

Modelling of PM emissions in different Nordic traffic environments

-Hornsgatan, Jagtvej and Runebergkatu

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- introduction
- data
- model description
- results from Hornsgatan, Jagtvej and Runebergkatu
- conclusions

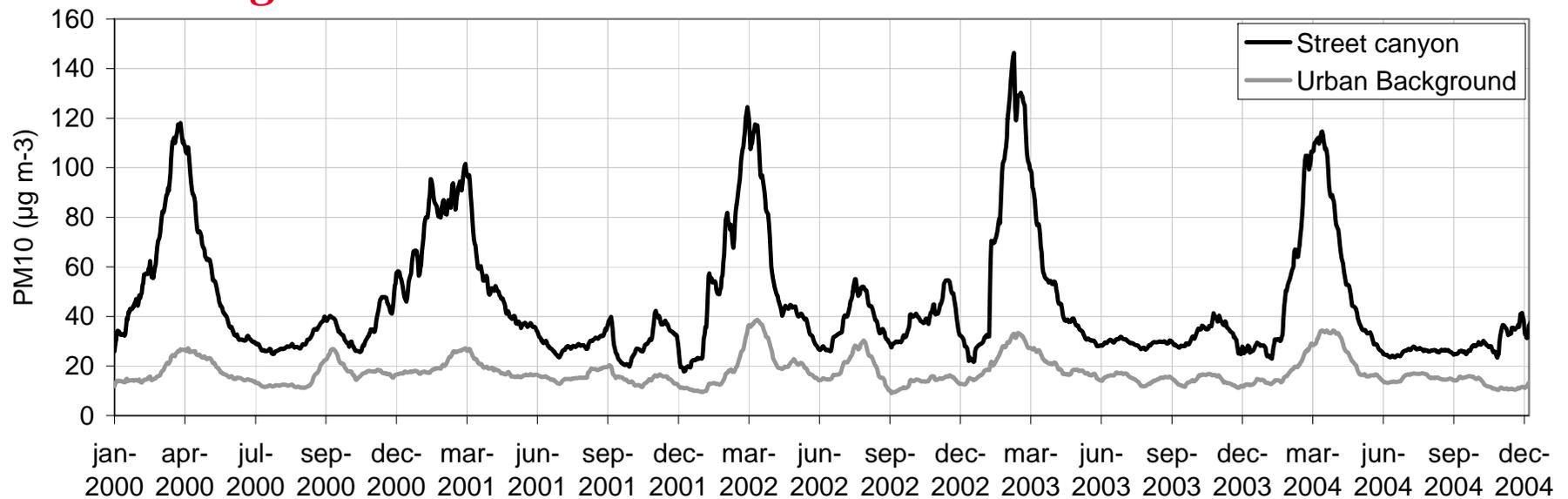
10/11/2005

SMHI



PM₁₀ (µg/m³) at Hornsgatan

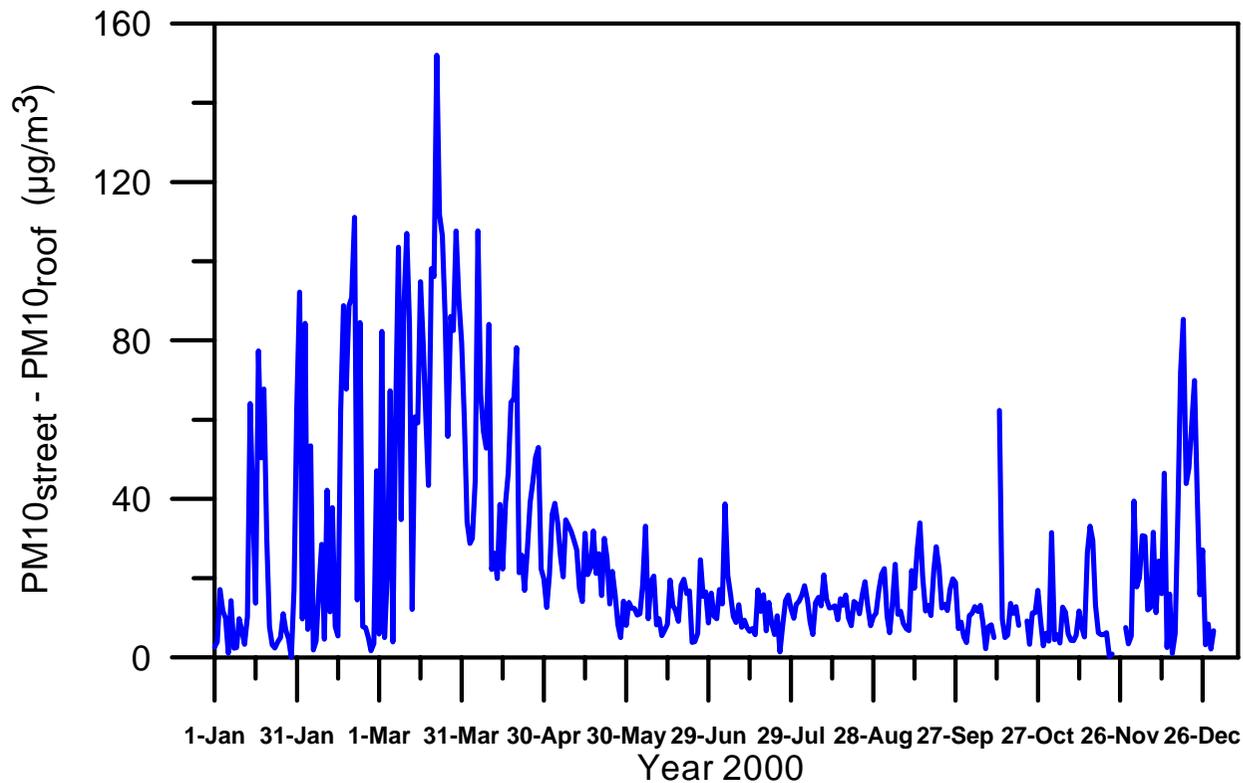
1. Strong seasonal variations



Measured concentrations of PM₁₀ at the kerb side site (Hornsgatan) and urban background rooftop (Rosenlundsgatan) presented as **running monthly average**.

