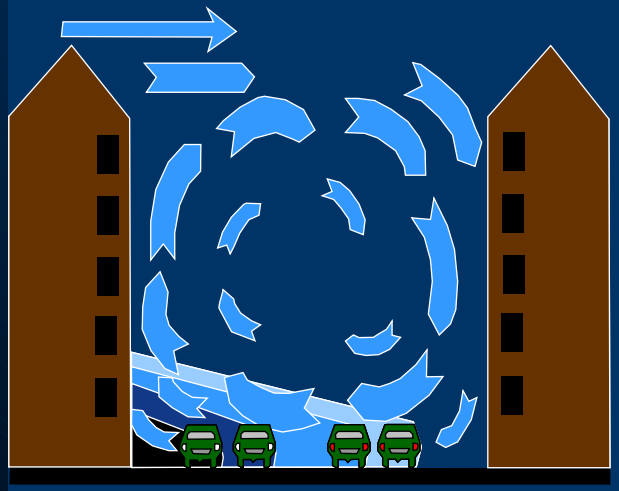
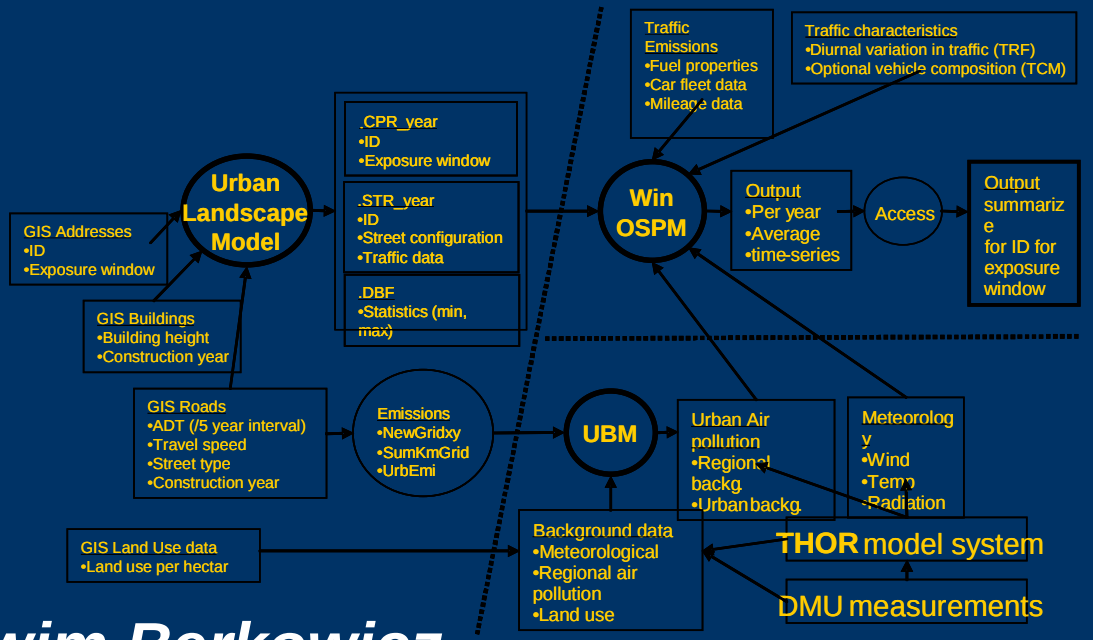
Validation of AirGIS - a GIS-based Air Pollution and Human Exposure Modelling System





Matthias Ketzel, Ruwim Berkowicz, Martin Hvidberg, Steen Solvang Jensen

National Environmental Research Institute, Aarhus University, Denmark,

and Ole Raaschou-Nielsen

Institute of Cancer Epidemiology, Copenhagen, Denmark

Outline

Funding provided by project Airpolife
(Air Pollution in a Life Time Health Perspective)
Danish Centre of Excellence on Air Pollution and Health 2004-2008
http://www.airpolife.dk/

- Introduction
  - Motivation
  - Model description
- Validation
  - sources of error
  - results
    - hourly variation
    - daily averages
    - monthly
- Conclusions

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mke@dmu.dk

Motivation

- **Model estimates are useful for e.g.:**
  - assessment of compliance with air quality standards,
  - for validation and optimisation of emission reduction strategies,
  - for estimation of the personal exposure of groups of individuals in air pollution epidemiological studies
  - for air pollution forecast and information of the public.
- AirGIS system
  - ambient air quality levels with:
    - high temporal resolution – hours
    - high special resolution - address

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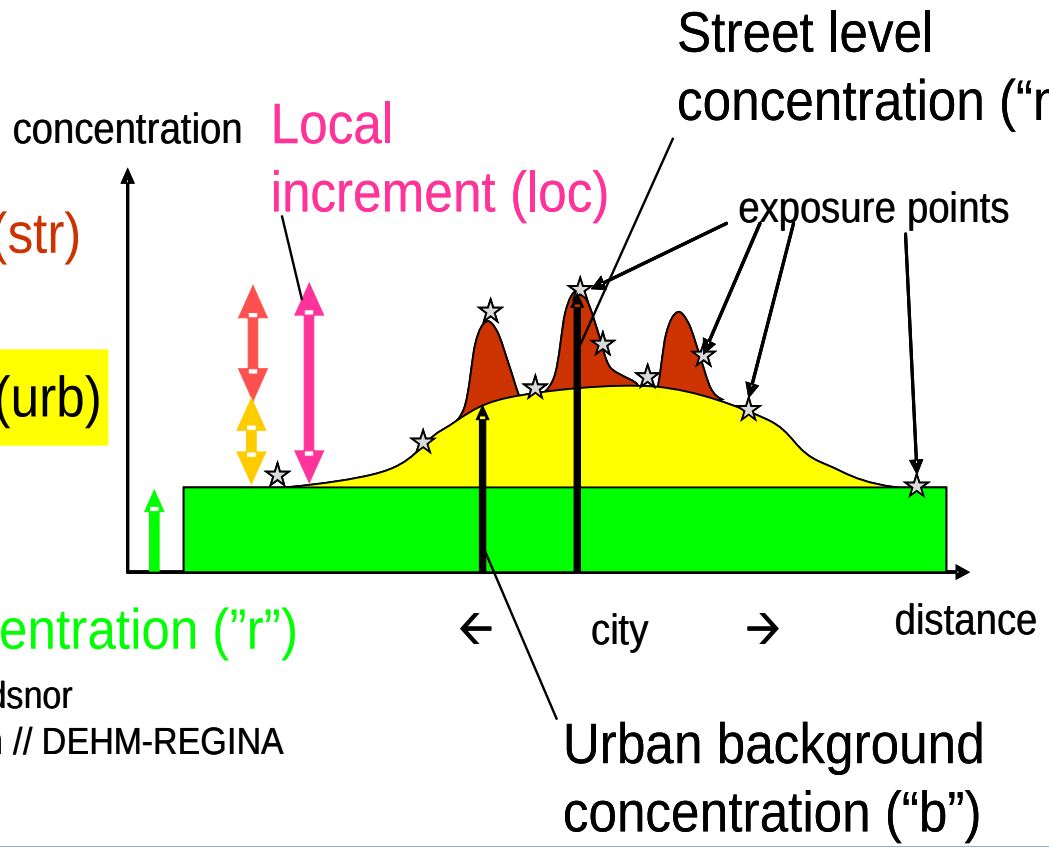
Spatial variation described by AirGIS

