

COMPARISON OF EXHAUST AND NON-EXHAUST EMISSION FACTORS IN NORTHERN EUROPE

SMHI , 4-5 October 2005

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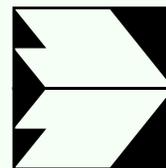
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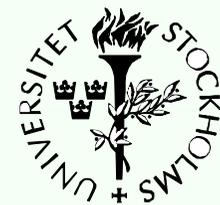
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DMU : Danmarks Miljøundersøgelser

National Environmental Research Institute of Denmark

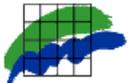


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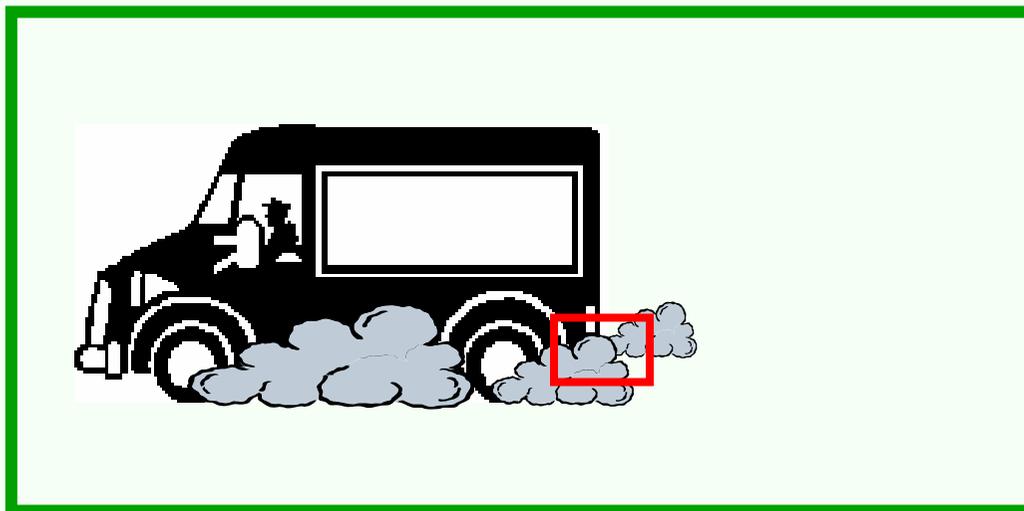
Vehicle PM emissions - exhaust

- Emission databases (HbEfa, COPERT, ..) rely on laboratory test bench measurements
- focus so far on the exhaust pipe emissions



Vehicle PM emissions - non-exhaust

- substantial part of the emissions comes from non-exhaust:



- need for field studies to estimate the emissions at: road tunnel, street canyon, highway, etc. using: NO_x / C as tracer or 'inverse' modelling

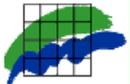


Particle sources

- primary emissions
 - exhaust emissions
 - tyre wear
 - road wear
 - brake wear
 - clutches
 - ...
- re-suspension of road dust and other deposited primary emissions

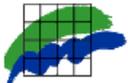
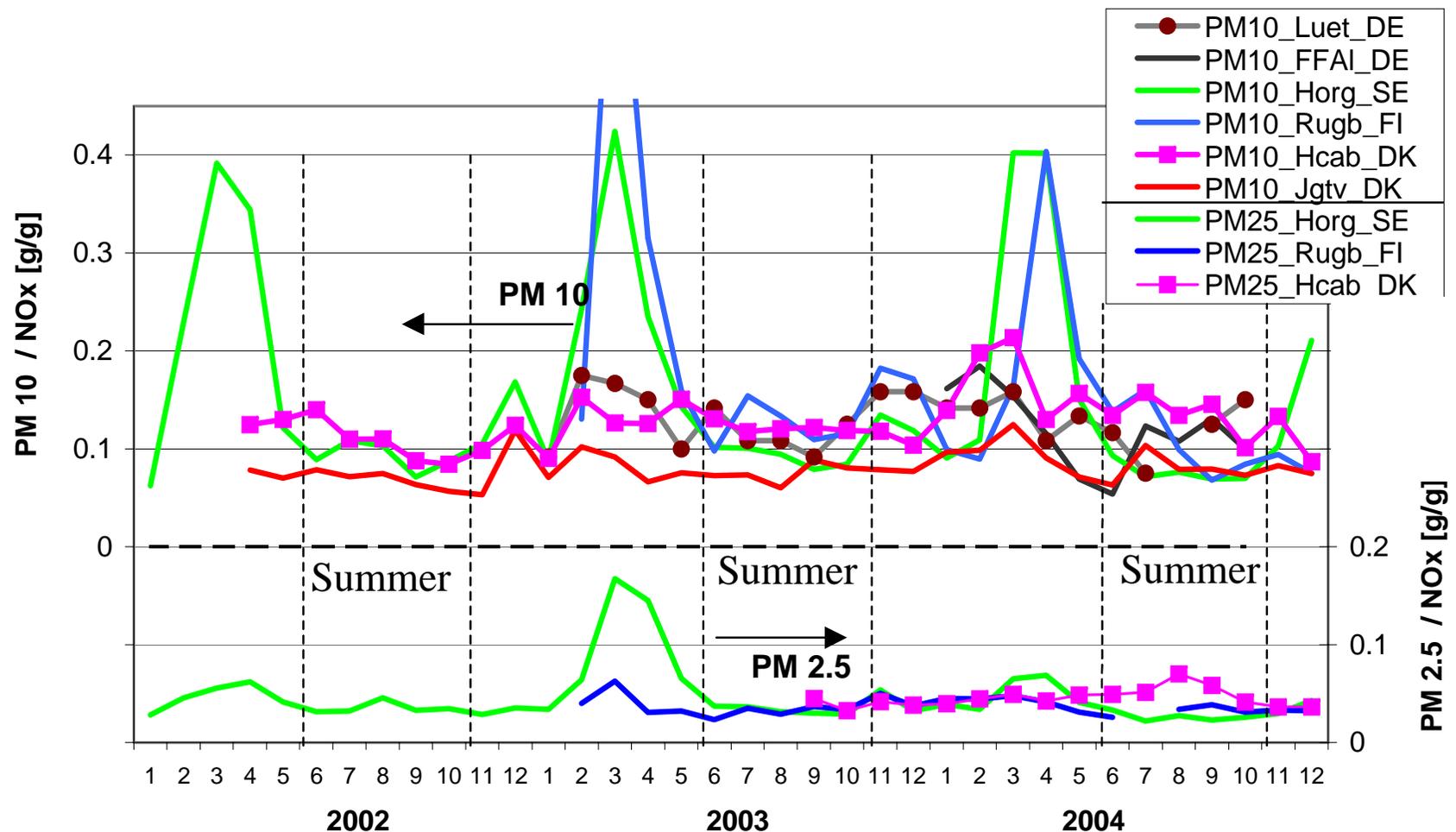
Influencing factors

- vehicle type
 - diesel // gasoline
 - brake type
- tyre type
 - summer // winter
 - studded tyres
- road surface type / condition
 - sanding
 - salting
- weather conditions
 - rain, snow, ice



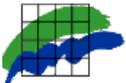
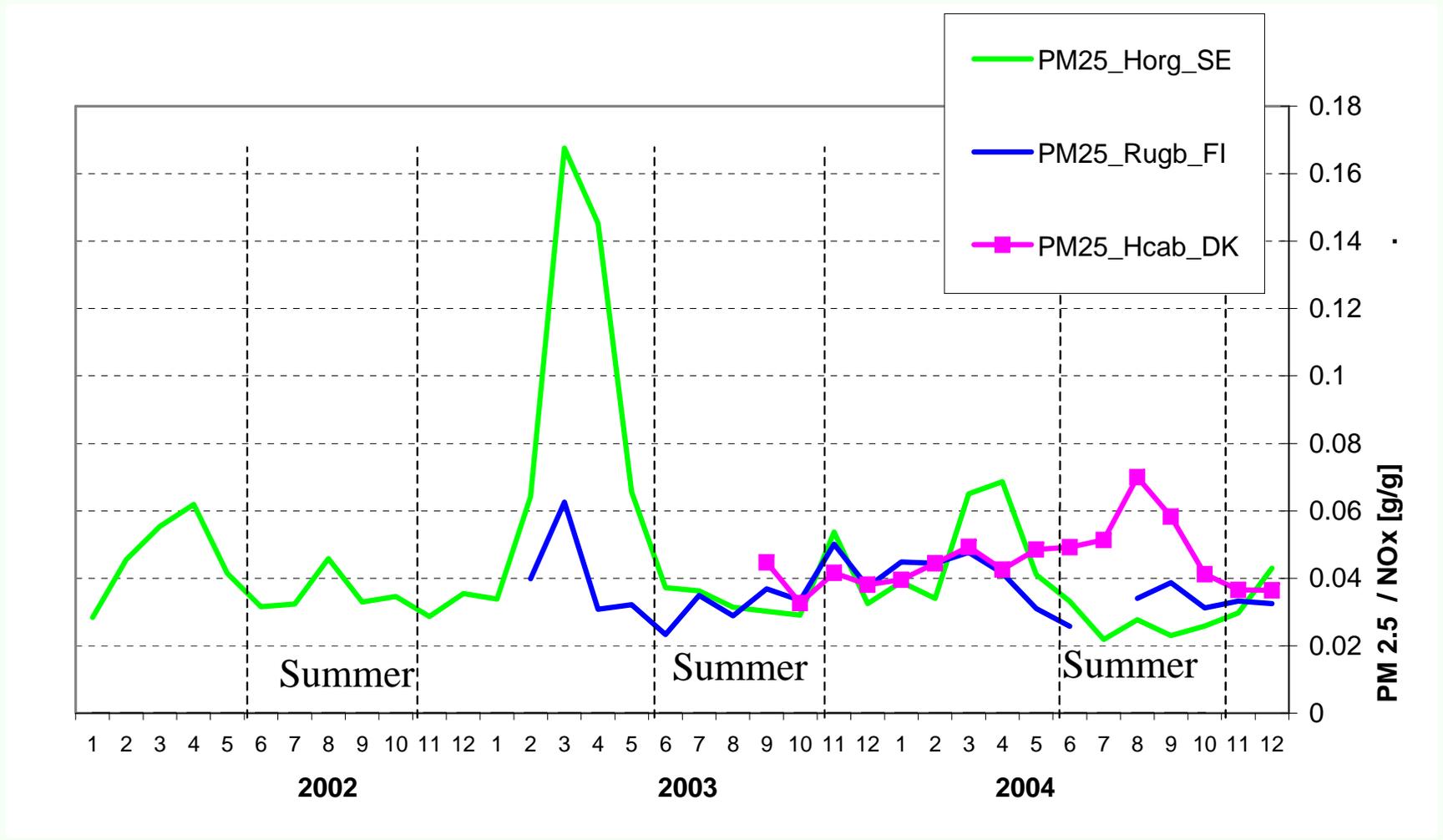
Measured variation of PM /NO_x ratios

