Urban and Local Scale Air Pollution

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including contributions of: C. Borrego, L. Bozó, S. Galmarini, D. Poppe, M. Schatzmann and P. Sturm

The problem (1)

Air quality guidelines are still exceeded in several European cities.

⇨ There is a need for

- further emission reductions
- higher air quality management efforts

The problem (2)

Bad urban air quality may result from

- in-city pollution sources
- long-range transport

⇨ Multi-scale interactions important

(in particular regarding aerosols, in view of secondary particle formation)

The problem (3)

Emissions are mainly released within or shortly above the canopy layer.

⇨ Urban geometry of high importance

Receptor points are close to the sources.

⇨ Siting of monitoring stations difficult.

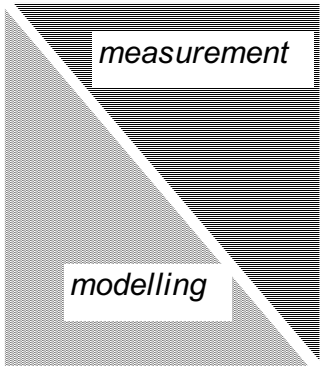
⇨ Need for a suitable method for the spatial generalisation of measurements.

The problem (4)

New EU air quality legislation prescribes

- establishing source-receptor relationships
- use of “supplementary” assessment methods

100% measurement



a. Measurement, no interpretation
b. Measurement + interpretation
c. Measurement + interpolation
d. Measurement + model fitted to measurements
e. Data assimilation
f. Model validated by measurements in the same zone
g. Model validated elsewhere
h. Unvalidated model

100% modelling

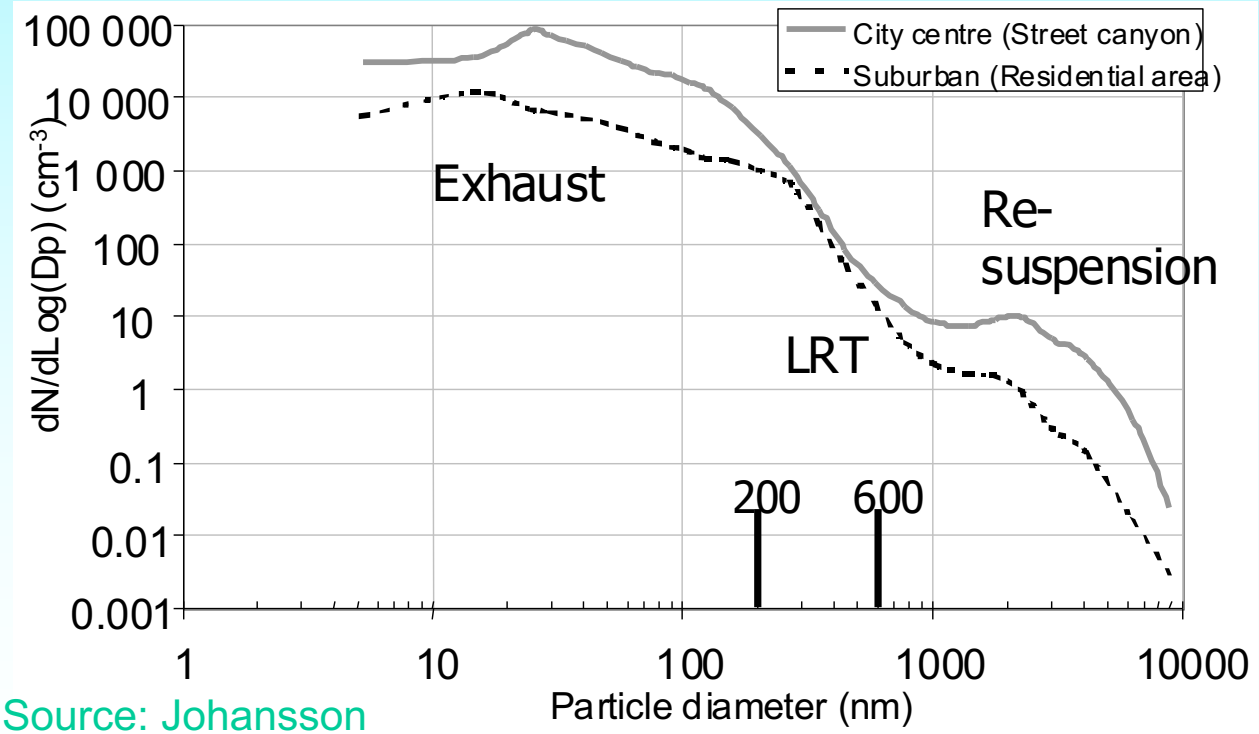
Source: V.d.Hout

Theme contents

1. What are the characteristics of ***particulate matter*** in polluted urban air?
2. Can contemporary model cascades describe the ***multi-scale character*** of urban air pollution?
3. What ***monitoring & modelling*** combinations are suitable for assessing air quality in cities?
4. How do ***uncertainties*** affect the credibility of model predictions (urban background, hotspots)?
5. Are recent scientific results sufficiently reflected in ***air quality management tools***?

Particulate matter

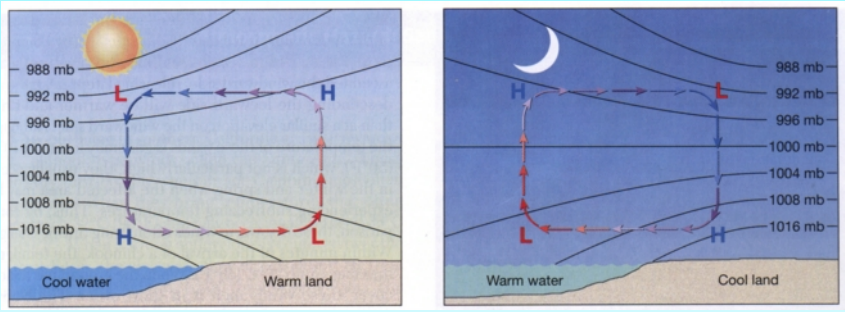
Traffic is the dominating source of ultra-fine particles while also having a significant contribution to PM_{10}



Source: Johansson

Multi-scale character

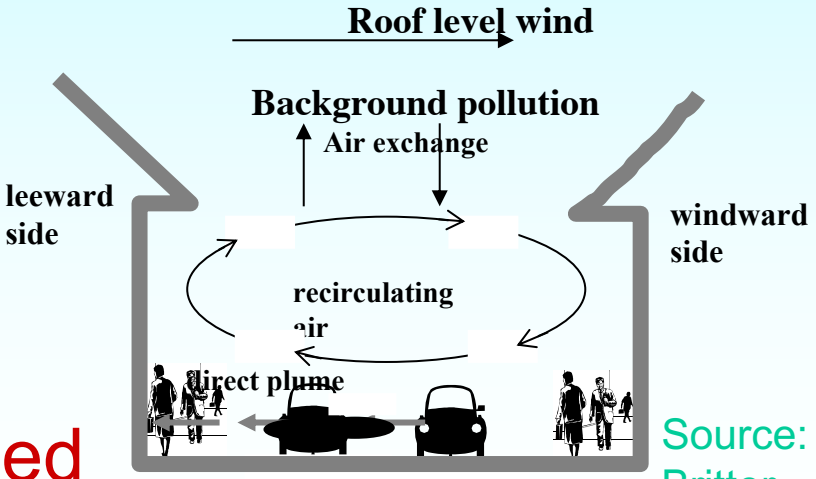
- Local concentrations influenced by regional scale processes.
- Urban air quality affected by mesoscale wind circulations.



Source: Lutgens *et al.*

⇒ Regional-to-urban coupling needed

- Circulations created by the city itself affect pollutant dispersion.
- Hotspot concentrations depend on street canyon scale effects.



