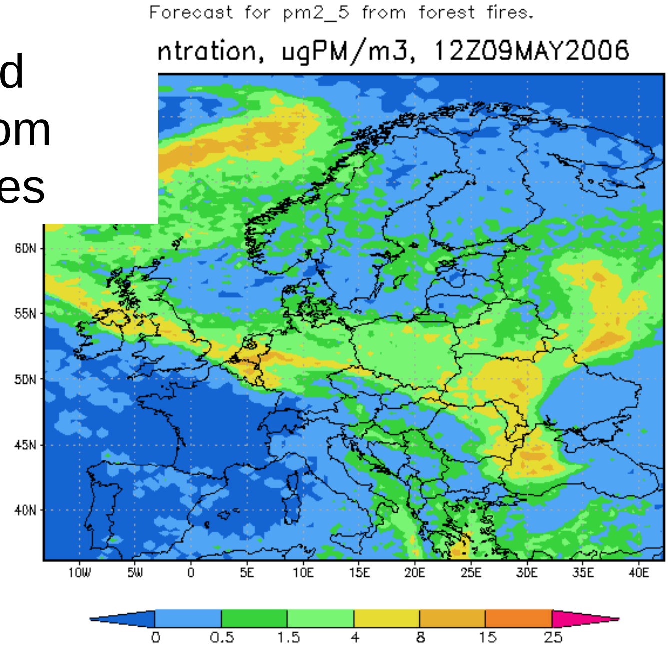
Predicted anthropogenic primary PM2.5



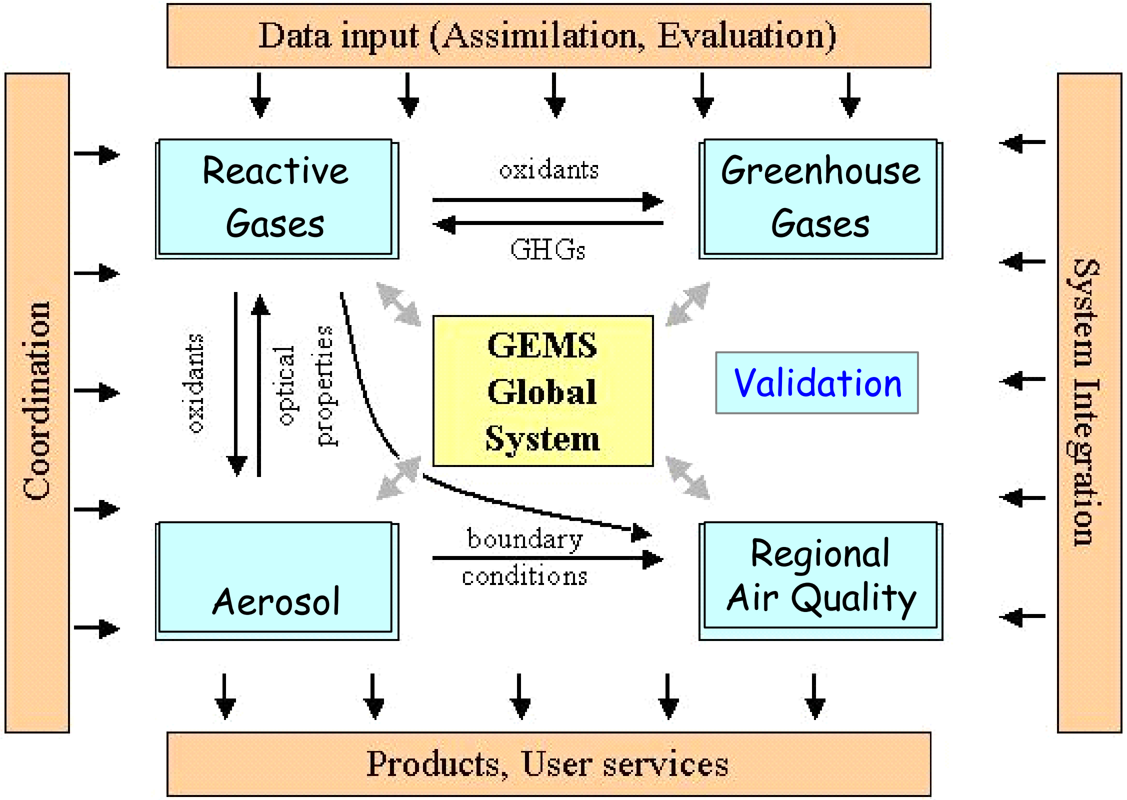
Predicted birch pollen concentrations



Predicted PM2.5 from forest fires

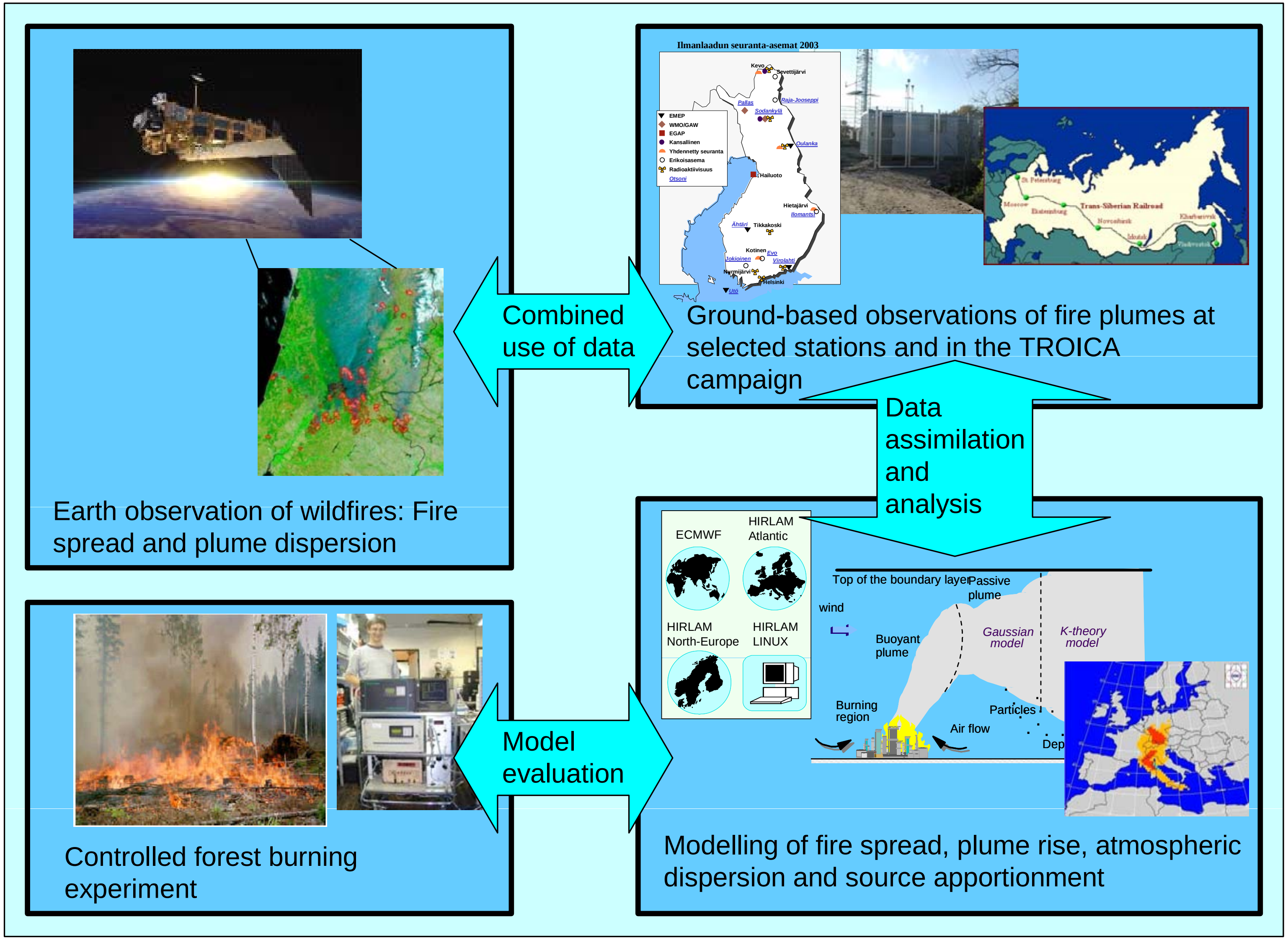


GEMS: ***G**lobal **E**arth-system **M**onitoring using **S**pace and in-situ data*



A centre of expertise at the Kumpula campus: wild-land fires

FMI Air Quality, Earth Observation, Climate and Global Change, Kuopio Unit, and Univ. Helsinki



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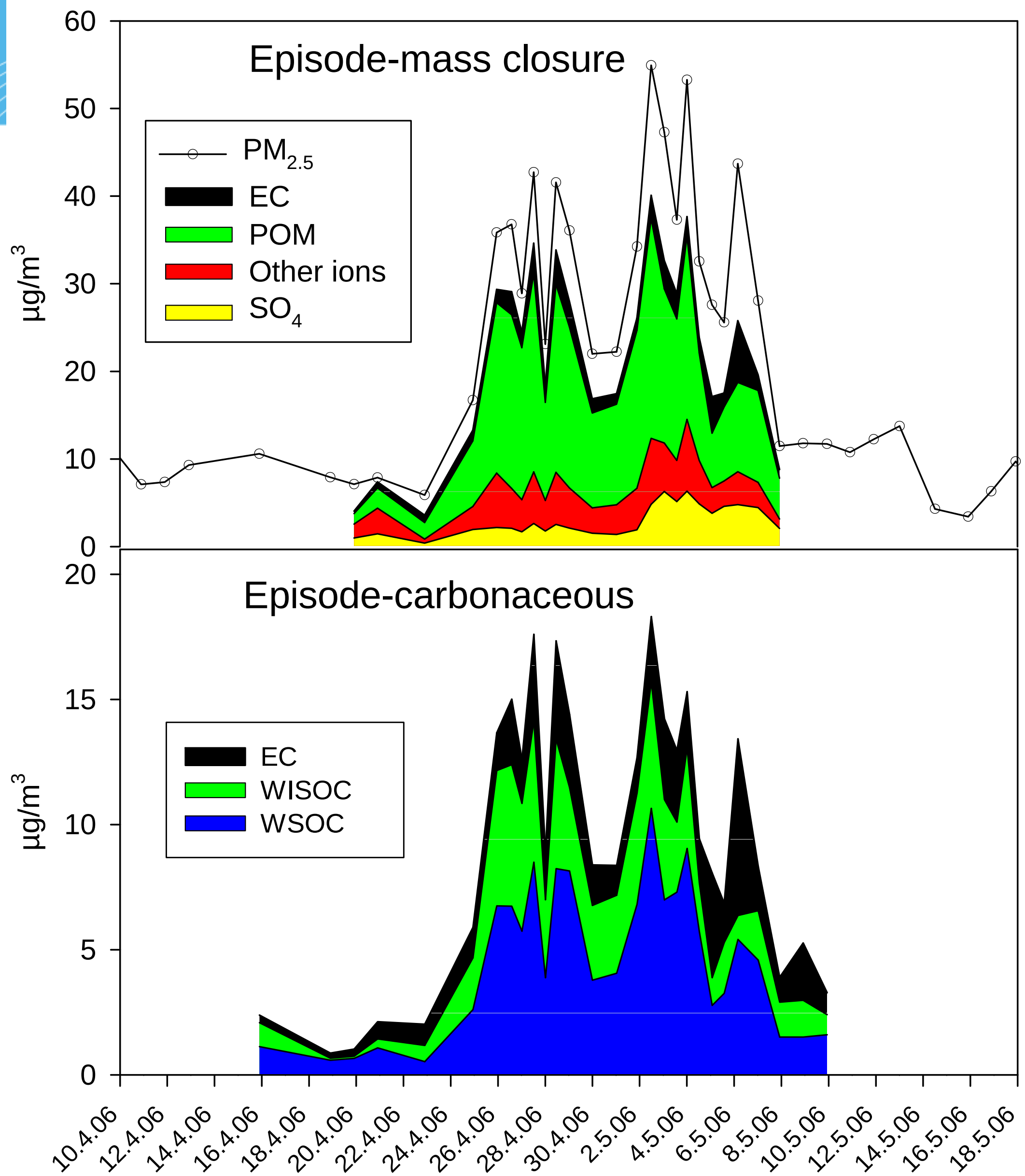
Forest fires in Russia in spring 2006