- street contribution only (background subtracted)
- direct TEOM results - no correction factor



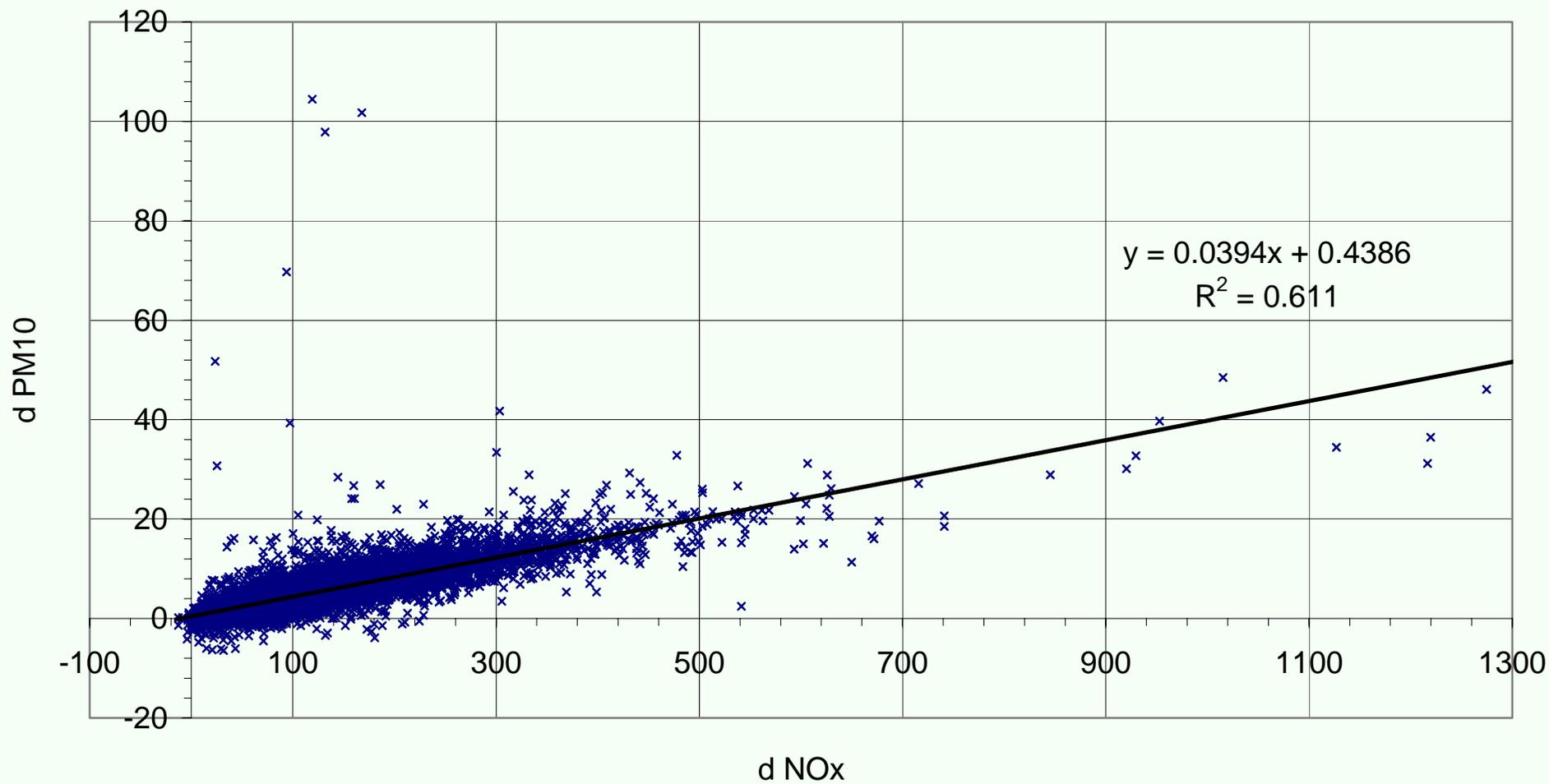
Measured variation of PM_{2.5} / NO_x ratios

- street contribution only (background subtracted)
- direct TEOM results - no correction factor



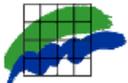
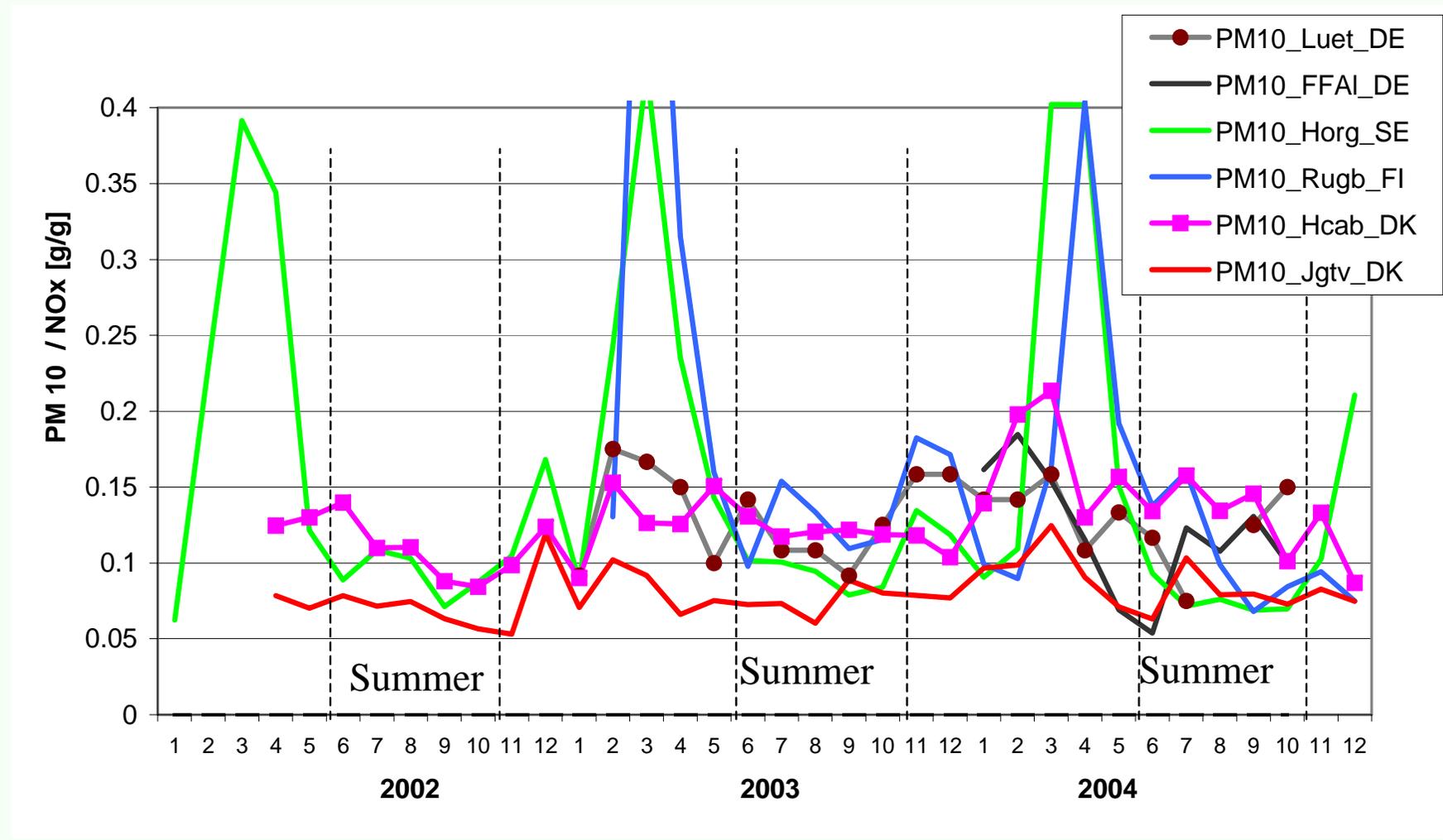
HCAB - PM2.5 all data 09/2003 - 2004

× HCAB_PM25str



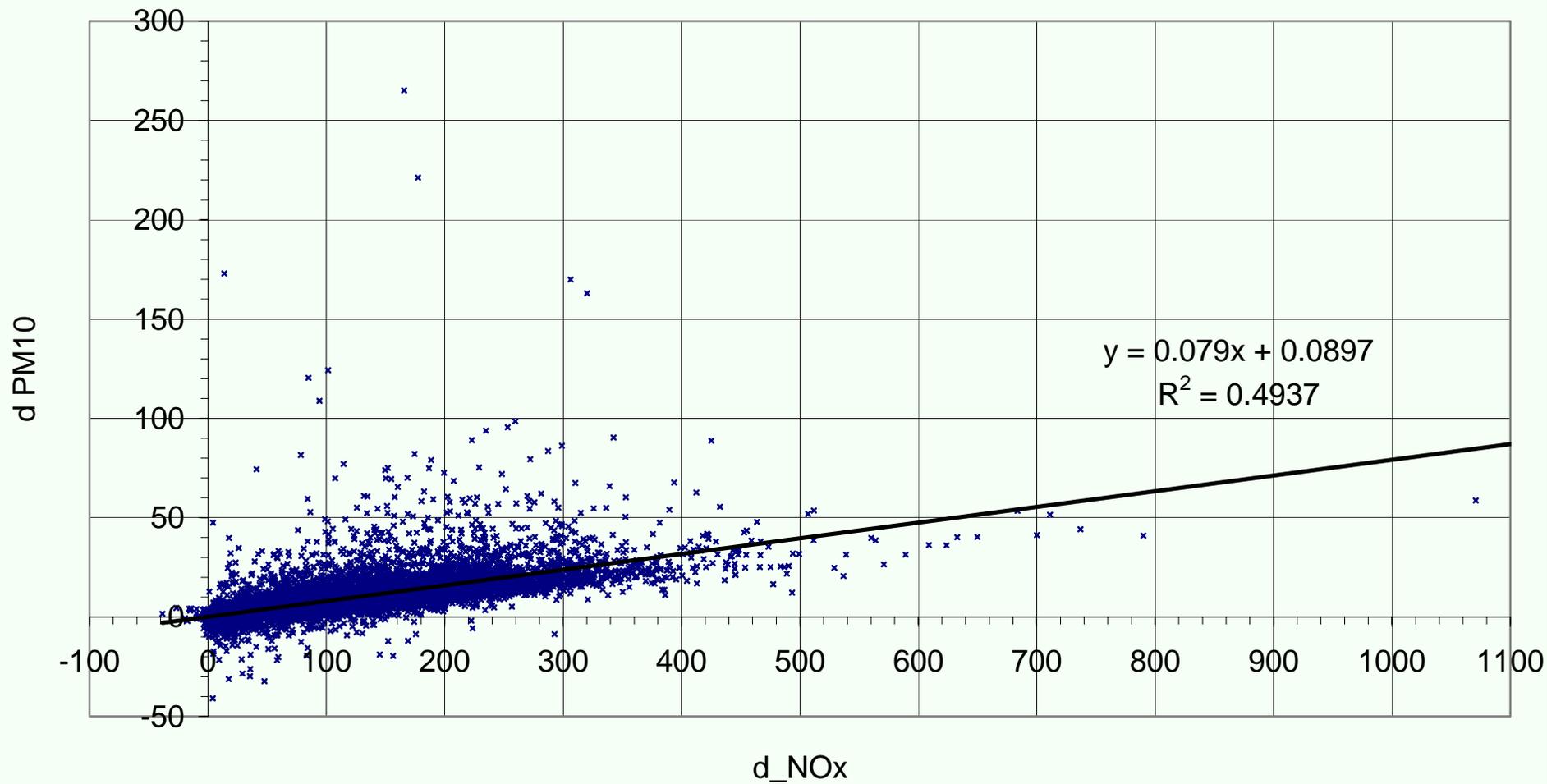
Measured variation of PM10 / NOx ratios

- street contribution only (background subtracted)
- direct TEOM results - no correction factor