Source: Britter

⇒ Urban-to-local coupling needed

Monitoring & modelling

- Data assimilation was further developed and its usefulness proved.
- Much effort was put on model QA/QC:
  - Development of model evaluation protocols
  - Organisation of model validation and intercomparison activities
  - Wind tunnel experiments in support of model validation

Uncertainties

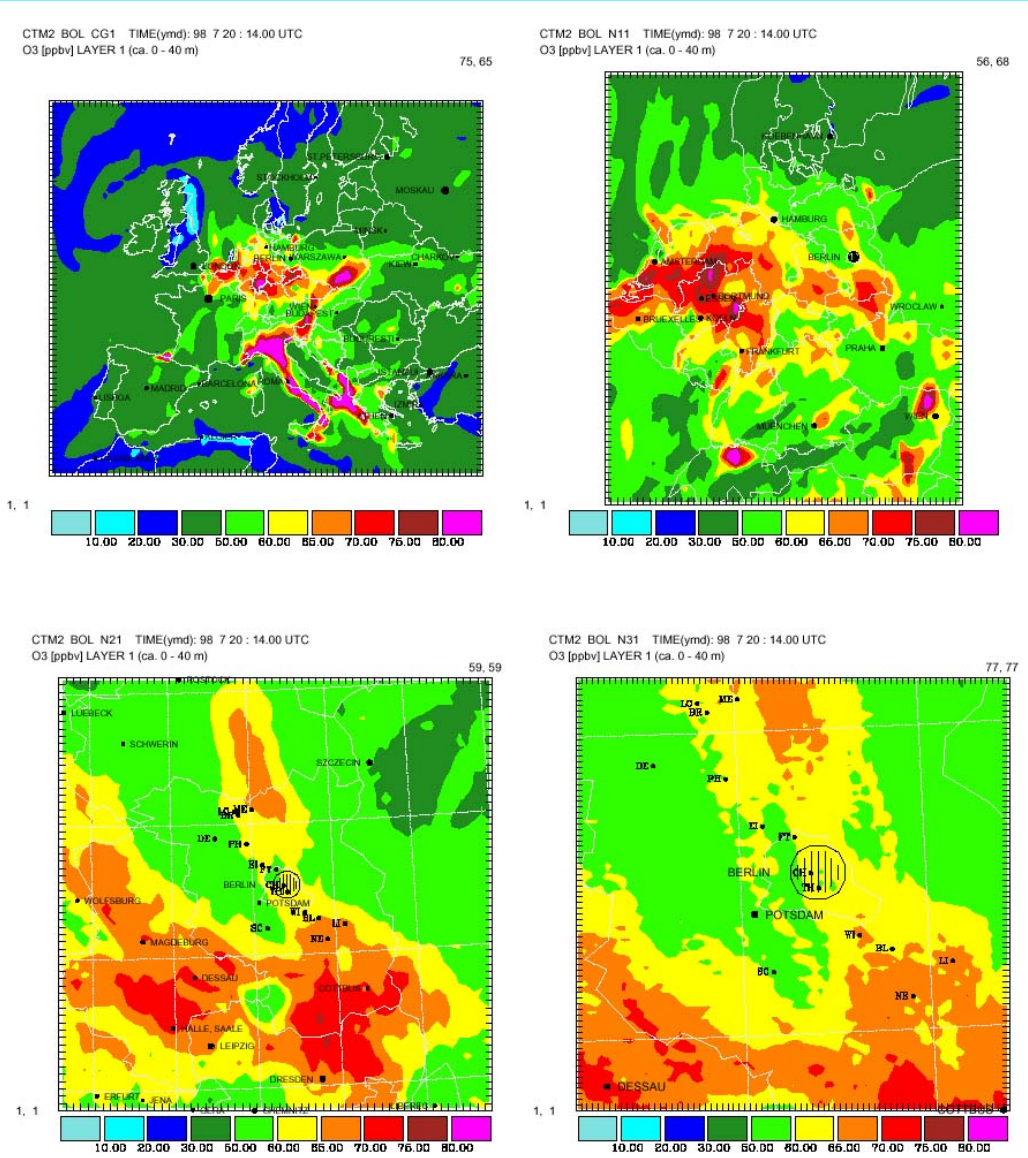
- Measured data uncertain because of
  - instrument inaccuracies
  - measuring concept shortcomings (e.g. lack of representativeness, too short averaging)
- Model results uncertain because of
  - input data inaccuracies
  - model concept shortcomings (e.g. wrong assumptions, bad parameterisations)

Urban air quality assessment

Multi-scale character

Regional-to-urban coupling

Example: O_3 calculated with EURAD for BERLIOZ (July 20, 1998, 14 UTC).