The measured concentrations of PM2.5 in Helsinki, Kumpula (urban background)

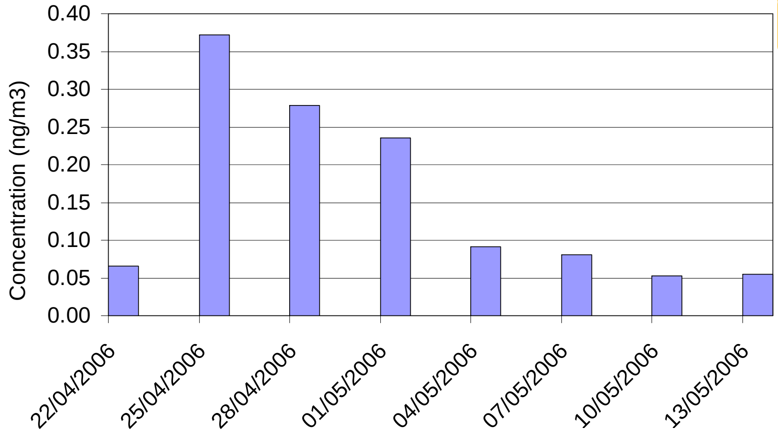
16 April – 10 May 2006

EC = Elemental carbon
OC = Organic carbon
POM = Particulate organic matter
SO4 = sulphate
WIS = water insoluble
WS = water soluble



Ref. Saarikoski et al., 2006. Major wildland fire episode in Northern Europe: chemical composition and atmospheric chemistry of aerosols. Atmos. Environ. 41 (2007), 3577–3589.

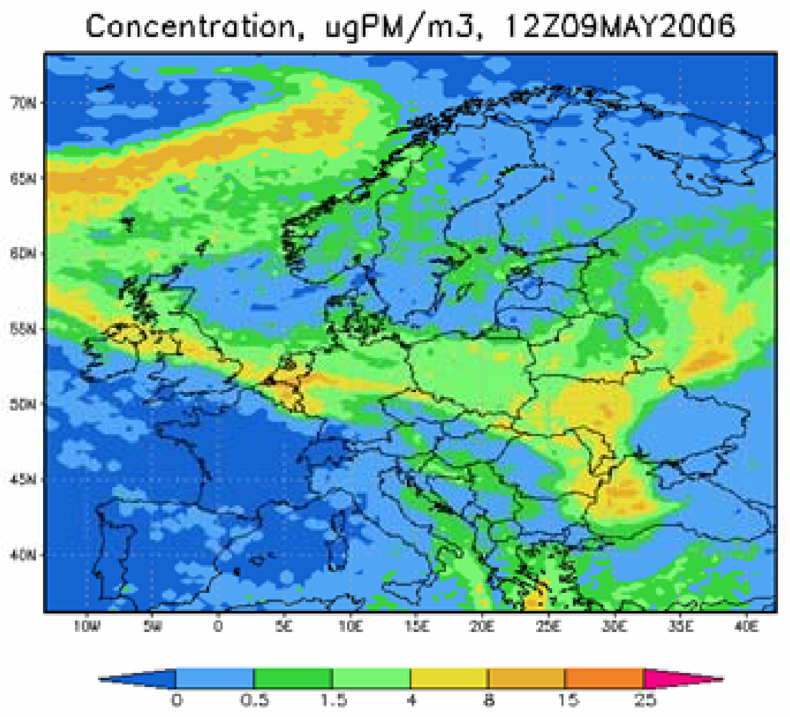
Concentration levels of organic compounds and mercury were also significantly increased in Finland caused by the Russian forest fires.



Benzo(a)pyrene concentrations in PM_{10} particles at Virolahti in April-May 2006 (Hellen et al., 2007)

The computed $PM_{2.5}$ concentrations from forest fires in Russia at 12:00 on 9 May 2006 (unit: µg/m³).

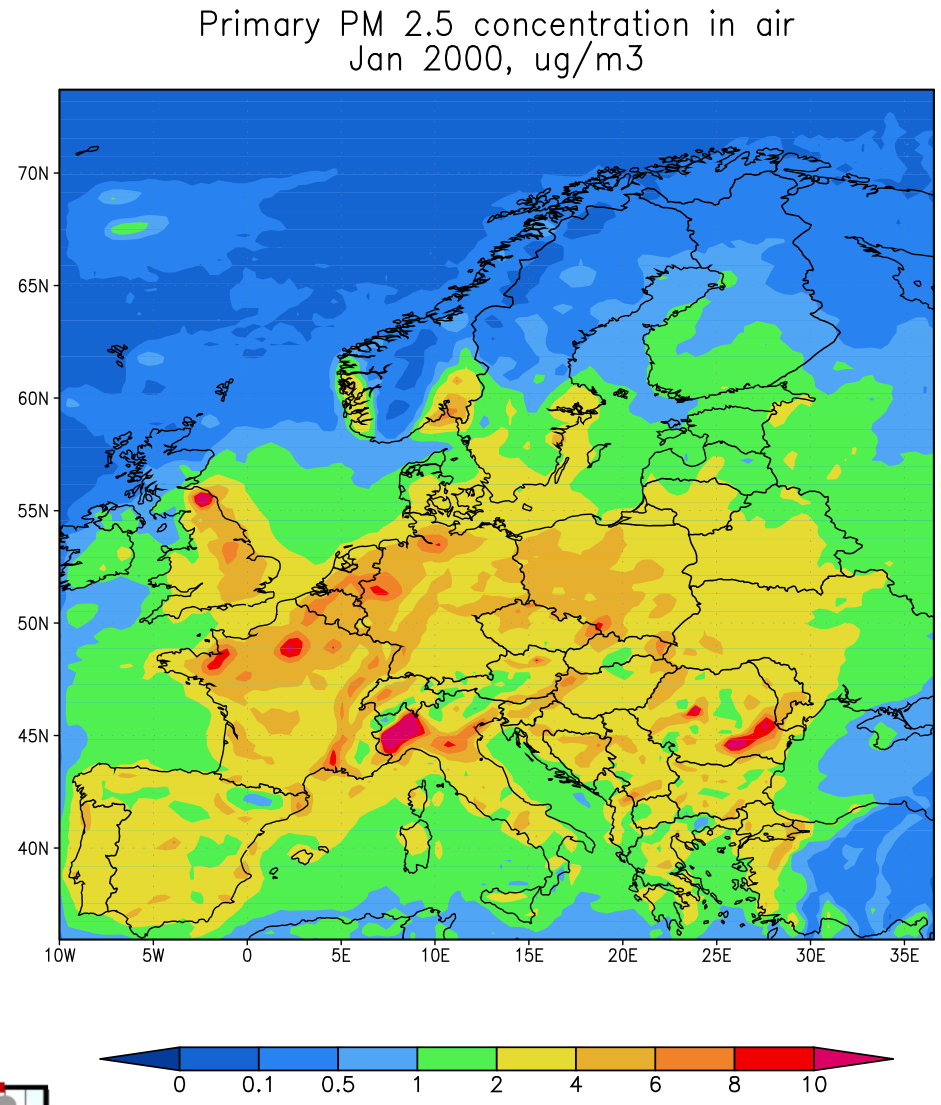
Computations: MODIS fire areas, SILAM dispersion computations.



It was estimated that the episode caused a $PM_{2.5}$-related premature mortality of approximately 30 in Finland (National Public Health Institute).