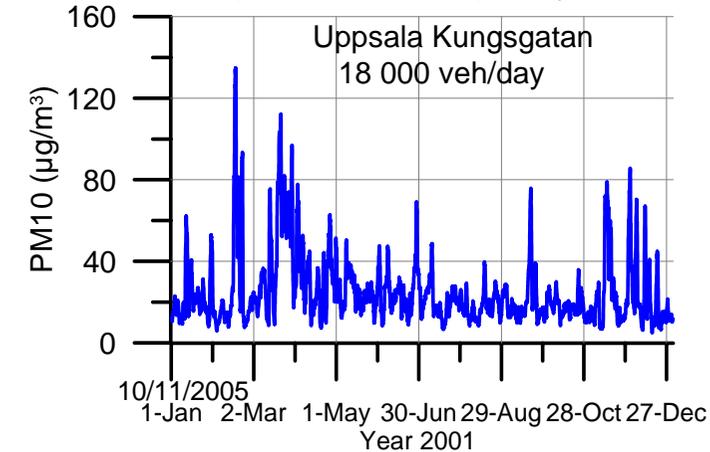
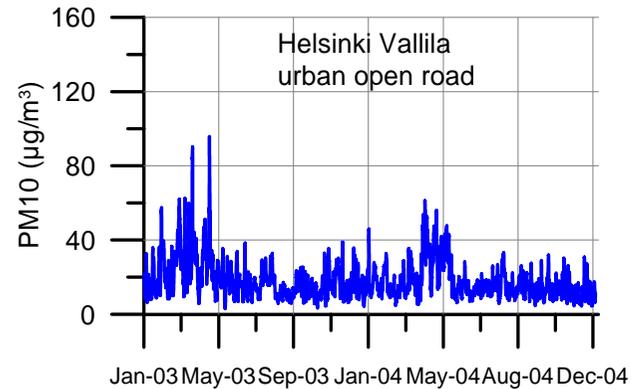
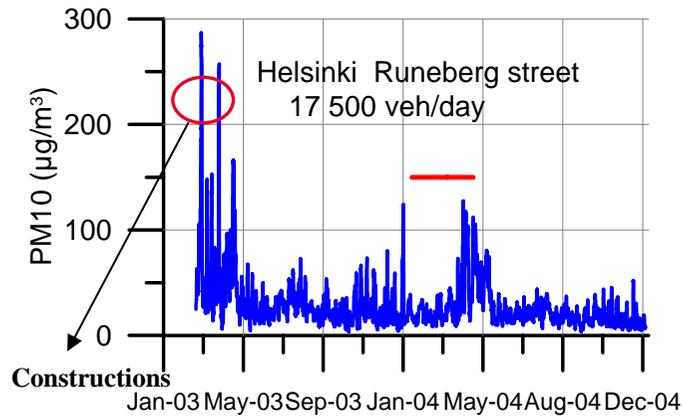
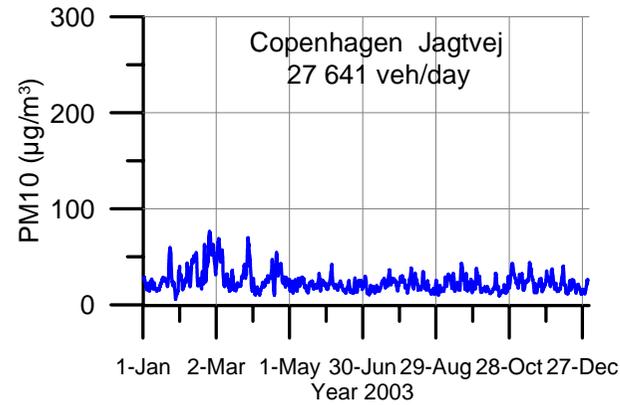
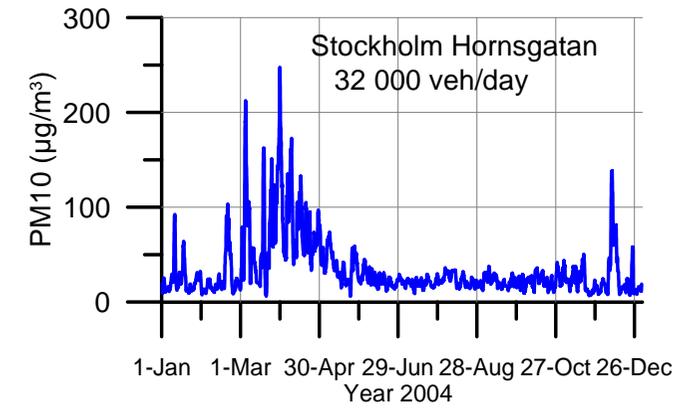
PM₁₀ (μg/m³) at Hornsgatan

2. Strong “synoptic” variations



Measured **daily mean** local concentrations of PM₁₀ (μg/m³) at Hornsgatan 2000

PM₁₀ (µg/m³) at other traffic environments



Measured PM₁₀ (µg/m³) presented as running daily mean

Model description

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

Processes	Emissionsfactor(mg/vkm)
Exhaust pipe	20
Tyre and brake wear	10
Road wear	10
Suspension (dry conditions)	100-1000

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

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

f_q is the source strength for vehicle-induced suspension which is related to the moisture amount of the road surface

l is the amount of dust on the road

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

Model description- basic assumptions

l is the dust layer (relative units)

$$\frac{d(l)}{dt} = So_l - Si_l$$

<i>Sources</i>	<i>Sinks</i>
<i>Sanding</i>	<i>Vehicle-induced suspension</i>
<i>Traffic related road wear dependent on studded tyres</i>	<i>Run-off with precipitation</i>

g (mm) is the moisture amount on the road surface

$$\frac{d(g)}{dt} = So_g - Si_g$$

<i>Sources</i>	<i>Sinks</i>
<i>Precipitation</i>	<i>Run-off</i>
	<i>Evaporation</i>

$$f_q = 1 - 0.93 * g$$

G. Omstedt, B. Bringfelt, C. Johansson
 A model for vehicle-induced non-tailpipe emissions of particles along Swedish roads. *Atm. Env.* 39, 2005.

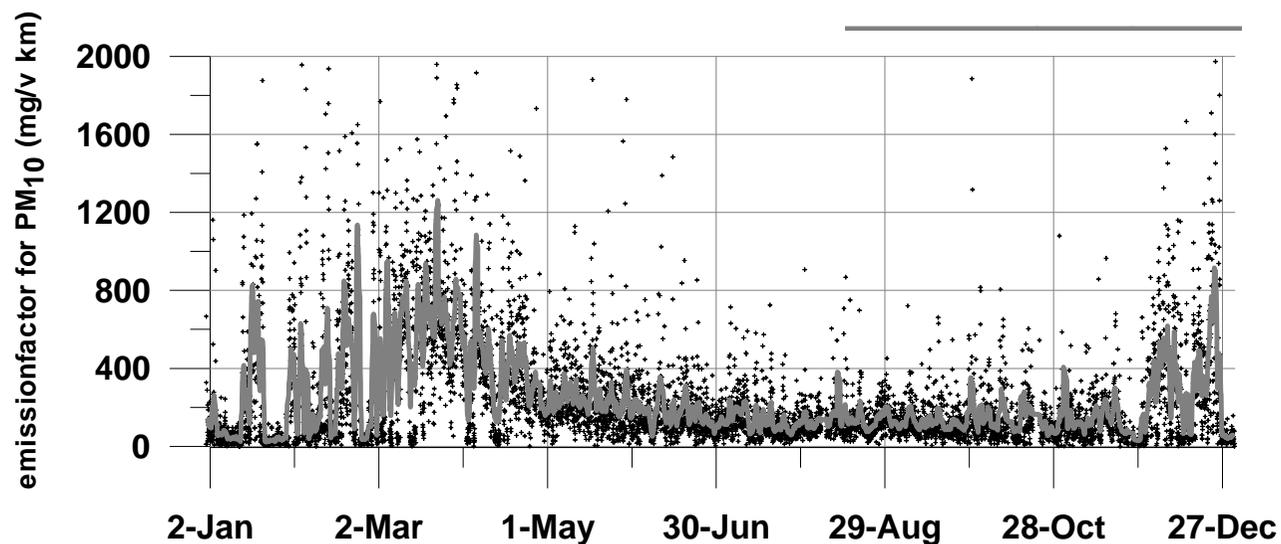
the tracer method

Model description

$$e_{f,PM_{10}}^{ref} = e_{f,NOx} \left[\frac{(C_{street}^{PM_{10}} - C_{roof}^{PM_{10}})}{(C_{street}^{NOx} - C_{roof}^{NOx})} \right]$$

