An approach for determining urban concentration increments

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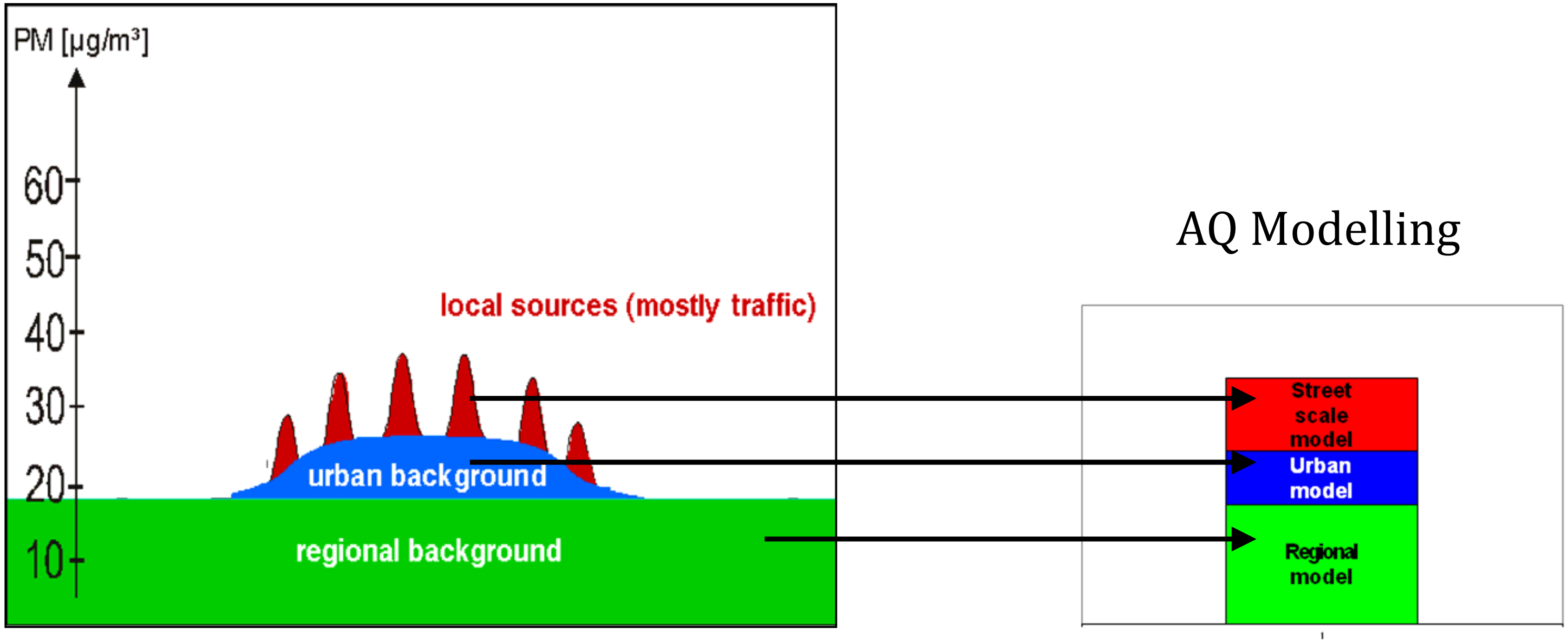
Multiscale modelling approaches



Downscaling methodologies include:

- Advanced coupling schemes
- "Simple" schemes

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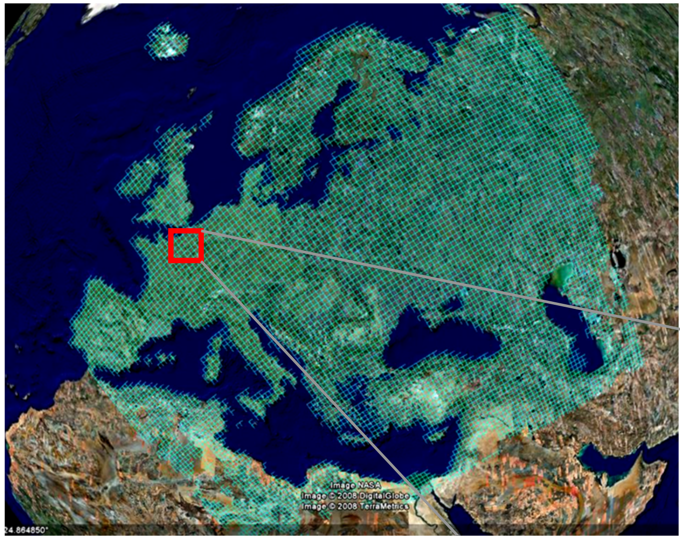
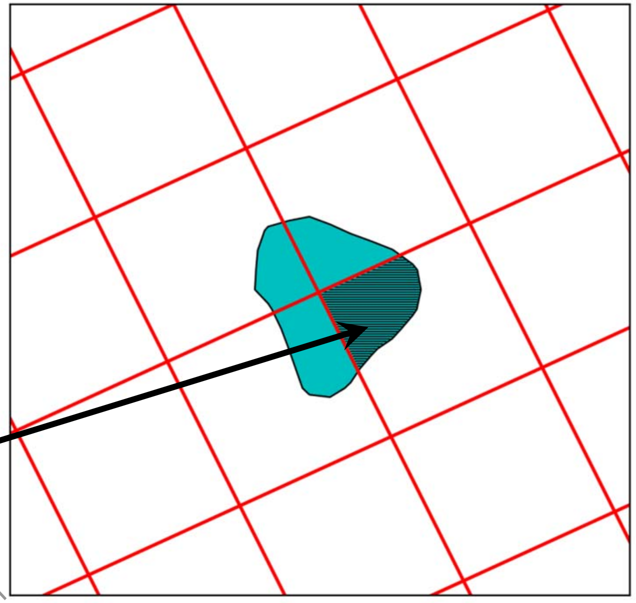
Urban increment: Motivation