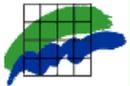
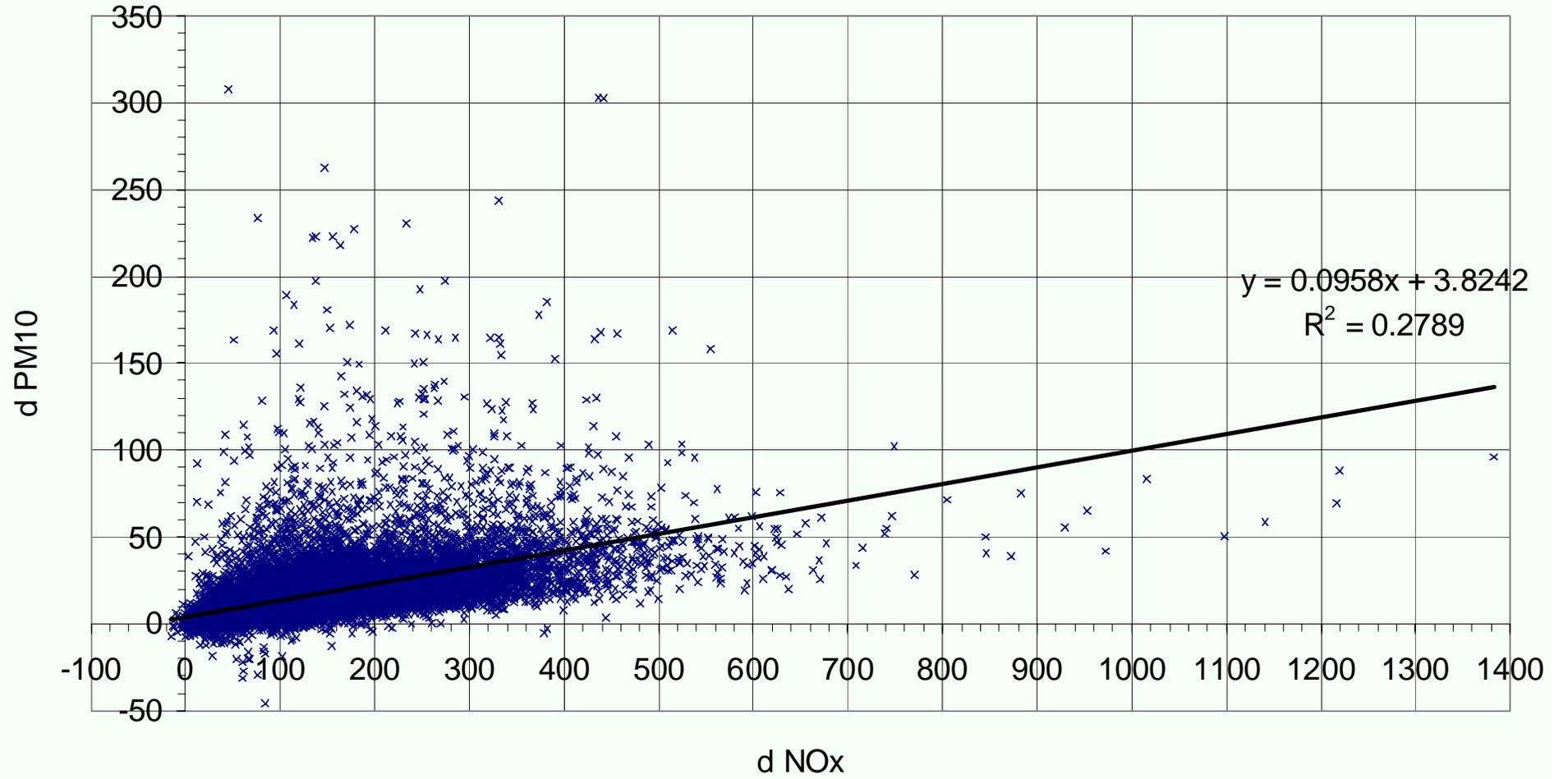
Jagtvej - PM10 all data 2002-2004

* JGTV_PM10str



HCAB PM10 all data 04/2002 - 2004

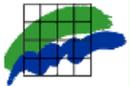
× HCAB_PM10str

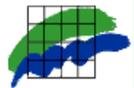
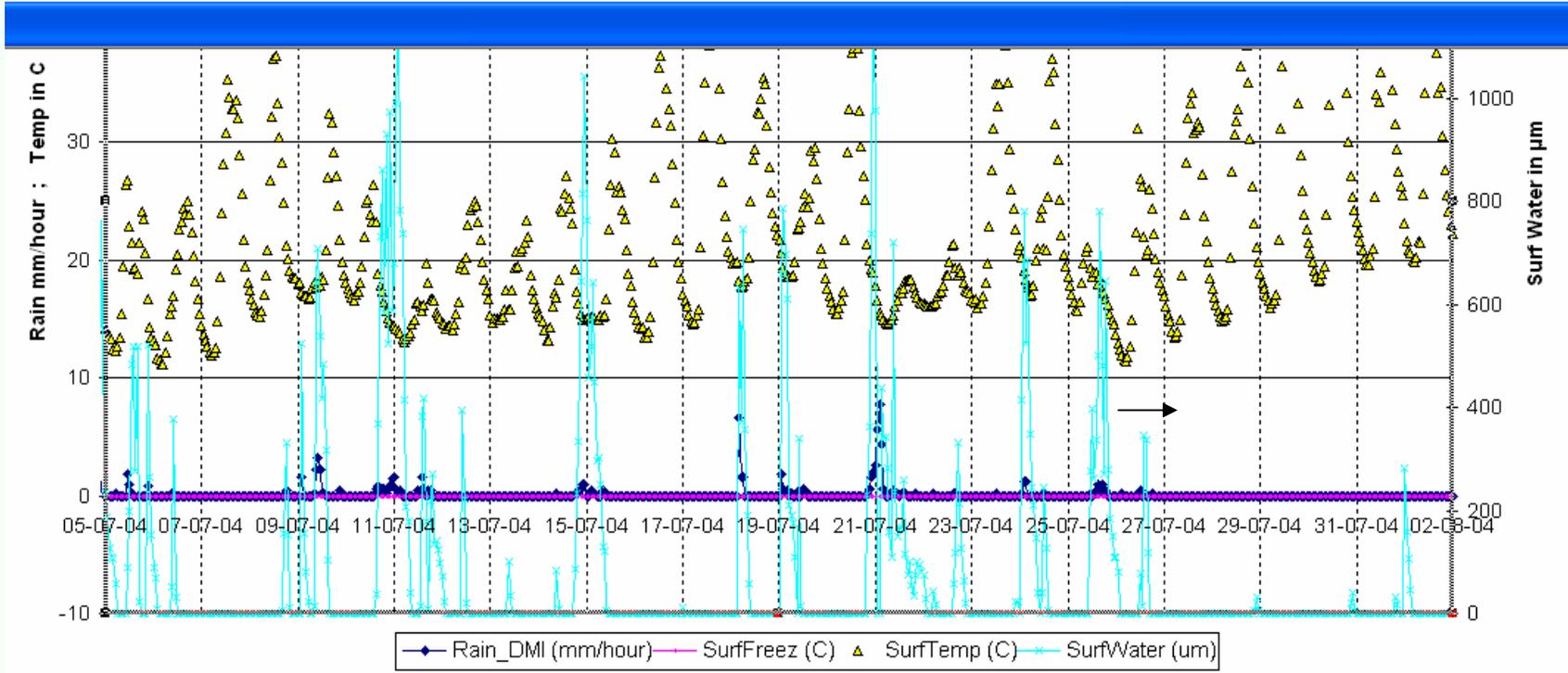
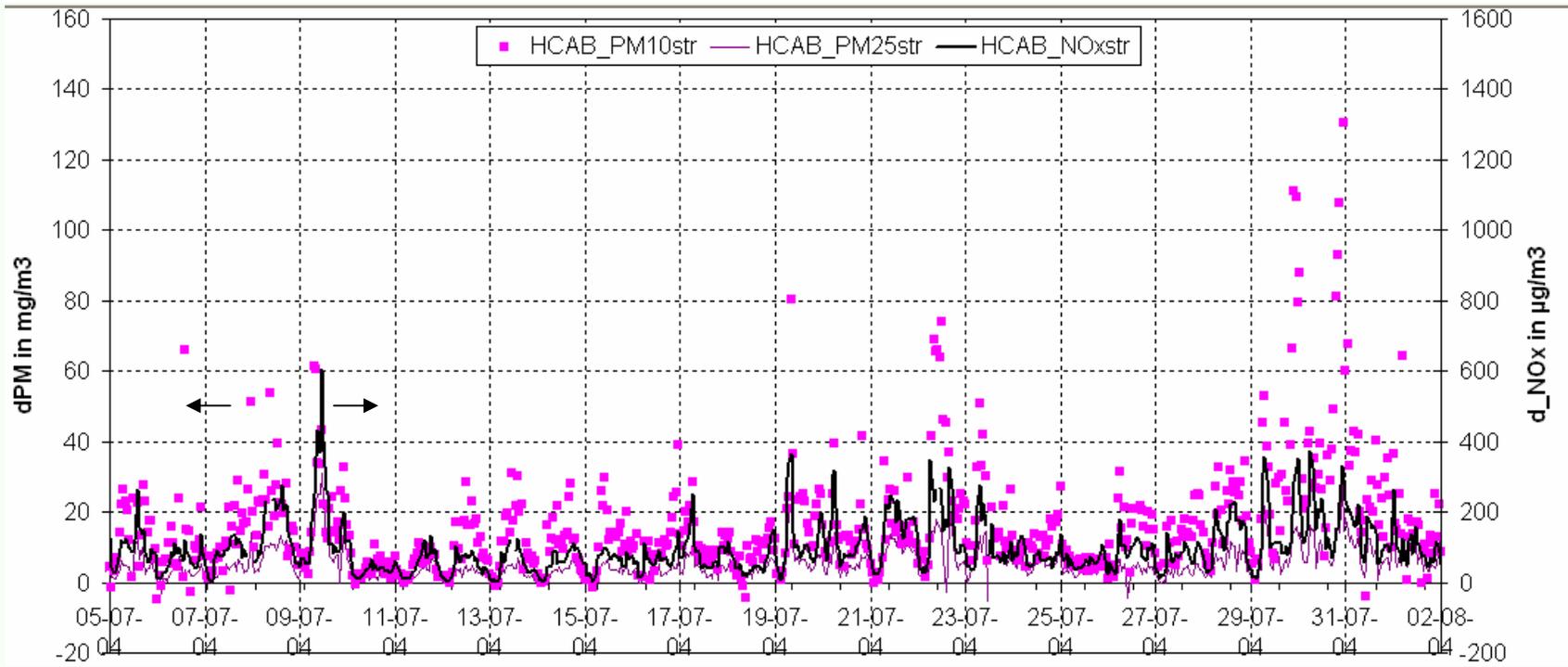


