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# Analysis of air quality research and gaps - implications for health

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# Report on current state of the art research in urban air quality and health (D4.1)

The report contains answers to selected key questions on:

- ❖ Ambient Air Quality
- ❖ Health
- ❖ Indoor Air Quality

## Why have we selected these key questions ?

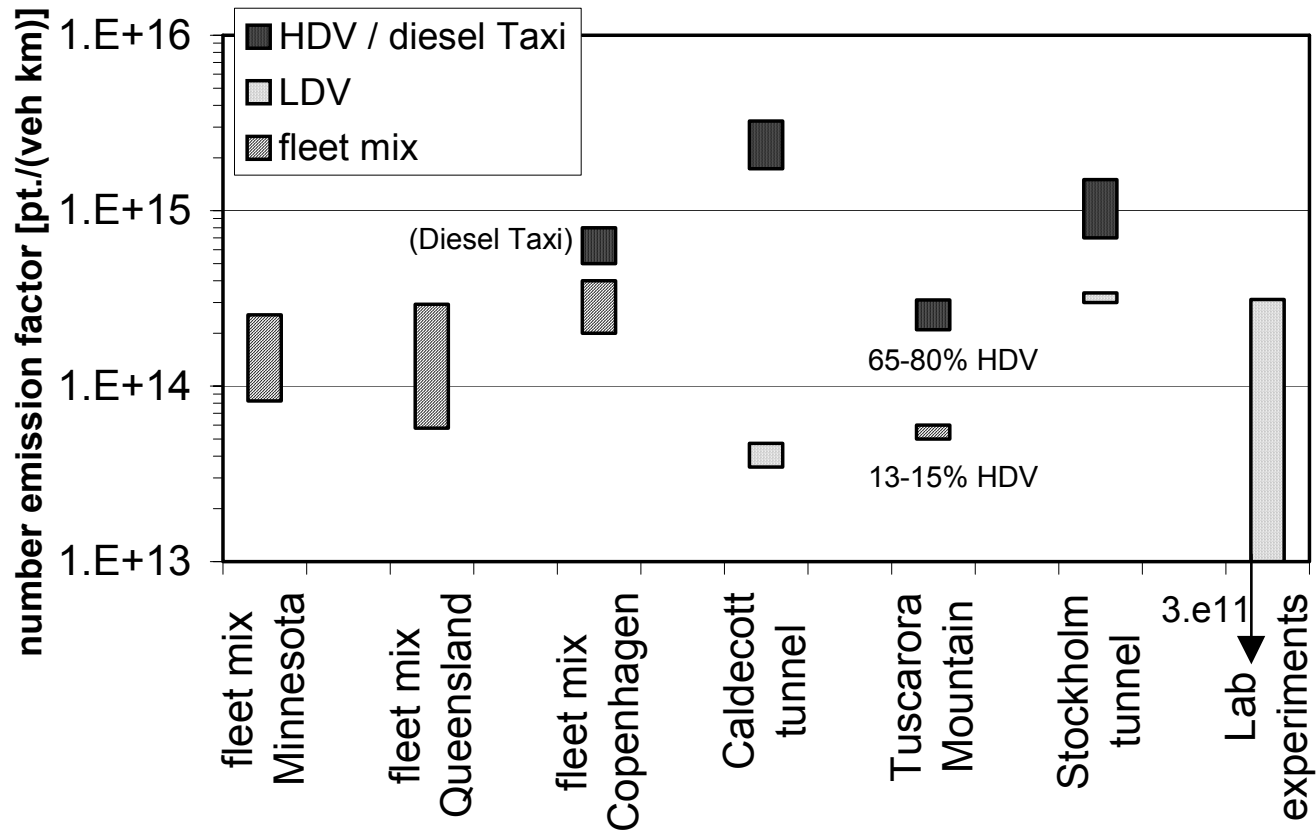
- a limited number of specific questions that can be expected to be answered reasonably well
- highlight new emerging issues and research needs
- an interest for the main stake-holders



