

# An new emission model for re-suspension of particles along roads

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- description of the model
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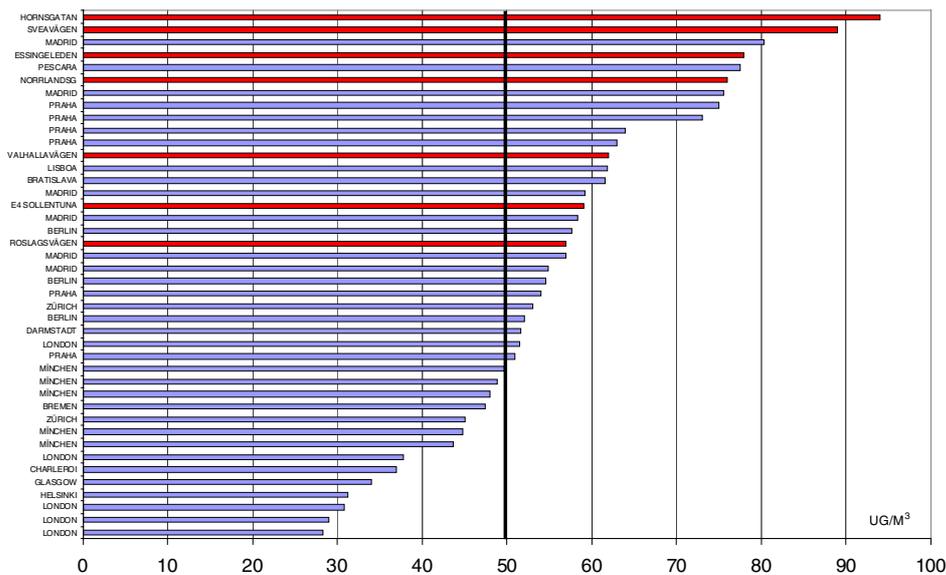


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## Introduction

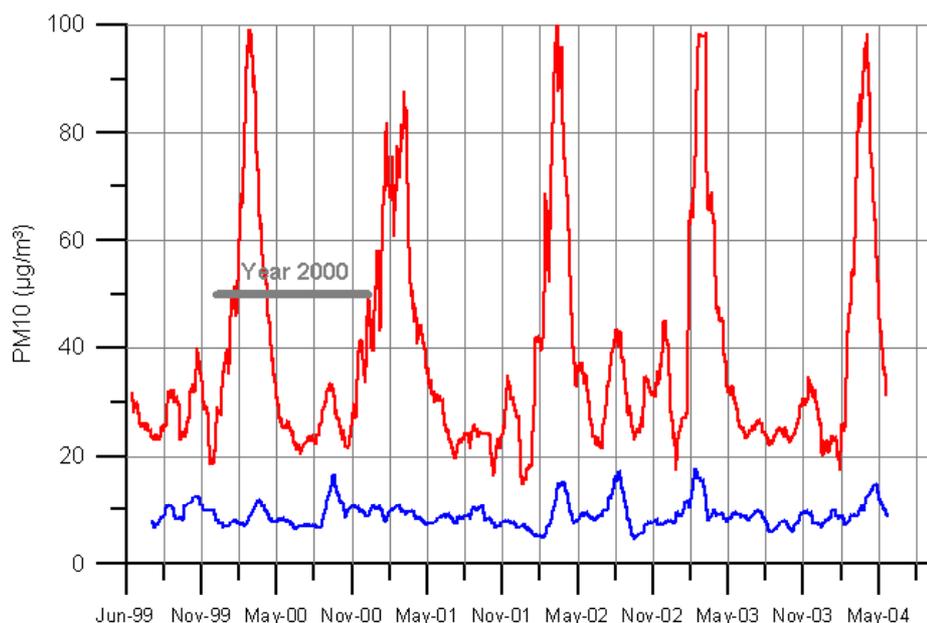


Measurements from 19 countries in Europe (including more than 700 measurement sites) of PM10 halter ( $\mu\text{g}/\text{m}^3$ ) as 90-percentiles (AirBase CAFE-PM, 2003)

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Measured concentrations of PM10 ( $\mu\text{g}/\text{m}^3$ ) at Hornsgatan presented as running monthly average. Red line is street level and blue line is roof level measurements. Model evaluations are done for the year 2000.