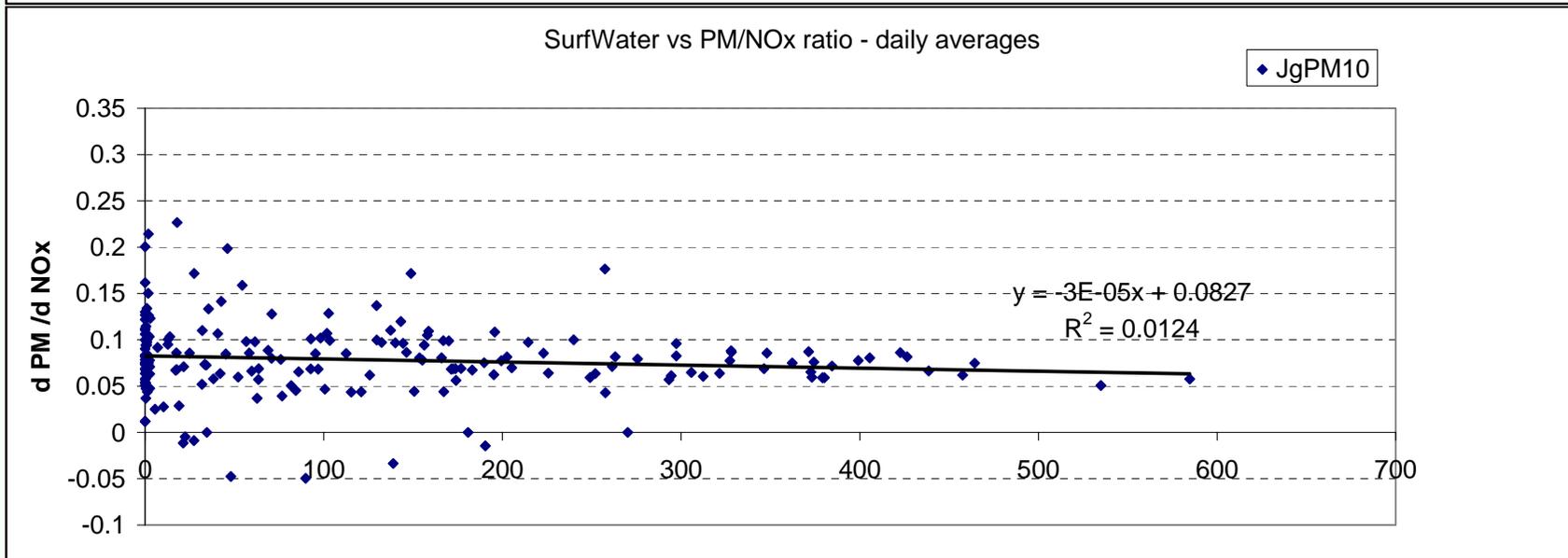
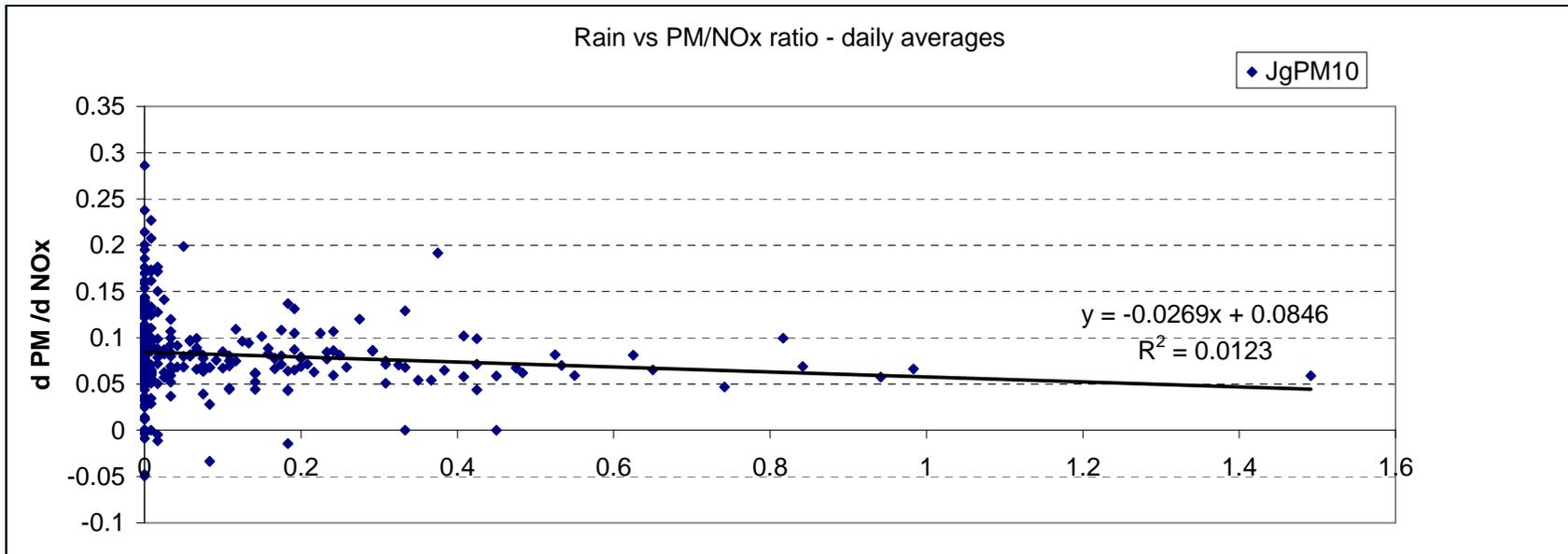
Road sensor at HCAB

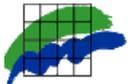
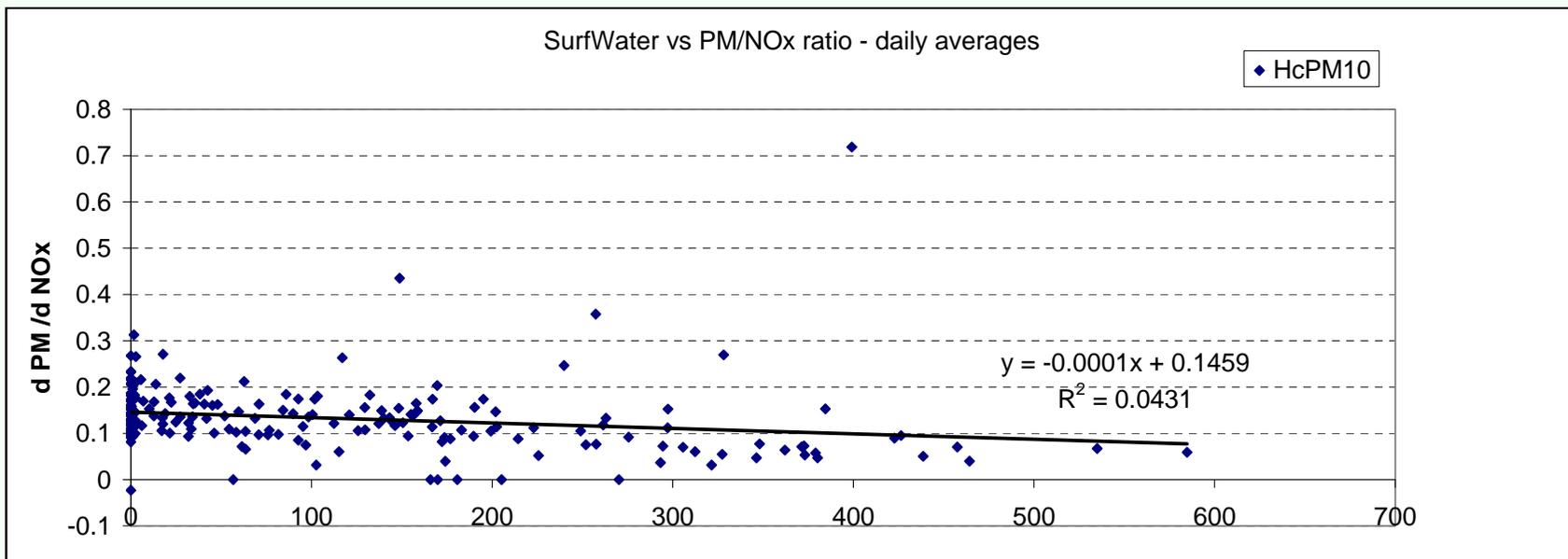
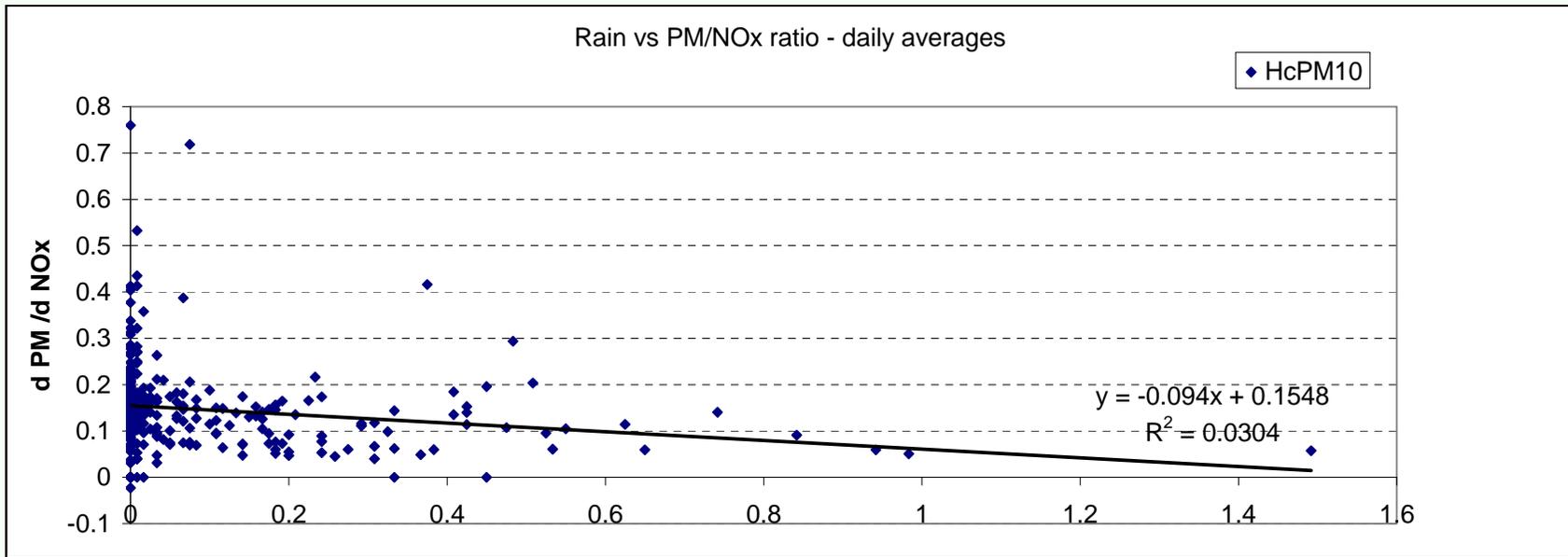