- street increment (str)
  modelled by OSPM
- urban increment (urb)
  modelled by UBM or SUB
  (or measurements)
- regional
  background concentration (”r”)

measured at Lille Valby / Keldsnor
or modelled by THOR system // DEHM-REGINA



http://www.dmu.dk/International/Air/Models/AIRGIS

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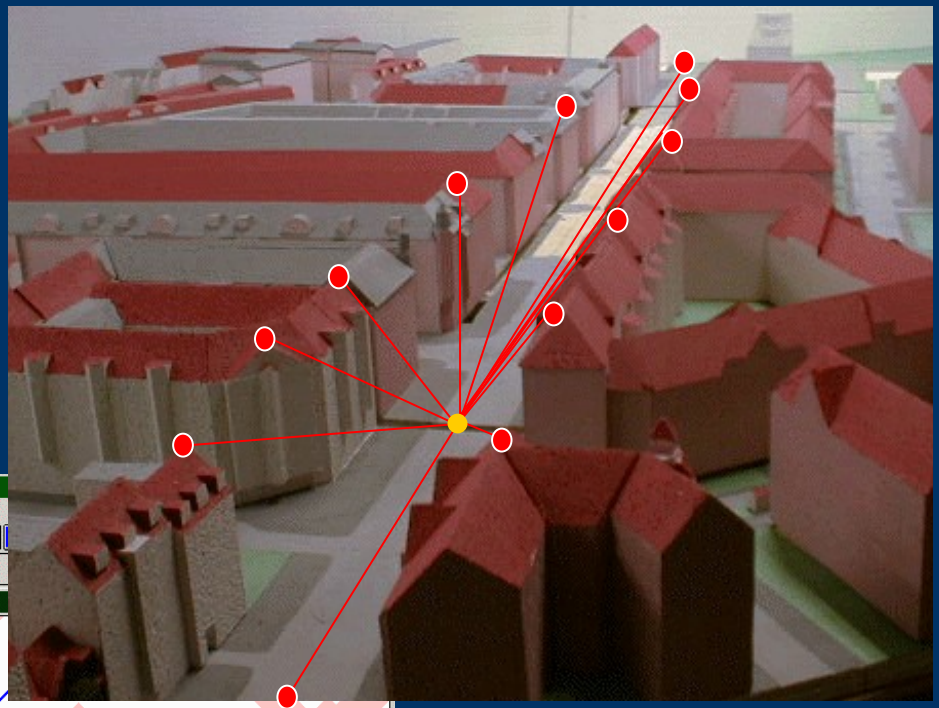
mke@dmu.dk

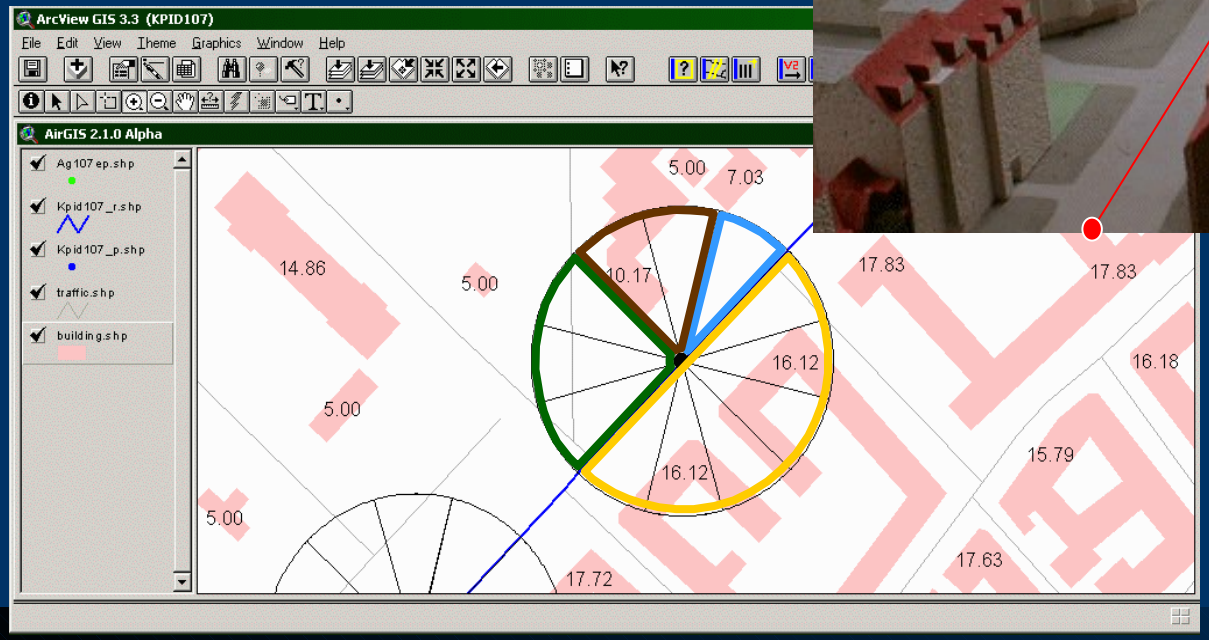
AirGIS

Street Configuration – Describing the local ”horizon”

To allow calculations for different meteorological conditions the building height is determined in 12 discrete intervals, equally distributed on either side of the street.



Modified from Hertel, O. 2006



From: AirGIS

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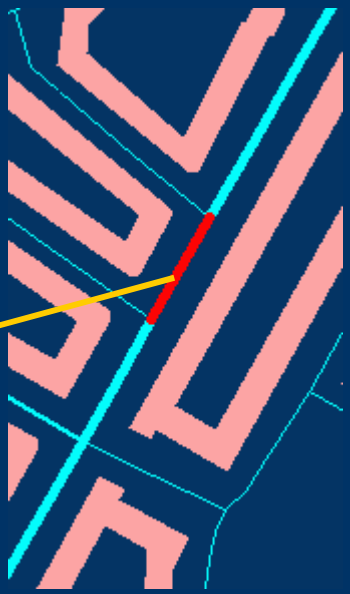
mke@dmu.dk

AirGIS Base data – Traffic

Each street holds information about the local traffic.