## Which emission sources are the most significant for the health of EU citizens – Research needs

- Emissions of **particulate matter** (PM): commonly only the mass fractions (e.g., PM<sub>10</sub> and PM<sub>2.5</sub>) have been addressed, although we should consider also:
  - ❖ the **chemical composition** of PM emissions.
  - ❖ **size-resolved** emission data, including ultrafine and nano- PM
- **Non-anthropogenic emissions**, including those from wild-land fires, bioaerosols (e.g., allergenic pollen), and biogenic VOC's
- **Non-exhaust traffic emissions** of PM
- Emissions originated from **small-scale combustion**; these can be a substantial source of fine PM and hydrocarbons
- **Primary NO<sub>2</sub>** emissions (i.e., the NO<sub>2</sub>/NO<sub>x</sub> fraction in emissions)

# Review of PM number emission factors



Refs. Kittelson, 5. ETH Conf. Zurich 2001, Jarmiska et al. 2001, Ketzel et al., 2003, Jagtvej 2001, Abu-Allaban et al. 2002, Kristensson, Johansson et al. 2002, Graskow et al. 1998/99



# How are urban air pollutant levels changing in the long term – Research needs on future trends

## ❑ Particulate matter:

- Projections for the future are significantly uncertain, due to **uncertainties in the methodologies and the emission projections**.
- The contributions from **non-anthropogenic** sources are especially challenging to predict.

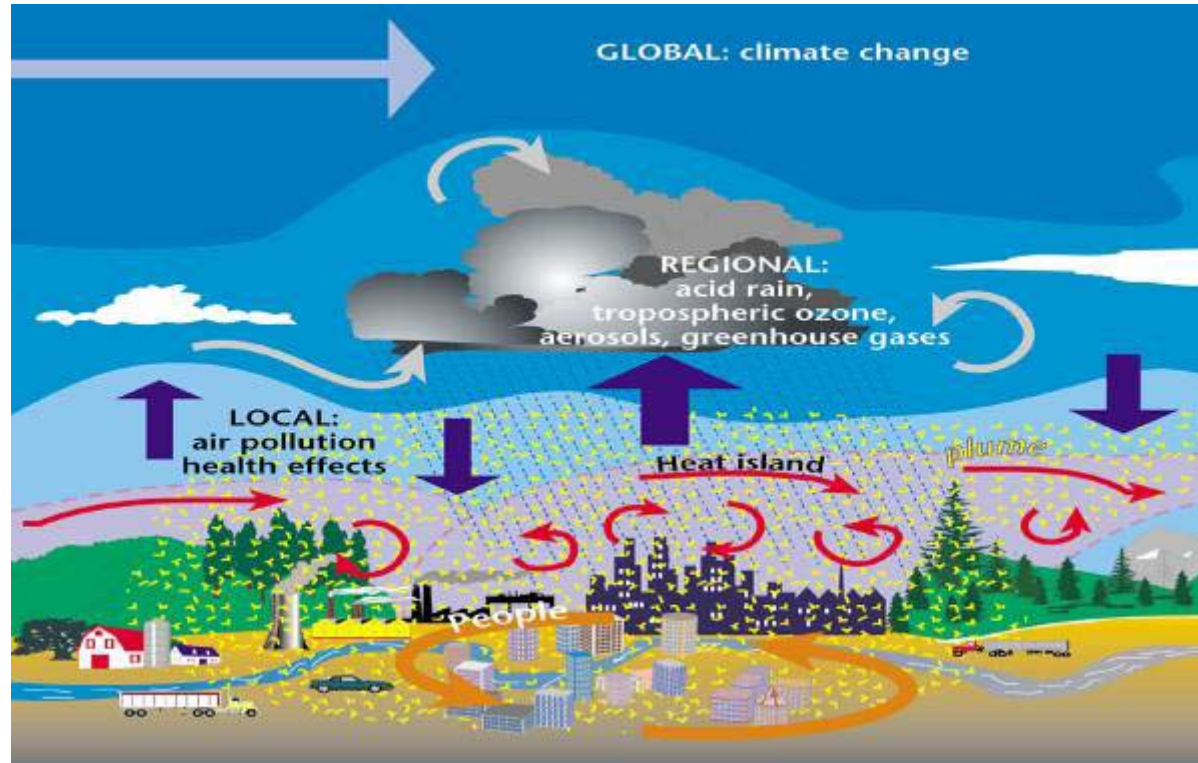
## ❑ Ozone: there are substantial **uncertainties regarding the trends** of ozone concentrations, especially due to climate change.