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## Model description

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

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

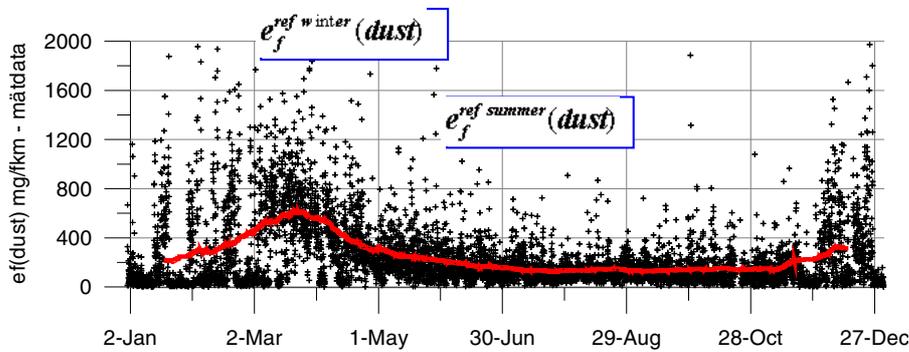
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# Model description

$$e_{f,PM10}^{ref} = e_{f,NOx} \left[ \frac{(C_{street}^{PM10} - C_{roof}^{PM10})}{(C_{street}^{NOx} - C_{roof}^{NOx})} \right] \quad \text{the tracer method}$$



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## Model description- basic assumptions

$d$  is the dust depot (relative units)

$$\frac{d(d)}{dt} = So_d - Si_d$$

Sources	Sinks
Sanding/salting	Re-suspension
Traffic related road wear	Run-off with precipitation

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

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

Sources	Sinks
Precipitation	Run-off
	Evaporation

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## Model description- the $f_q$ parameter

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

$$g = \min(1.0, g + rr) * gred$$

$rr$  is hourly precipitation  
 $gred$  is hourly reduction factor  
 for  $g$  due to evaporation

$$gred = \exp(-k * E_p)$$

$E_p$  is evaporation;  $k$  empirical factor found  
 to be  $k=0.075$

obtained by solving the budget equation:

$$\frac{dg}{dt} = -g * \frac{E_p(m)}{g_m}$$

where  $g_m$  is maximum moisture amount and  $E_p(m)$  is evaporation rate when  $g=g_m$ .

## Model description- the $f_q$ parameter

$$E_p = 3600 * \left( \frac{R_n \frac{\Delta}{\gamma} r_a + \Delta e \frac{\rho c_p}{\gamma}}{L(1 + \frac{\Delta}{\gamma}) r_a} \right)$$

$R_n$  is net radiation,  $r_a$  aerodynamic resistance  
 $\Delta e$  the saturated vapour pressure deficit

$$f_q = 1 - 0.93 * g$$

$f_q$  is the source strength  
 for re-suspension

## Model description- the $d$ parameter, sources

### a) sanding/salting

if we have no data on sanding/salting then we assume that sanding/salting occurs during days with slippery conditions

$$anskid = anskid + 1 / nanskid$$

$anskid$  is the accumulated number of days with sanding/salting during the current winter season

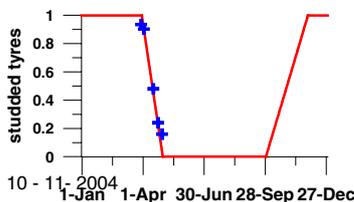
### b) action by studded tyres

$$tyre = tyre + k_t * a_{dubb}$$

$tyre$  is the ratio of accumulated depot of material, released by friction between studded tyres and pavement, to the highest depot at the end of the winter season