ADT: Avg. Daily Traffic (cars/day) in 5-years intervals from 1960 till today.
Road construction year
Street type (A..F)
Allowed speed
Actual speed

Shape	PolyLine
Vejtype	1303
Agtrafcoyr	1917
Agtraalwsp	50
Agtrafsp	40
Agospmstty	D
Agadt1960	18546.40647
Agadt1965	28683.72887
Agadt1970	30202.32134
Agadt1975	26230.53196
Agadt1980	21748.95890
Agadt1985	21190.71562
Agadt1990	21876.95279
Agadt1995	21148.43218
Agadt2000	21046.21609
Agadt2005	20944.00000
Agtraf2dir	1
Agtrafuniq	108551



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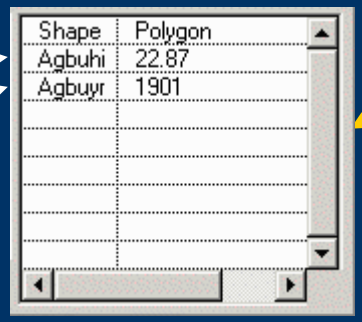
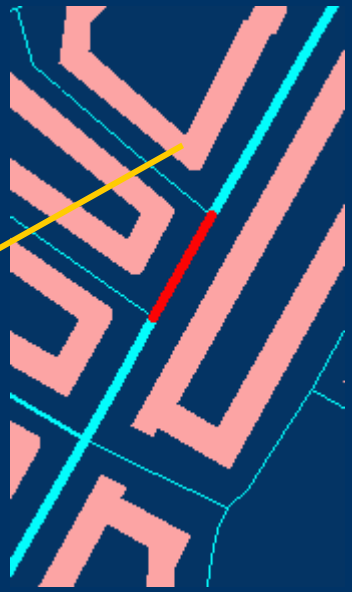
AirGIS Base data – Buildings

Each building holds information about itself.

Building height
Building construction year





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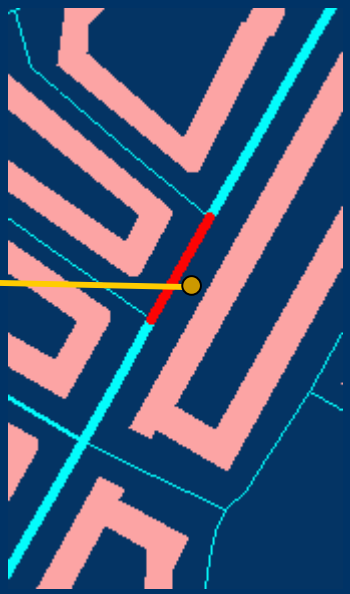
AirGIS Input data – Exposure points

Each exposure point (EP) holds information about itself.

Time start / stop
Receptor height
Transport mode
Person travle speed
Working hours, e.g. 9am – 5pm
Weekend days, e.g. Sat. – Sun.

Shape	Point
Agkpid	10821600040
Agfisotime	2006-09-27 16:02:18
Agtisotime	2006-09-27 16:10:59
Agrehi	0.00
Agtranmo	0
Agperssp	0.00
Agworkfr	0
Agworkto	0
Agwendfr	0
Agwendto	0



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mke@dmu.dk

AirGIS - temporal variation and pollutants

- temporal variation
  - hourly (basic calculation unit)
  - daily averages
  - monthly averages
  - exposure periods (split in max. 1 year parts)
- Pollutants
  - NO_x, NO_2, O_3, CO, benzene, PM_{10} and $PM_{2.5}$
  - NOx and CO for historic emissions back to 1960

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Validation results

- sources of errors
- permanent monitoring stations
  - HCOE (bg), Jagtvej, H.C. Andersens B.
  - annual / daily / hourly
- childhood cancer campaign
  - 204 addresses in Greater Copenhagen area
  - 6 x 4 weeks of NO_2 averages

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mke@dmu.dk

Sources of errors

- **Input data**
  - background concentrations
  - meteorology
  - street configuration (W, H, location of buildings)
  - traffic data (traffic volume, composition)
  - fleet composition (age, technology EURO 1 / 2 etc.)
  - emission factors (g per km, depending on speed)
- **Dispersion model**
- **Front door concentration**

- **correct measure for exposure? right pollutant?**
  - positive relation with health effect
    -> still might be right for wrong reason
  - no correlation found -> still method might be OK, just an error in some data, or one of the many steps

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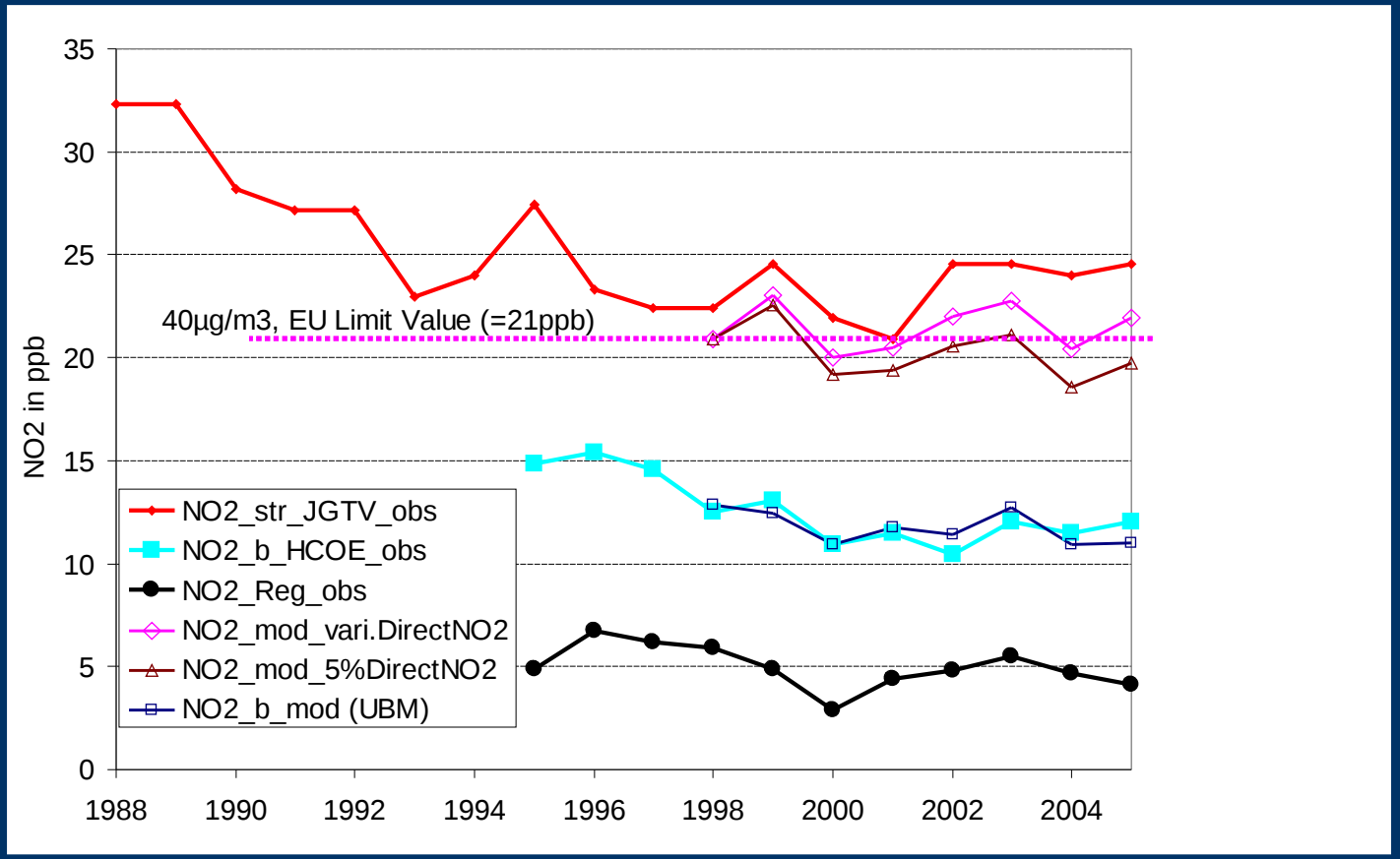
Validation results – annual means for NO_2

- JGTV – Jagtvej, Copenhagen, HCOE - urban background
  Reg - regional background
- 'Obs' – observations, 'mod' - model results.