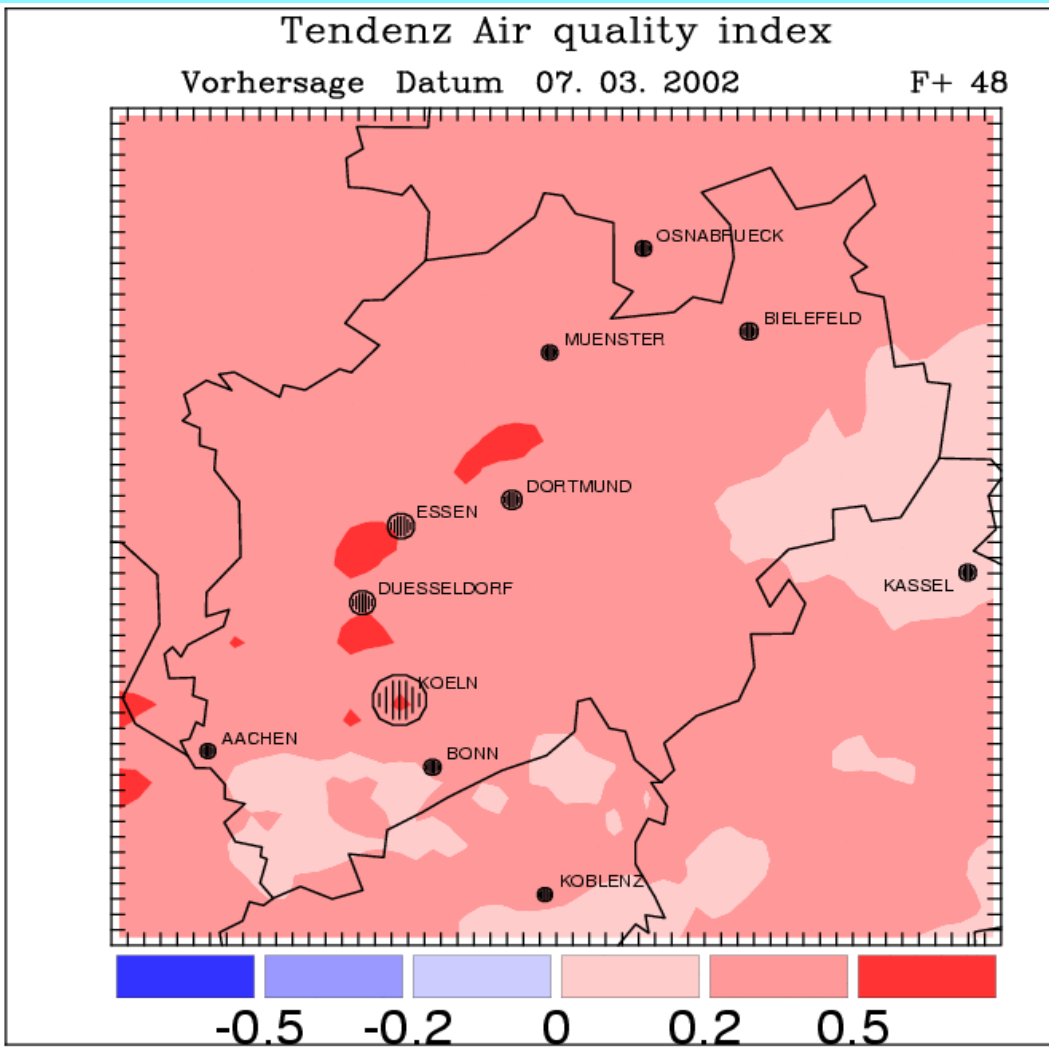
Source: Memmesheimer

Urban air quality assessment

Multi-scale character

Regional-to-urban coupling

Example:
Operational daily ozone forecasts for North Rhine Westphalia



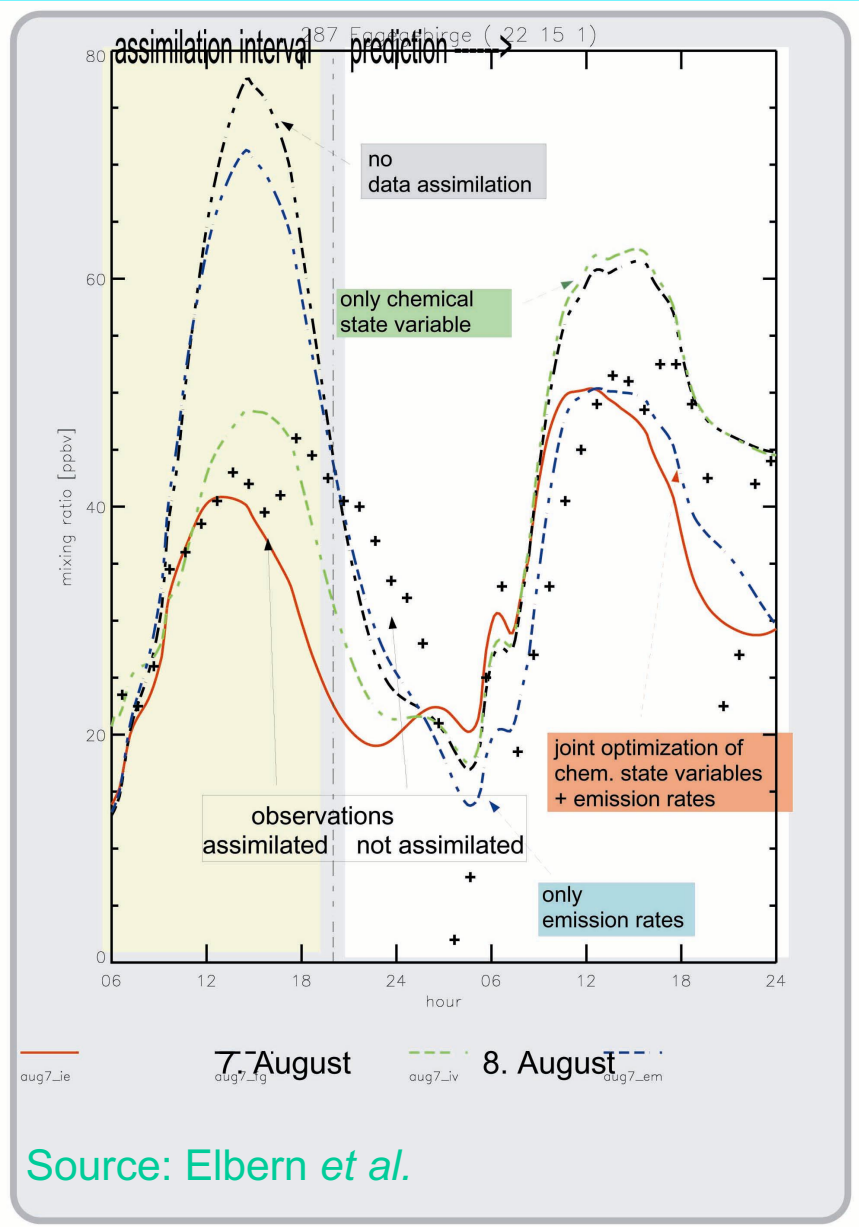
Source: Memmesheimer

Urban air quality assessment

Monitoring & modelling

Data assimilation

Timeseries for 42-hour simulations August 7-8, 1997, based on the assimilation of O_3 measurements (06 - 20 UTC)



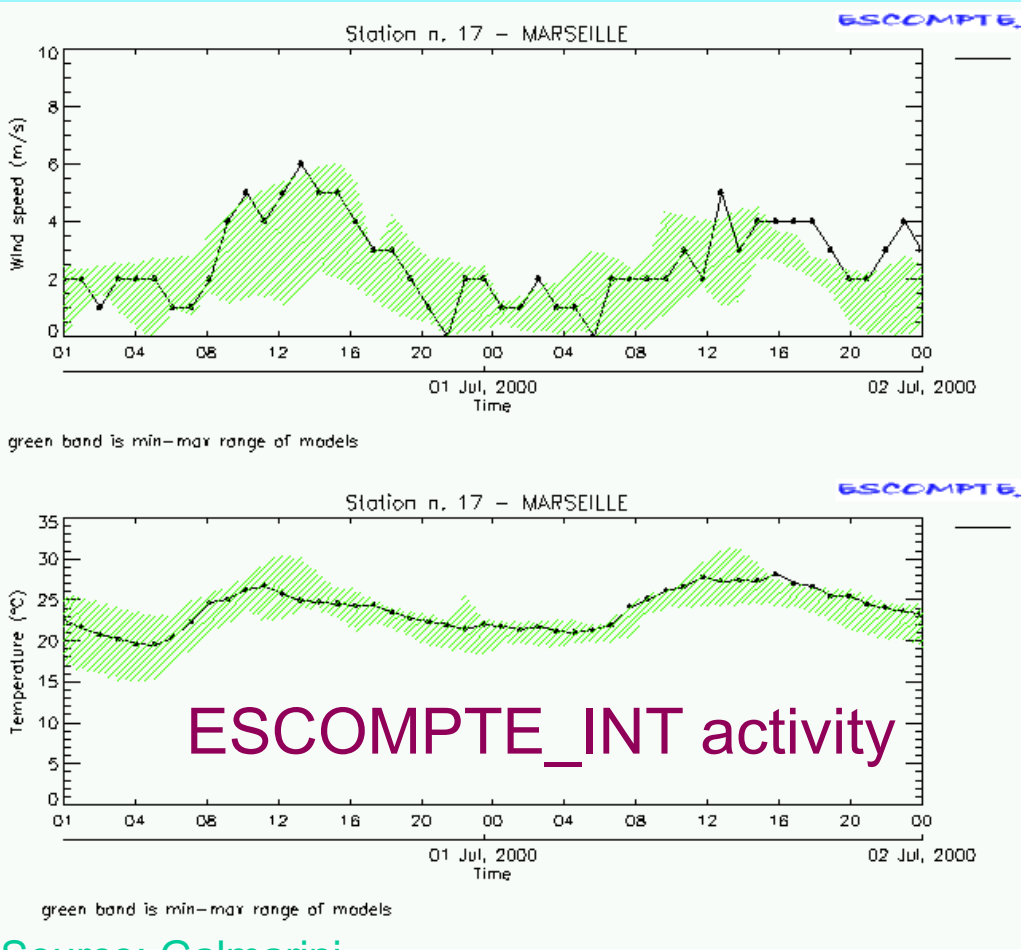
Source: Elbern *et al.*

Urban air quality assessment

Monitoring & modelling

Model validation

Model intercomparison activities are convenient approaches for gradually and systematically testing model performance