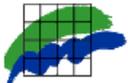
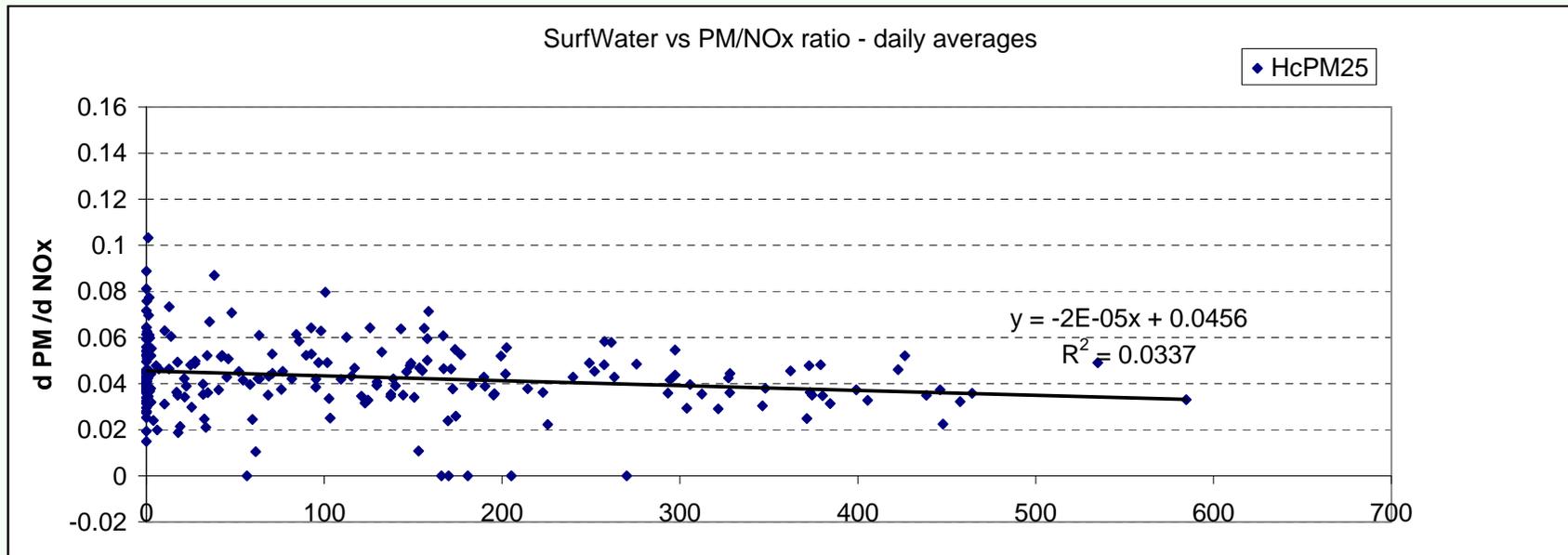
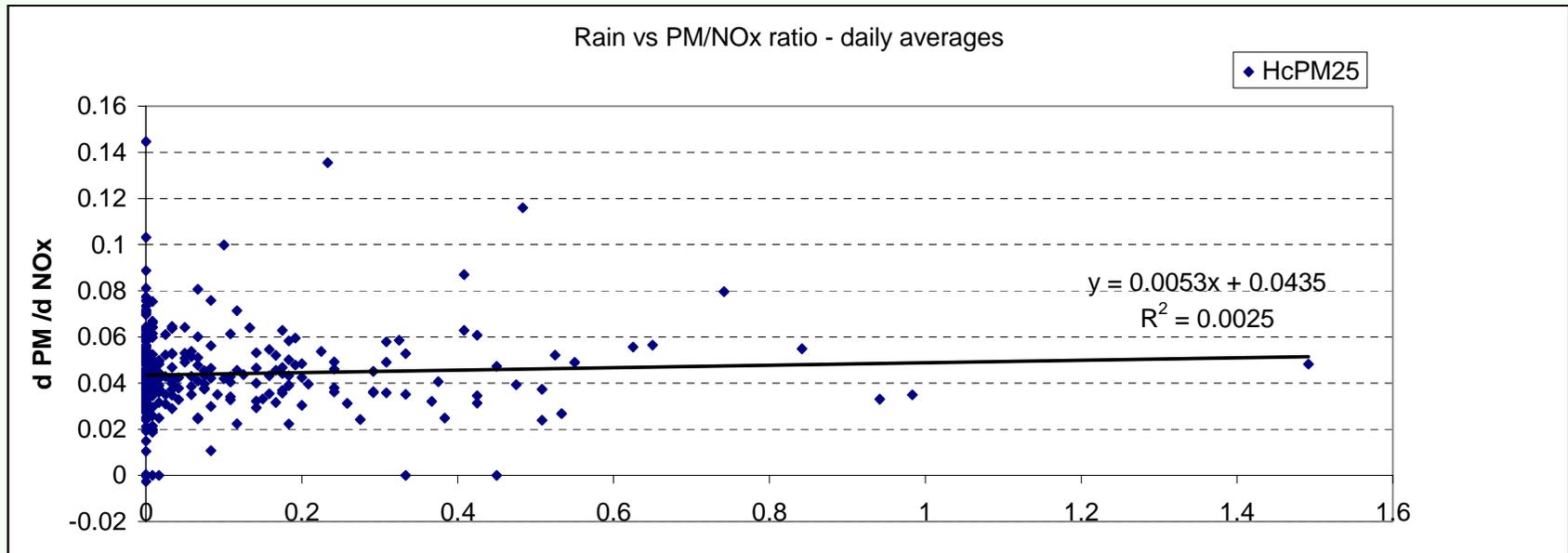
- Does road surface conditions explain the higher PM10 values?











The Swedish Model: description

$$e_f^{tot} = e_f^{direct} + e_f^{re-suspension}$$

<i>Processes</i>	<i>Emissionsfactor(mg/vkm)</i>
<i>Exhaust pipe</i>	20
<i>Tyre and brake wear</i>	10
<i>Road wear</i>	10
<i>Re-suspension (dry conditions)</i>	100-1000

$$\text{Winter} \quad e_f^{re-suspension} = f_q * d * e_{f,PM}^{ref winter} (dust)$$

$$\text{Summer} \quad e_f^{re-suspension} = f_q * e_{f,PM}^{ref summer} (dust)$$

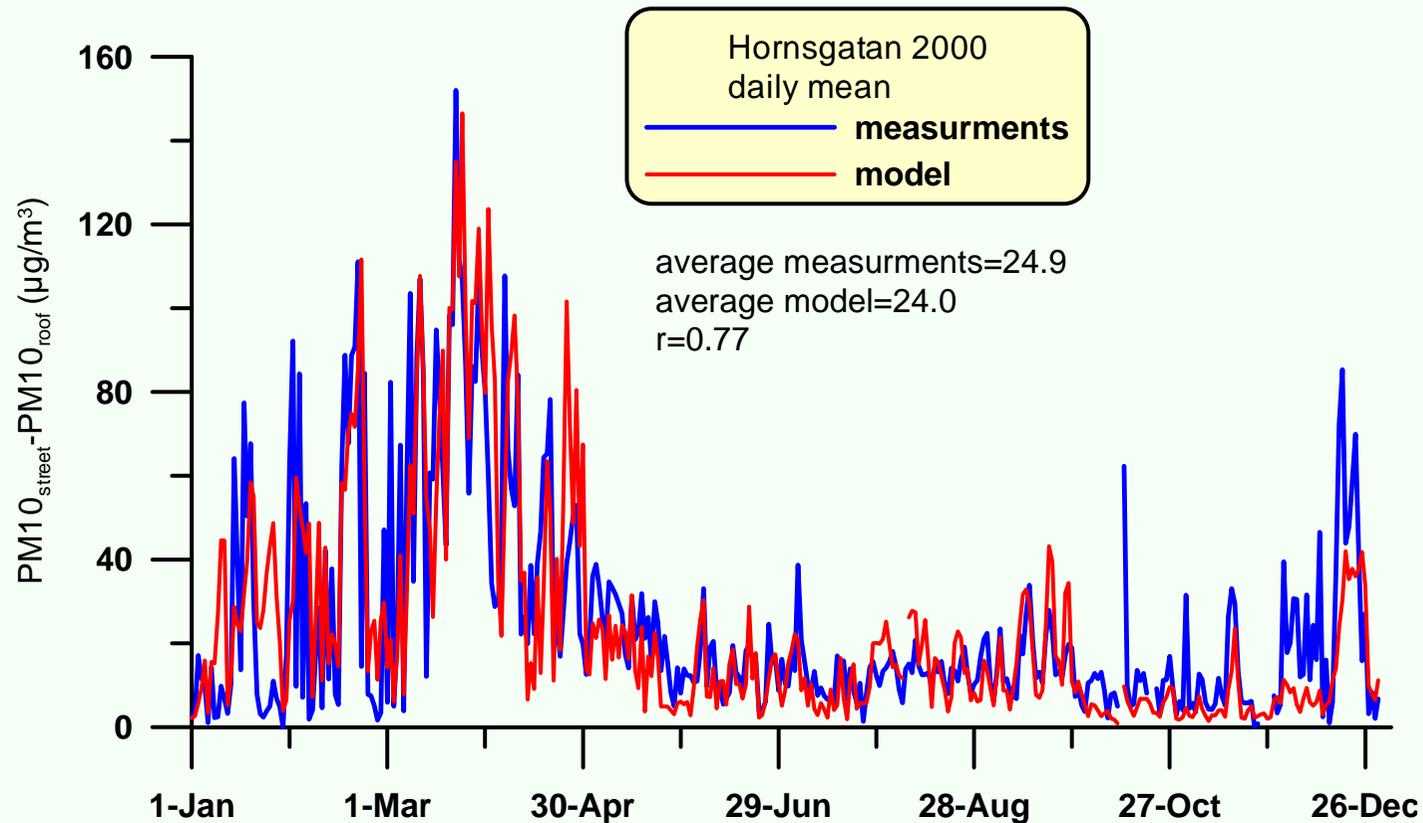
f_q is the source strength for re-suspension which is related to the moister amount of the dust on the street surface