Concentrations of primary fine particles ($PM_{2.5}$) in Europe

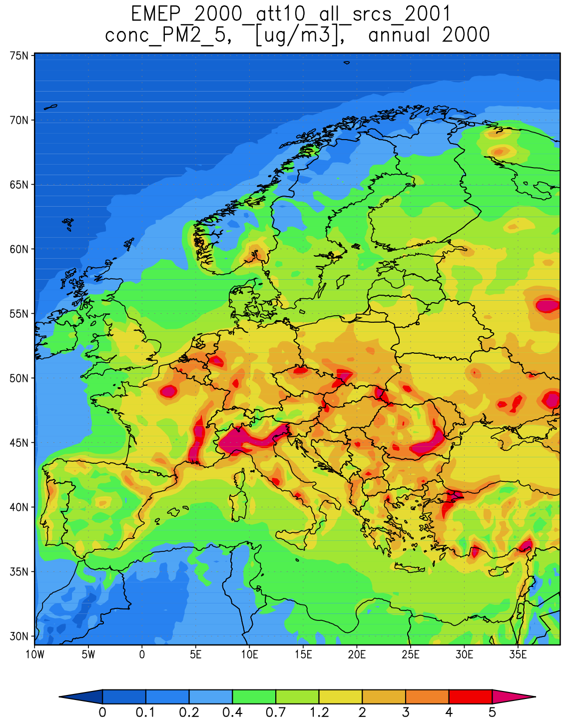
- Model: HIRLAM 6 + SILAM
- Emissions: EMEP 2000
- Resolution 10 - 30 km
- Figure: January 2000, unit μg/m³
- Limitations:
  - Temporal variation of emissions: only diurnal variation included
  - The emissions of Russia are partly missing



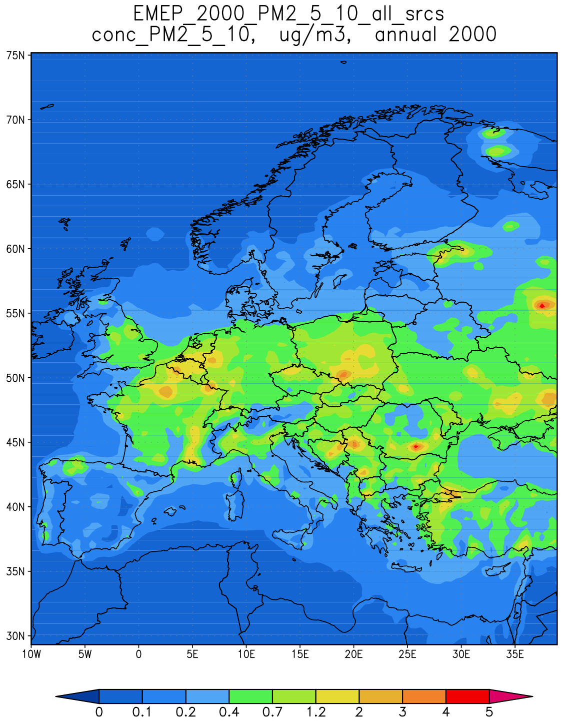
Lähde: M.Sofiev

FINE

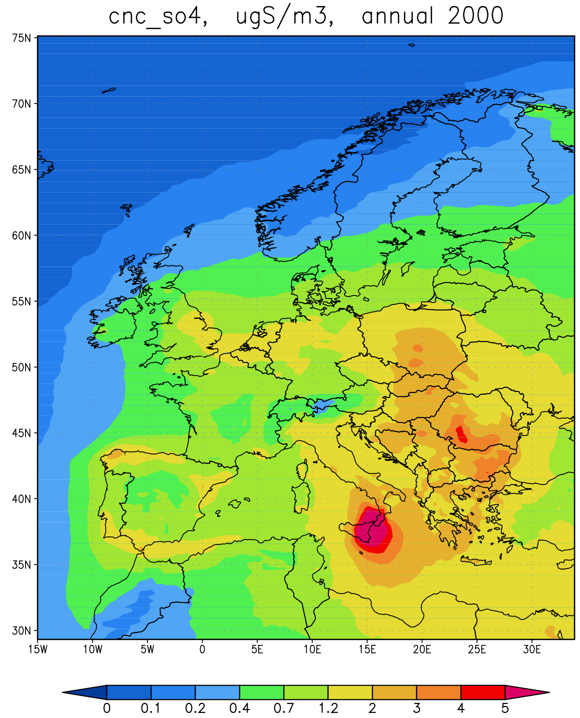
Predicted European PM concentrations, 2000



Primary fine, PM2.5



Primary coarse, PM2.5-10



Sulphate

- Emissions: EMEP 2000
- Models: HIRLAM 6 + SILAM
- Resolutions: met data 30 km, emissions 50 km
- Scales up to 5 $\mu g/m^3$

The continental scale PM computations could be used as input in European epidemiological studies, but there are still some problems in the closure of the aerosol budget, such as …

(1) secondary organic and inorganic aerosols due to aerosol dynamics and
(2) wind-blown dust: approaches need to be refined for non-desert conditions

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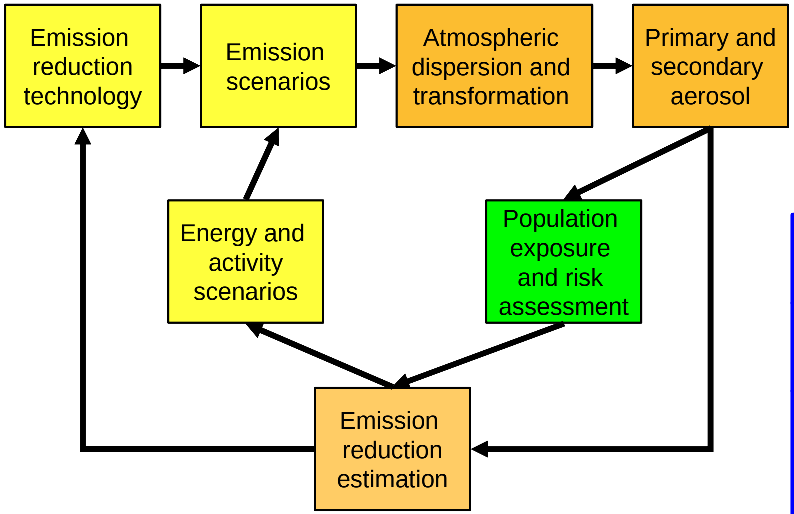
Modelling from emissions to health effects



Emissions	Exposed population		
Finnish emissions	Finland	Other Europe	Total
Small scale combustion	**52**	**39**	**91**
Traffic	**49**	**27**	**76**
Other sources	**49**	**35**	**85**
Total	150	102	252
European emissions	195		
All emissions	345		

The predicted mortality caused by primary $PM_{2.5}$

Premature deaths due to primary fine particles in 2000

Emission	Exposed population		
Emission in Finland	**Finnish**	**Other Europe**	**Total**
Area sources (solid fuel)	12	7	19
Domestic combustion	52	39	91
Traffic	49	27	76
Agriculture+peat	14	9	23
Large power plants	13	11	24
Large industrial plants	10	8	18
Total	**150**	**102**	**252**
Source in Europe, total	195	..	
All emission sources	**345**	**..**	

All fine particles were estimated to be equally toxic as fine particles on average

FUMAPEX - Forecasting urban meteorology, air quality and exposure

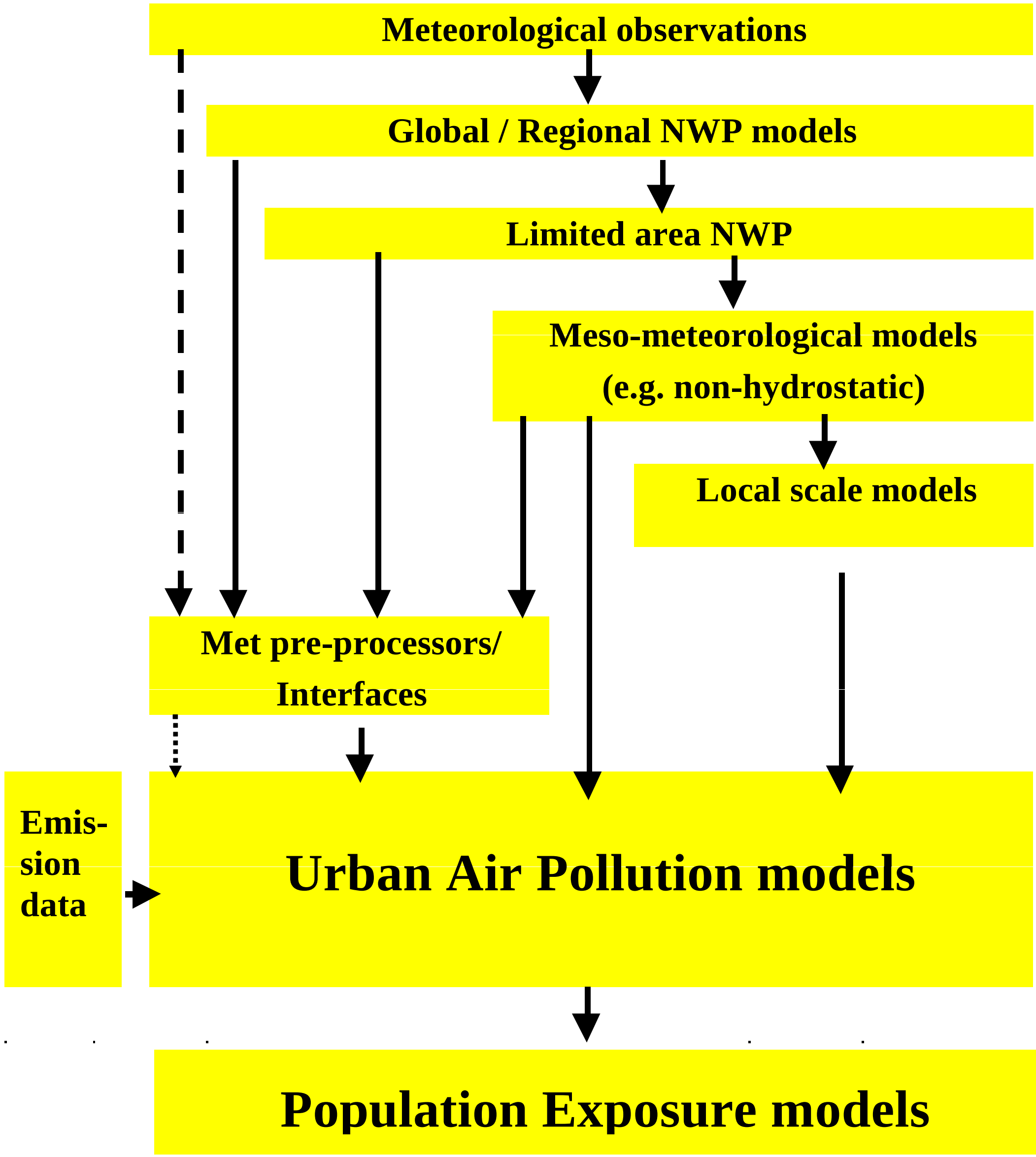
Resolution of models, e.g.:

≥15 km ECMWF/HIRLAM

~ 1-5 km LM, HIRLAM,

> 0.5 km MM5, RAMS, LM

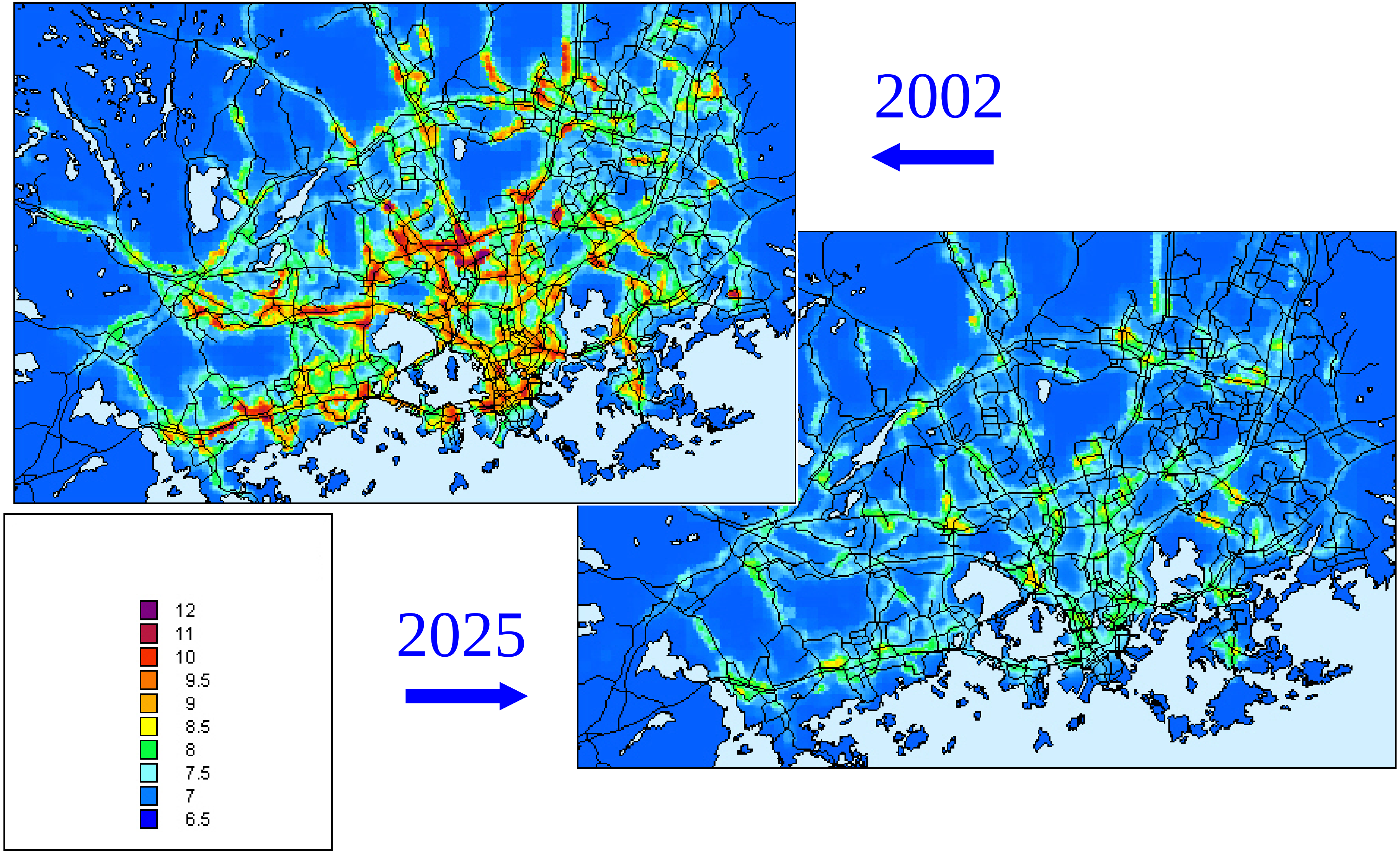
~ 1-10 m CFD, box models



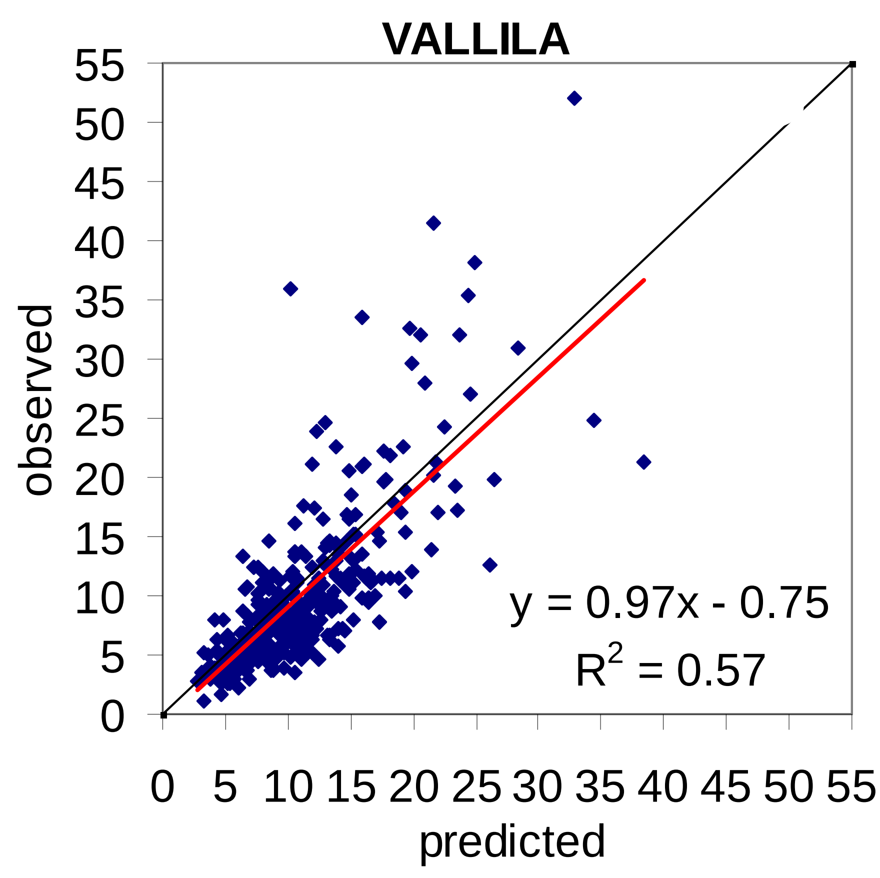
Health effects of urban particulate matter

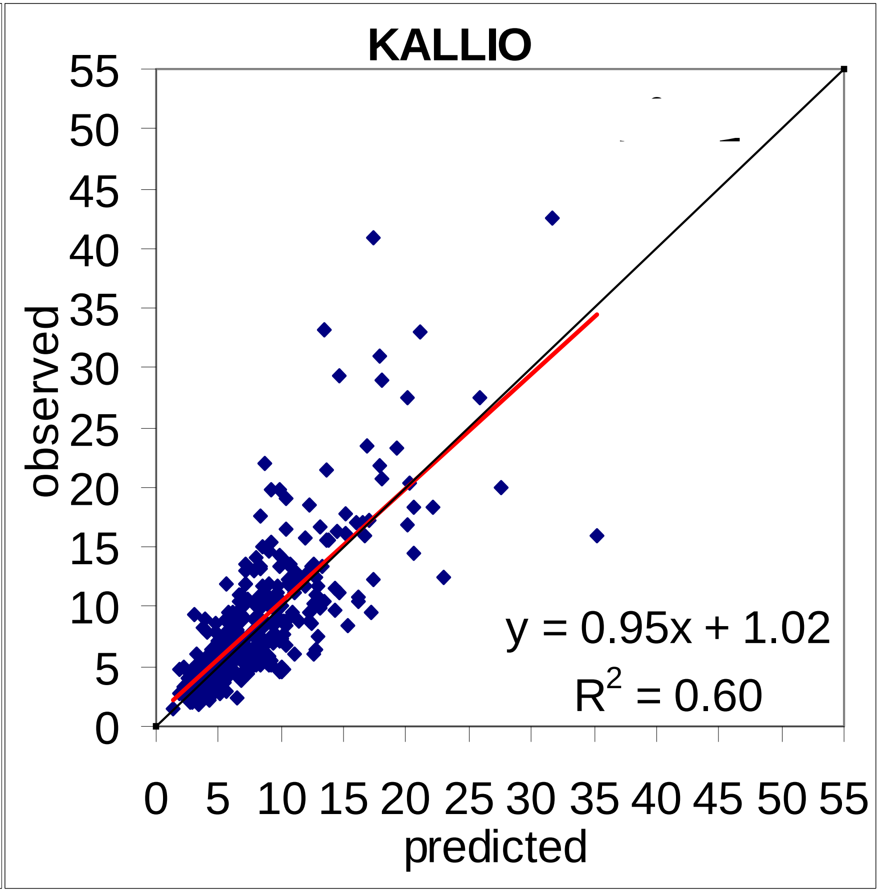
- World Health Organisation has estimated that due to particulate pollution, the reduction in life expectancy is about 1 year in Central Europe.
- It is not known which source categories and properties of fine particulate matter (chemical composition, size etc.) are responsible for the most harmful exposures.
- There is a strong indication that the adverse health effects of PM may not be due mainly to particle mass, but instead particle number concentration or the chemical content of particles.

Predicted annual average $PM_{2.5}$ concentrations ($\mu g/m^3$) in the Helsinki metropolitan area in 2002 and 2025



Predicted vs. observed daily mean $PM_{2.5}$ concentrations at two stations – scatter plot, Correlation Coefficient squared (R^2) and Index of Agreement (IA)