$a_{dubb}$  is the share of studded tyres

$k_t$  is an empirical factor



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## Model description- the $d$ parameter, sinks

### a) re-suspension

$$f_{susp} = 1 - decay * f_q$$

$f_{susp}$  is the relative hourly decay of the dust depot due to re-suspension

$decay$  is an empirical parameter

### b) run-off

$$r_f = \max((g + rr) * E_p - 1, 0)$$

$rf$  is the hourly water runoff

$$\text{if } rr < 2 \quad frf = 1.0$$

$frf$  is the hourly dust depot decay factor due to run-off

$$\text{if } rr \in [2, 10] \quad frf = 1 - 0.05 * (r_f - 2) / (r_{f_{max}} - 2)$$

$$\text{if } rr > 10 \quad frf = 0.95$$

For every hour  $anskid$  and  $tyre$  are reduced due to re-suspension and run-off

$$anskid = anskid * frf * f_{susp}$$

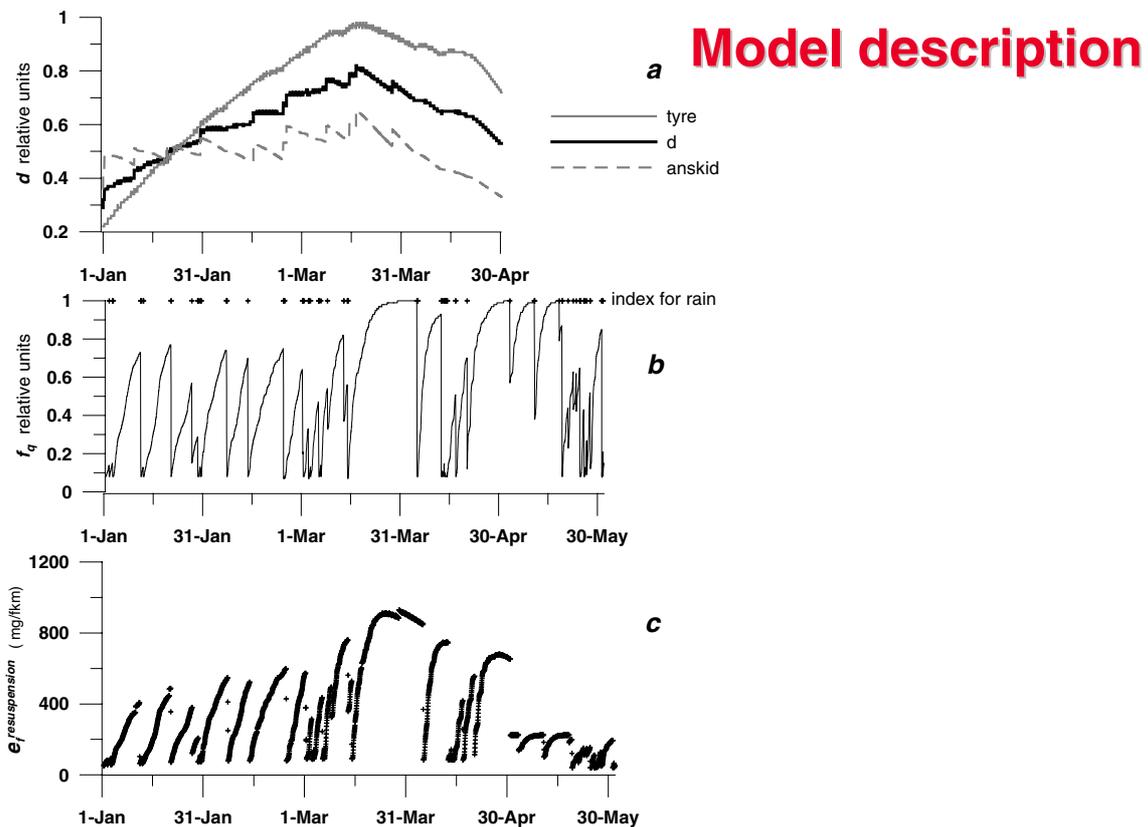
$$tyre = tyre * frf * f_{susp}$$

## Model description- the $d$ parameter

$$d = resusp\alpha * tyre + resusp\beta * anskid$$

$resusp\alpha$  is the share of tyre and road particles in the total road dust depot