d is the amount of dust on the street

$e_{f,PM}^{ref} (dust)$ is a reference emission factor

The Swedish Model

PM10 Hornsgatan year 2000

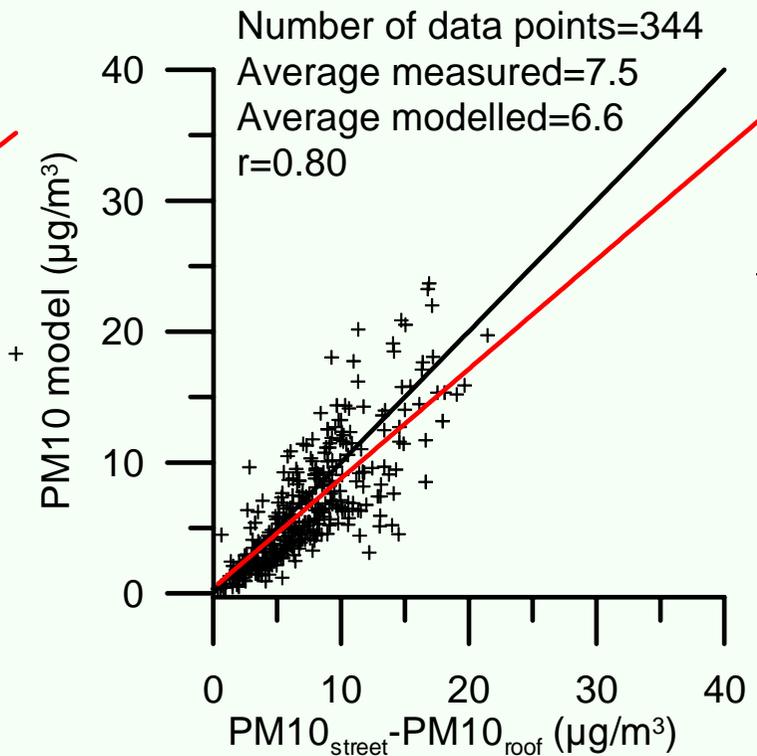
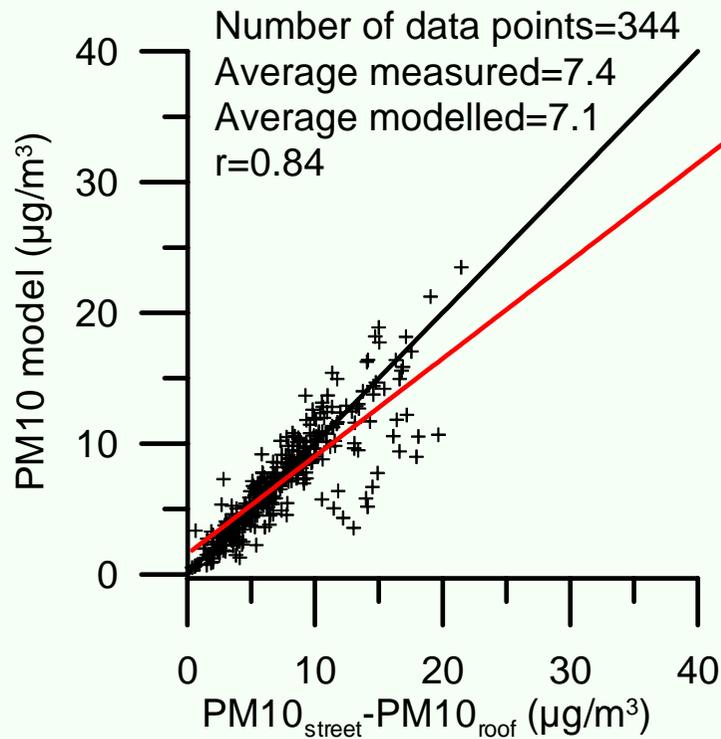


Comparison of measured and modelled concentrations of PM10 (µg/m³) .

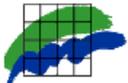
Swedish Model for Jagtvej

Constant emission factor of 129 mg/(veh km)

SMHI's PM emission model, adapted for Danish conditions



Comparison of measured and modelled daily mean local concentrations of PM10 at Jagtvej 2003. Model results are based on measured local concentrations of NOx.



„German“ method for PM10 non-exhaust emission factors (Düring et al., 2004)

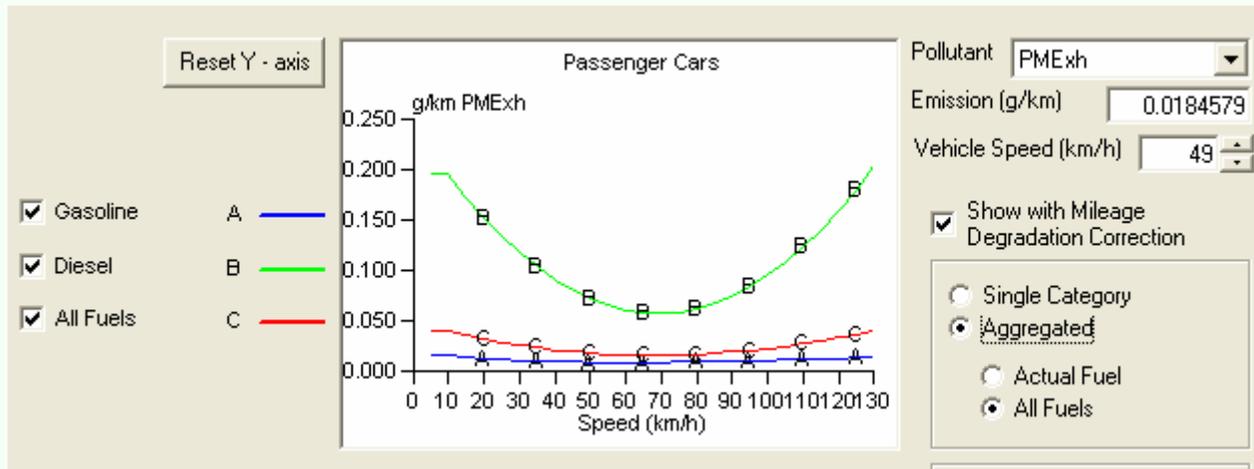
Verkehrssituation	Tempolimit [km/h]	Anteil Konstant fahrt [%]	Stand anteil [%]	PM10-Auf/Ab [mg/km]	
				PKW inkl. LNF	SV
AB>120	-			22	200
AB_120	120			22	200
AB_100	100			22	200
AB_80	80			22	200
AB_60	60			22	200
AB_StGo	-			22	200
AO1	100	60	1	22	200
AO2	100	53	1	22	200
AO3	100	28	1	22	200
IO_HVS>50	60	46	1	22	200
Tunnel AB_100	100			10	200
Tunnel AB_80	80			10	200
Tunnel AB_60	60			10	200
Tunnel IO_HVS>50	60	46	1	10	200
HVS1	50	46	1	22	200
HVS2	50	52	1	30	300
HVS3	50	44	7	40	380
LSA1	50	44	7	40	380
HVS4	50	37	14	50	450
LSA2	50	32	20	60	600
LSA3	50	28	26	90	800
IO_Kern	50	23	33	90	800
IO_NS_dicht	50	32	5	90	800

Recommended emission factors for good road condition

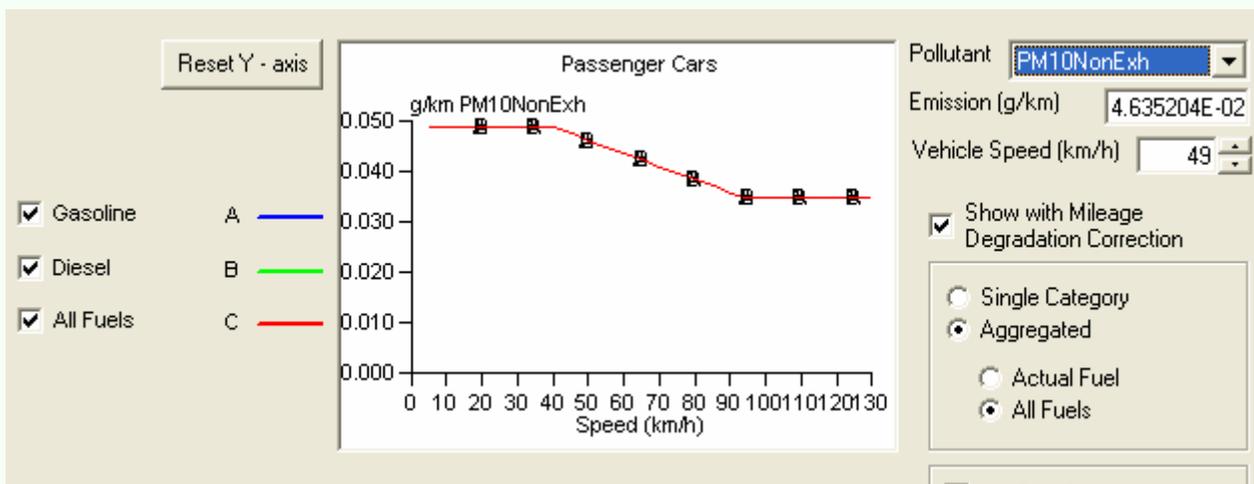
- High relevance of HDV (ca. factor 10)
- No significant effect of traffic speed limit
- Strong dependence on traffic situation (acceleration/deceleration)



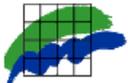
„Danish“ method for PM10 non-exhaust emission factors (Berkowicz et al., 2005)



exhaust part adopted from the UK-TLR method



non-exhaust part adopted from EMEP CORINAIR Emission Inventory Guidebook



Comparing the different models

Table 1: Simplified version of the proposed German PM₁₀ emission factors for non exhaust emissions (last two columns) in dependence on the traffic situation. Values for a fleet mix with 4% heavy duty traffic and exhaust emissions according to (UBA , 2004) are given. For comparison the emission factors are given for specific streets applying the Danish and Swedish methods.