VALLILA: $R^2 = 0.57$, IA = 0.84

KALLIO: $R^2 = 0.60$, IA = 0.86

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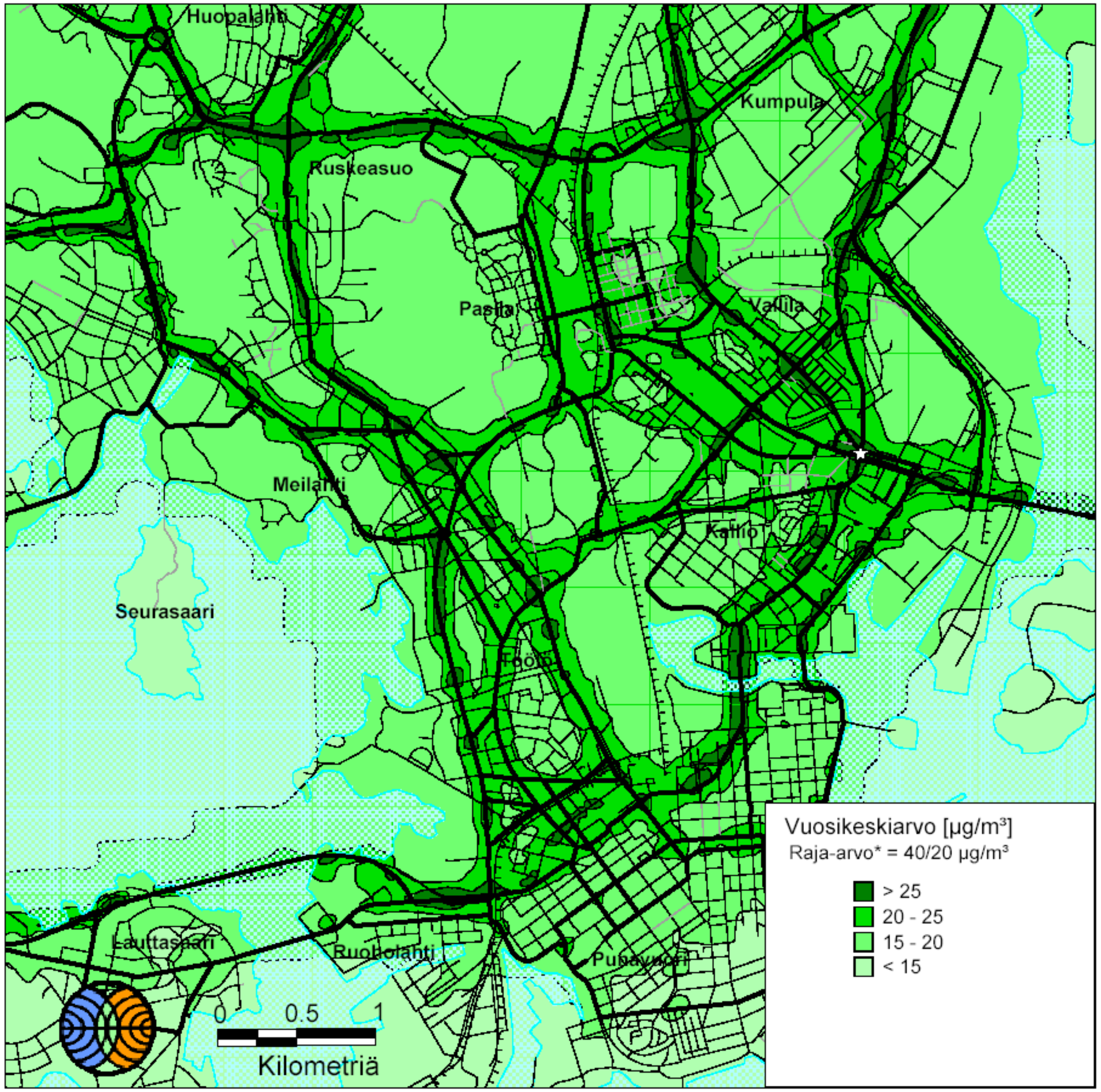
Central Helsinki Annual average of PM_{10} in 2000

The two darkest shades of green > 20 $\mu g/m^3$



A centre of expertise at the Kumpula campus: Aerosol process and atmospheric modelling

FMI Air Quality, Climate and Global Change, Earth Observation and Kuopio Unit, Univ. Helsinki, Helsinki Polytechnic

SILAM model
Long-range transport

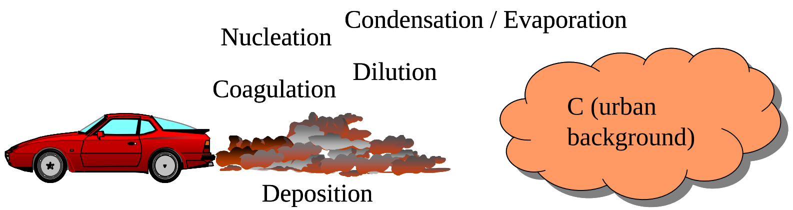
Aerosol process models:
UHMA (U Helsinki, FMI)
MONO32 (U Helsinki, Stadia)

CAR-FMI, roadside

MPP-FMI,
Meteorological pre-processing model

European Integrated Project on Aerosol - Climate - Air Quality Interactions
EUCAARI, 2007 - 2011

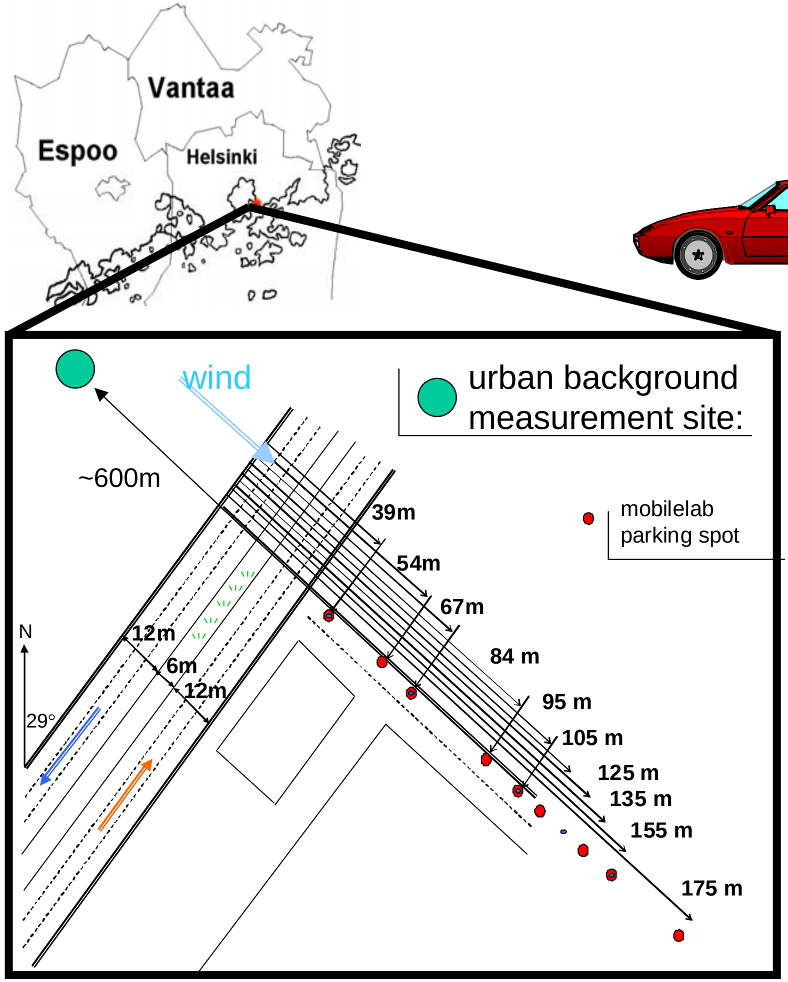
Coordination: University of Helsinki with Finnish Meteorological Institute

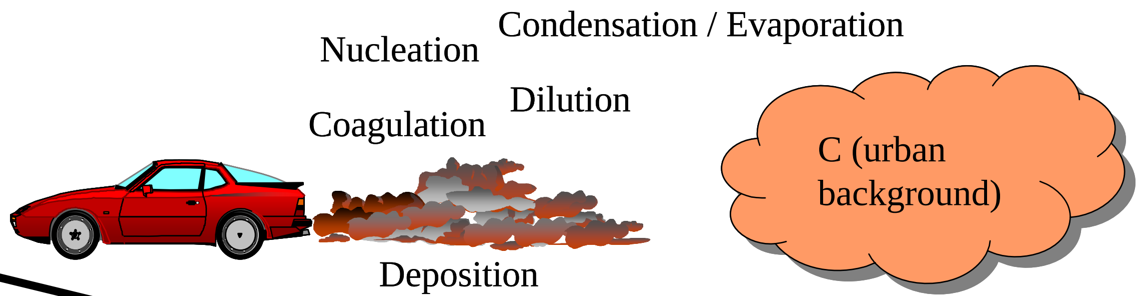


Modelling aerosol dynamics in the atmosphere

using the MONO32 model

FMI, University of Helsinki and Helsinki Polytechnic





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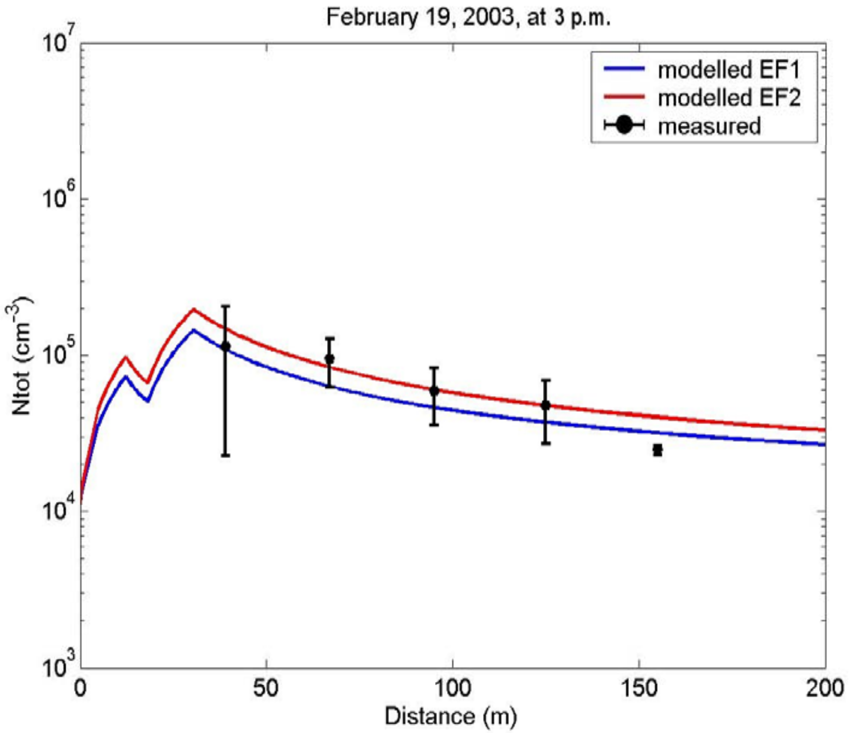
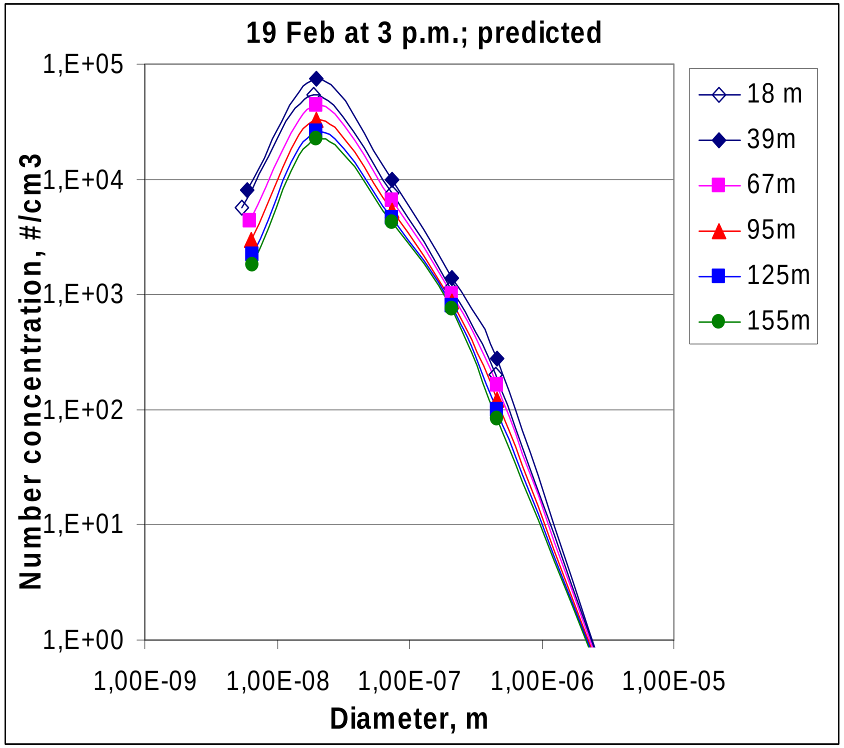
Total number concentrations against distance from a road



