Statistically estimated seasonal $PM_{2.5}$ emission factors at Vallila monitoring site in Helsinki (2002)

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1. Computational methods:

When NOx is a tracer, emission factor for PM is

$$e_f^{PM} = e_f^{NOx} * \frac{C_{PM}^{roadside} - C_{PM}^{background}}{C_{NOx}^{roadside} - C_{NOx}^{background}} \qquad (1)$$

where the total emission factor of NOx is scaled by the ratio of PM to NOx concentration emitted from the road

PM2.5 background concentrations are estimated by the ionsum C_{ion} method (Karppinen et al., 2004)), while the city-background is used for NO_x.

$$C_{ion} = 3.0\left(SO_4^{2-}\right)_S + 4.4\left(NO_3^- + HNO_3\right)_N + 1.3\left(NH_4^+ + NH_3\right)_N \qquad (2a)$$

$$C_{ion} = \sum_{i=1}^{3} \chi_i \; C_{ion,\,i} \qquad (2b)$$

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A multiple regression equation for the roadside $PM_{2.5}$ is

$$C_{PM\,2.5}^{roadside} = k_0 + k_1\, C_{ion}$$

$$+ k_2\, (C_{NOx}^{roadside} - C_{NOx}^{background}) \qquad (3)$$

$$+ k_3\; RH * L^{-1}$$

- the first row terms on the rhs associate with local + regional + LRT background concentrations,
- the second row term associates with emissions from the nearest road
- the lowest row includes the interaction term between relative humidity (RH) and surface layer stability (L = M-O-length).

The coefficient k_2 corresponds the scailing ratio in equation (1).

$$k_2 = \frac{C_{PM\,2.5}^{roadside} - k_0 - k_1\ C_{ion} - k_3\ RH * L^{-1}}{C_{NOx}^{roadside} - C_{NOx}^{background}} \quad (4)$$

Equation (1) is rewritten into

$$e_f^{PM\,2.5} = k_2\ e_f^{NOx} \quad (5)$$

where k_2 is seasonally solved by regression from measured and modelled hourly values.

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2. General data:

- *Monitoring sites (YTV):*
- Vallila: z = 4m, d =14 m, 13000 veh/day, PM2.5, NOx
- Travel speed is 80 km/h, HDV of total vehicles = 10 %, converter equipped LDV = 60 % and diesel LDV = 20 % of total LDV.

- Kallio: z = 4m, city-background station, NOx

- *Total exhaust emission factors in Helsinki are estimated according to Laurikko/ Technical Reseach Centre, 2003:*
- $e^{PM2.5}$ = 18 mg/vkm
- e^{NOx} = 1.5 g/vkm

- *Regression* is solved in downwind conditions at Vallila grouped seasonally to winter (Jan, Feb, Dec), spring (Mar, Apr, May), summer (Jun, Jul, Aug) and autumn (Sep, Oct, Nov), in 2002.

3. Results:

Table 1. Number of cases N, the regression coefficients k_i with corresponding p-values (in parenthesis) and adjusted R^2.

	N	k_0	k_1	k_2	k_3	R^2
Winter	363	1.593(0.038)	1.922(0.000)	0.028(0.038)	0.072(0.311)	0.323
Winter2	363	1.625(0.035)	1.925(0.000)	0.032(0.015)		0.322
Spring	550	1.009(0.062)	2.295(0.000)	0.076(0.000)	0.102(0.002)	0.671
Summer	545	3.483(0.000)	1.537(0.000)	0.046(0.000)	0.117(0.001)	0.360
Autumn	723	3.082(0.000)	0.986(0.000)	0.099(0.000)	0.296(0.000)	0.548

- In winter the interaction term is insignificant
- Squared correlation (R^2) is low in winter and summer, while it is rather high in spring and autumn