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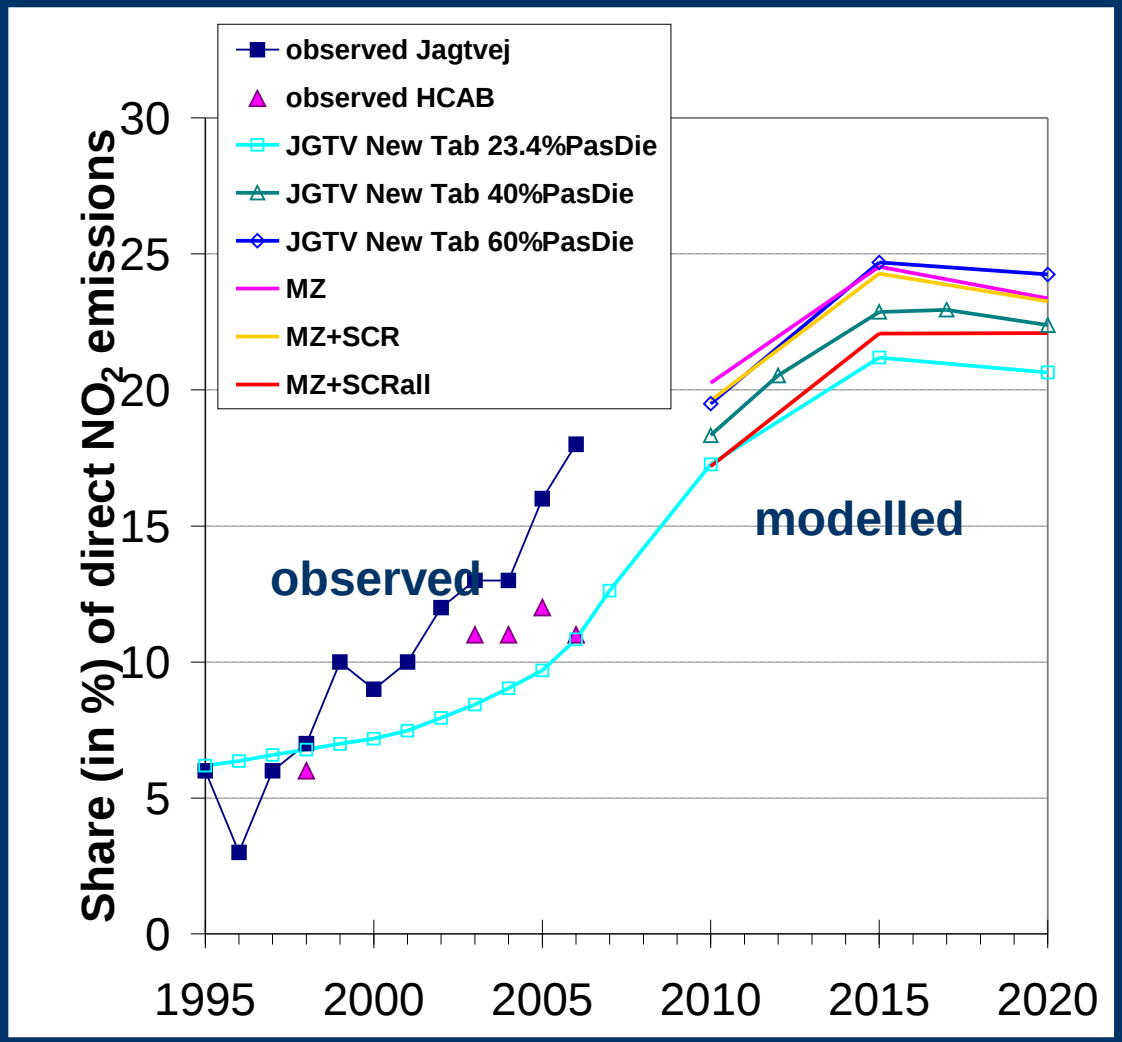
Share of direct NO_2 emissions is increasing



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Share of direct NO2 emissions is increasing

- Direct NO_2 emissions (% of NO_x) from different vehicle classes, based on literature data
- earlier 3-15% , now up to 45% due to CRT particle filters

red: COPERT	Før EURO	EURO I	EURO II	EURO III	EURO IV	EURO V	EURO VI
Benzin personbiler	4 3	4 5	4 5	3 5	3 5	3 5	2 5
Diesel personbiler Taxi	11	11	11	25	55	5-70	5-70
Diesel varebiler	15	15	15	30	40	40	20
Diesel lastbiler Diesel busser	1 8	11 8	11 8	14 8	14 45	10 20	10 20

35(+CRT)

Sources: COPERT 4 Handbook Aug. 2007,
U. Lambrecht IFEU 2008

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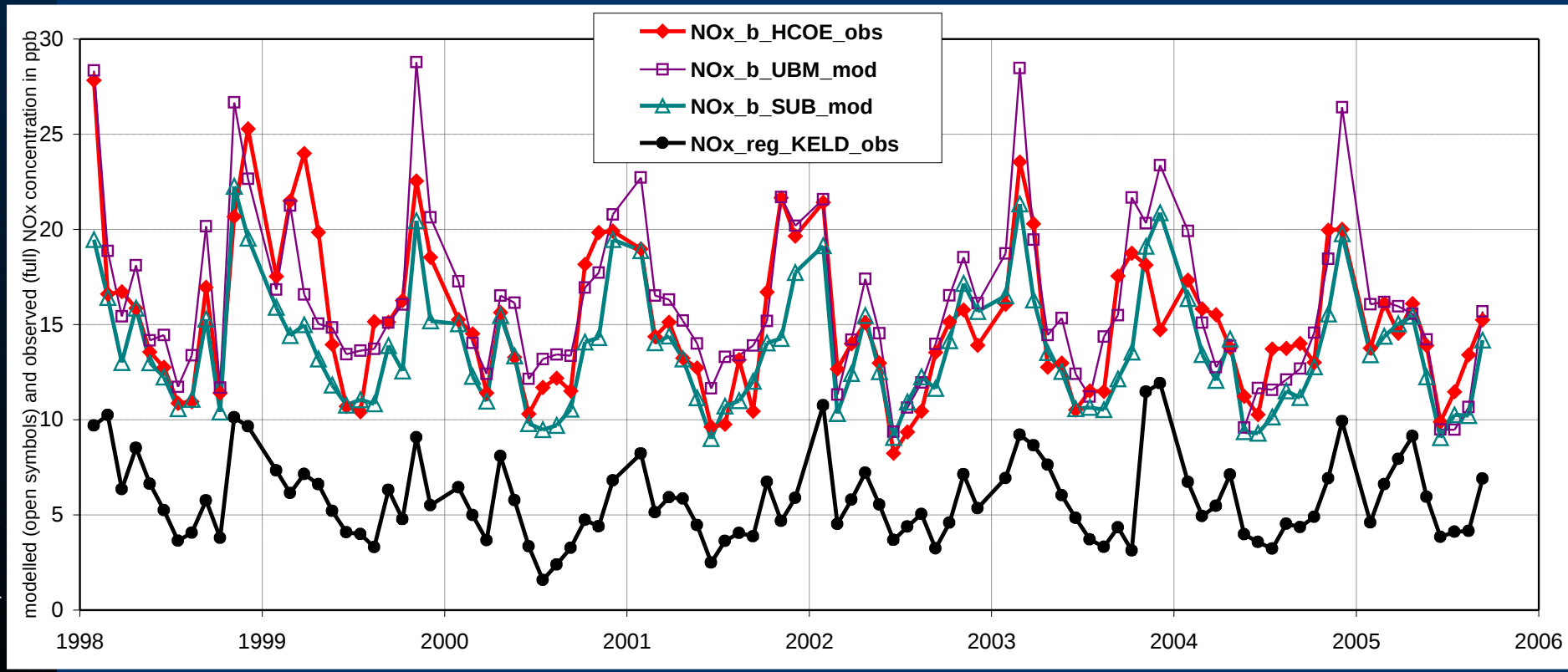
Validation results – monthly means