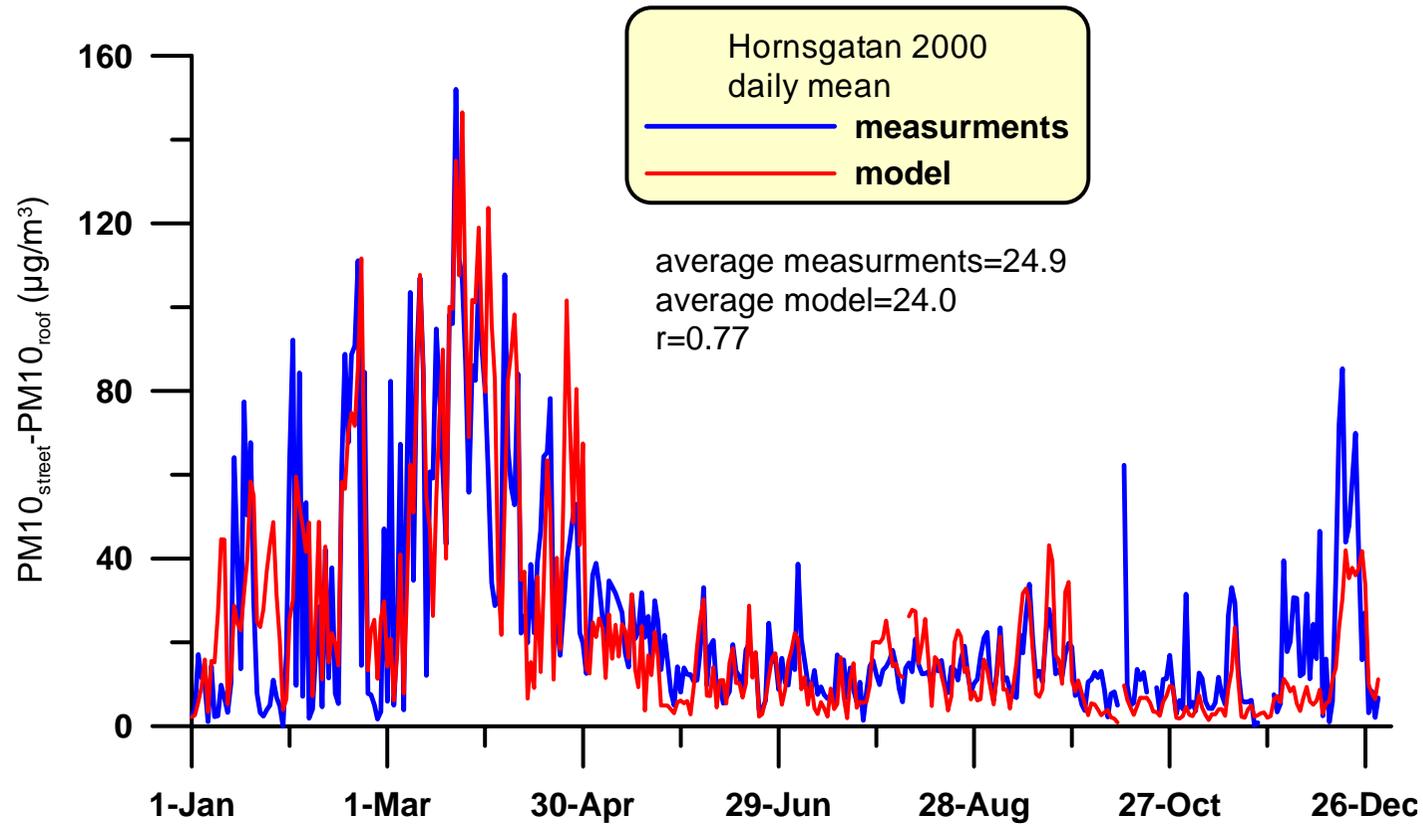
Values of reference emission factors used for Hornsgatan

	Winter	Summer
PM ₁₀ (mg vkm ⁻¹)	1200	200
PM _{2.5} (mg vkm ⁻¹)	150	30



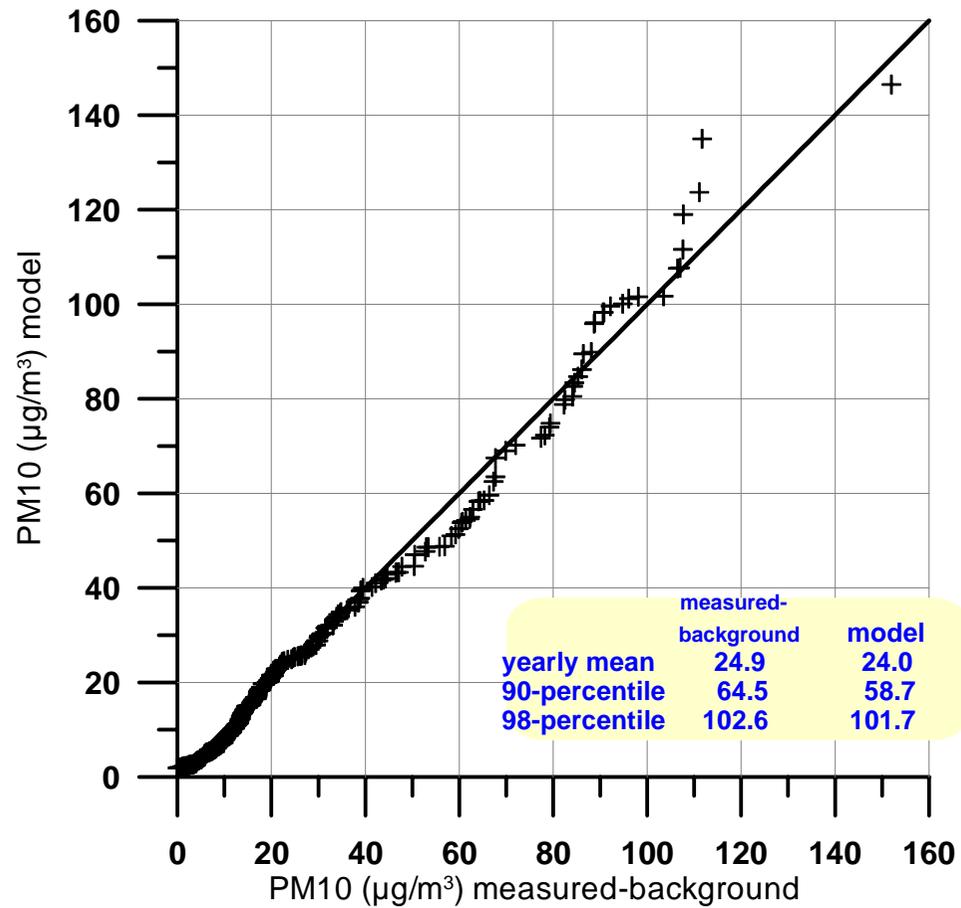
Emission factors for PM₁₀ estimated by the tracer method. Hourly data from Hornsgatan/Sweden for the year 2000. Grey line is running daily average