## ❑ All pollutants:

- Lack of **concentration projections on the national and city scale**
- Overall need for an evaluation of **integrated economic and emission + regional climate change and air quality scenarios** (+ possibly also combined with health and ecosystem effects)



# Interactions of climate change and air quality



Economic development and trends of emissions affect both climate change and air quality

Climatic conditions influence air chemistry and dispersion, i.e., air quality

Many air pollutants are also climatically active species (e.g., PM and O<sub>3</sub>)



## Are the current pollutant limit values attainable - the effectiveness of reduction measures – Research needs

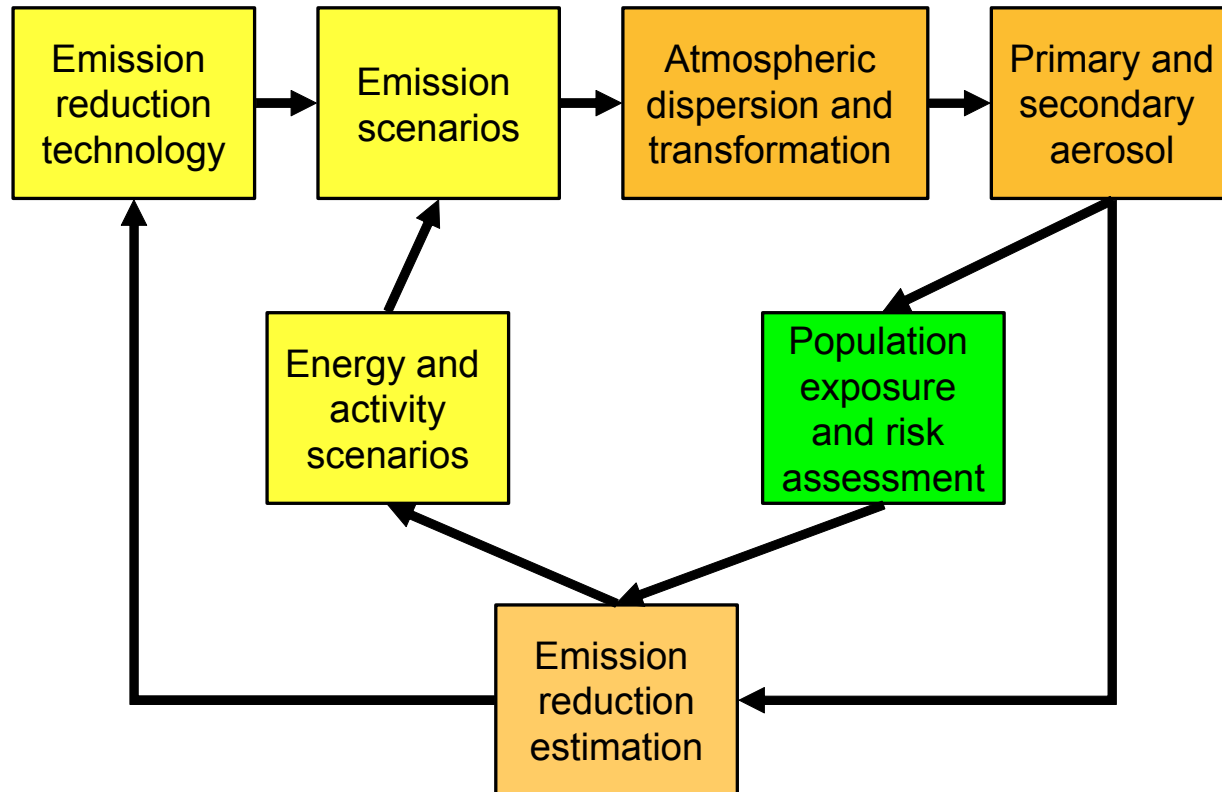
- ❖ **Robust European scenarios** on emissions and regional background levels of PM -> air quality management on a local level.
- ❖ **The abatement measures** on primary PM and precursor emissions
- ❖ The abatement options for **traffic emissions from abrasion of tyres, brakes and the road surface**
- ❖ The **cost-effectiveness** of measures, and integrated assessments including, e.g., **both climate change and health** effects
- ❖ **Challenges**: the uncertainties in emission estimates, problems in modelling PM levels and uncertainties on the efficiency of measures