- performance of the two background models
  - Urban Background Model (UBM)
  - simplified urban background procedure (SUB)



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Validation results - statistics

- monthly means (ppb) during 1998-2005
- Av= average, CoV= coefficient of variation
- Corr (R) = correlation coefficient R, model vs. observed

Location	Method	NOx			NO2			O3			CO		
		Av	CoV	Corr(R)	Av	CoV	Corr(R)	Av	CoV	Corr(R)	Av	CoV	Corr(R)
Keldsnor	r_obs	5.7	0.38		4.8	0.41		30.2	0.26				
THOR	r_mod	7.1	0.17	0.71	6.3	0.17	0.60	26.0	0.27	0.92			
HCOE	u_obs	15.1	0.26		11.8	0.20		25.1	0.27		0.28	0.24	
HCOE	u_UBM (r_obs)	16.1	0.27	0.84	11.9	0.19	0.80	23.9	0.34	0.93	0.19	0.20	0.80
HCOE	u_SUB (r_obs)	13.6	0.23	0.79	10.8	0.19	0.75	24.8	0.32	0.92	0.28	0.16	0.82

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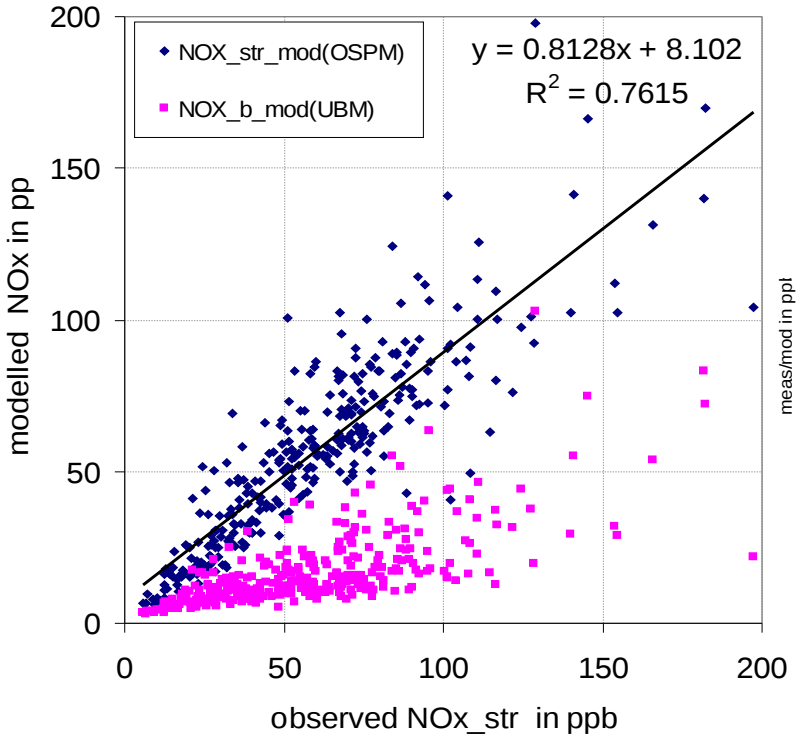
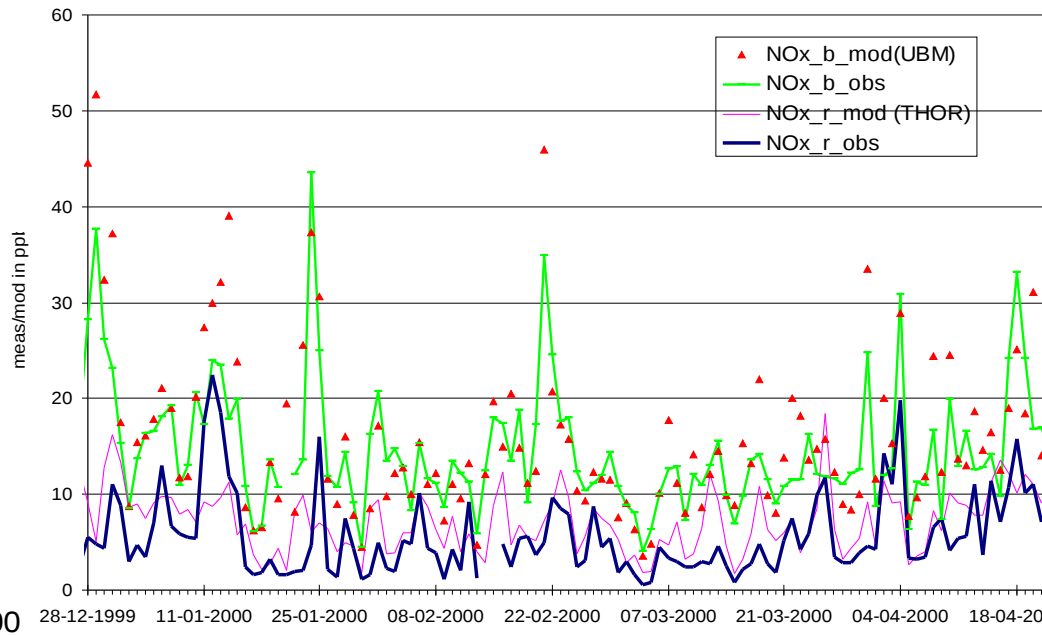
Validation results – daily means

- daily street concentrations of NOx, 2003, mod vs. obs
- (modelled background)
- Time-series, mod and obs daily urban background NOx concentrations