$resusp\beta$  is corresponding share for sand/salt particles



# Hornsgatan, Stockholm

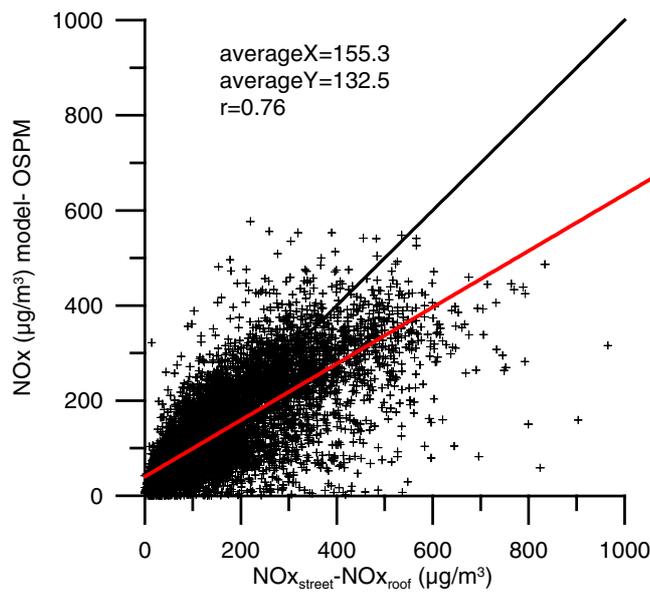
## 40 000 v/d



**Figur 5.** Hornsgatan monitoring station North (N) and South (S). The houses are of similar height, 24 m, total street width is 24 m. Uphill slope westward is 2.3% (Gidhagen et al., 2004). Measurements of PM10 are only done on the north side (<http://www.slb.nu/>).