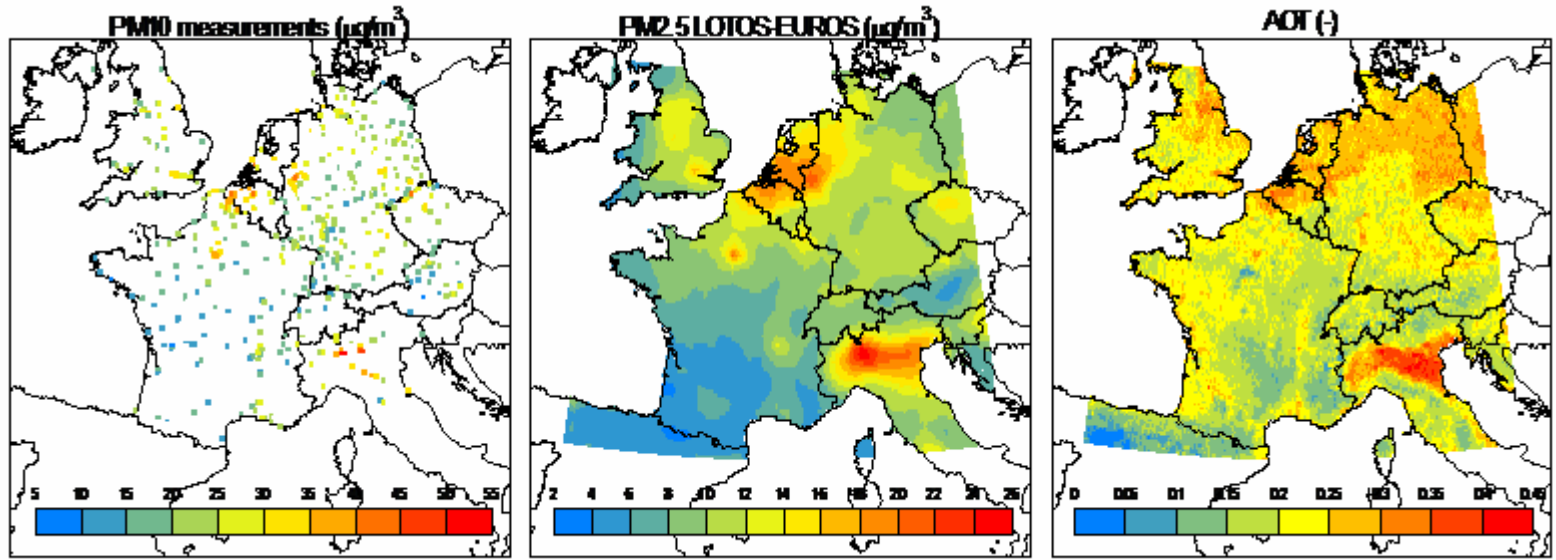
## Integrated assessment tools for estimating the health impacts of air pollution – Research needs

- ❑ particularly recommended in the case of PM, due to the diversity of their main sources, their intense interaction with a range of pollutants and various effects
- ❑ improve source inventories, including scenarios
- ❑ integrate air quality, health and climate change assessments
- ❑ should include multi-scale and multi-pollutant processes
- ❑ integrate policies on air pollution with those in other sectors; for local authorities: develop best practice and toolkits
- ❑ assess the effects of sustainable economic, social and environmental development
- ❑ the causal chain from emissions, and outdoor and indoor pollution to health effects

## Research need: Pan-European integrated study including all processes from emissions to exposure, toxicity, human health outcomes, caused by fine particulate matter



# Motivation for using satellite information



Monitoring

Models

Satellite

Goal: operational system taking into account all sources of information

# Research needs concerning the chemical composition and size distribution of urban PM

- ❖ For health effects, **the ultrafine PM and the particle number concentrations, and chemical composition** may be more important than the particle mass.
- ❖ Need to distinguish the **contributions originated from various source categories**. There is also a need for **high temporal resolution** PM measurements.
- ❖ The **mass closure of the chemical composition** of fine PM can currently be determined only at a few intensive measurement locations in Europe.
- ❖ Specific interest: **heavy metals and carboneaceous** aerosols.
- ❖ Various **source inventories need to be re-examined**.
- ❖ **Measurement methods of PM mass** are still debated. Current automatic monitoring methods in use in EU are not in all cases equivalent to the defined reference method in case of PM<sub>10</sub>; for PM<sub>2.5</sub> no reference method. **Monitoring site criteria** should be uniform.