Source: Galmarini

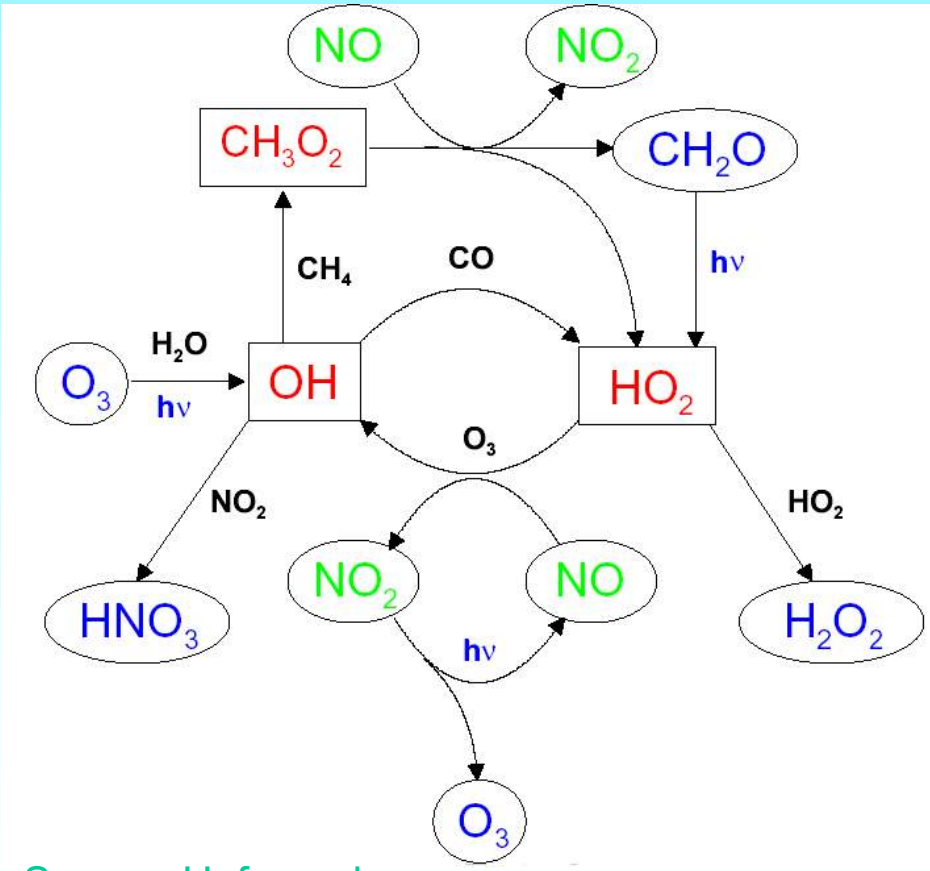
Urban air quality assessment

Uncertainties

Chemistry (1)

Possible errors due to:

- unknown chemistry
- uncertain rate parameters
- inaccuracies related to mechanism reduction

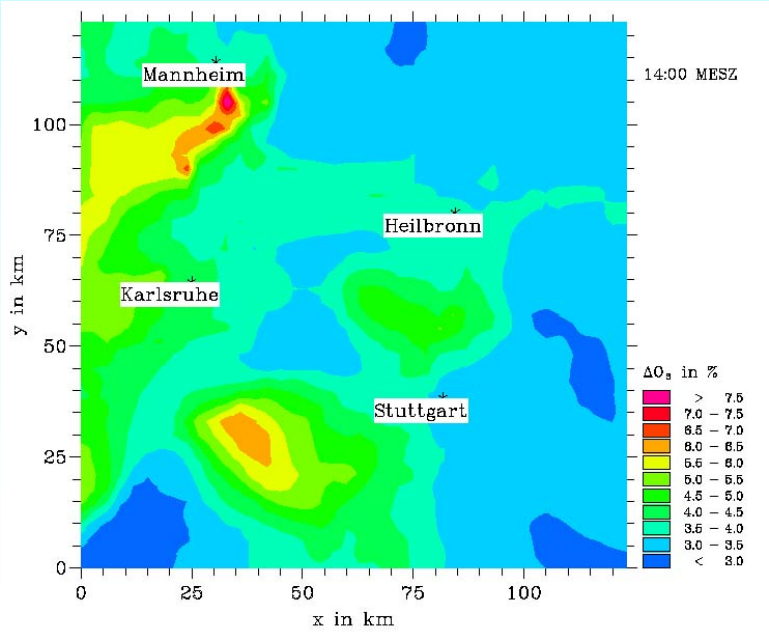


Source: Hofzumahaus

Urban air quality assessment

Uncertainties

Chemistry (2)



Source: Vogel *et al.*

All potential error sources were studied systematically and operational chemical schemes were developed that are suitable for use in conjunction with urban scale models.

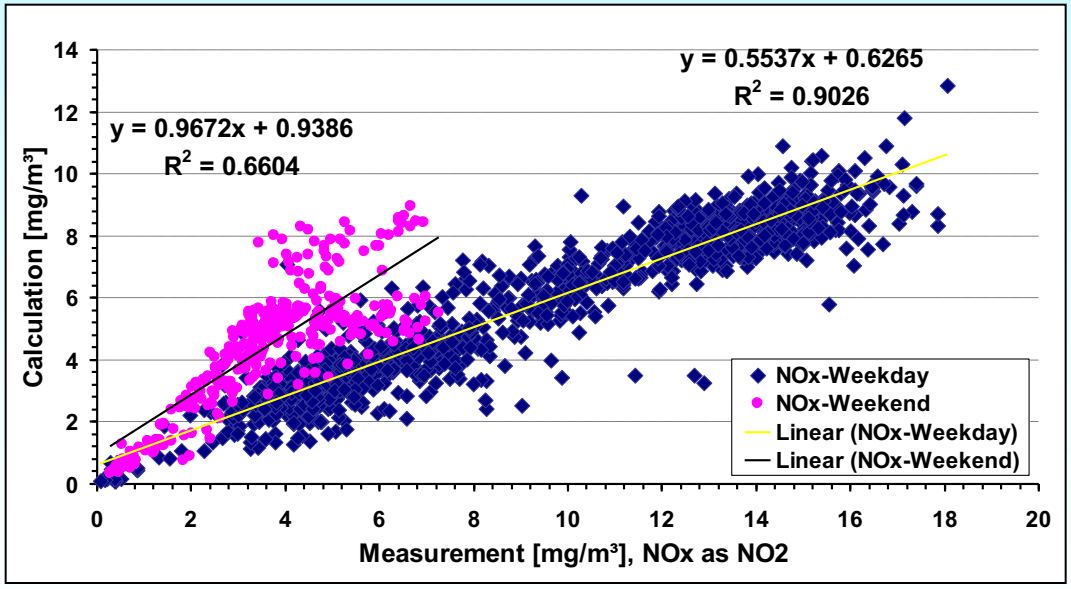
← Impact of a 17% decrease of the rate constant for $HO+NO_2 \rightarrow HNO_3$ on ozone predictions for Baden-Württemberg

Urban air quality assessment

Uncertainties

Traffic emissions

Errors related to traffic emissions are becoming gradually quantifiable on the urban scale.