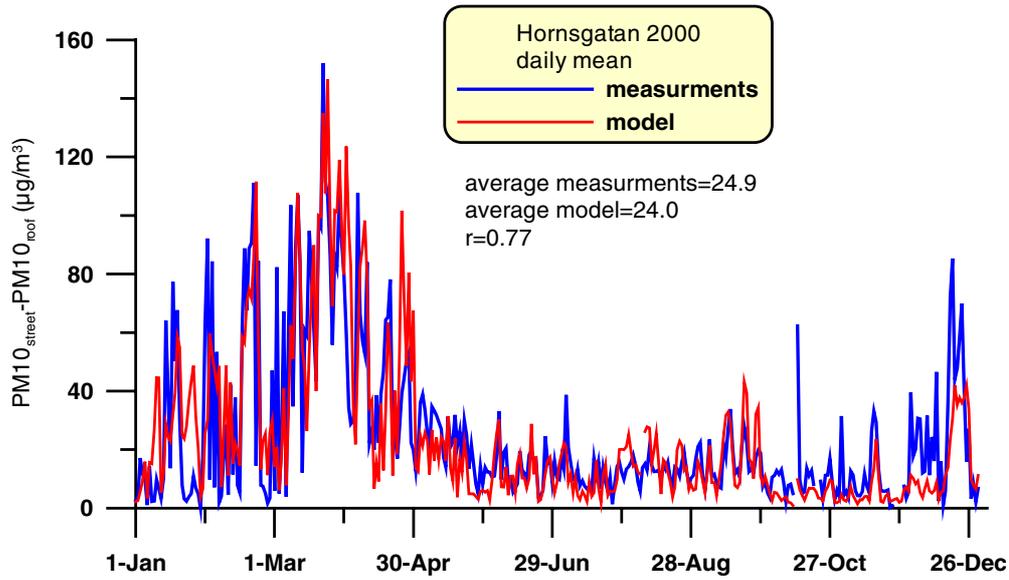
# NOx Hornsgatan

## year 2000



**Comparison of measured and modelled concentrations of NOx**

# PM10 Hornsgatan year 2000



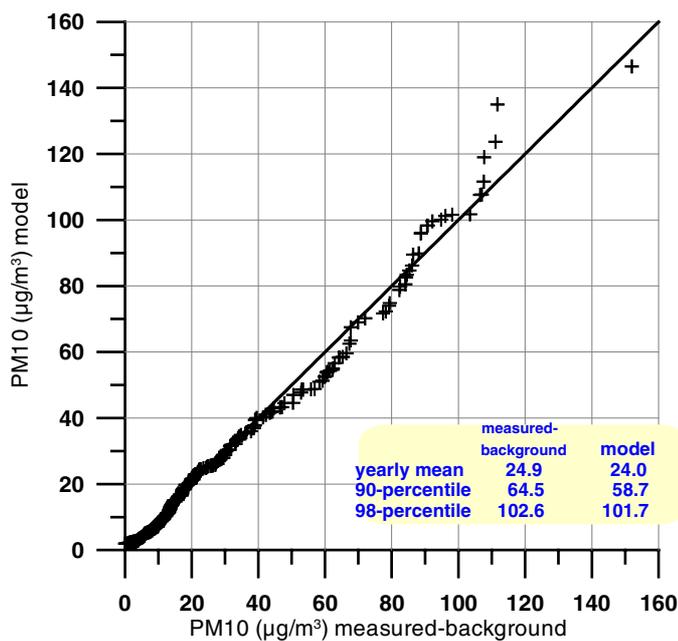
Comparison of measured and modelled concentrations of PM10 ( $\mu\text{g}/\text{m}^3$ ).

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# PM10 Hornsgatan year 2000



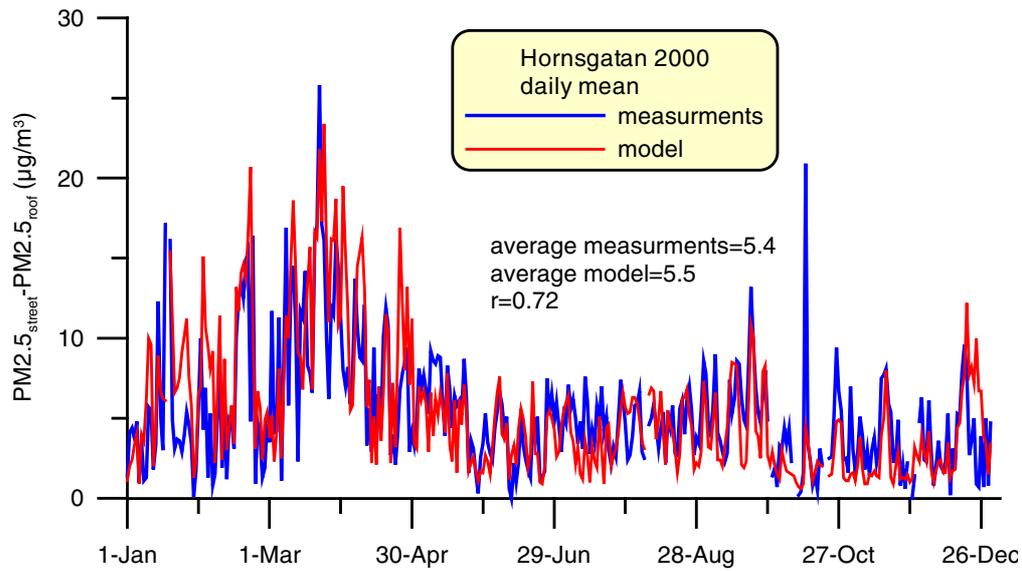
As the last figure but sorted in size

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# PM 2.5 Hornsgatan year 2000