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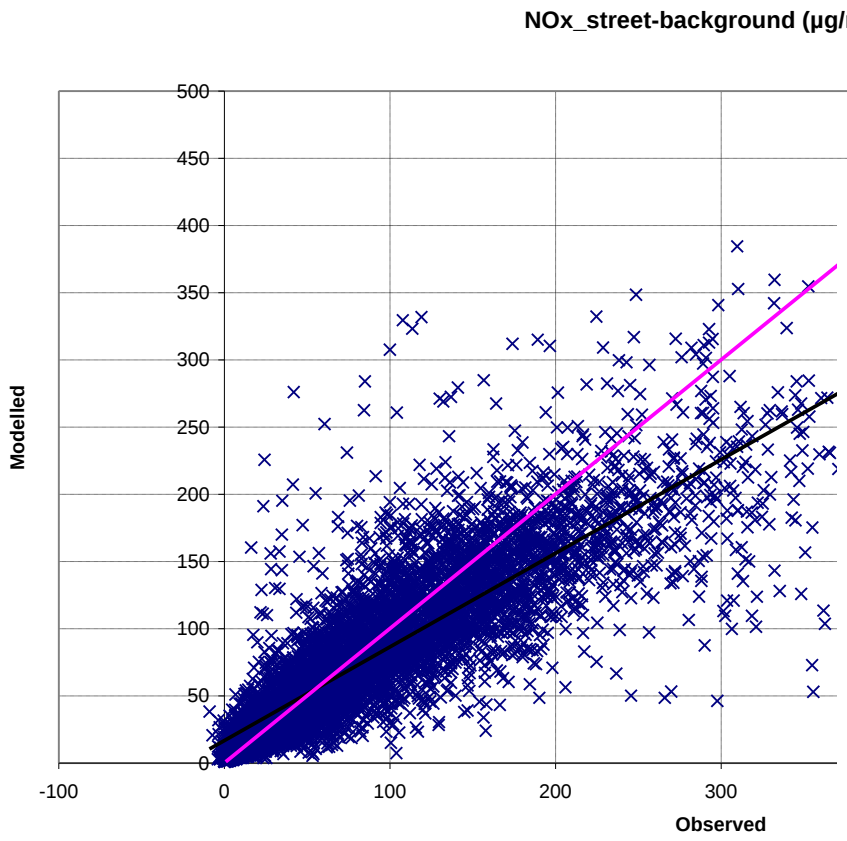
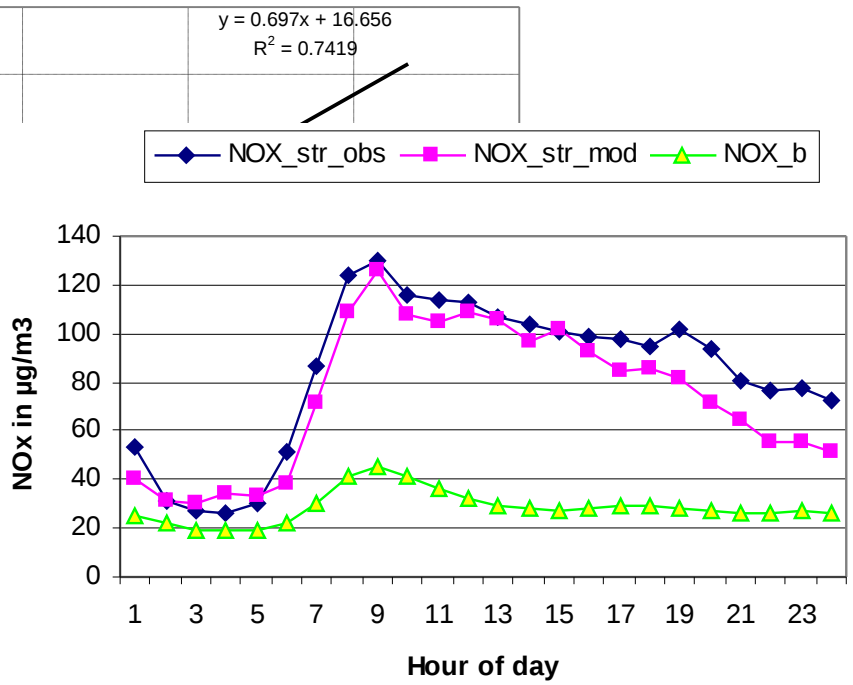
Validation results – hourly data

- scatter plot
- average diurnal variation





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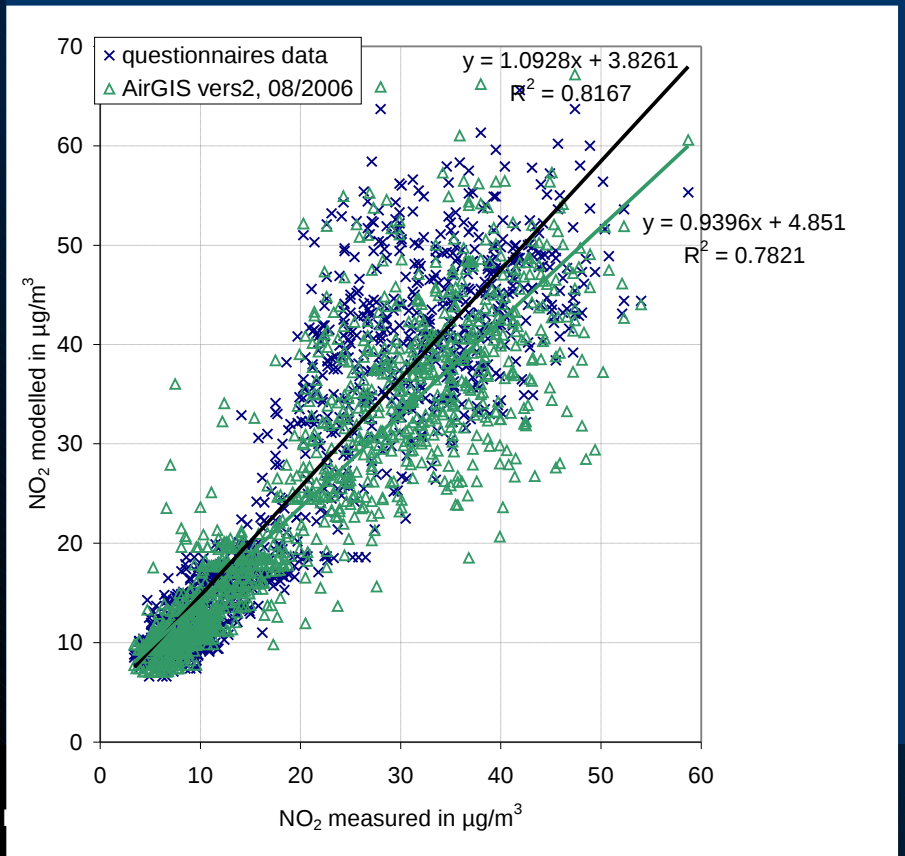
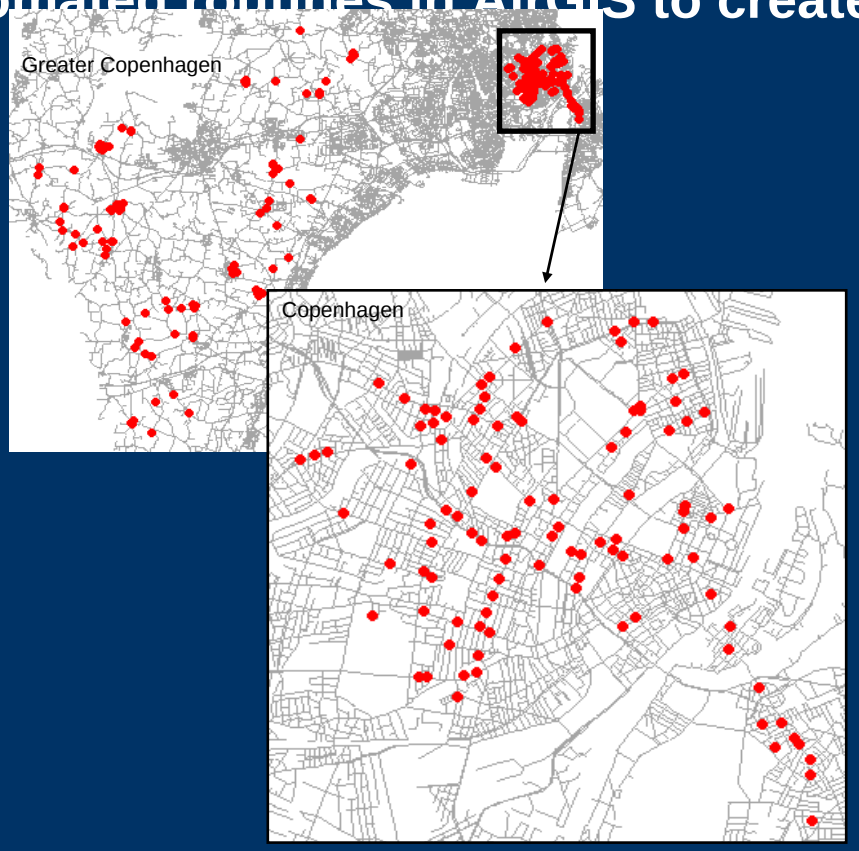
Validation results – 204 streets