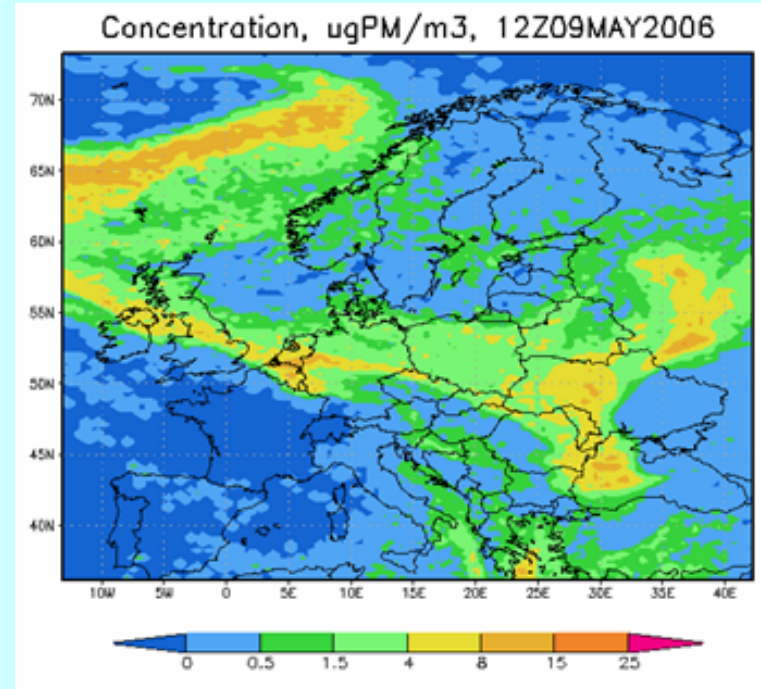
# The adverse health effects of urban PM - Research needs

- **PM from wood smoke, wild-land fires and other biomass fuel combustion products.** Forest fire smoke has similar toxic characteristics as PM from combustion sources.
- **Ultrafine particles (UFP)** have been associated with serious adverse health effects. However, **the health effects due to PM mass cannot be attributed to UFP.** A guideline should be designed for UFP.
- Adverse health effects of PM may occur **at shorter time periods** (within a few hours) than those used in the guidelines (daily and annual averages). -> **Epidemiological exposure-response studies** are therefore needed, regarding exposure **to traffic pollution** and while **in traffic**, especially addressing congestion conditions.
- Stronger or as strong independent effects for **coarse PM**, as for PM<sub>2.5</sub> for chronic obstructive pulmonary disease, asthma, respiratory as well as cardiovascular hospital admissions.



# Wild-land fires and health

- ❖ Serious negative impacts on safety, air quality, health and economies
- ❖ The smoke contains numerous hazardous gaseous (e.g., CO and VOC's) and particulate compounds (e.g., PAH's and other organics)
- ❖ Plumes can be transported all over Europe, where they can constitute a substantial health risk for the populations.



The computed PM<sub>2.5</sub> concentrations from forest fires in Russia at 12:00 on 9 May 2006 (unit:  $\mu\text{g}/\text{m}^3$ ). It was estimated that the episode caused a premature mortality of approximately 30 in Finland.



# Allergenic pollen

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

Pollen species cover all of Europe, e.g.,

- ✓ olive trees (Mediterranean region),
- ✓ birch (Central and Northern Europe),
- ✓ ragweed (Southern and partly Central Europe)
- ✓ grass species (the whole of Europe)



Branches and fruit of an olive tree



Ragweed

## OK ... but can anything be done about it ?

- ❖ Air quality forecasting systems for pollen: health information and warnings for susceptible population sub-groups
- ❖ To take the problem into account in urban and community planning (as for other pollutants)
- ❖ To take into account in health studies as one species that influences health -> more reliable multi-pollutant evaluations



## Conclusions

We have reviewed the current state of the art research on urban air quality and health. The review was focused on a limited number of selected questions.