Starting from regional model results, can we provide estimates of how much concentrations differ inside urban areas?



"Urban increments" can either refer to the increment in the urban fraction of each regional model cell or to the increment of a city as a whole.

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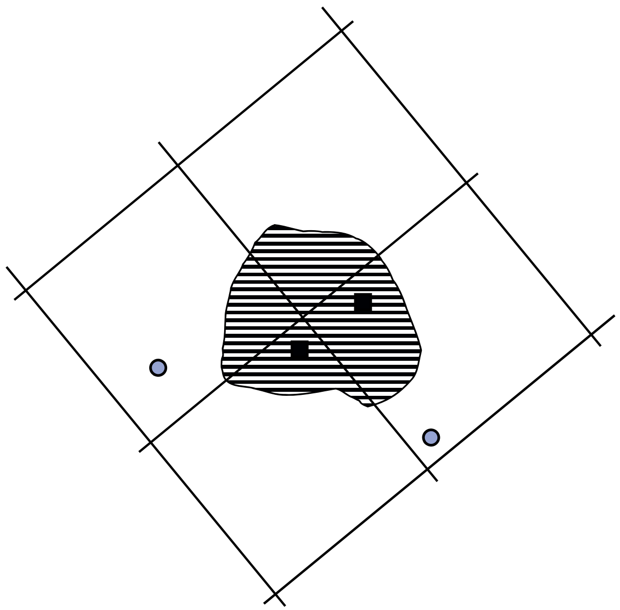
Urban increment: Methodology

- Spatial sampling: Extract initial (sample) increments using either of two methods
  - Measurement station pairs
  - Urban scale models
- Multiple regression analysis to formulate a functional relationship between urban increments and emissions, city size and meteo variables (wind speed, stability, etc.)
- Generalisation: Use functional relationship to estimate urban increment on cities accros Europe



Measurement station pairs
in sample city

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Urban increment: Formulation

$$C_{i\ urban} = f(E_{iUE}, A_{UE}, u_{avg}, S, C_{i\ rural})$$

Where:

$C_{i\ urban}$ = Urban increment of pollutant i.

E_{iUE} = Total emission of pollutant i within an urban entity in tons.

A_{UE} = Urban area in km^2.

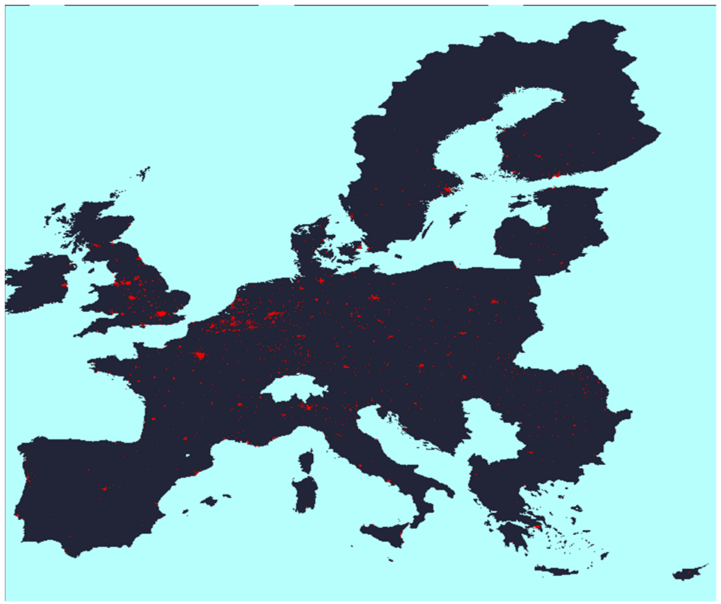
u_{avg} = average 10m wind speed in m/s.