- Childhood Cancer project (Raaschou-Nielsen et al. 2000)
- each street 6 x 4 weeks passive sampled NO_2
- model results from 2000 based on input data from questionnaires
- new calculations using the automated routines in AirGIS to create the input data





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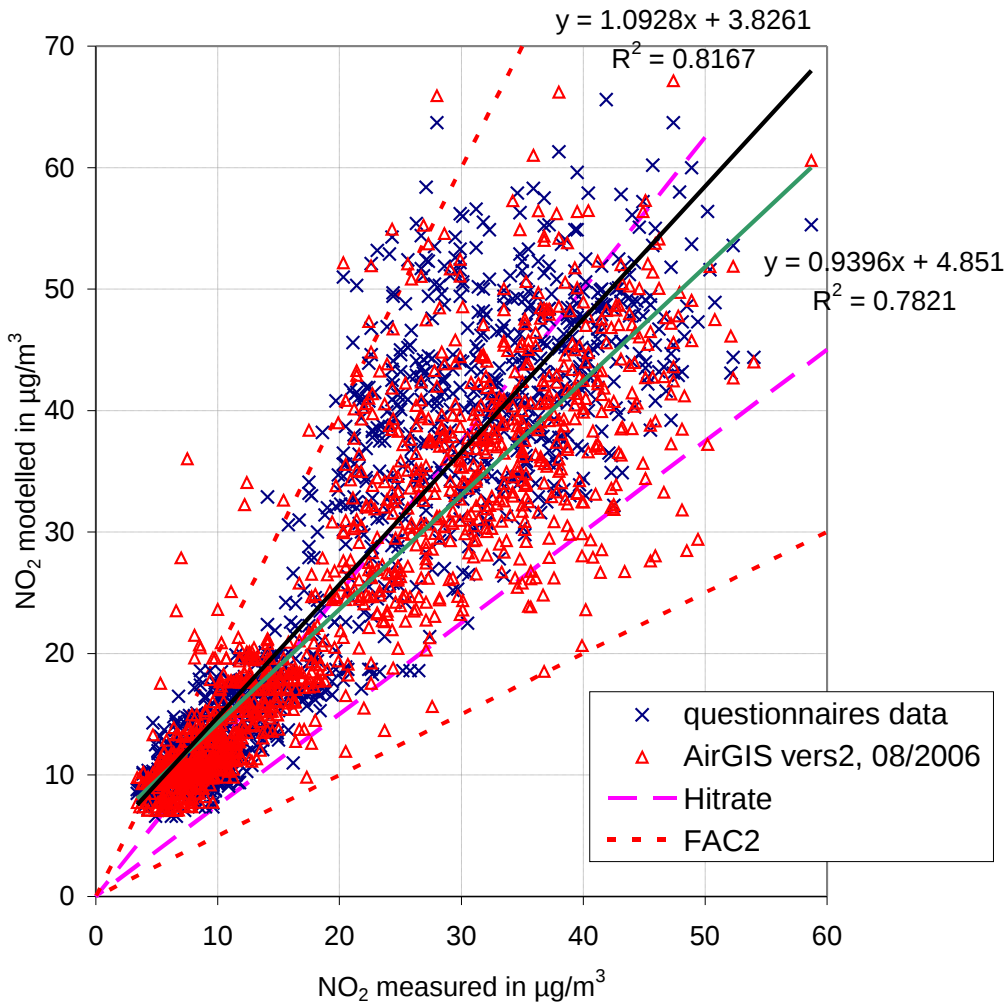
Validation results – 204 streets

- **Childhood Cancer project (Raaschou-Nielsen et al. 2000)**



	Hitrate	Fac2
question.	0.453	0.952
AirGIS	0.536	0.951

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Other examples for AirGIS application

- Geograpgic distribution of exceedances of NO2 limit value
- exposure to air pollution during travelling