PM10 Hornsgatan year 2000



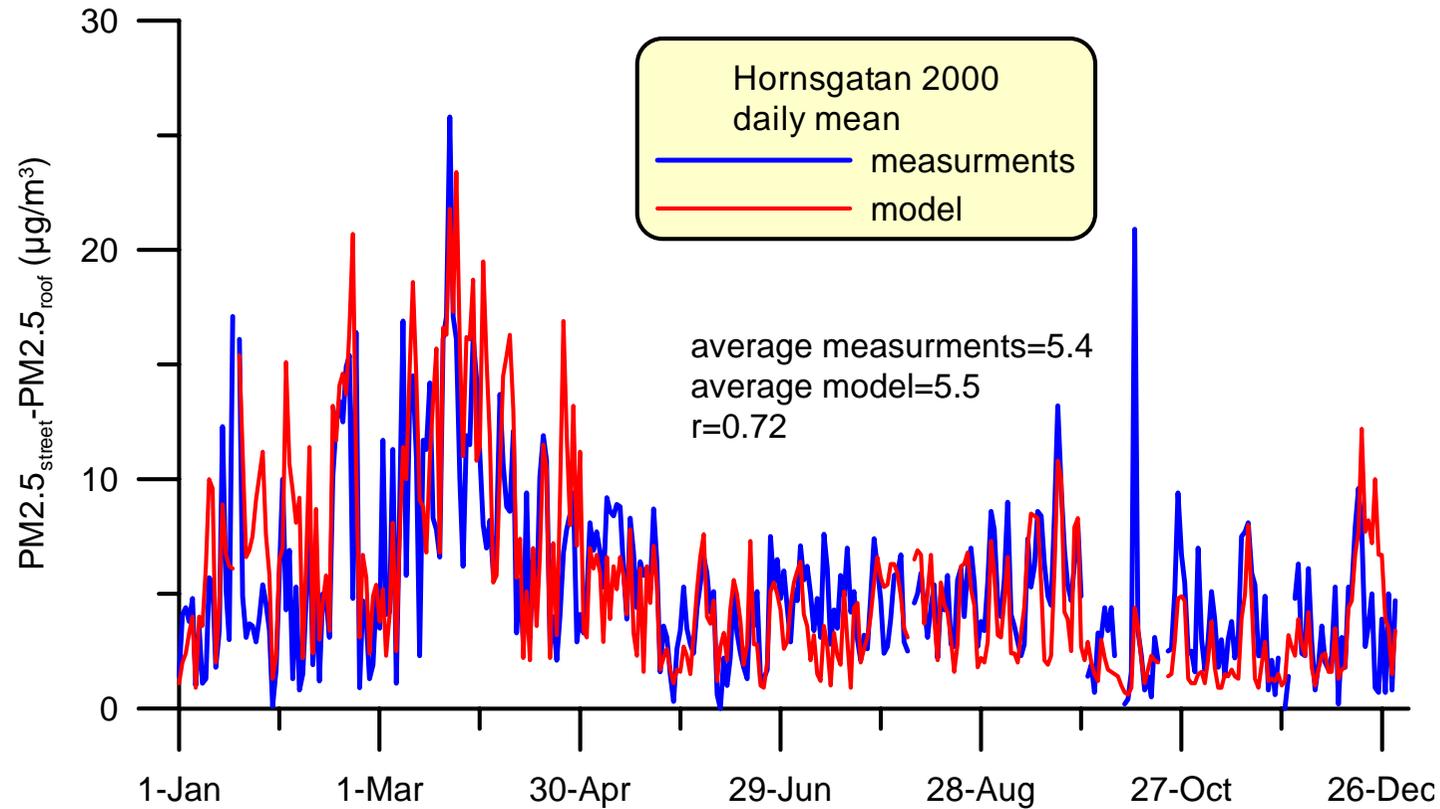
Comparison of measured and modelled concentrations of PM10 (µg/m³) .

PM10 Hornsgatan year 2000



As the last figure but sorted in size

PM 2.5 Hornsgatan year 2000



Comparison of measured and modelled concentrations of PM2.5 (µg/m³)

Hornsgatan 2004, Jagtvej 2003 and Runebergkatu 2004-01 - 2004-04

We calculate the dispersion part by two types of models:
OSPM and OpenRoad/DispersionRoad
but for the comparison in this workshop we describe the
dispersion by using measured NOx concentrations.

$$c = Q * dispersion + c^{background}$$

$$dispersion = (c - c^{background}) / Q$$

$$Q = F * e_f \quad F \text{ is vehicle flow}$$

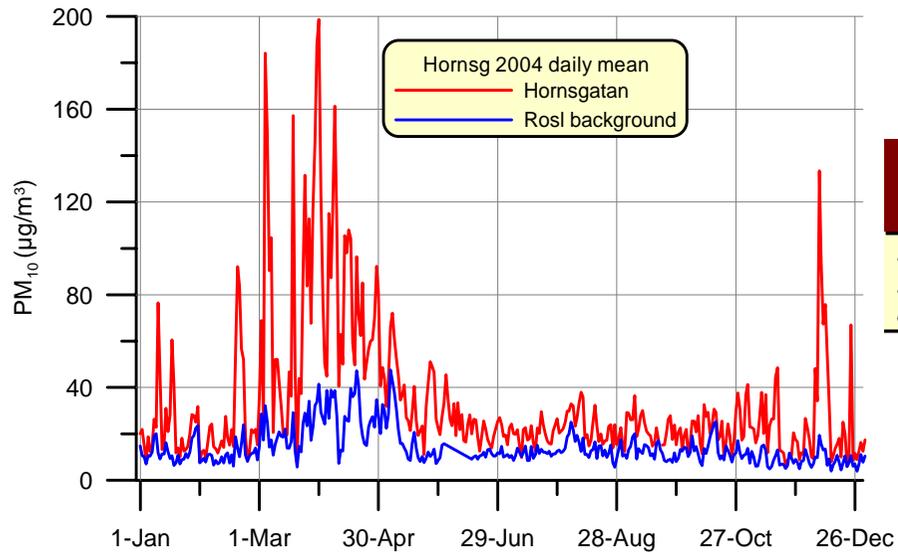
$$c_{PM10} = \frac{e_f^{PM10}}{e_f^{NOx}} * (c_{NOx} - c_{NOx}^{background}) + c_{PM10}^{background}$$

Measurement sites

	<i>height of the street canyon (m)</i>	<i>with of the street (m)</i>	<i>number of vehicles (veh/day)</i>	<i>vehicle speed (km/h)</i>	<i>share of heavy vehicles (%)</i>
<i>Hornsgatan</i>	24	24	32 000	40	5
<i>Jagtvej</i>	18	25	27 641	45	3.5?
<i>Runebergkatu</i>	23	24	17 500	42	11%

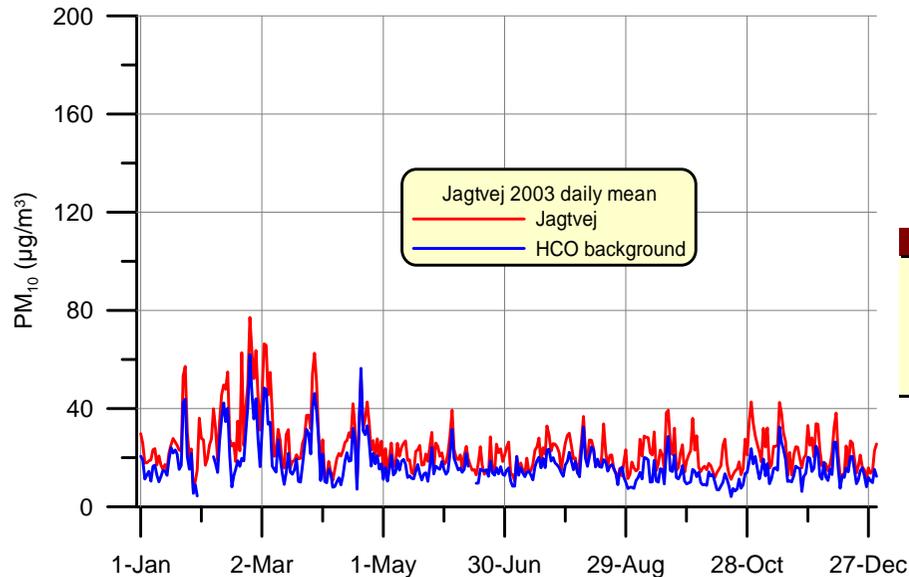
	<i>antiskid treatment</i>	<i>share of studded tyres on passenger cars(%)</i>
<i>Hornsgatan</i>	sand	70
<i>Jagtvej</i>	salt	0
<i>Runebergkatu</i>	mainly salt but sand in the tram lanes	84

PM10 Hornsgatan/ Jagtvej



	<i>Yearly mean (µg/m³)</i>	<i>90- percentile (µg/m³)</i>	<i>Number of days exceeding 50 µg/m³</i>
<i>Hornsgatan 2004</i>	34.0	69.6	61
<i>Jagtvej 2003</i>	23.9	36.5	15