S = atmospheric stability

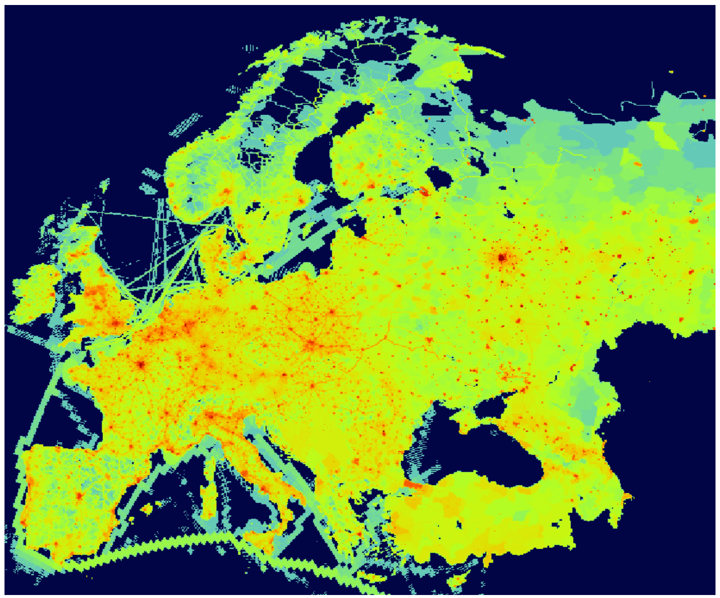
$C_{i\ rural}$ = Rural background concentration of pollutant *i* in $\mu g/m^3$

Urban increment: Data requirements

- Meteorological regional scale model (e.g. PARLAM-PS) output: wind speed as well as temperature and cloud cover necessary to calculate stability
- “Fine” scale emissions for Europe (e.g. TNO)
- Urban entity characteristics (area and shape) per grid cell, available through a GIS-framework



Urban-suburban areas in Europe (CLC2000)



European yearly CO emissions (tons) map (TNO)

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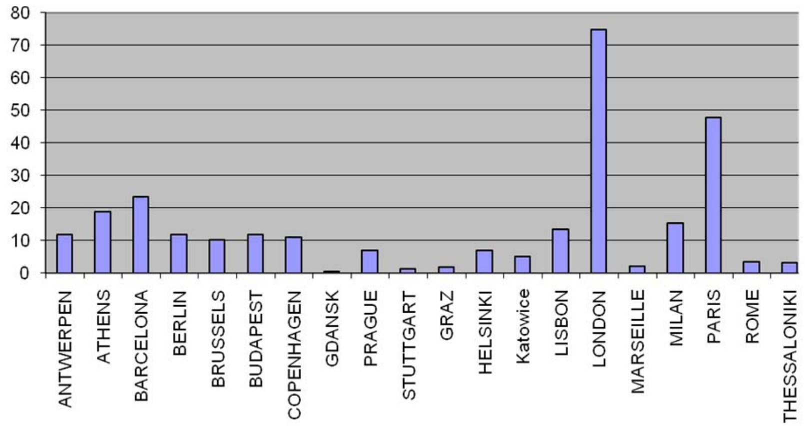
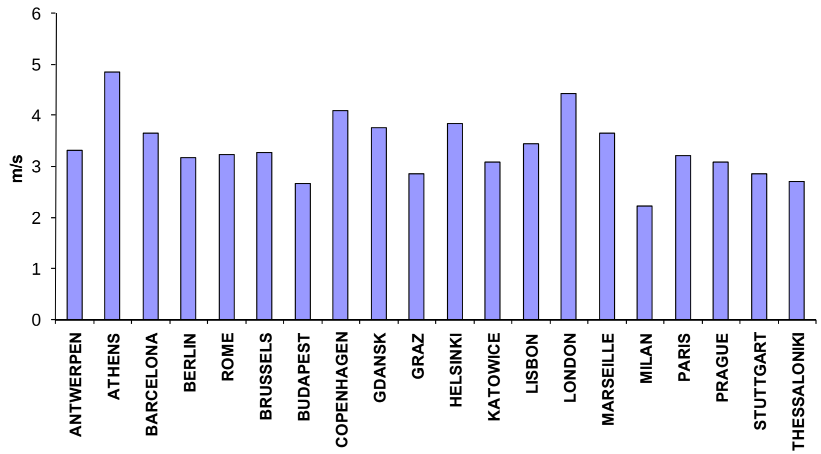
Urban increment:
Input data pre-processing



Urban emission estimates in tons for NO_x,, based on the TNO emissions dataset and CORINE land use



Mean annual 10-m wind speed for the 20 preselected cities as calculated with the aid of the "Meteorology Generator".