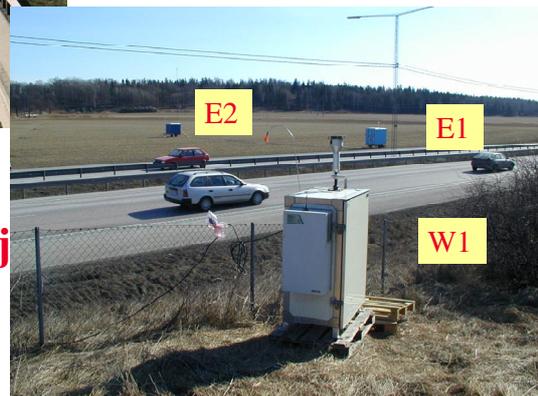
Comparison of measured and modelled concentrations of PM2.5 (µg/m<sup>3</sup>)

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# Vallstanäs, E4:an norr om Stockholm 52 300 v/d



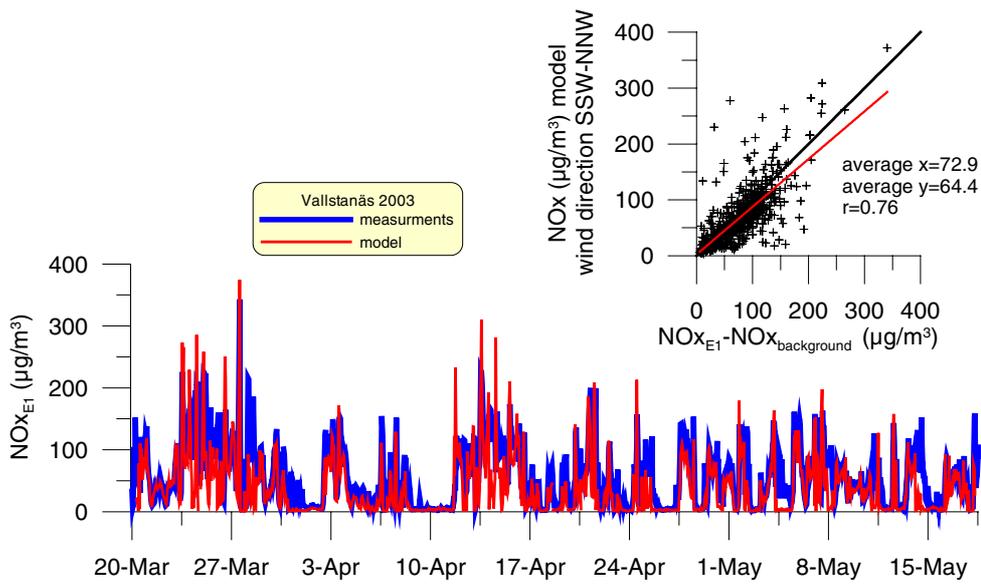
Monitoring campain 2003 mars-maj

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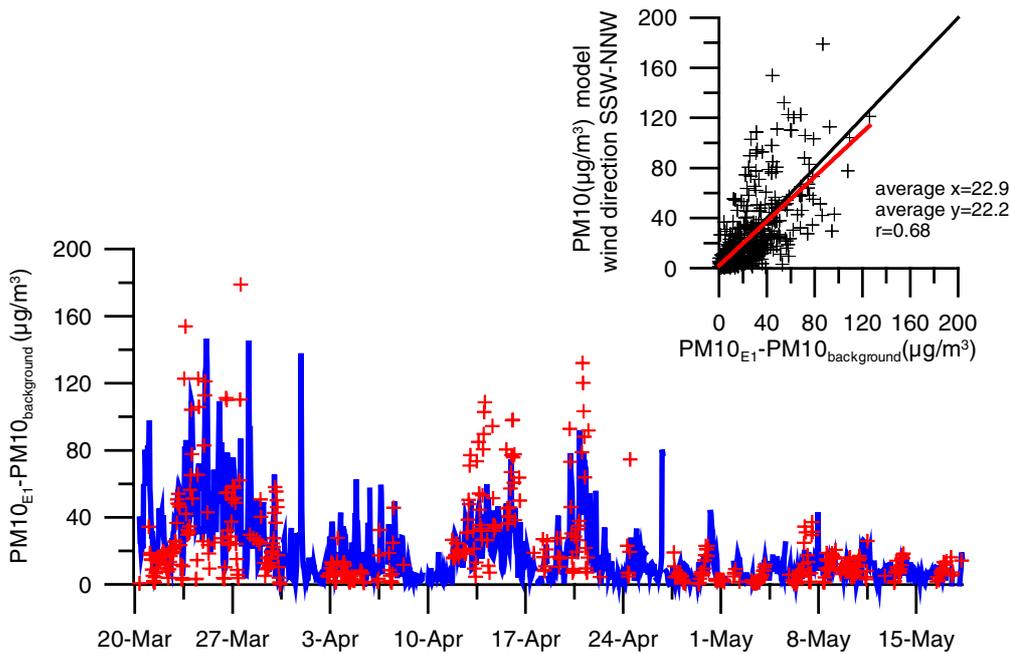