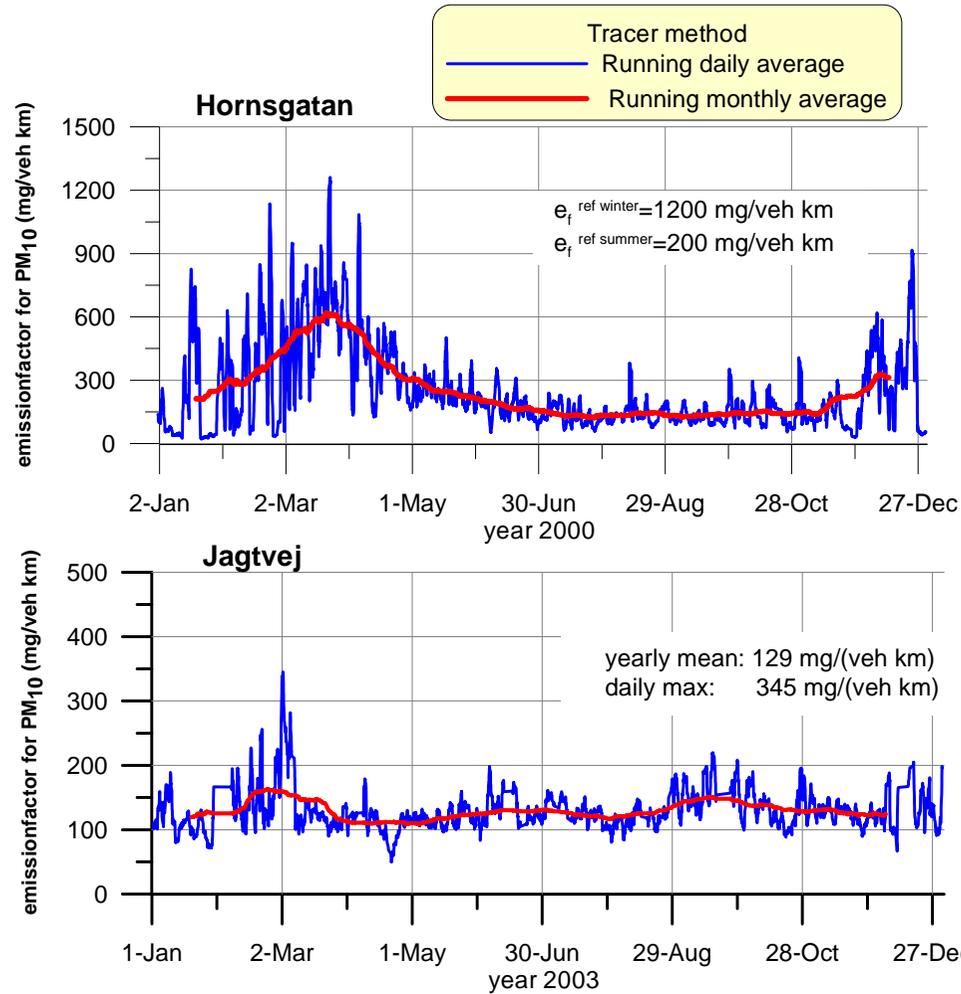
The local contribution as 90-percentil is about 4 times higher at Hornsgatan compare to Jagtvej!



<i>PM₁₀</i>	<i>Jagtvej 2003</i>	<i>Hornsgatan 2004</i>
<i>yearly mean (µg/m³)</i>	24	34
<i>background (%)</i>	71	42
<i>local direct contribution (%)</i>	15	8.5
<i>local contribution due to suspension of road dust (%)</i>	14	49.5

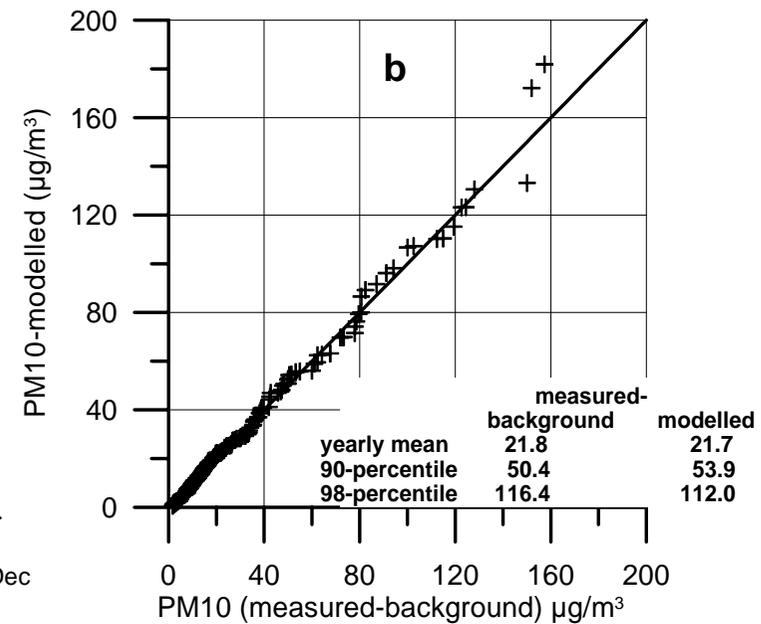
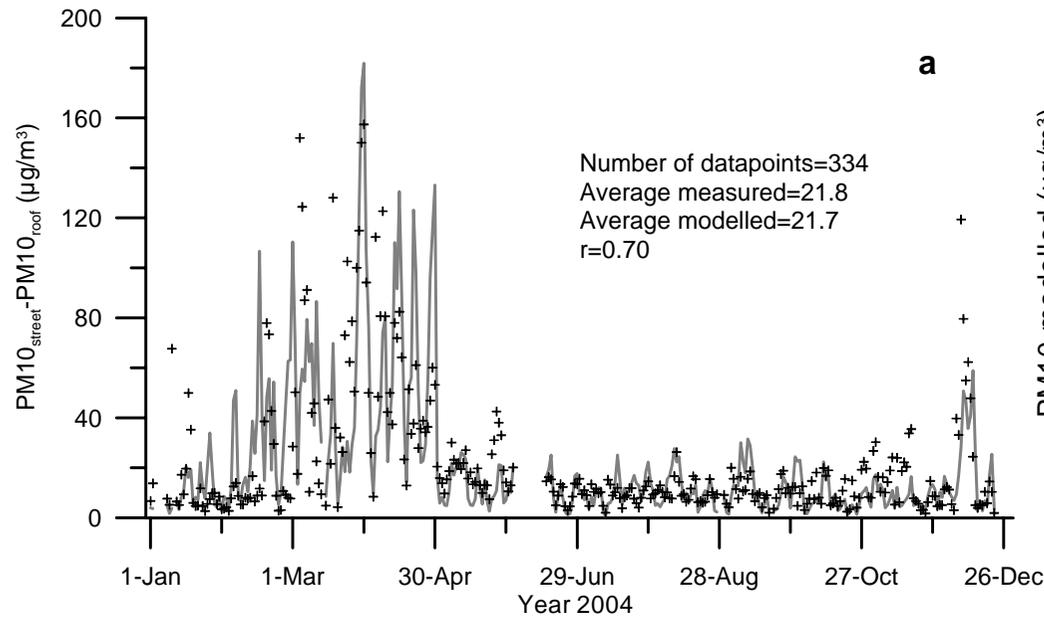
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PM10 Hornsgatan/ Jagtvej



$$e_f^{PM} = e_f^{NOx} * \frac{C_{PM}^{roadside} - C_{PM}^{background}}{C_{NOx}^{roadside} - C_{PM}^{background}}$$