Method/ Traffic situation	average Speed [km/h]	Share of constant speed driving[%]	exhaust emiss. factor (fleet-mix) [mg/km veh]	non-exhaust emission factor (fleet-mix) [mg/km veh]	non exhaust emission factor* [mg/km veh]	
					cars / vans	trucks
<i>German method:</i>						
motorways or outside cities	60-130				22	200
tunnel	60-100				10	200
city main road (HVS1)**	56	46	19	29	22	200
city main road (HVS2)**	44	52	20	41	30	300
city main road (HVS3)**	34	44	22	54	40	380
city main road (HVS4)**	28	37	26	66	50	450
city traffic lights (LSA2)**	24	32	28	82	60	600
city slow traffic (IO_Kern)**	17	23	32	118	90	800
<i>Danish method</i> for JGTV	45		57	57	50 / 70	230
<i>Swedish method</i> for HORG	40		37	205***		

* Values for good quality of the road surface, flat terrain and conditions of rain as usual in Germany.

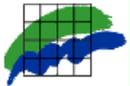
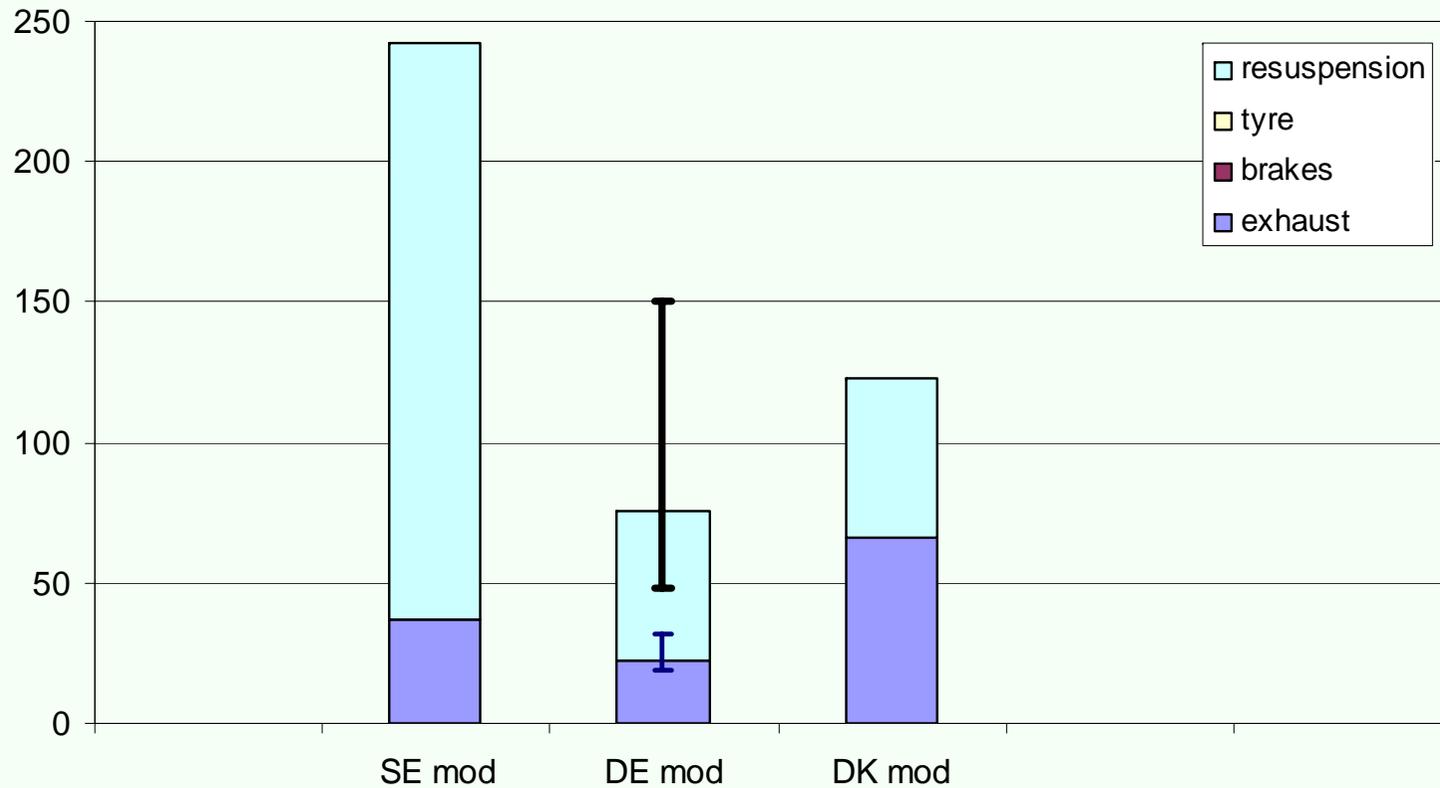
** Speed limit = 50 km/h;

***annual average for the year 2000



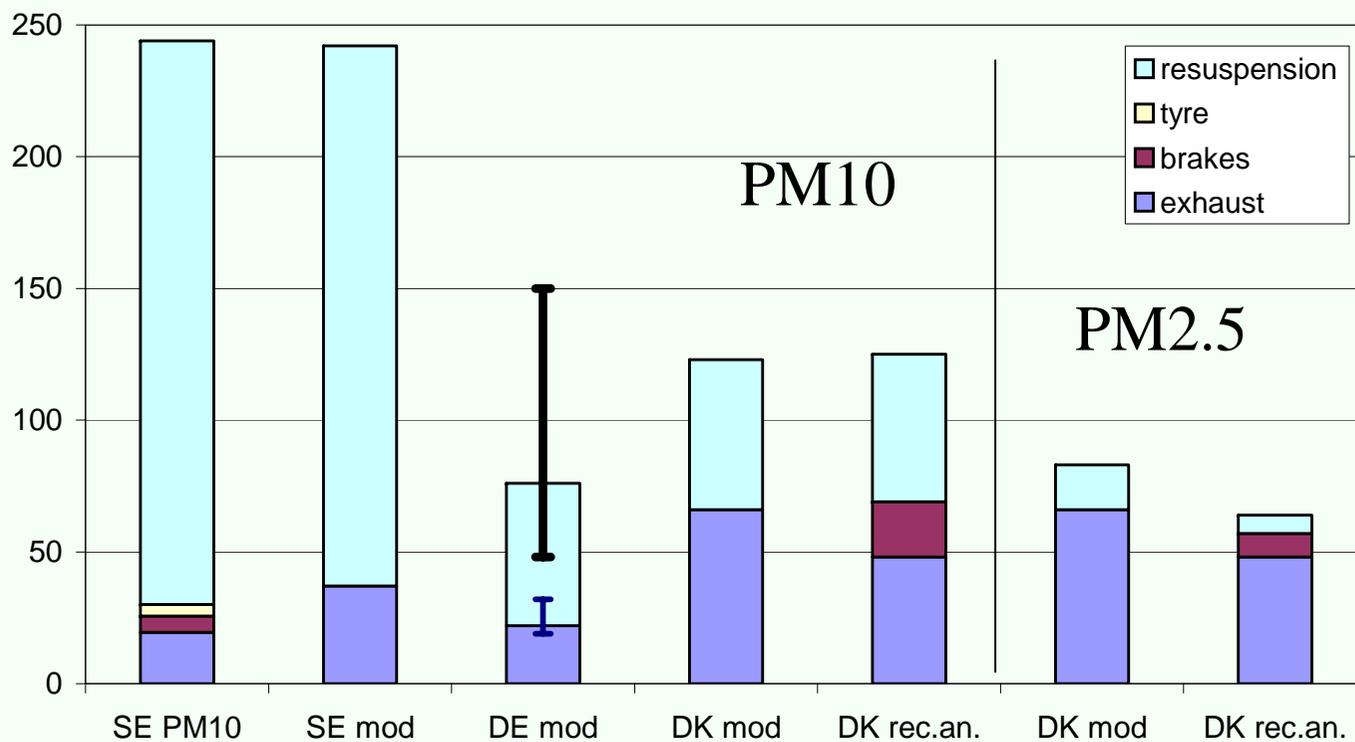
Comparing the different models

PM emission factors in mg / (veh km)



Comparing the different models

PM emission factors in mg / (veh km)



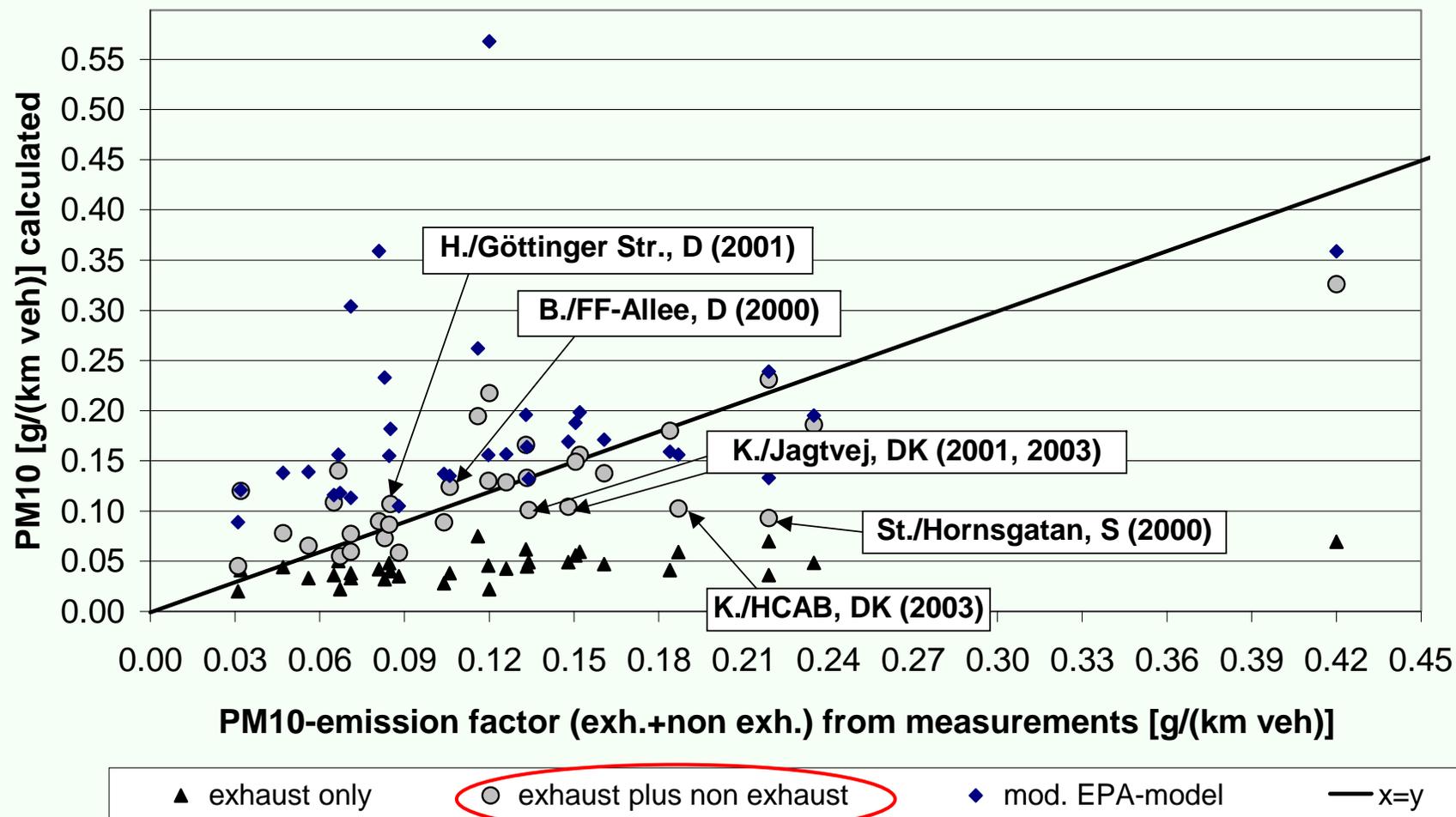
Receptor analysis
for Stockholm
C. Johansson et al. 2005