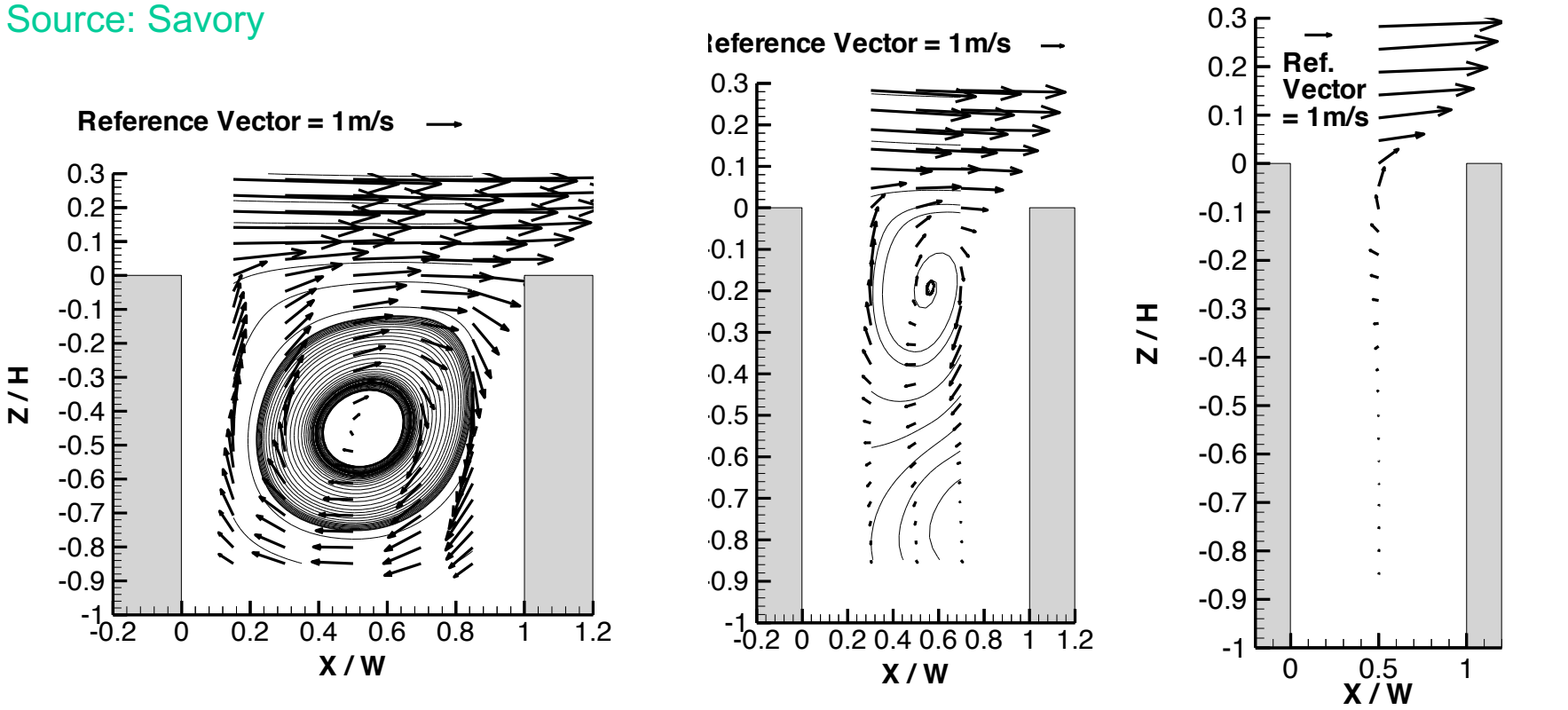


Source: Sturm

← Comparison between measured and calculated emission data (tunnel measurements)

Urban-to-local coupling

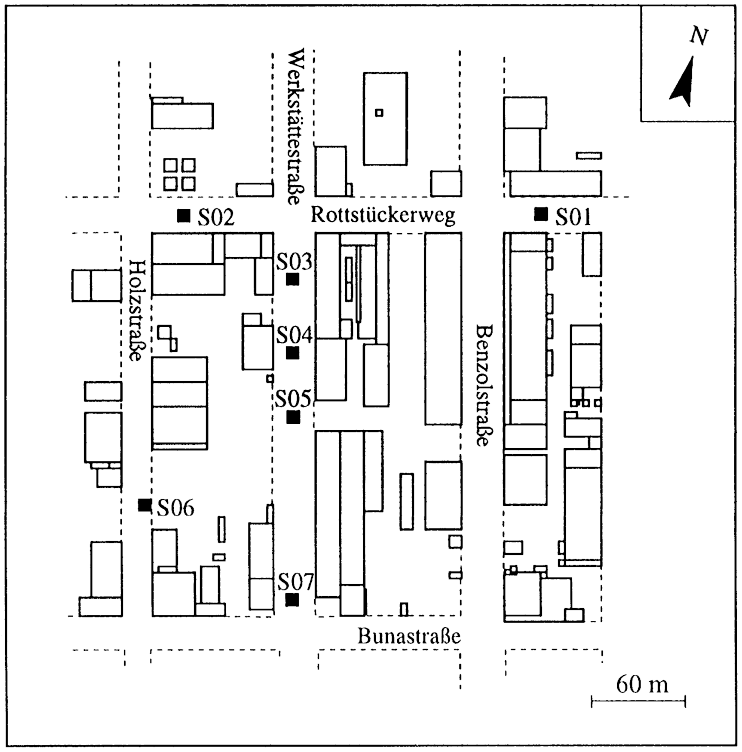
Source: Savory

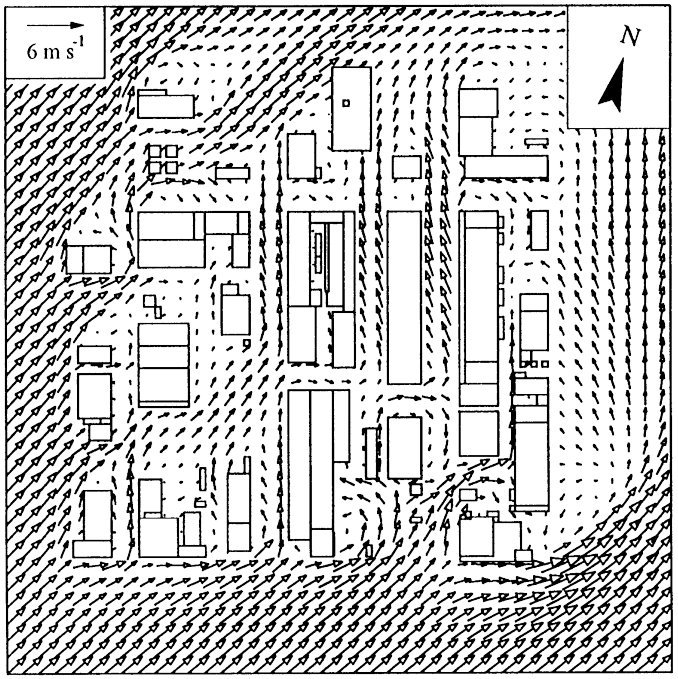


Airflow regimes developing in a two-dimensional street canyon for aspect ratios: 1.0, 0.5 and 0.3

Hotspot air quality assessment Multi-scale character

Urban-to-local coupling

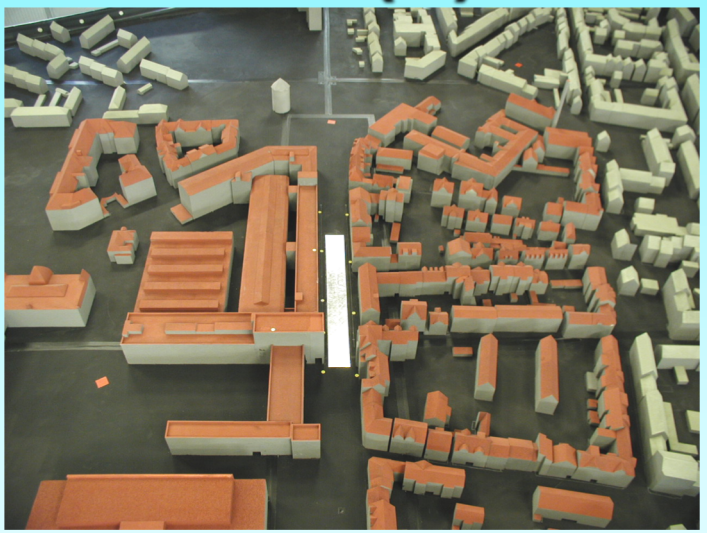


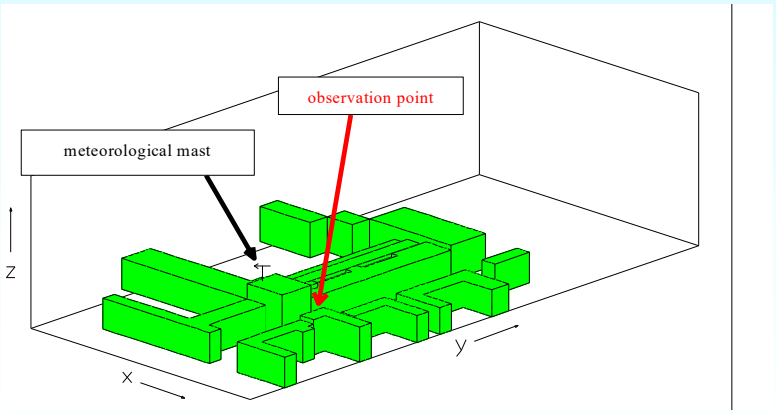


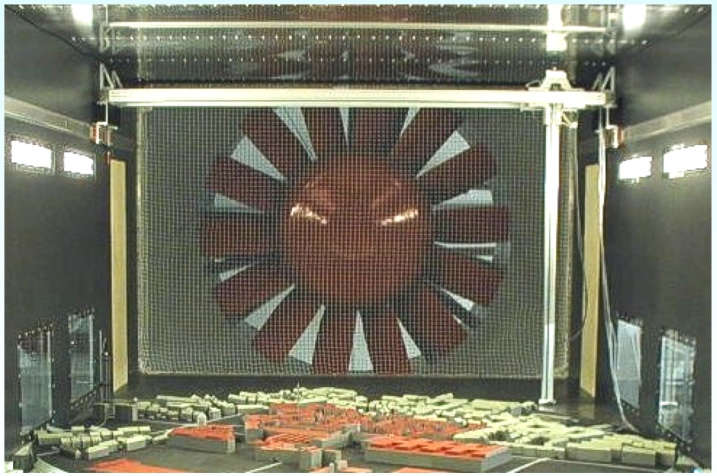
Source: Moussiopoulos

Example: Wind flow over BASF (resolution: 4 m)