PM10 Hornsgatan year 2004

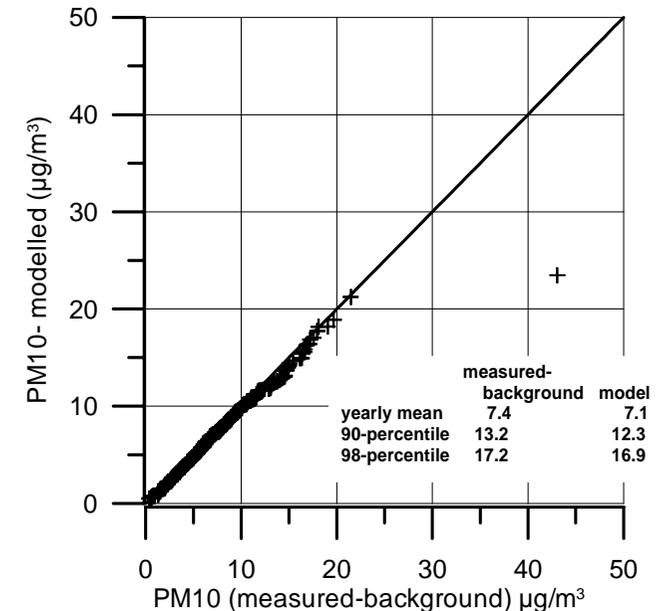
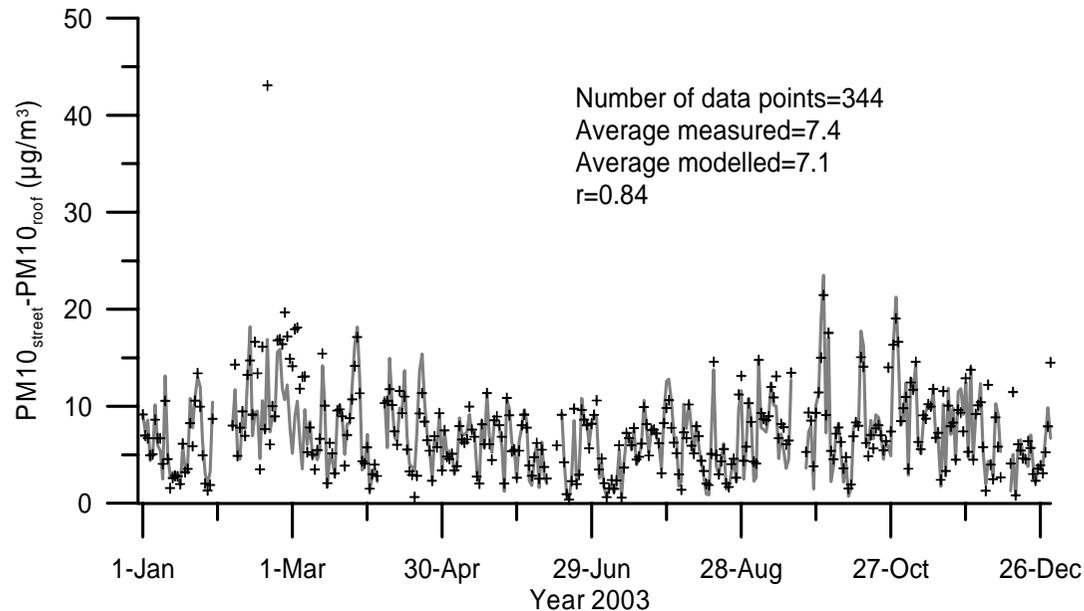


Comparison of measured (+) and modelled (solid line) daily mean concentrations of PM10 ($\mu\text{g}/\text{m}^3$) at Hornsgatan for the year 2004. (b) The same results as (a) but sorted according to size

PM10 Jagtvej year 2003

Experiment 1: constant emission factor

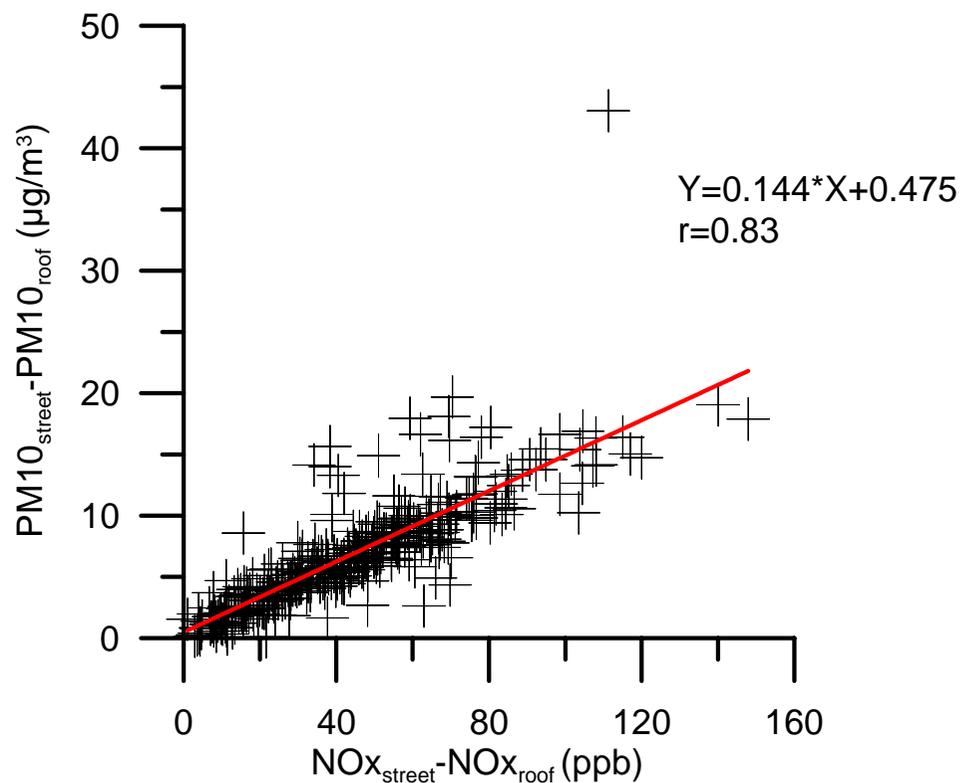
$$e_f^{total} = e_f^{direct} + e_f^{suspension} = 129 \text{ mg / veh km}$$



Comparison of measured (+) and modelled (solid line) daily mean concentrations of PM10 ($\mu\text{g}/\text{m}^3$) at Jagtvej / Copenhagen for the year 2003.(b) The same results as (a) but sorted according to size. Model results are based on measured NO_x concentrations.

Experiment 1: constant emission factor

PM10 Jagtvej year 2003



Comparison of measured local concentrations of NO_x and PM10 at Jagtvej 2003

Experiment 2: reduction factor due to moisture on the road surface on the road surface

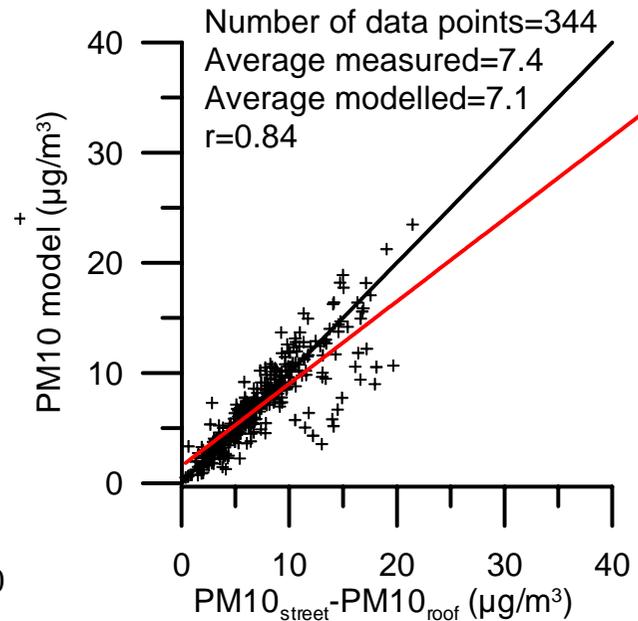
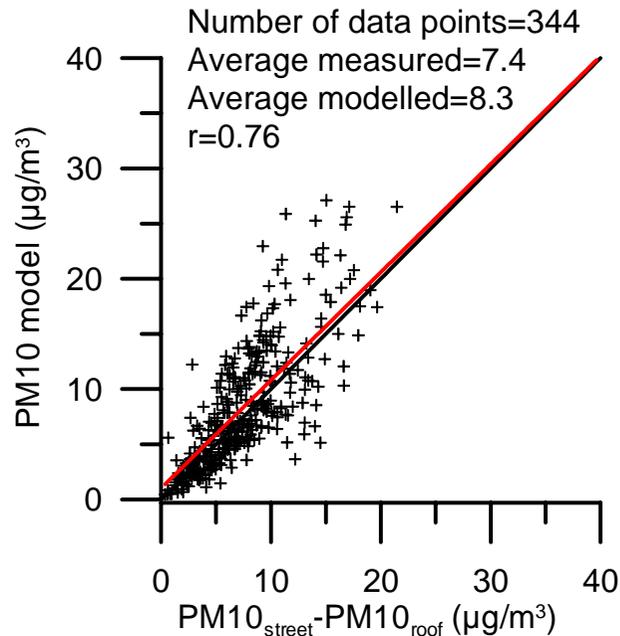
PM10 Jagtvej year 2003

$$e_f^{total} = e_f^{direct} + f_q * e_f^{ref summer}$$

Jagtvej (mg/veh km): 66* 200**

*according to Ketzal et.al

**summer part of SMHIs model



(left) Including a reduction factor due to the moisture on the road surface.