Receptor analysis
for Copenhagen
P. Wåhlin et al. 2004



Measured versus modelled emission factors

■ 'German' emission method



Conclusions

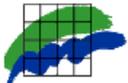
- all models / measurements show consistently large part of PM emissions from non-exhaust (50%-85%)
- measures relying on reducing the exhaust part of the vehicle emissions can have a very limited effect on ambient PM levels
- The Swedish model is able to reproduce the observed strong seasonal variation of non-exhaust emissions.
- less pronounced annual variation for Danish and German conditions might allow the application of simpler methods based on constant emission factors

- Road wetness does not show very high correlation with PM/NO_x ratios



Open Questions

- Influence of driving speed / driving pattern?
 - German data show higher emissions for lower speeds and more „Stop and Go“.
- Influence of rain?
- Influence of bad road surface conditions?
 - German model gives a high additive term for „bad“ conditions.
- **What is the difference between JGTV and HCAB ??**



Motivation

- EU PM10 limit value has been exceeded e.g. Munich
- discussion about effective reduction measures:
 - road pricing?
 - diesel particle filter?
 - environmental zones?

SPIEGEL ONLINE POLITIK

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FEINSTAUB

Umweltpolitiker streiten über Fahrverbote und Rußfilter

Nachdem mit München zum ersten Mal eine deutsche Stadt die EU-Grenzwerte für die Feinstaubbelastung überschritten hat, hat sich ein Streit über mögliche Konsequenzen entsponnen. Umweltminister Trittin macht Ländern und Kommunen heftige Vorwürfe; dort warnt man vor Aktionismus.

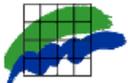


REUTERS

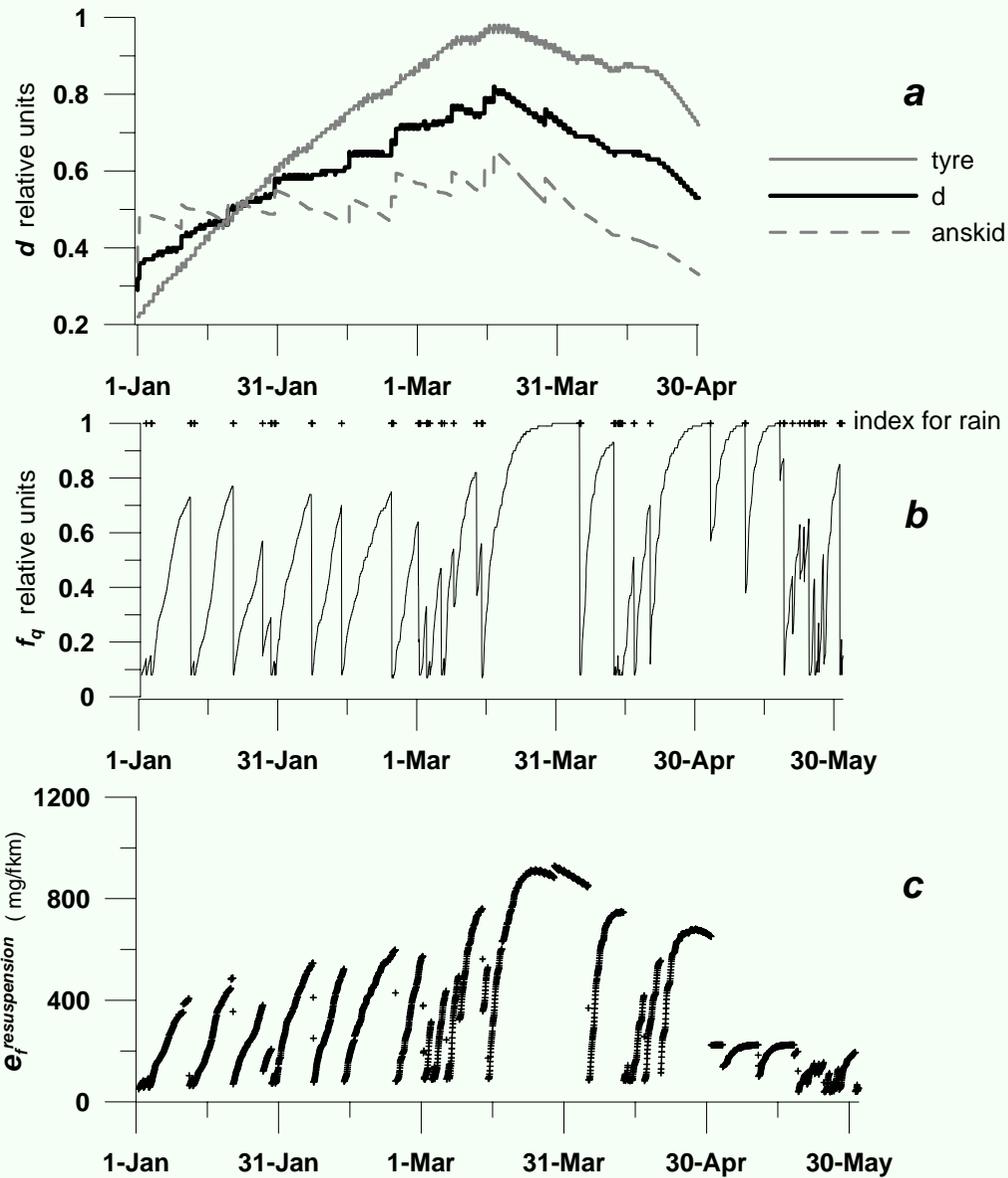
Rußschleuder Auspuff:
Abhilfe durch City-Maut

Berlin - Jürgen Trittin (Grüne) kritisierte Ländern und Kommunen, weil sie die seit Jahresanfang geltende EU-Richtlinie nicht umsetzten. Zudem forderte er eine beschleunigte Einführung von Dieselpartikelfiltern.

Der Deutsche Städte- und Gemeindebund plädierte dafür, den Lastwagen-Verkehr aus Wohngebieten zu verbannen. Der bayerische Umweltminister Werner Schnappauf (CSU) warnte dagegen vor Aktionismus. Generelle Fahrverbote oder die Einführung einer City- Maut seien unverhältnismäßig.

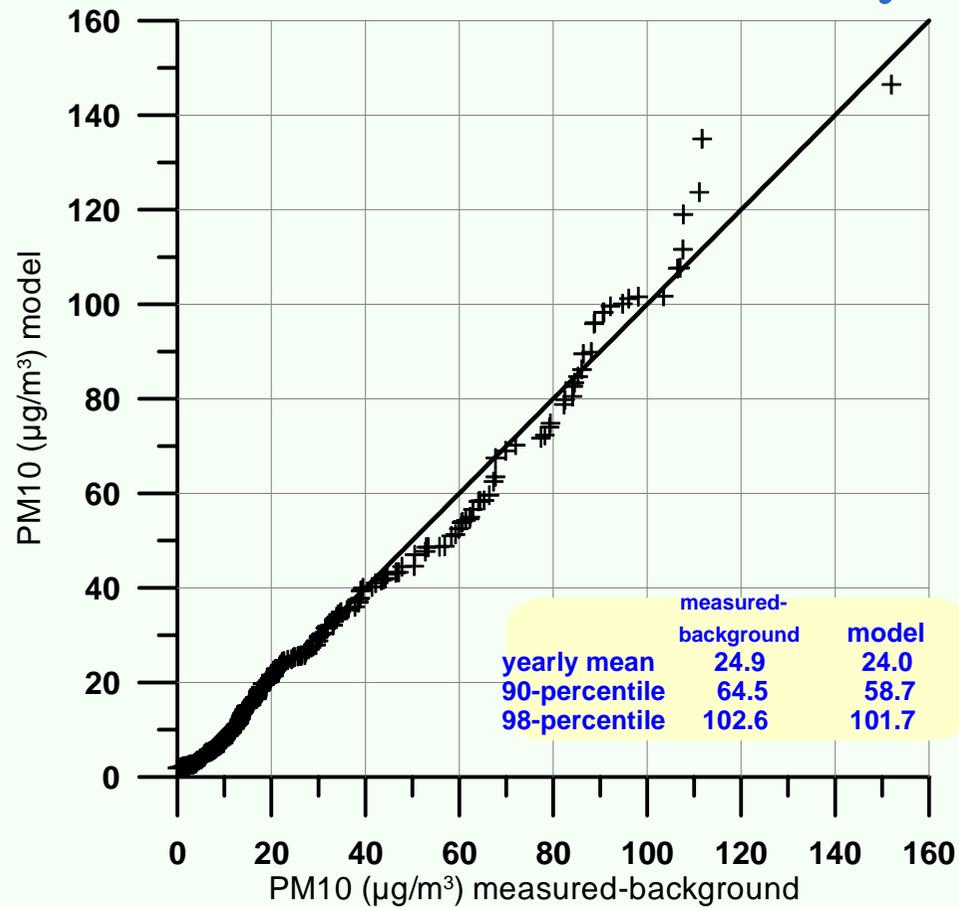


The Swedish Model: emissions



The Swedish Model

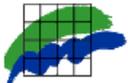
PM10 Hornsgatan year 2000



As the last figure but sorted in size

Outlook / Open questions

- apply the detailed Swedish model for DE / DK
- influence of road material and road quality ??
- influence of traffic speed and slope of the road ??
- influence of rain ??



Acknowledgement

- Swedish National Road and Traffic Administration (Vägverket)
- Stockholm County Council (Landstinget)
- Swedish EPA SNAP Programme (Swedish National Air Pollution and Health Programme)
- Danish EPA - Funding for the aerosol measurements
- Danish Research Council
- **Thanks for your attention!**