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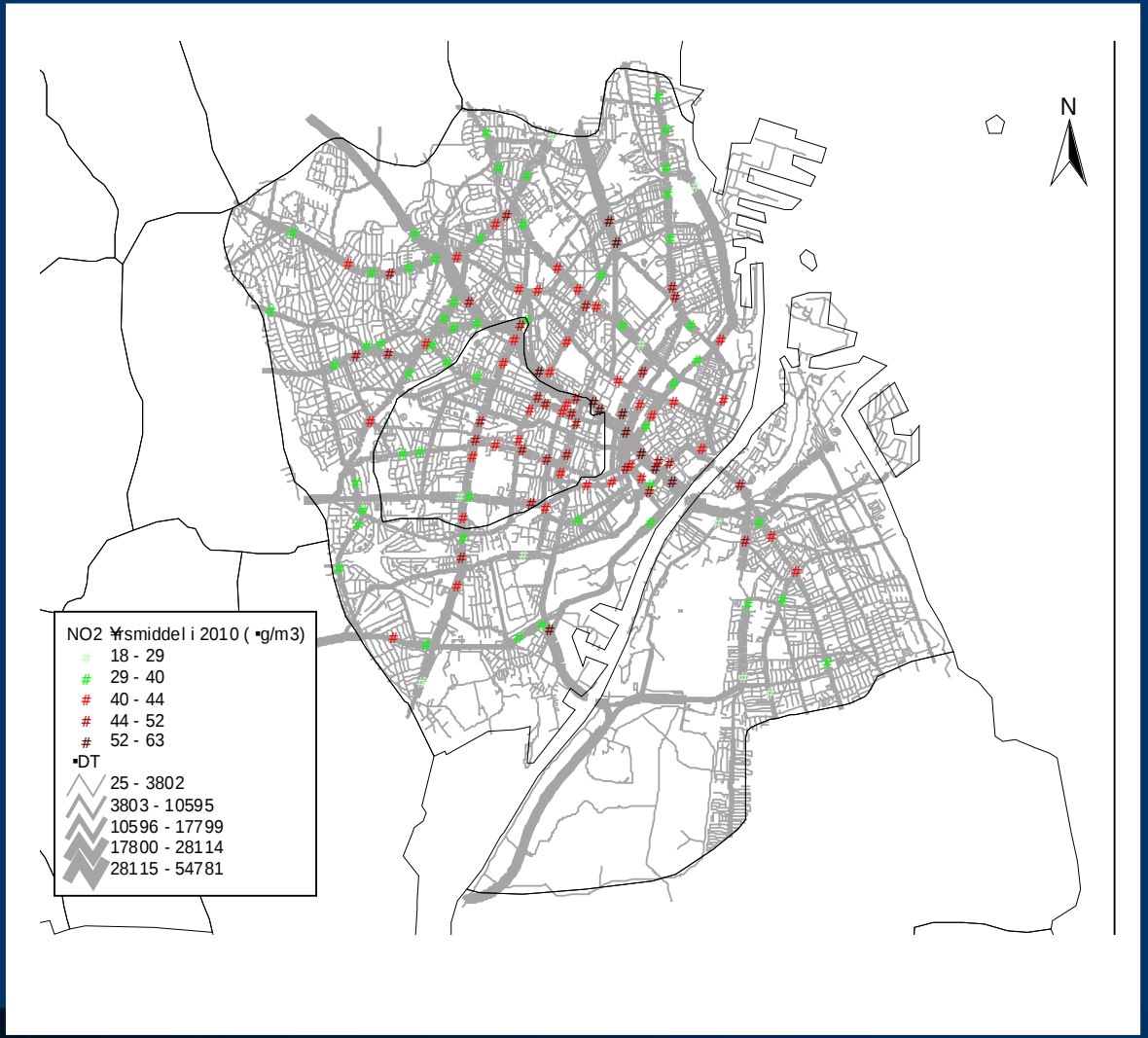
Geographic distribution of exceedances

- About 80 exceedances of NO_2 limit value out of 138 streets in 2010



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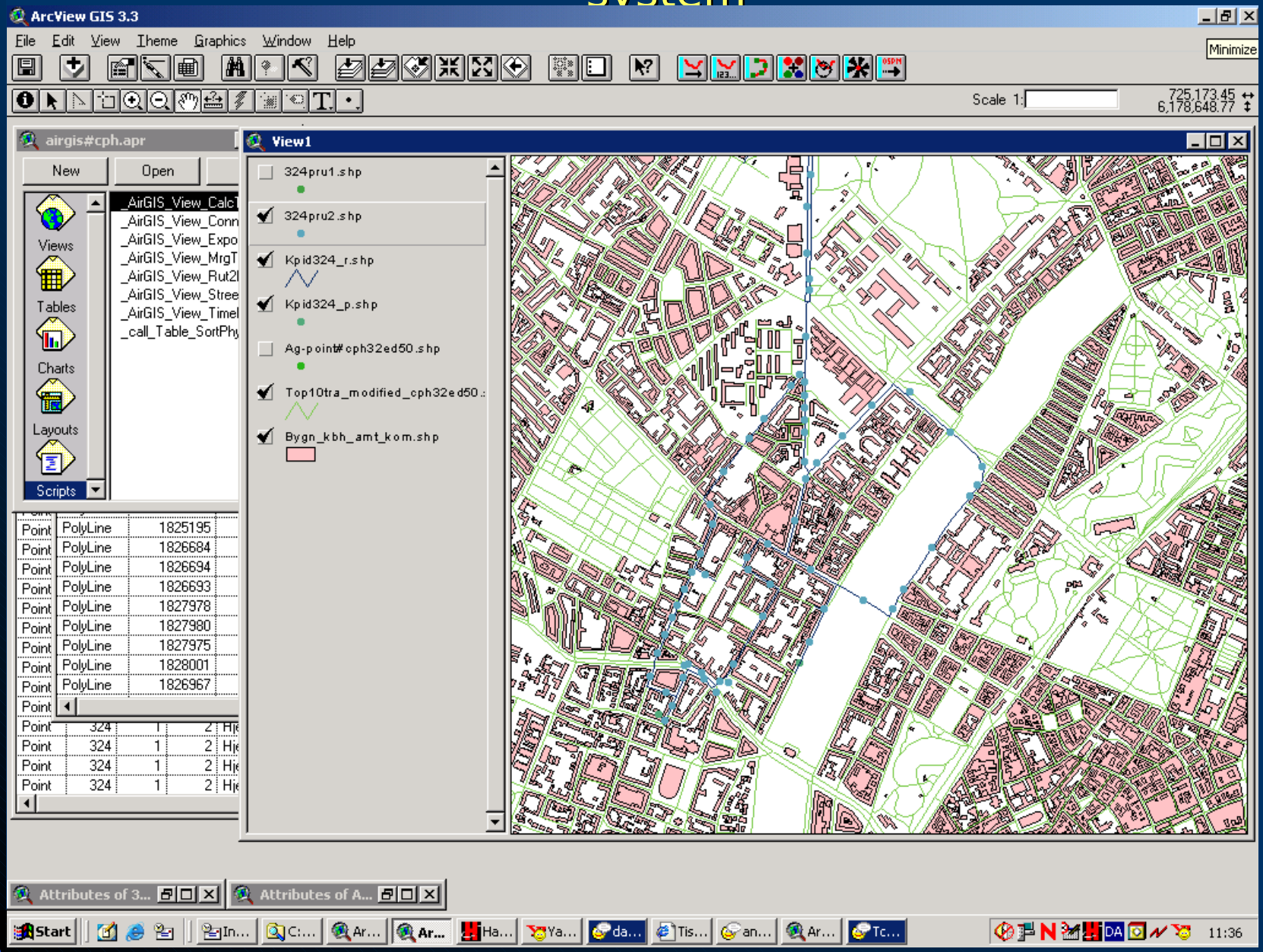
Calculation of Air pollution along a route in AirGIS system



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mke@dmu.dk

Conclusions

- The air pollution and human exposure modelling system, AirGIS, has been validated against observations at permanent monitoring locations. The system shows a good performance for long-term averages (annual and monthly averages).

- AirGIS also performs well for short-term averages (hourly and daily).
  - High correlation coefficient 0.84 and 0.79 for NOx, for UBM and SUB respectively.
  - Also for other pollutants the background models show high correlations and reproduce both the averages and the variation in the data expressed as coefficient of variation (CoV= ratio of standard deviation and average).

- **AirGIS is therefore well suited for air pollution and exposure assessment in epidemiological studies.**

National Environmental Research Institute, University of Aarhus mke@dmu.dk