Lines: predictions using two sets of emission factors
Dots and error bars: measurements

Predicted evolution of particle size distribution



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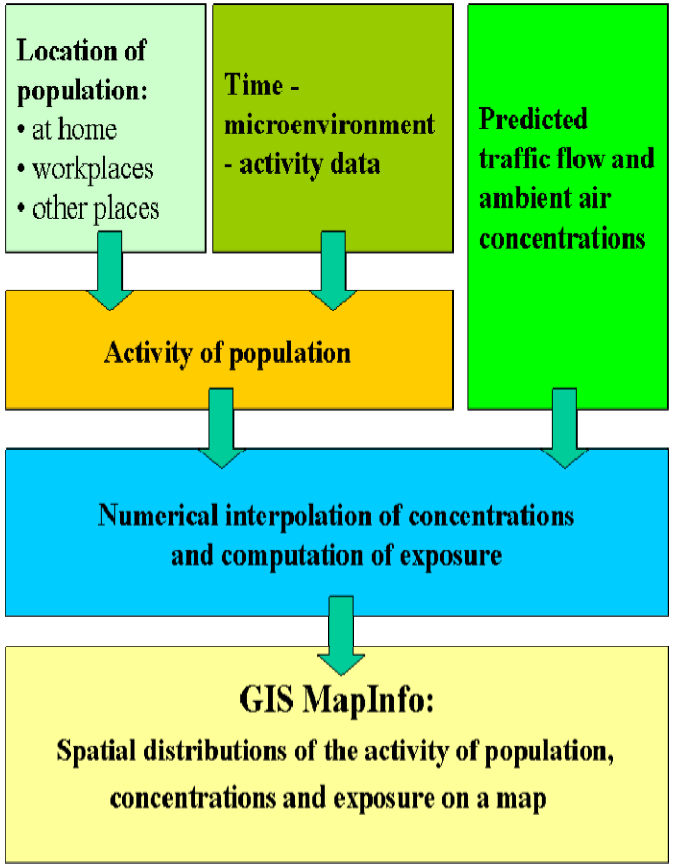
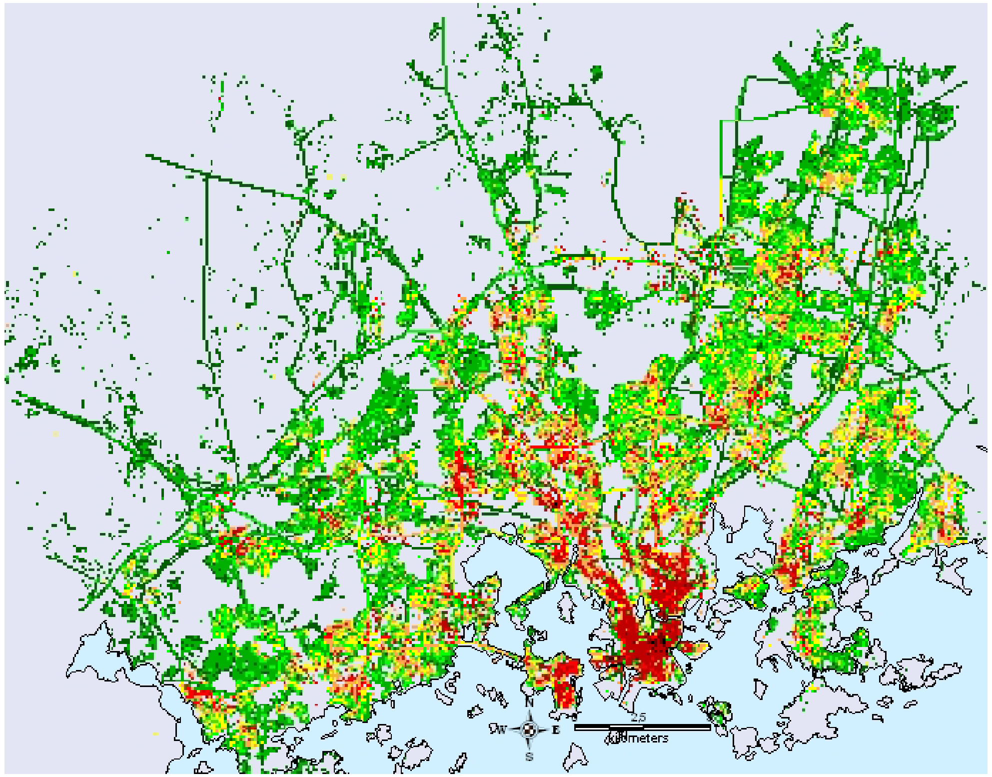
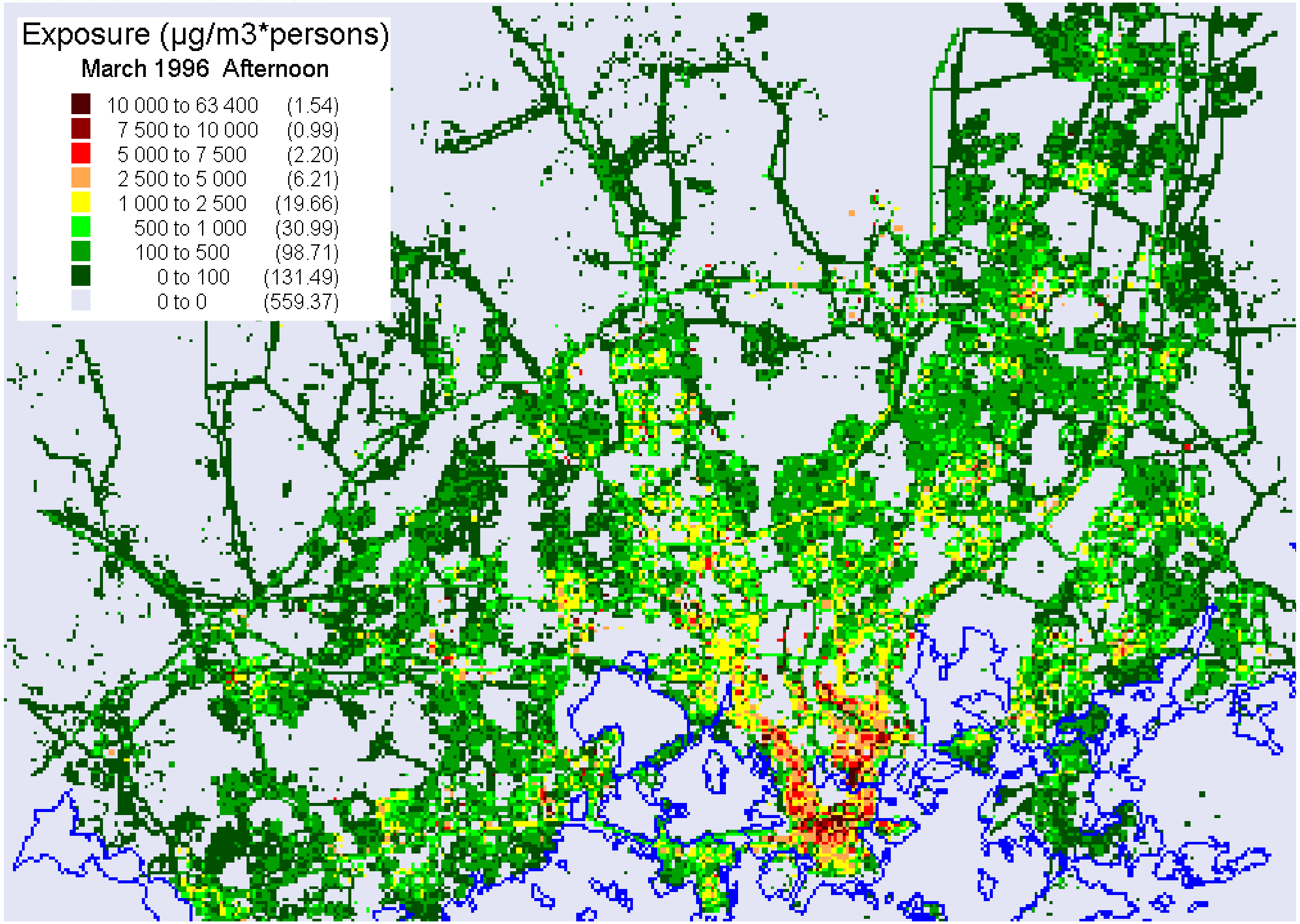
Pohjola et al., 2005, 2007, Pirjola et al., 2005

Population exposure modelling







The predicted exposure of population to NO_2 in the afternoon (3 - 6 p.m.), in March 1996, (µg/m3 *persons).