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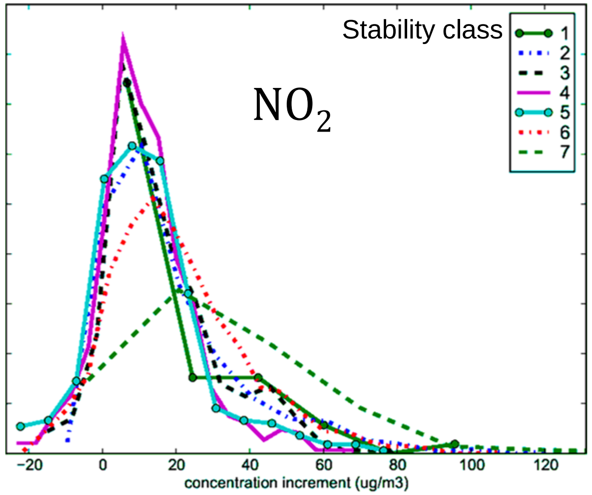
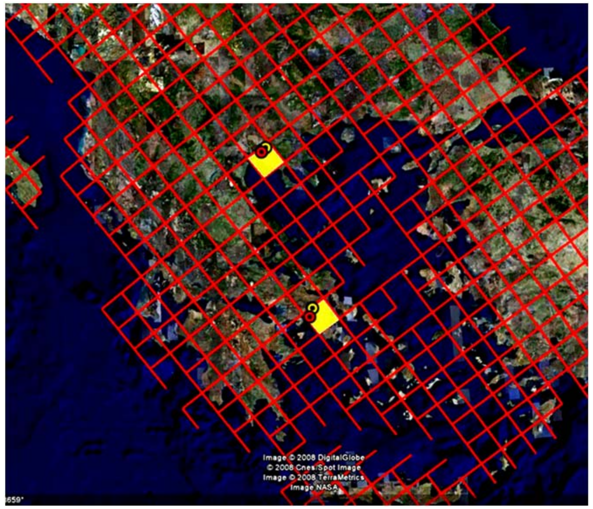
Urban increment

Improvements over older similar approaches

- Local meteorological parameters are calculated for the station pairs locations & the reference year using a consistent interpolator (“Meteorological Data Generator”)
- Taking into account atmospheric stability has an effect on urban increments
- Scenario calculations for the urban increments are possible, based on scenario modelled rural concentrations
- A wide range of pollutants (PM_{10}, $PM_{2.5}$, NO_2 and possibly CO, EC, PAHs) can be taken into account
- The methodology has already the form of a module that could be used as a regional scale model post-processor





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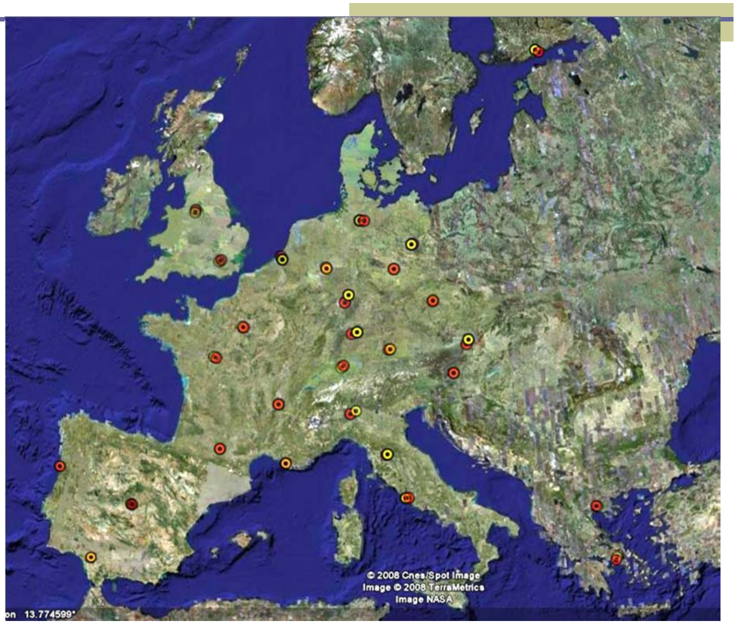
Urban increment