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# NOx Vallstanās



Comparison of measured and modelled concentrations of NOx (µg/m<sup>3</sup>)

# PM10 Vallstanās



Comparison of measured and modelled concentrations of PM10 (µg/m<sup>3</sup>)

# Source-receptor modelling

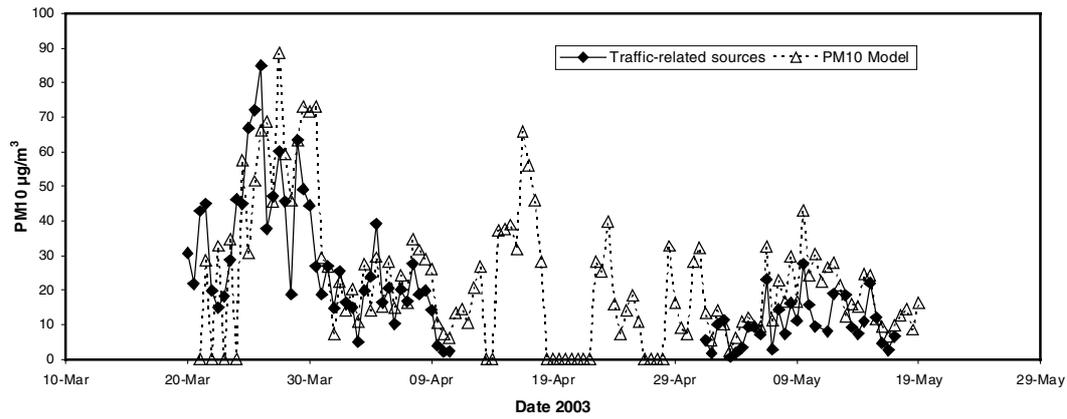
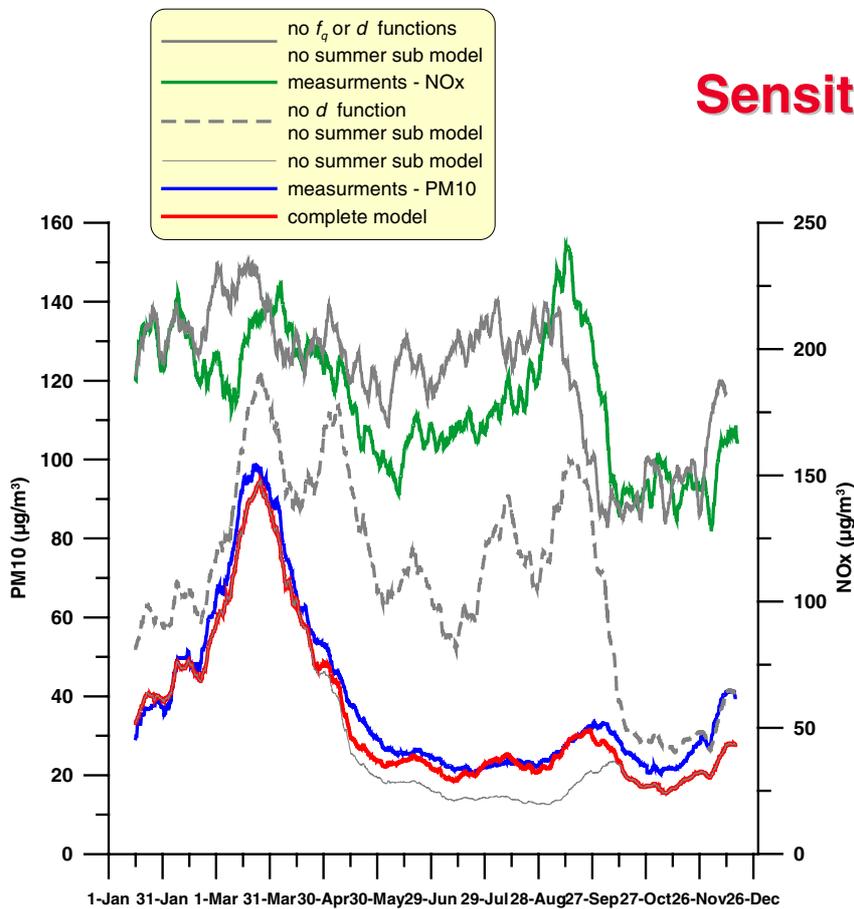