Model validation (1)

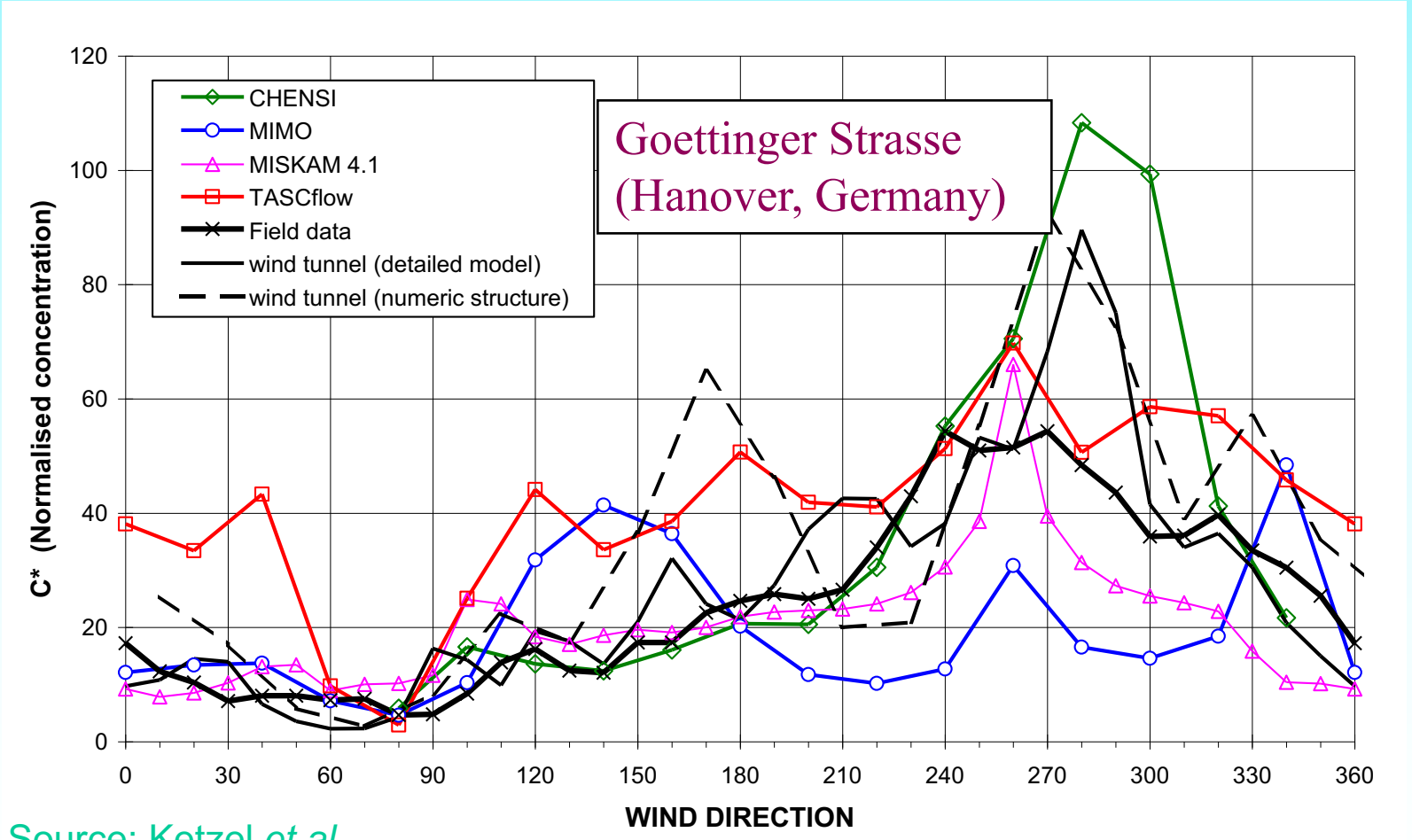






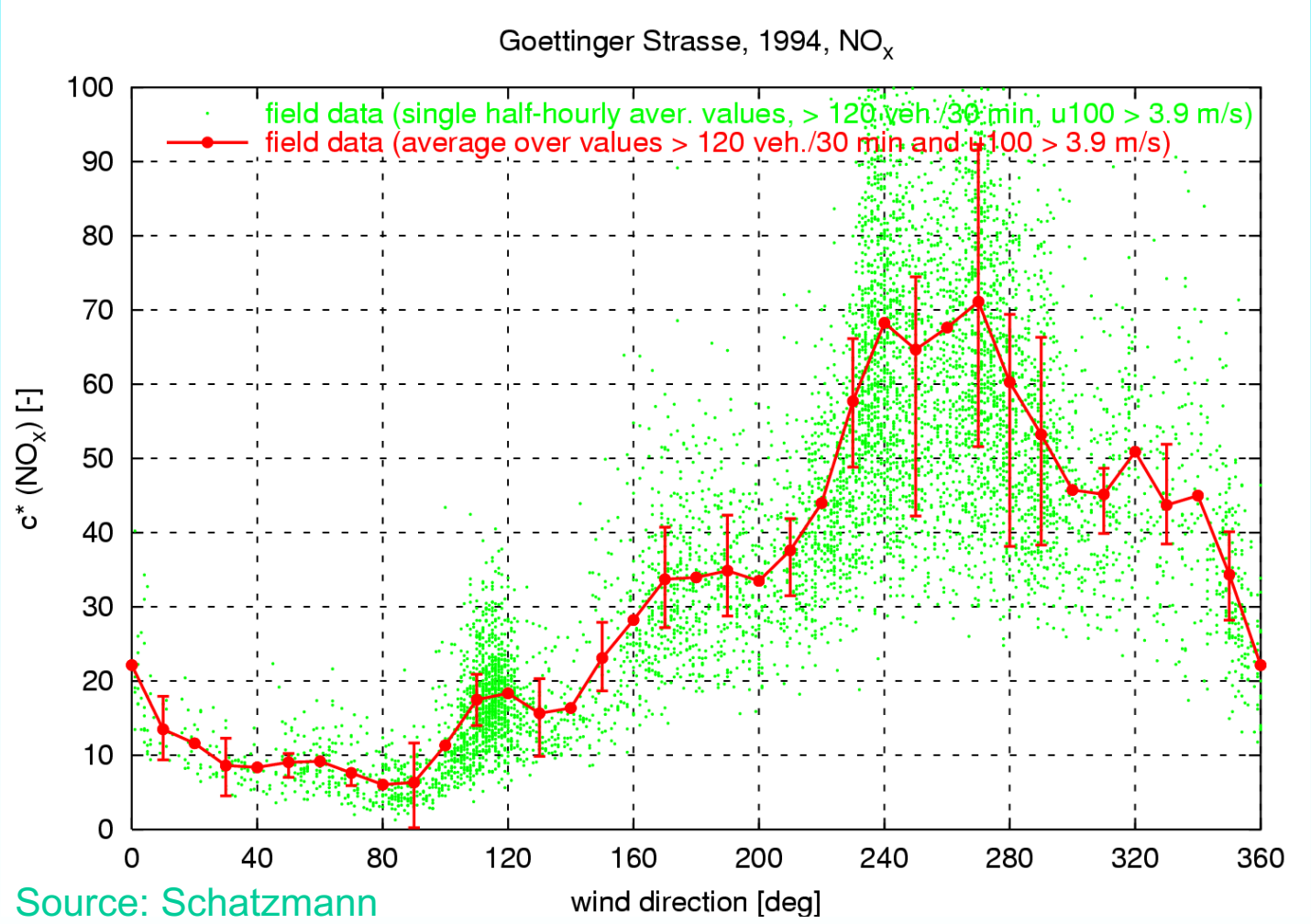
Source: Schatzmann

Model validation (2)