Application example: Selection of rural-urban station pairs

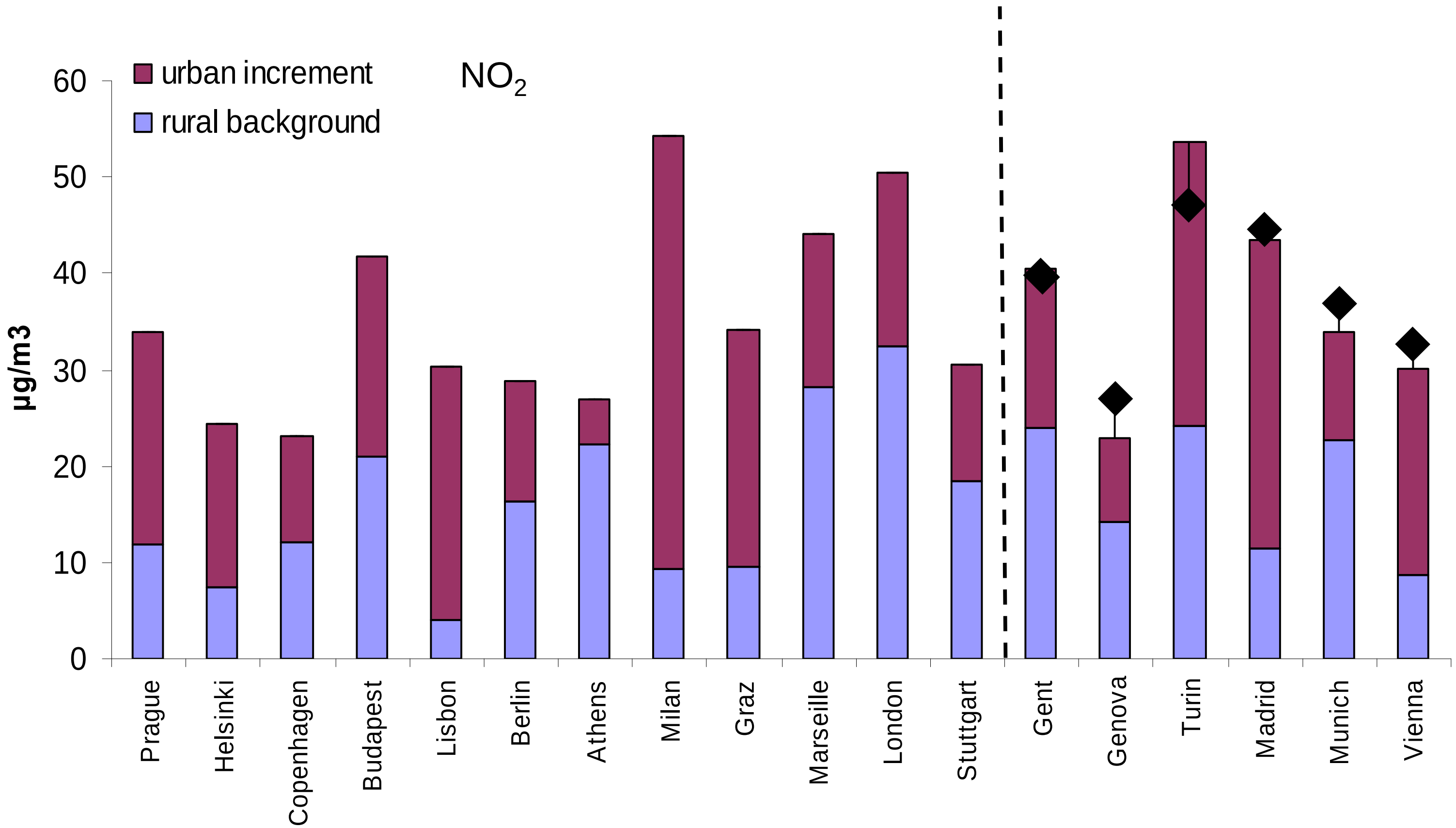
- 12 countries
- 28 station pairs for NO_2
- 15 station pairs for PM_{10}



- Pair selection criteria:
  - One suburban/rural background station, one urban background station (AirBase)
  - Stations should have better than 90% (NO_2) or 75% (PM_{10}) data completeness for the reference year
  - Should ideally be located within the same regional model cell