Figure 1. Comparison between the PMF source-receptor model apportionment of PM10 concentrations for the sum of the four traffic-related sources and the PM10 concentrations estimated by the SMHI PM10 model.

*Erik Swietlicki et al., 2004*

# Sensitivity analysis



## Conclusions

- A new model for calculation of emissions from re-suspended particles (PM10 and PM2.5) in traffic environments is presented.
- The model is compared with measurements, both from a narrow street canyon in Stockholm (Hornsgatan) and for an open highway, with good results.
- The model is able to account for the main features in the PM10 variability, especially the peak in PM10 concentrations in late winter and early spring that is commonly experienced in the Nordic countries where studded tires are used.
- More tests on other streets and roads need to be done

## Indata

*Meteorologiska data: vind, temp, fukt, nederbörd, globalstrålning, moln*

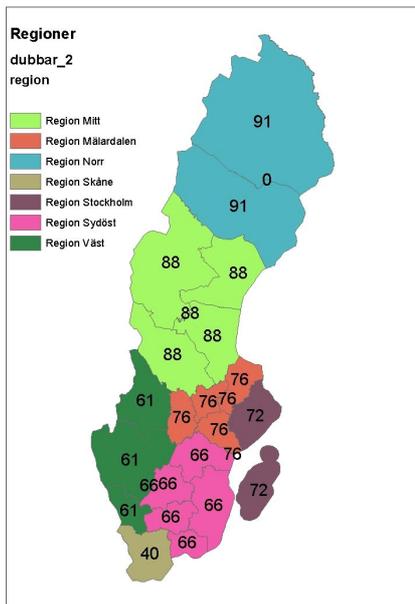
*Bakgrundshalter: bakgrundshalter av PM10*

*Trafik data: fordonsmängd, andel tunga fordon, hastighet*

*Geometrisk data: gatans/vägens riktning, bredd, byggnadshöjder  
antal körfält*

*Vägdata: vägbanans fuktighet, sandning/saltning, snöröjning,  
dubbdäcksandelar, renhållning, egenskaper hos vägbeläggning*

*Information som ofta saknas!*



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