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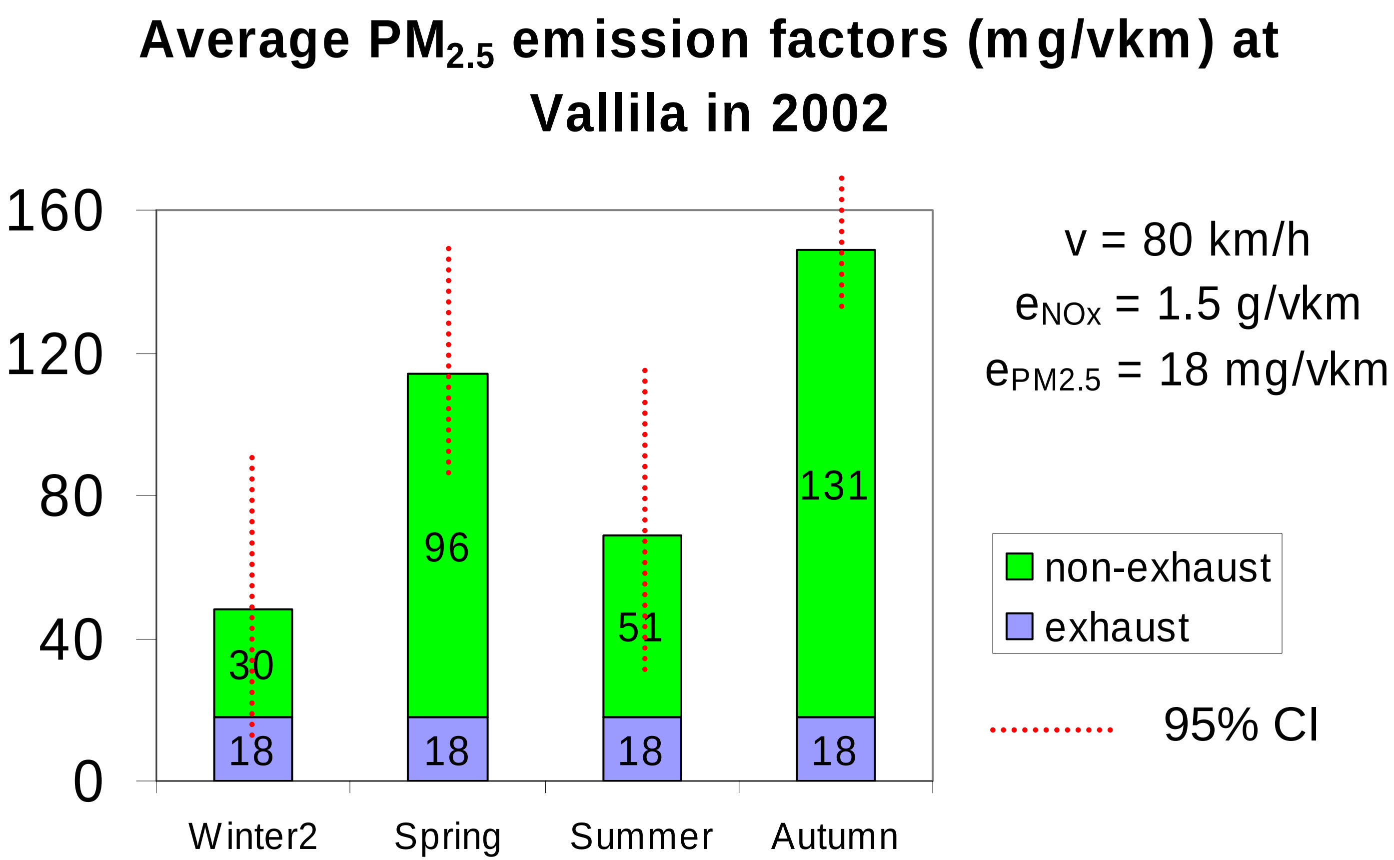
Table 2. The coefficient k_2 and seasonal $PM_{2.5}$ emission factors with 95% confidence intervals

	k_2	L 95%	U 95%	$e^{PM2.5}$	L 95%	U 95%
Winter2	0.032	0.006	0.057	48	9	86
Spring	0.076	0.053	0.098	114	80	147
Summer	0.046	0.017	0.076	69	26	114
Autumn	0.099	0.089	0.109	149	134	164

- Uncertainty in k_2 is directly reflected to the emission factor estimates ($e^{PM2.5} = k_2 * e^{NOx}$)

Non-exhaust $PM_{2.5}$ emission factor (mg/vkm) = computed total $PM_{2.5}$ emission factor - exhaust $PM_{2.5}$ emission factor



4.Conclusions:

- The one-year time series used is too short for seasonal and monthly analysis
- Organic particle indicators are missing in the regression equation used
- Winter and summer are statistically most problematic in term of both PM2.5 and coarse particle emission factors
- Severe collinearity is observed in case of coarse particle regression especially during winter and summer
- PM2.5 emission factors are described in a statistically reliable way in spring and autumn