Urban increment: Validation

Mean annual urban increments in calibration and validation urban areas



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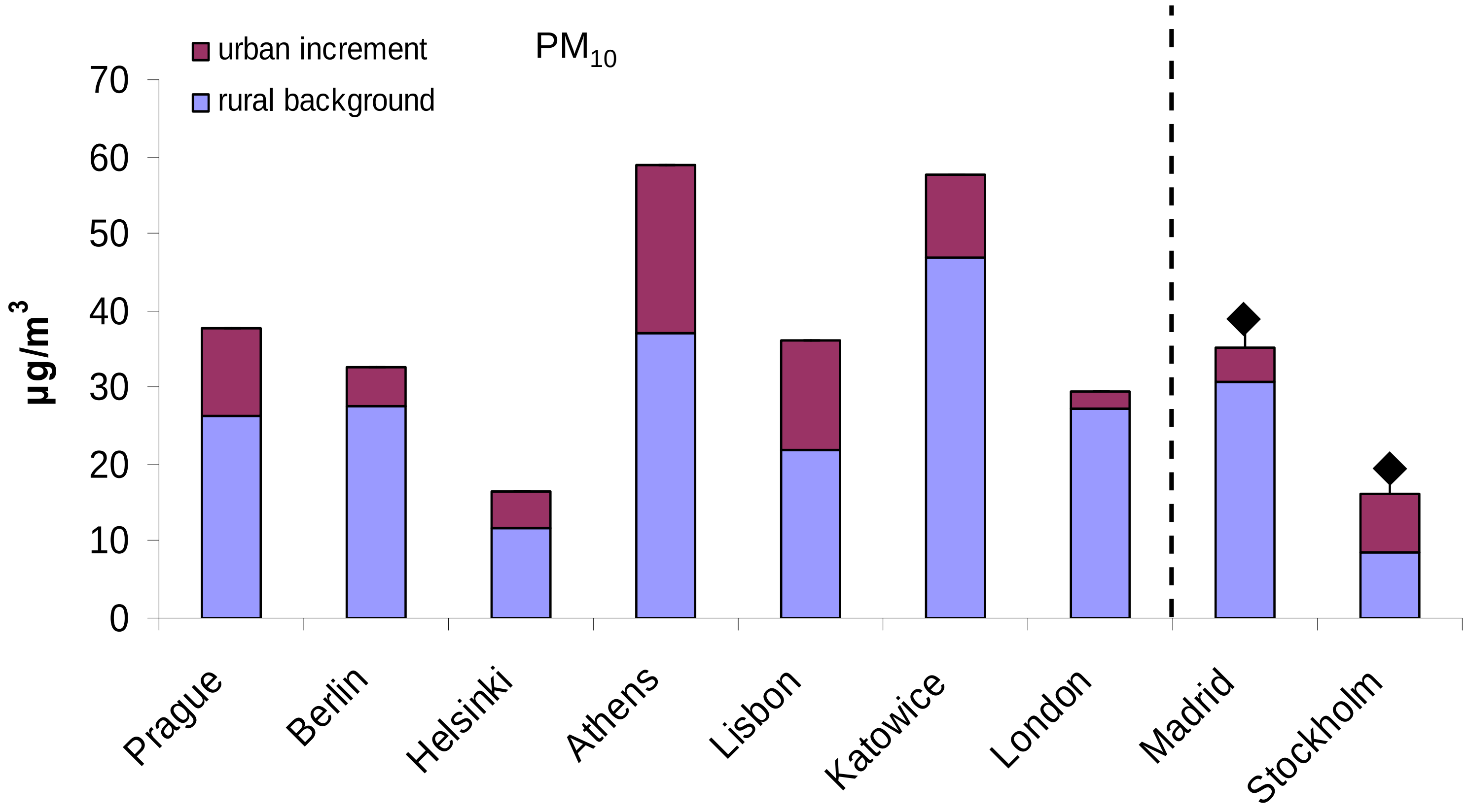
Urban increment: Validation

Mean annual urban increments in calibration and validation urban areas



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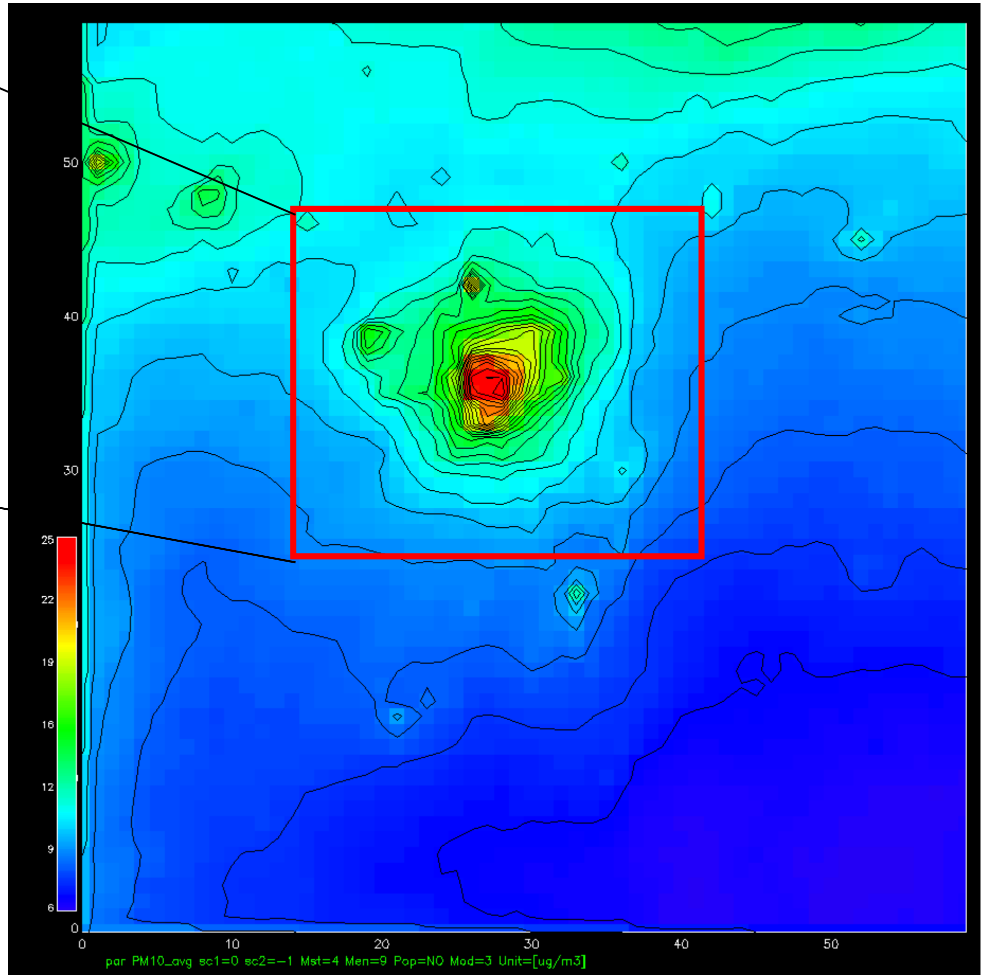
Urban increment:
The use of urban scale models