(right) Using a constant emission factor (129 mg/veh km). Model results are based on measured NOx concentrations.

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Experiment 3: SMHIs PM emission model adopted for “Danish conditions”

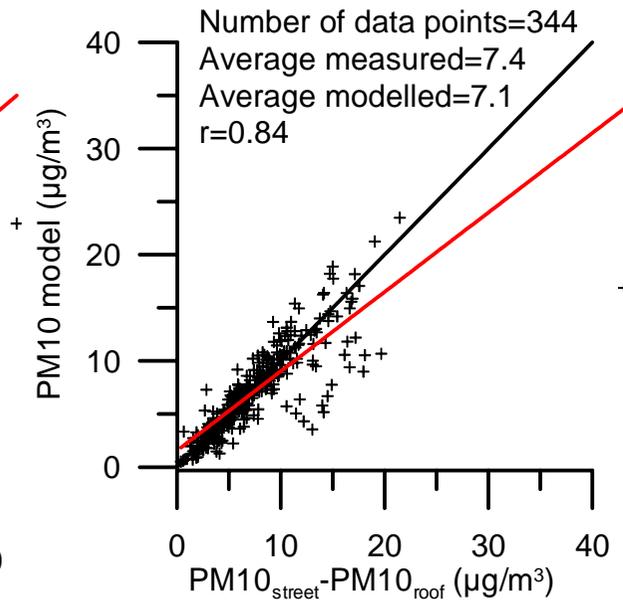
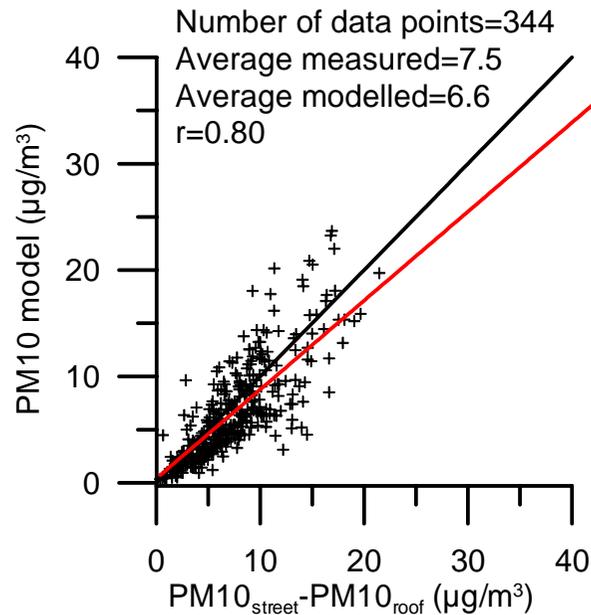
- no studded tyres
- no sand
- dust layer dependent only on road wear

PM10 Jagtvej year 2003

$$e_f^{total} = e_f^{direct} + f_q * l * e_f^{ref}$$

Jagtvej (mg/veh km): 66 279

* daily max=345 according to tracer method



(left) SMHIs PM emission model
(right) Using a constant emission factor.

Model results are based on measured NOx concentrations.

Conclusions:

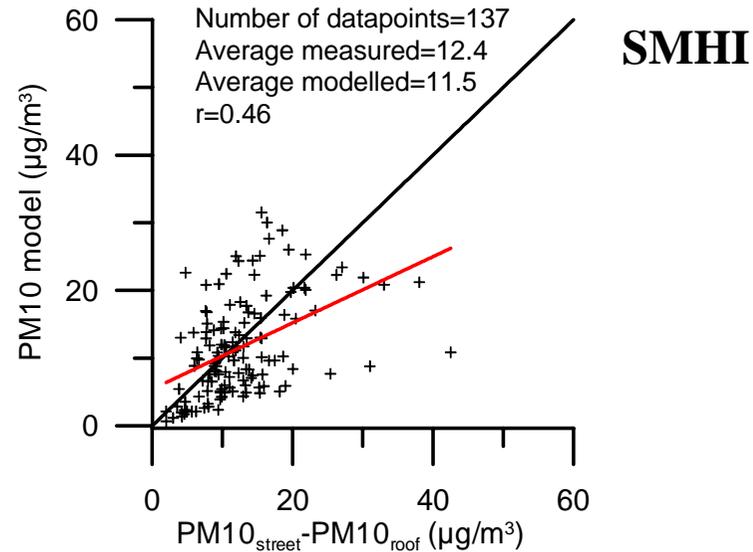
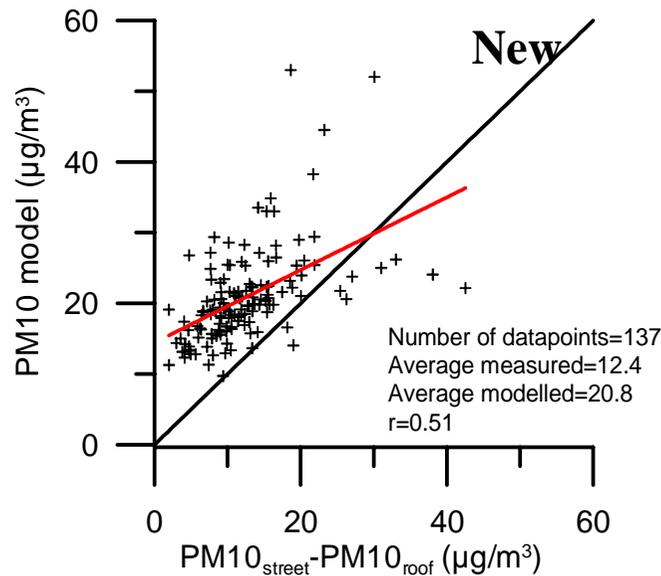
- simple method gives the best results

Experiment 4: Should the summer part of SMHIs model use a constant emission factor? Test on data from Hornsgatan.