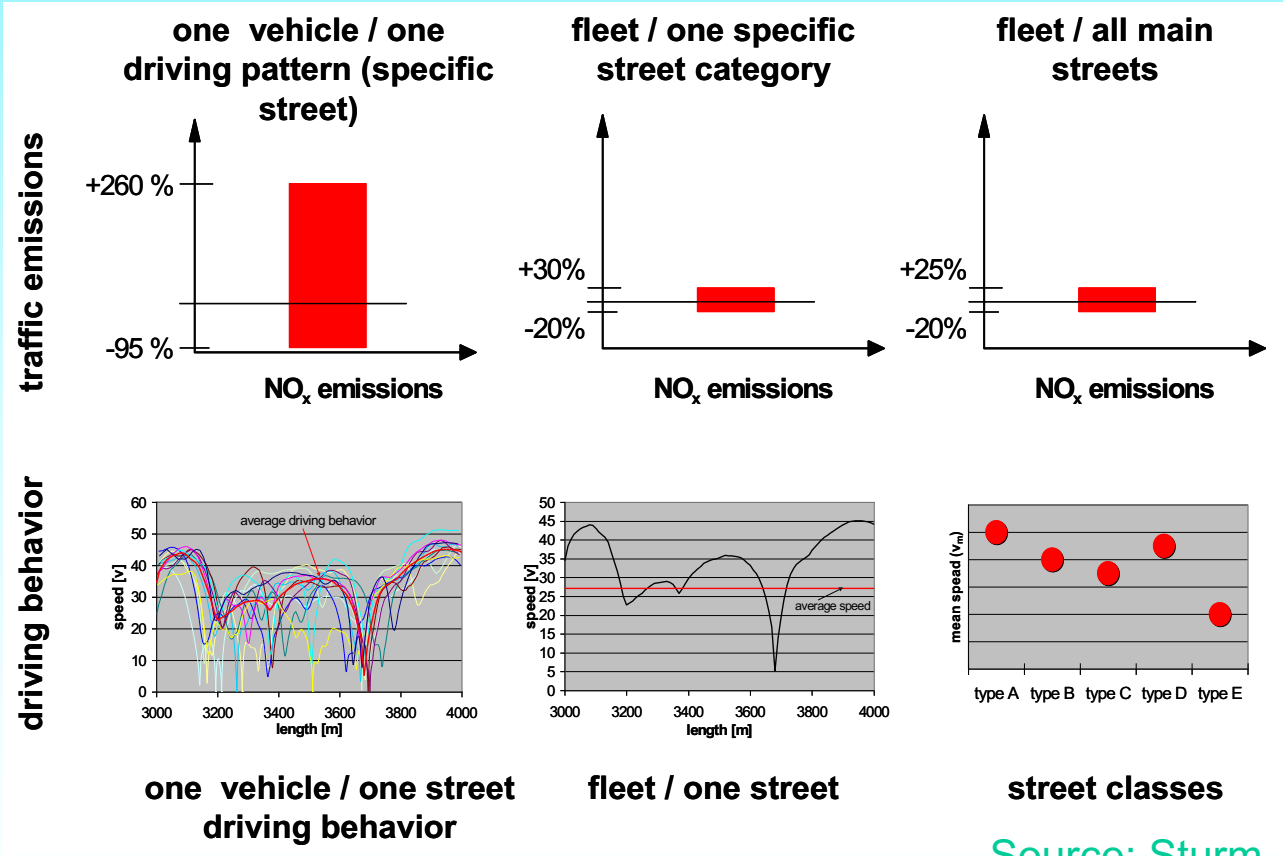
Source: Ketzel *et al.*

Monitoring data inaccuracy



Source: Schatzmann

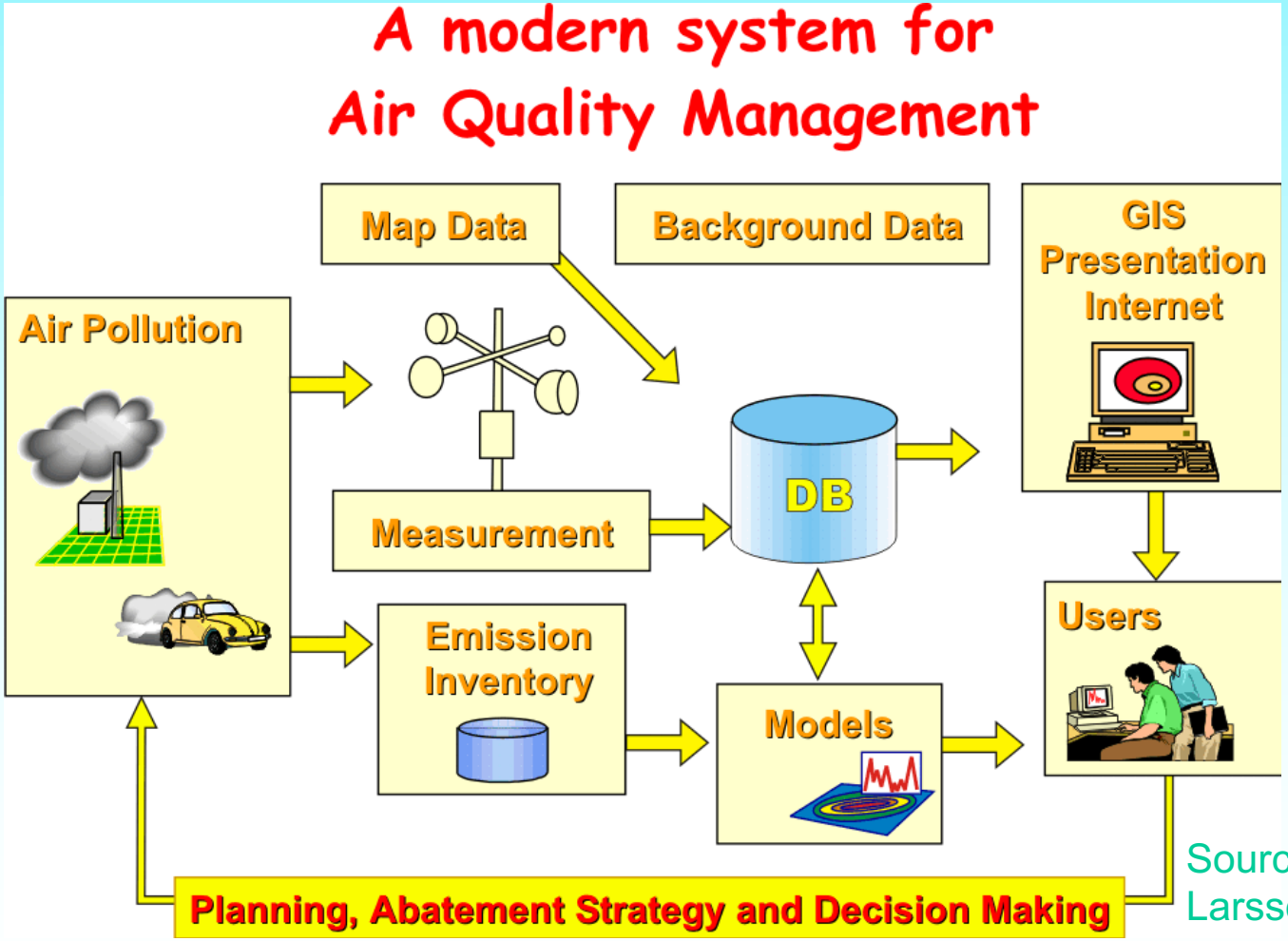
Traffic emission data



Source: Sturm

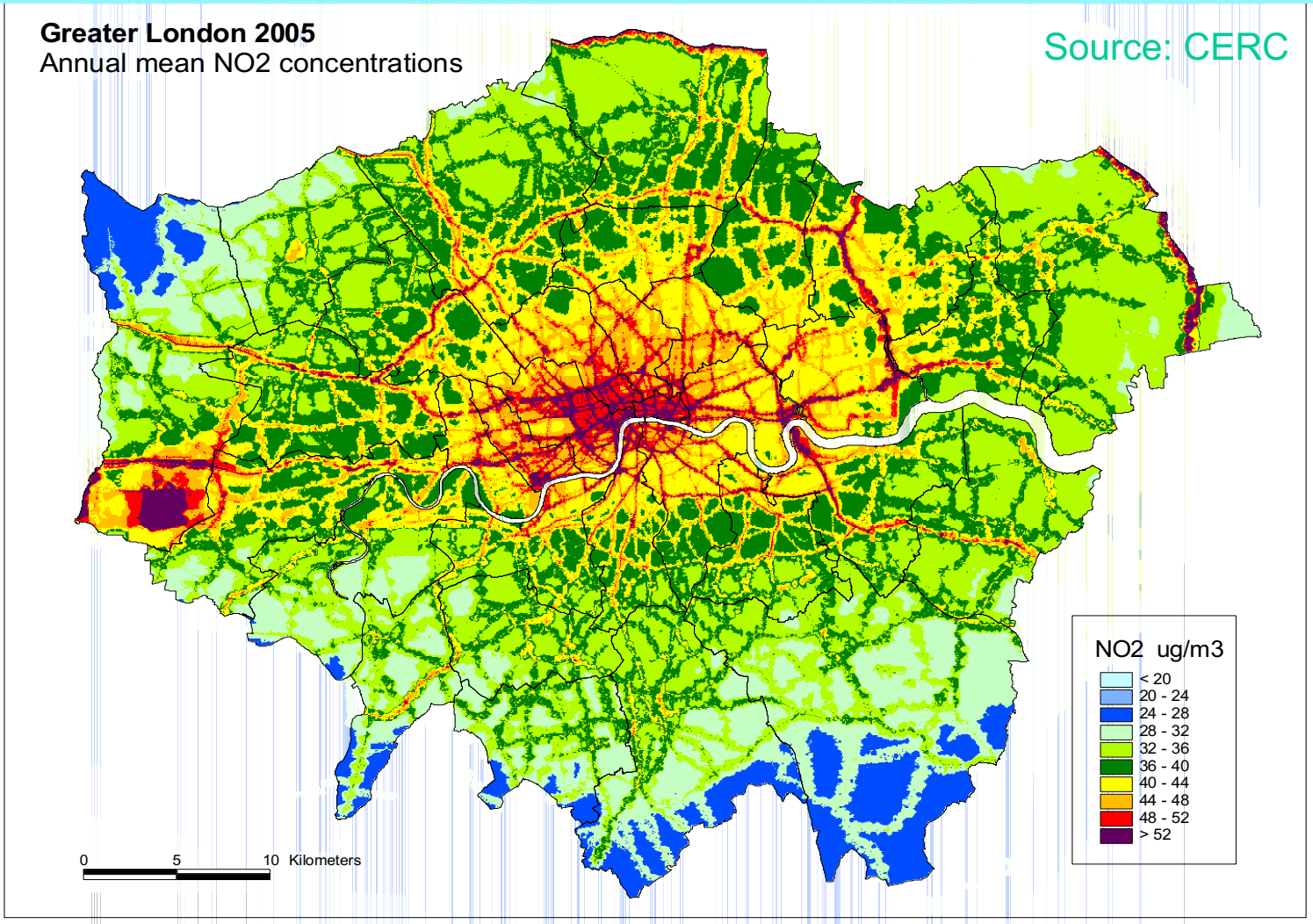
Data for local scale problems are highly uncertain!

Air quality management tools (1)

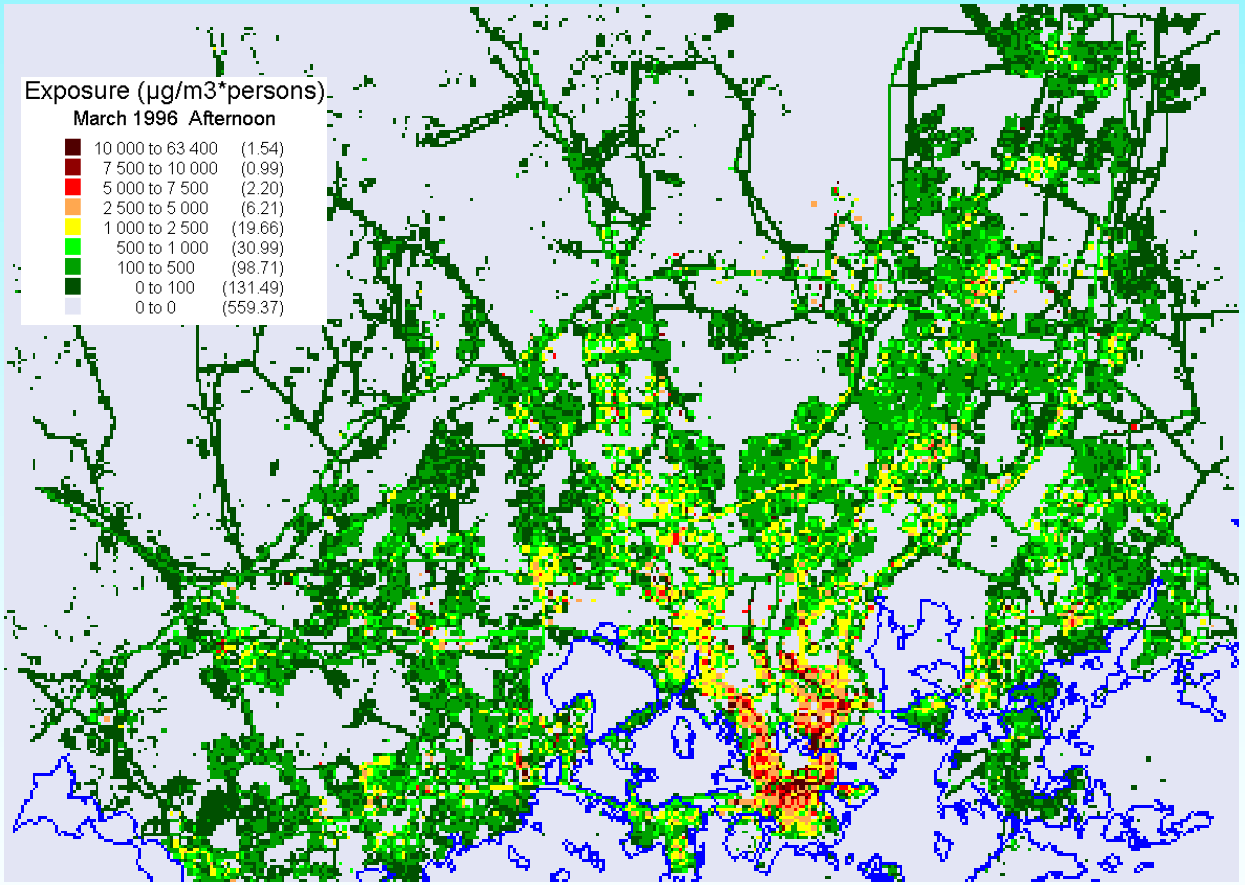


Source:
Larssen

Air quality management tools (2)



Air quality management tools (3)



Source: Kukkonen

Population exposure to NO_2 in Helsinki

Conclusions

- Understanding of urban and local air pollution advanced considerably.
- Progress resulted in the development of improved air quality management tools.
- Despite this progress, still much to do:
  - Study urban aerosol sources and properties
  - Increase robustness of air pollution models
  - Improve methods for hotspot assessments

More information
on this subject
may be found in …