We have especially highlighted important new emerging issues, gaps of knowledge and research needs.

Future work is aimed also to evaluate and highlight the implications of these findings and research needs, e.g.,

- which of these gaps could be closed within reasonable resources, and
- what could be achieved with better knowledge and methodologies



# Additional material

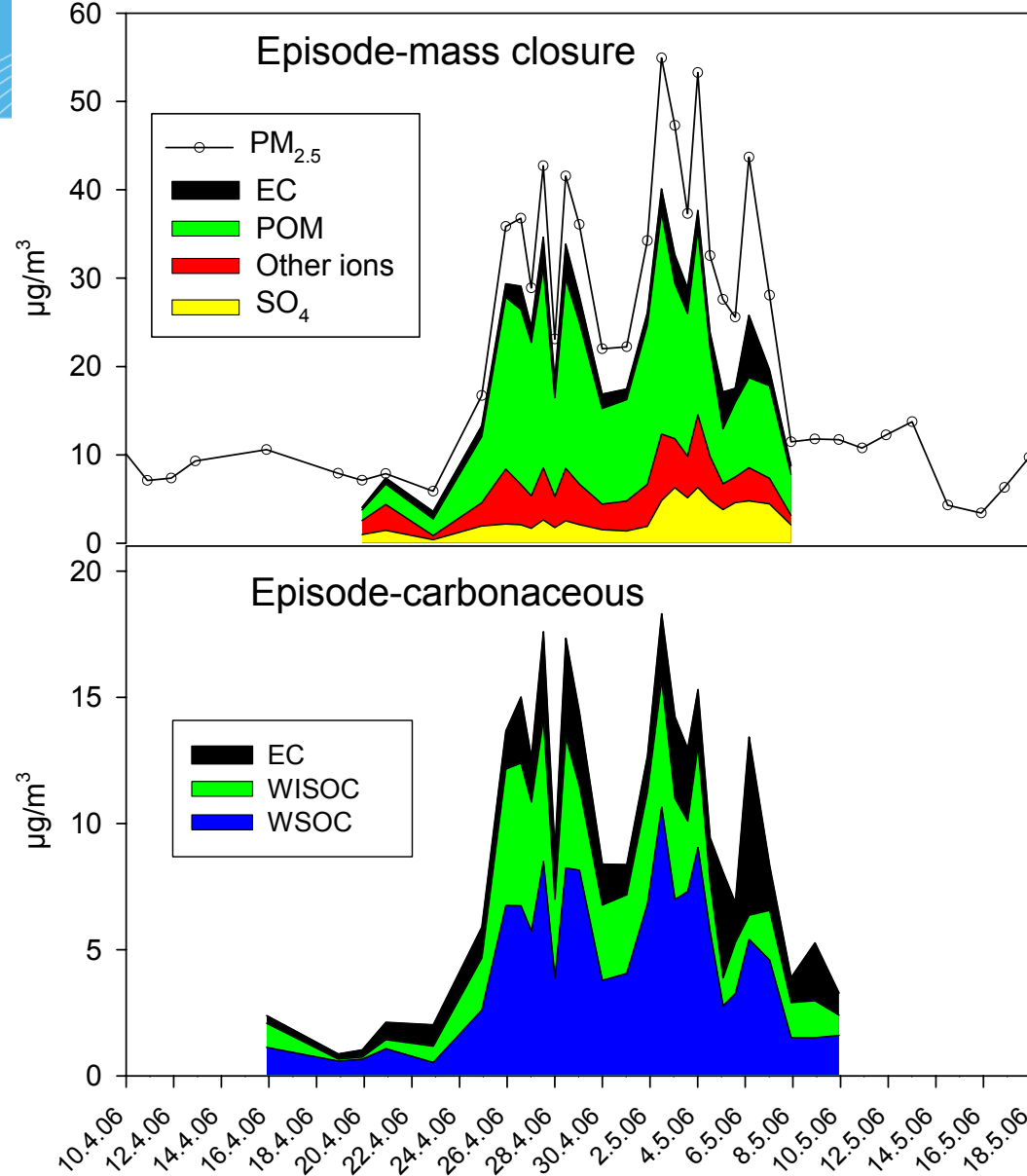


## Forest fires in Russia in spring 2006

The measured concentrations of PM<sub>2.5</sub> in Helsinki, Kumpula (urban background)