PM10 Hornsgatan year 2004

SMHI: $e_f^{total} = e_f^{direct} + f_q * e_f^{ref\ summer} = 25. + f_q * 200.$

New: $e_f^{total} = e_f^{direct} + e_f^{dust} = 25. + 57.*$ * Ketznel et al.,2004



Conclusions:

- **no improvements**
- **over predict low concentrations**
- **it is better to keep the SMHI formulation**

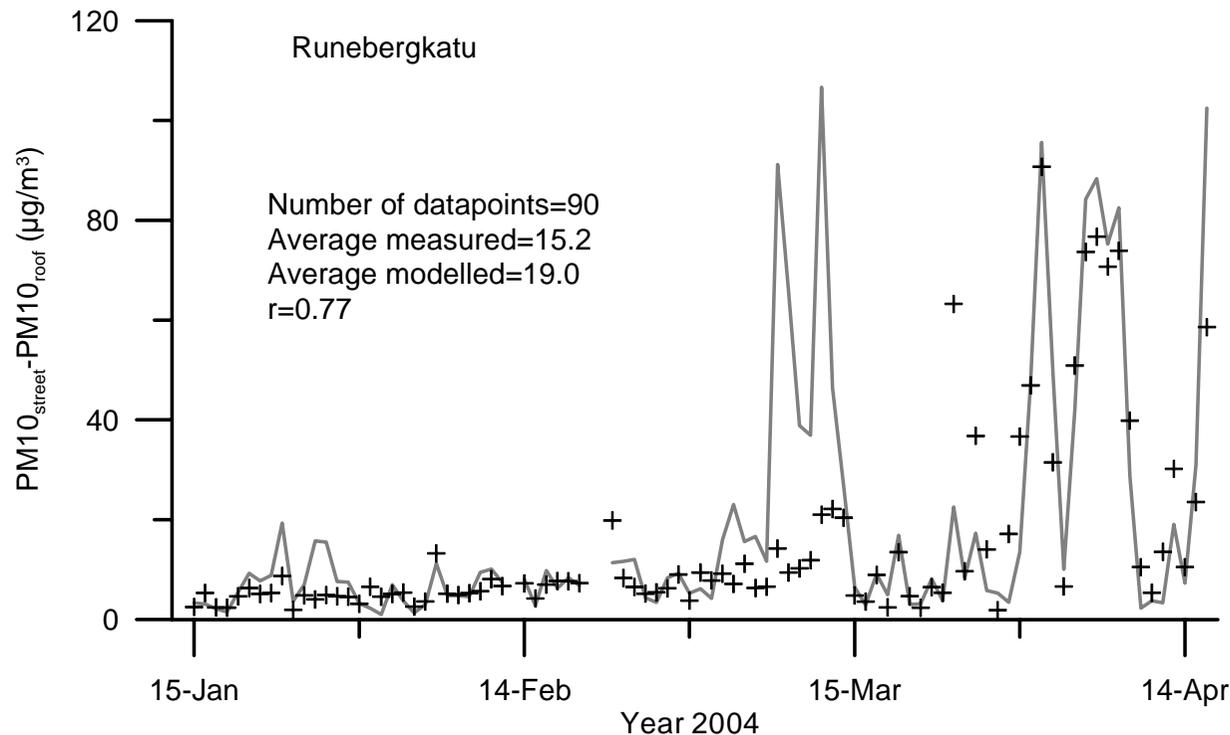
Meget høy luftforurening i Oslo og Trondheim (NILU mars,2004)

Mye stov på veiene har gitt dålig luftkvalitet i Oslo og Trondheim i begynnet måned. Forurensningen skyldes en kombinasjon av tørre og bare veier, etter veifuktig period, lite vind og mye veistov som ligger i og langs veibanen. Sitt gradvis bedre etterhvert som veistov-depotet ” tomme”

Runebergkatu 2004-01 - 2004-04

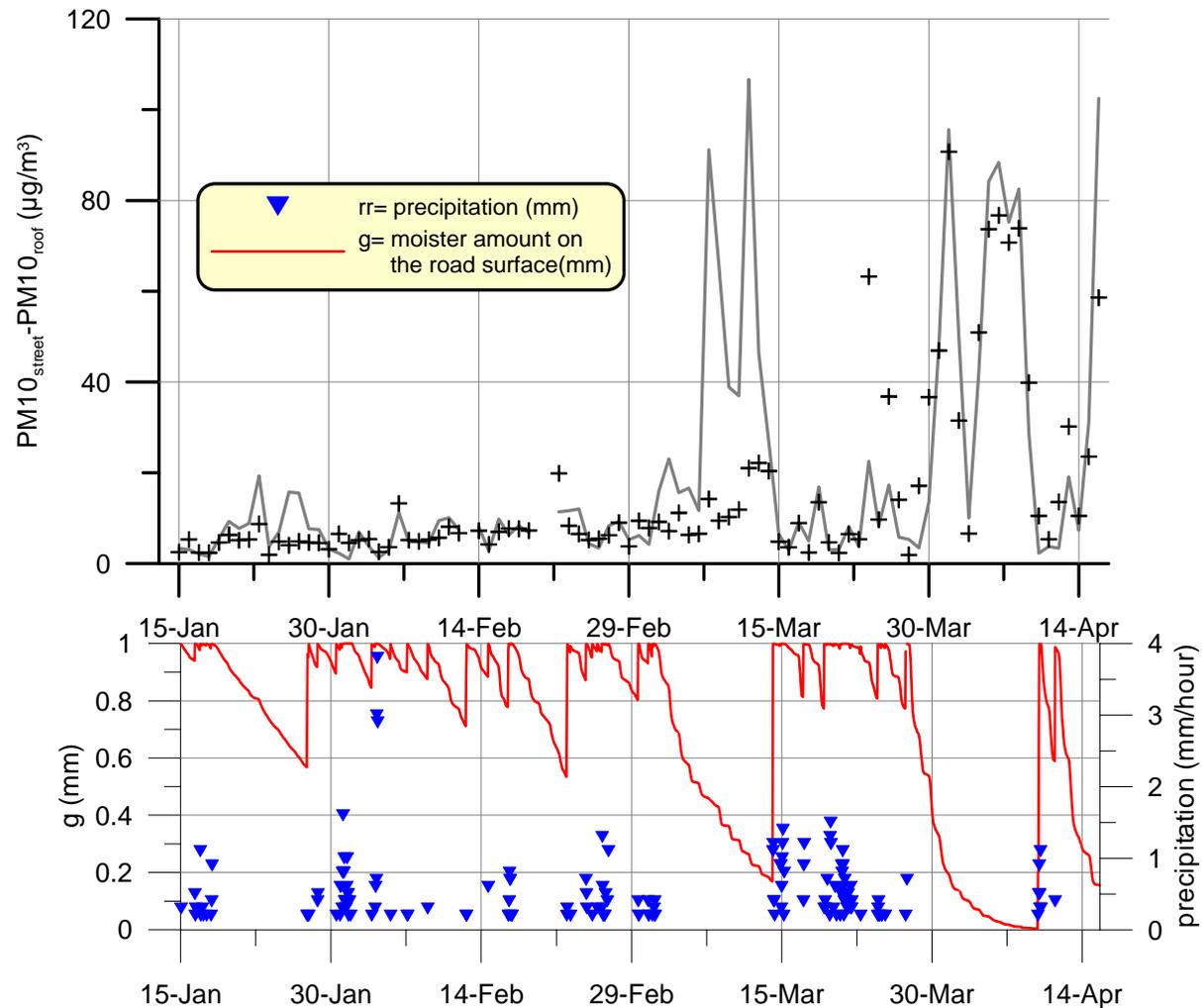
<i>Station</i>	<i>Parameter</i>
<i>Runebergkatu (street canyon)</i>	PM ₁₀ , NO _x , windspeed, winddirection
<i>Kaisaniemi (urban background)</i>	PM ₁₀ , NO _x
<i>Kaisaniemi (meteorological station)</i>	temp, global radiation, precipitation, humidity, total cloud cover

PM10 Runebergkatu



Comparison of measured (+) and modelled (solid line) daily mean concentrations of PM10 ($\mu\text{g}/\text{m}^3$) at Runebergkatu. Model results are based on measured NO_x concentrations and “standard” model parameters.

PM10 Runebergkatu



Conclusion:
important with good
precipitation data

Conclusions

Are these methods for PM emission estimation good enough for the prediction of air quality standards according to the EU legislation ?

Answer: yes (?)

Why do we have such high PM10 concentrations?

Answer:

- 1. Narrow street canyons with a lot of traffic**
- 2. Road wear due to studded tyres maybe in combination with sand**
- 3. Dust reservoirs at the edges of the streets due to sanding and probably also due to road wear**
- 4. Dry weather conditions (after a longer period with wet conditions)**

Is it possible to “harmonise” on a common Nordic method?

Answer: Yes but not only on one method