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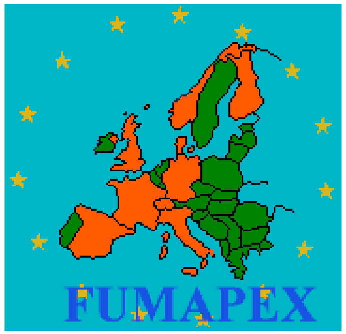
Complementary exposure models– deterministic (EXPAND) and probabilistic (EXPOLIS)



Meteorological Models

↓

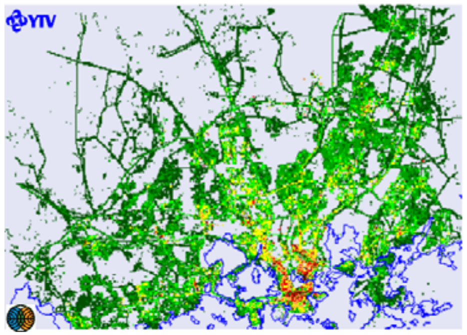
Emis-sions → **Urban Air Pollution Models**

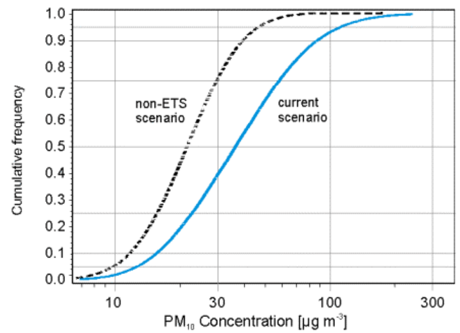
↓

Population Exposure Models

- **Population time activity**
- **Ambient Concentrations**

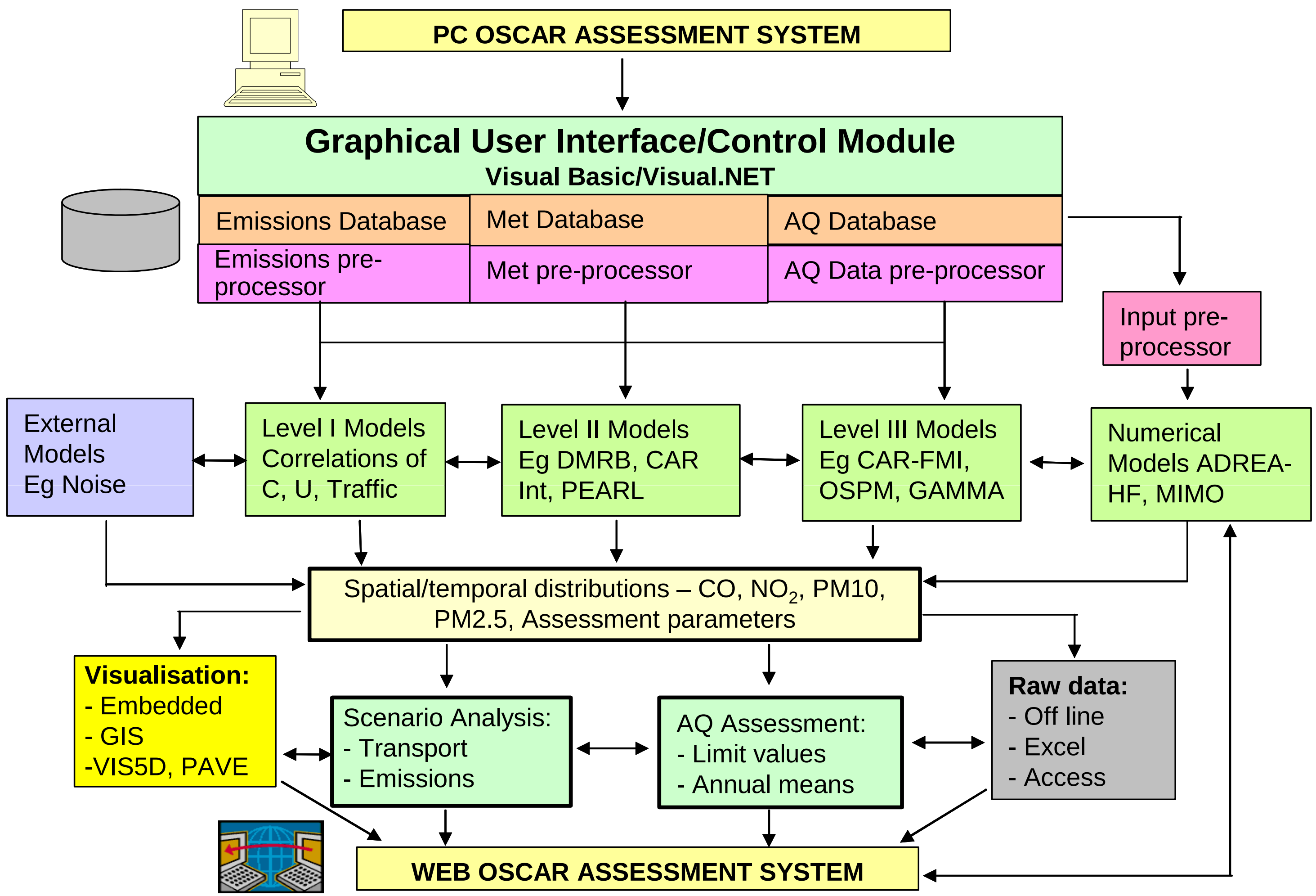
↓ **EXPAND** | ↓ **Simulation**



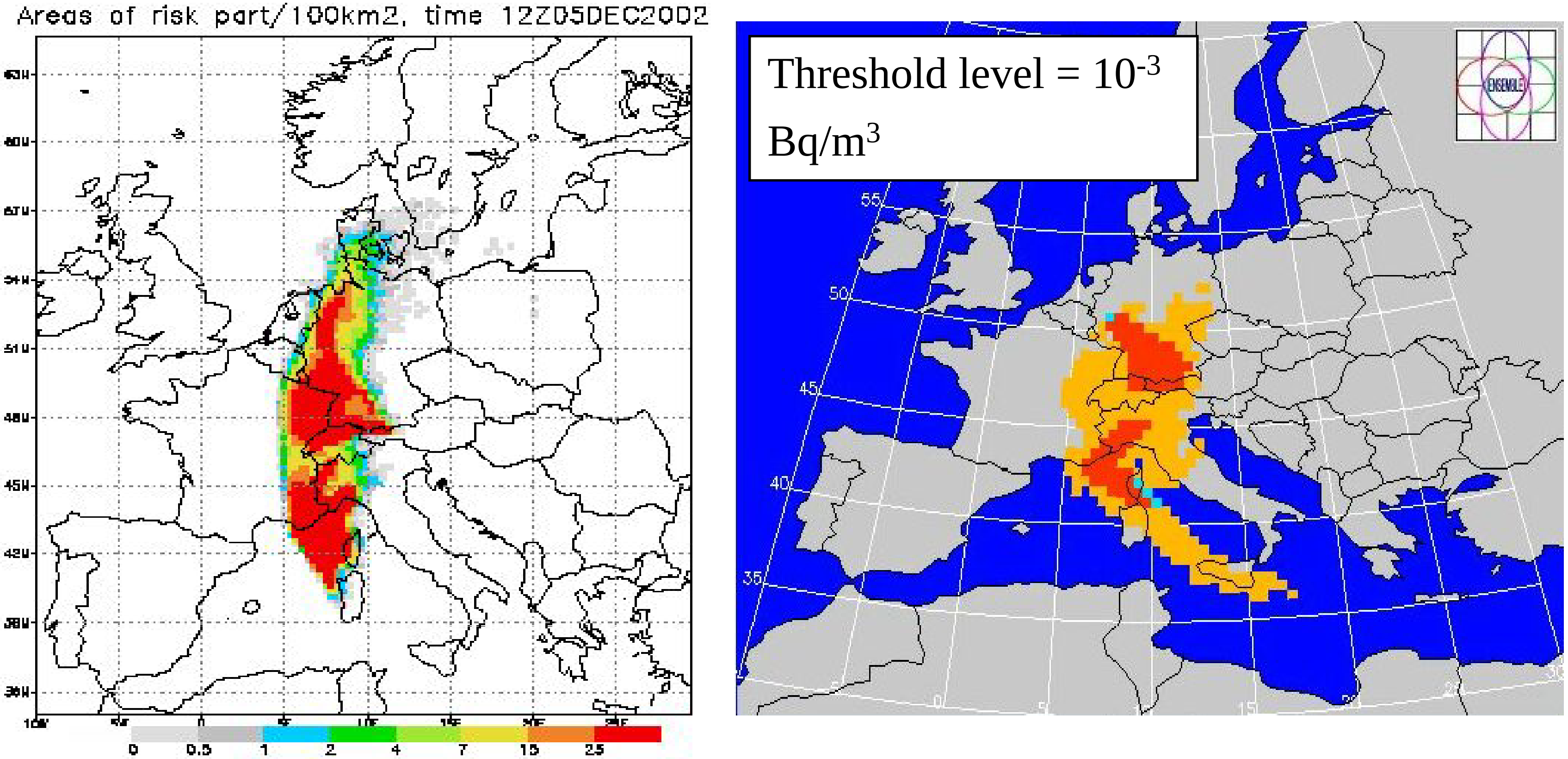


Hänninen et al., 2005, Kousa et al., 2005

Need for an Integrated approach



SILAM



Predictions for a conceived accident scenario using the SILAM model (left panel), compared with the corresponding results computed with the models of the Swedish, Norwegian, Danish and U.K meteorological offices (right panel).

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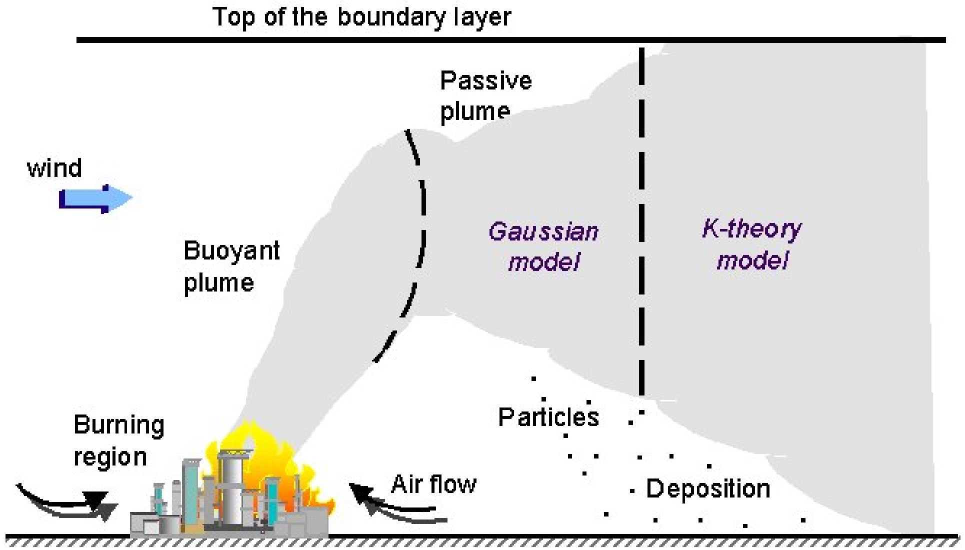
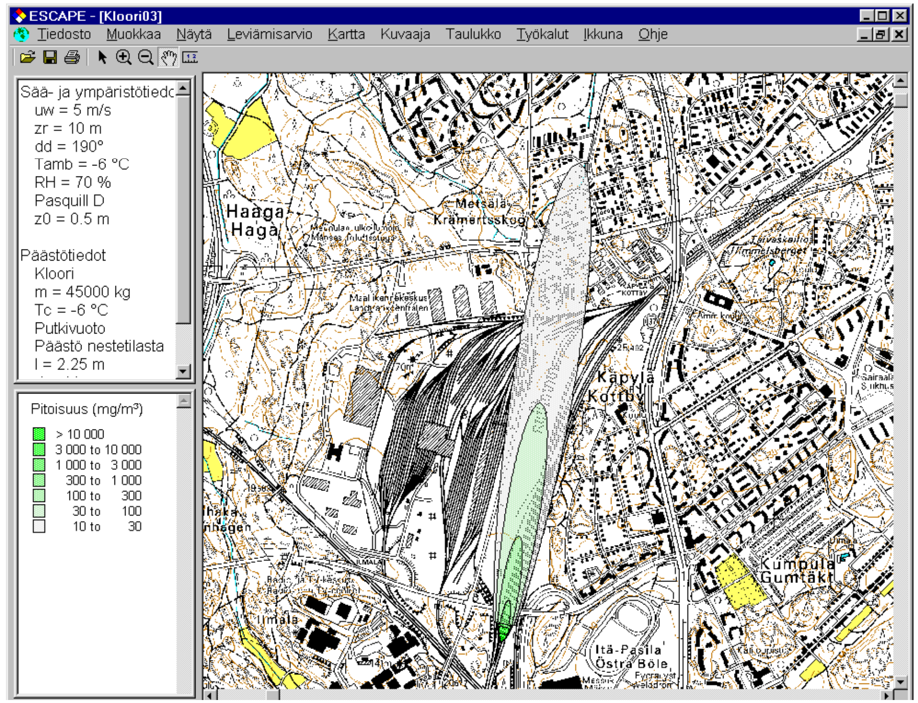
BUO-FMI –