16 April – 10 May 2006

EC = Elemental carbon  
OC = Organic carbon  
POM = Particulate organic matter  
SO<sub>4</sub> = sulphate  
WIS = water insoluble  
WS = water soluble



# **HQ1 “Which health effects are caused by air pollution?”**

- Studies that evaluate the **effects of long-term exposure to air pollution, traffic intensity and traffic noise on mortality together** in one study are needed.
- Little information is available about the **validity of the exposure assessment** of existing studies.
- The **biological mechanisms by which exposure to particulate matter may relate to adverse health effects**, like cardiovascular mortality, remain partly unclear although various general mechanisms of action have been suggested recently.
- Research gaps and questions relate to **what specific air pollutants, combinations of pollutants, sources of pollutants, and characteristics of pollutants are most responsible for the observed health effects**.
- **Exposure-response functions for long-term health effects** are needed from large EU cohort studies.



## HQ2 “Which population groups are at high risk?”:

- The **identification of specific subpopulations most sensitive** to air pollutants is one of major interest and one of the most important gaps in our current knowledge.
- **Studies on vulnerability markers** are in their infancy, and are needed to deepen our understanding of biological mechanisms.
- More research has emerged on the **modifying effect of social economic status indicators** on air pollution and health relationships. Emerging data on this issue suggests three possibilities a) persons with lower SES may receive higher exposures to air pollution; b) may be more susceptible to the health effects c) a combination of these two above.
- **Identification of individual determinants of susceptibility** like nutritional factors is seen as worthy of further pursuit.



## **HQ3 “Will a reduction in air pollution improve health?”**

- The health effect institute (HEI) research programme on accountability was launched in 2003 to evaluate the effectiveness of certain air quality interventions. However, this research programme is work in progress and results are not published for any of the air quality interventions yet.
- Studies which evaluate **effects of abatement measures on both air pollution levels and the effects of changes in pollution on health** are needed.
- There is a need for a **toxicity evaluation for new technologies** before entering the market.



## HQ4 Are there safe pollution levels?

- Scientific evidence shows that adverse health effects are associated with the current levels of air pollution. Thresholds are addressed for PM and O<sub>3</sub> in new time series analyses including three independent meta-analyses on ozone. **Until now, no evidence of a threshold has been found on air pollutants and associated adverse health effects in time series studies.** For long-term studies, the issue of thresholds is more difficult to address. But also for long term exposure no evidence for a threshold was found.



## HQ5 O<sub>3</sub> - what is the **appropriate averaging time for a guideline?**

- Mortality effects of O<sub>3</sub> have been reported. Increasing numbers of epidemiological studies suggest that ozone is detrimental to children's respiratory health. Effects on the lungs can be long-lasting.
- There are some new analyses of human laboratory data which have questioned the appropriateness of the current guidelines for O<sub>3</sub>.
- However, this **has to be investigated by further research.**



# HQ6 NO<sub>2</sub> - what new information is there pertaining to the current Air Quality Guidelines for nitrogen dioxides?

**It is still not clear whether NO<sub>2</sub> can cause adverse health effects by itself** at the relatively low levels encountered in urban atmospheres or that it serves as a marker of traffic-related air pollution. The Children's Health Study has reported important new findings on the long-term exposure to NO<sub>2</sub> and lung growth and asthma. Results from cohort studies have shown mixed results on the long-term mortality effects of mixtures represented by NO<sub>2</sub>.

- There is evidence of an increased trend in road transport NO<sub>2</sub> /NO<sub>x</sub> emission ratios in primary exhaust. **A changing composition of roadside air pollution mixtures and the potential consequences for NO<sub>2</sub> concentrations in the air and health effects** is an important gap in knowledge which needs to be addressed in the near future.