Yearly mean PM_{10} concentration map for Paris (CHIMERE model)

- Modelled concentrations available from CityDelta results for 8 European cities
- Sample increments were extracted using a central point (yellow) and the averaged concentrations of eight peripheral points (red)

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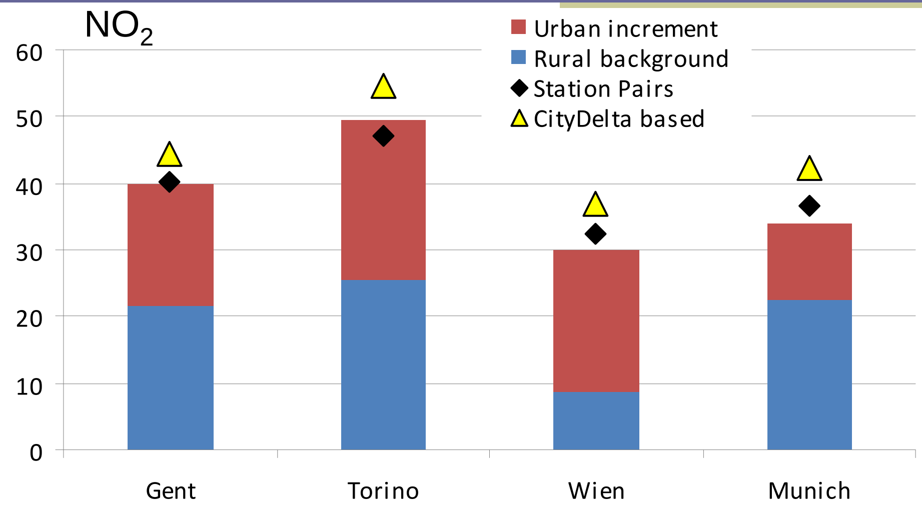
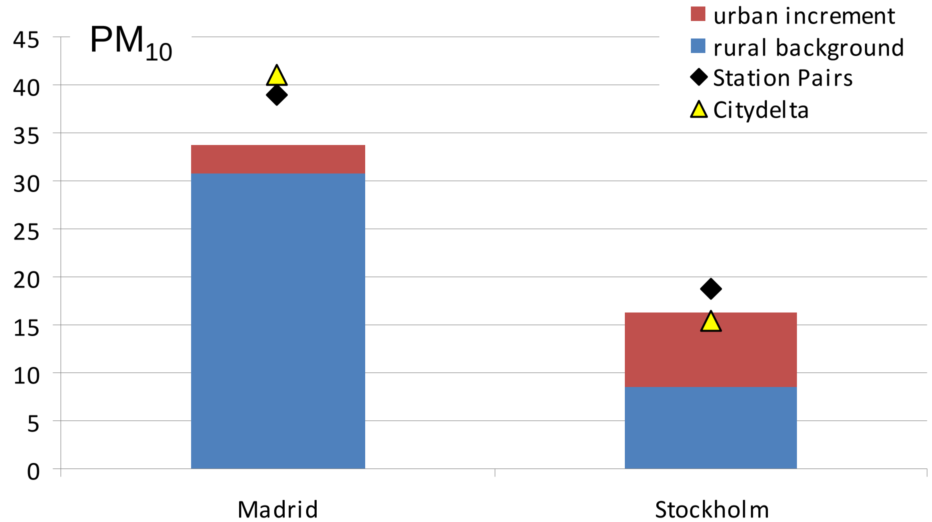
Urban increment:Validation

- Urban scale model results (CityDelta) were used to extract sample increments and the functional relationship
- Calculated concentrations using the UI methodology are evaluated against measurements and "station pairs" approach





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Urban increment: Conclusions and next steps

- The urban increment methodology shows remarkable potential for providing fast but still reliable estimations of urban air quality that can then be used in calculations of exposure or health impact assessment
- Refinement of the methodology and further testing (e.g. for different averaging periods) is required in order to identify possible limitations
- Simplified model calculations such as this should also be tested versus the detailed model calculations
- Aim is for wide applicability, by providing estimates for more pollutants as well as for scenario calculations

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Thanks for you attention!