Dispersion from Strongly Buoyant Sources – Finnish Meteorological Institute



ESCAPE –

Expert System for Consequence Analysis using a PErsonal computer



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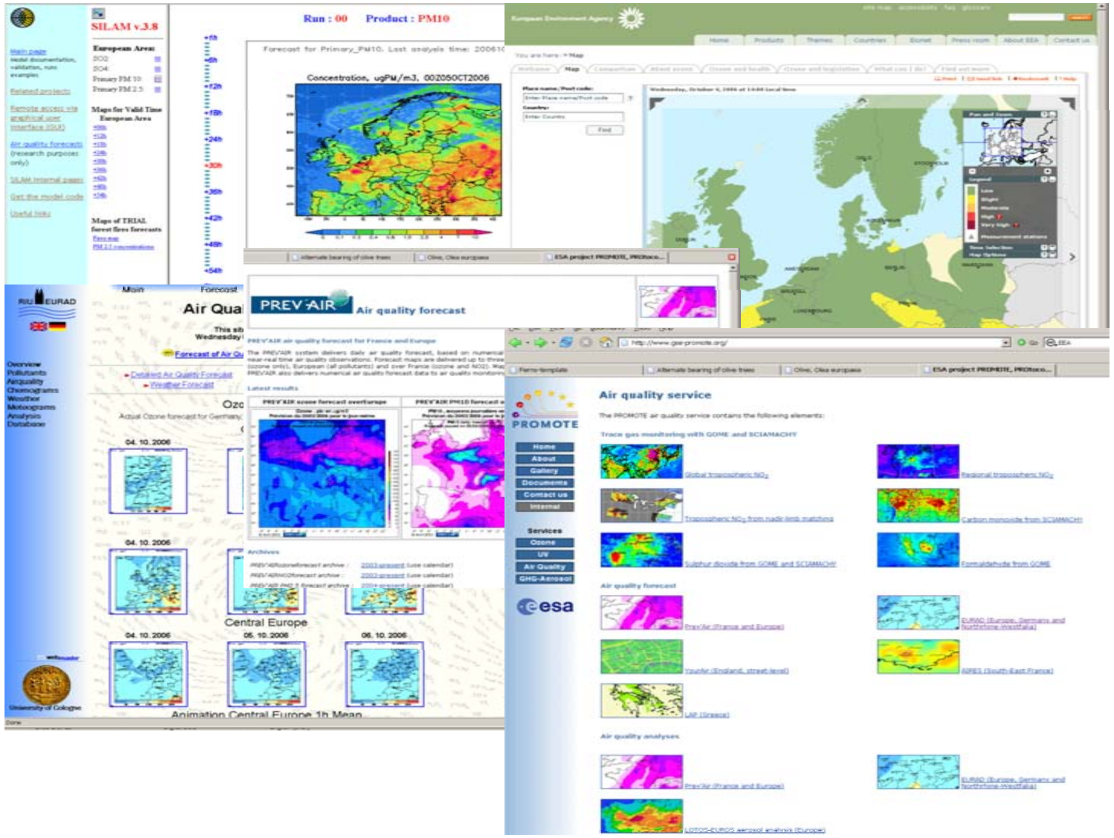
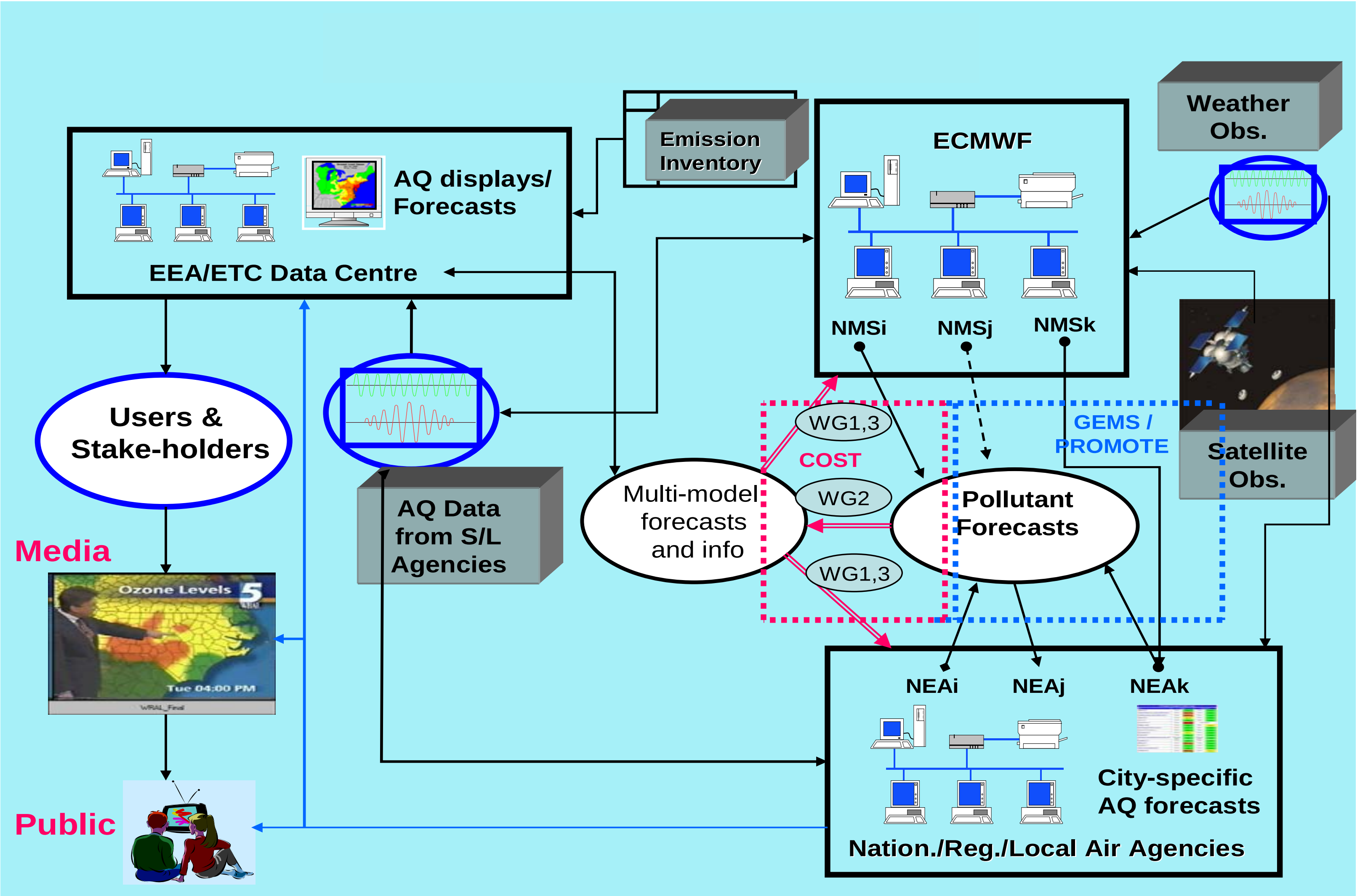
Towards a European Network on Chemical Weather Forecasting and Information Systems



http://www.chemicalweather.eu/

ENCWF: scope and interactions



Allergenic pollen

The prevalence of seasonal allergic rhinitis in Europe is about 15 % and it has steadily increased in many countries at least for a decade.

Diseases due to aeroallergens, such as rhinitis and asthma, are major causes of loss of productivity and demand for healthcare.

E.g., the exposure to high levels of birch pollen in infancy increases the risk of allergic asthma.

Catkins of birch

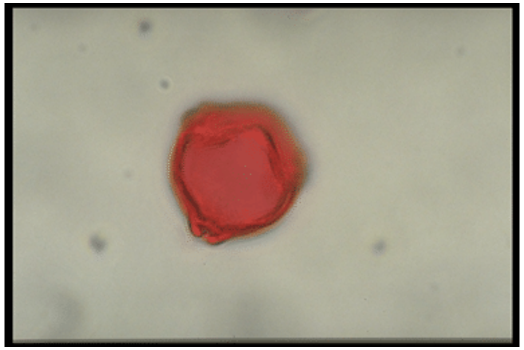
What could be done ?

The adverse health effects of allergens could be significantly reduced by pre-emptive medical measures, behavioural adaptation and long-term measures.

However, their planning requires reliable allergy-related forecasts several days ahead, and assessments of pollen distributions.

Pollen monitoring stations commonly observe high concentrations already before the local flowering season starts.

These could be forecasted using long-range transport atmospheric dispersion models.



Birch pollen grain (about 20 μm in diameter, density about 800 kg m^{-3})

The pollen species in European regions

Ragweed

The Action will focus on species that are important in various European regions, have substantial adverse health effects, and for which the required scientific information is available.

Examples are:

- ✓ olive trees (Mediterranean region),
- ✓ birch (Central and Northern Europe),
- ✓ ragweed (presently over Southern and partly Central Europe, invading to new areas)
- ✓ grass species (the whole of Europe)

The scope of the action will include local-, regional- and continental-scale dispersion.

Branches and fruit of an olive tree