## HQ7 SO<sub>2</sub> - what new information is there to support the current Air Quality Guideline for sulphur dioxide?

- **Contribution of sulphate to the health effects attributed to PM<sub>2.5</sub> is still not clear.**
- **New data on PM composition suggests a role of metals like Ni in the found associations of SO<sub>2</sub> and SO<sub>4</sub> levels and mortality.** However, **exact mechanisms** are not clear and thus further research is needed on this topic.



## HQ8 “How will climate change affect health?”

- Changes in climate can affect health by affecting the concentrations of outdoor air pollutants. Two components in particular are important with respect to this: **O<sub>3</sub> and PM**.
- **O<sub>3</sub>** episodes are likely to increase in the coming years.
- **Modelling studies on the effects of climate change on ozone episodes and associated health effects are rare.** The exact magnitude of the effects is not known. If winters become on average less cold due to climate change, winter PM levels could decrease.
- Evidence of **effects on length of pollen season and on geographic distribution of allergenic plants** is growing, but still a lot is unknown.



# HQ9 Which health indicators are most appropriate

for comparative risk assessment?

Communication of air pollution effects as effects on **life expectancy rather than on the number of cases** attributed to air pollution is far more understandable and of greater public health interest.

- A more holistic approach is needed with **complementary indicators of health burden including the DALYs and monetary valuation approaches.**
- There is a gap to be filled in to identify, quantitatively assess and to deal with **uncertainties in environmental health risk estimates.** This will improve transparency, applicability and robustness of these estimates.

# IAQ Data requirements and gaps in knowledge related primarily to **identification and exposure to pollutants**:

- **Comprehensive review of the existing data on the indoor air pollutants; definition of the major pollutants and their concentrations range in each Member State of EU, and set up of a pan European database.** Database should compile the existing information on indoor pollutants, including allergens, and should facilitate the use of the data at an EU level. This information could drive both possible regular monitoring programs in the EU and future research. The European Commission's Joint Research Centre (JRC) and the European Environment Agency (EEA) are working towards the design and implementation of a concept document regarding the **creation of a European Human Exposure Data Centre** for chemicals comprising both indoor and outdoor sources and exposure pathways.
- Collection and systemization of practical experiences to establish **evidence-based risk assessment approaches**.
- Research on **exposure patterns** (short and long term in different environments) to indoor air pollutants, in quantitative terms, and **identification of the most relevant exposure indicators**.
- **Source apportionment of the pollutants in indoor environment**, including ambient air, preferably in quantitative terms. Identification of the main sources would help their mitigation.
- Research on **emissions of chemicals from consumer products**. More data on levels of the emissions in realistic use situations are needed in view of the large part of population handling such products.
- Existing **indoor source and transport/fate models should be identified, evaluated, validated and harmonized**. Taxonomy of sources consistent data sharing should also be developed.
- Information on **harmful emissions in water damaged buildings**, including compounds from decomposing building material, contributing to toxicity.
- Evaluation of potentially **harmful emissions from indoor combustion processes** (e.g. halogenated dioxins).

# IAQ Data requirements and gaps in knowledge related primarily to **health effects of indoor air pollutants**:

- **Effects due to combined exposure to indoor air pollutants** and objective methods for their evaluation, including development of validated modelling tools such as **biology-based dose-response models** taking into account the pharmacokinetics and pharmacodynamics of indoor pollutant mixtures.
- Adverse health **effects of microbes and bio-aerosols** present in indoor air, **especially other than respiratory tract effects**; responsible microbes and their components and toxins.
- **Contribution of indoor air pollutants to childhood respiratory diseases.**
- **Exposure-effect-relationships with particular emphasis on vulnerable groups.**
- **Effects and risks of products which emit indoor air pollutants that can react in indoor air**, for example, terpenes emitted by air fresheners and gaseous insect repellents that can react with ozone. The true role of such reaction products as indoor air pollutants is not clear.
- Possible effects and risks of **man-made nanoparticles** in indoor air.
- **Contribution of coarse, fine and ultrafine particles from indoor sources** to adverse health effects.
- **Controlled clinical studies** (including biochemical markers of effect) among persons suffering symptoms in **water damaged buildings** to clarify the associations and possibly to identify the most harmful microbes.