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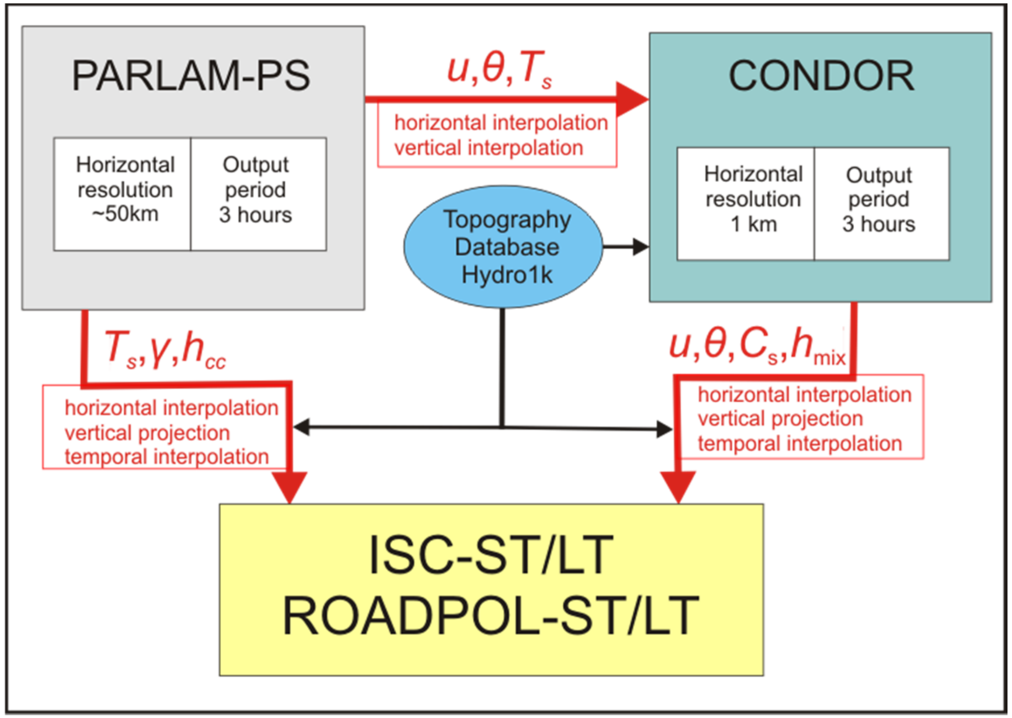
- Additional slides

Meteorological data generator (1/2)

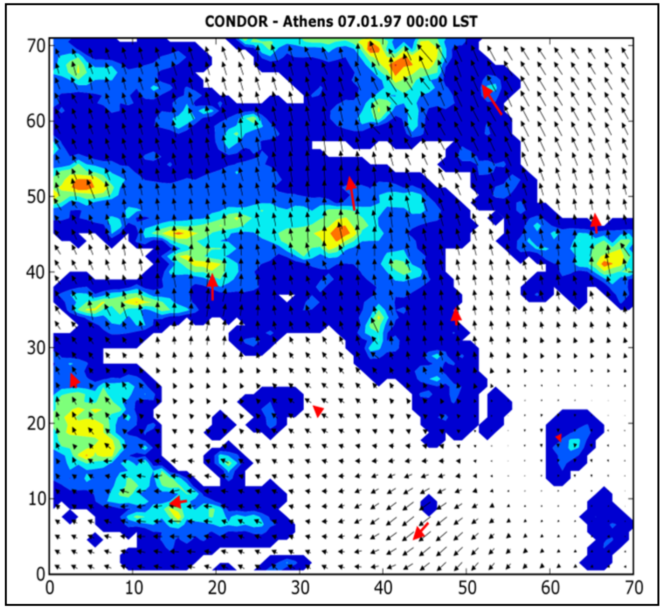
- **Purpose**: development of a tool able to calculate year-long timeseries of meteorological parameters for arbitrary locations in Europe to be used as input data in local scale calculations

- **Methodology**:
  - A diagnostic meteorological model (CONDOR v.5) is fed with vertical profiles for the basic meteorological variables (wind and temperature) coming from the regional model PARLAM-PS. Diagnostic wind models are a suitable compromise between computational efficiency and modeling accuracy.
  - The diagnostic model takes into account the forcing due to local topographical features.

Meteorological data generator (2/2)



The tool is able to generate hourly values of temperature, wind speed and direction, humidity, cloud cover fraction and ceiling height, as well as precipitation.



Any arbitrary location within the EMEP model grid (i.e. most of Europe, parts of Northern Africa) is supported. Currently the tool can generate timeseries for the reference years 1997 or 2003.

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