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Supplement of

Modelling and measurements of urban aerosol processes on the neighborhood scale in Rotterdam, Oslo and Helsinki

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S1. The effect of different concentration of condensable organic vapors

In this study, particle growth was assumed to occur by condensation of gaseous n-alkanes which represent the typical range of volatility of vapors related to vehicle exhaust emissions. Roadside concentrations of n-alkanes and other condensable organic vapors are not well known. Zhang and Wexler (2004) showed that 1 ppbv or higher concentration of n-alkanes is required for condensational growth to compete with dilution during the initial dilution stage between tailpipe and roadside.

Only few reports on volatile organic compound (VOC) concentration measurements in the air in the street environment of European cities have been published. Average measured total VOC concentration (excluding VOC with less than 4 carbon atoms and benzene) was 7.9 ppbv at a traffic sites in London (Schneidemesser et al., 2010), 32.6 ppbv in a street canyon in Copenhagen (Hansen and Palmgren, 1996), and 44.3 ppbv in urban air in Hamburg (Bruckmann et al., 1988). Hellén et al. (2006) measured VOC concentration at an urban site in Helsinki; average winter concentration of the sum of several different VOC were $4.9\text{x}10^4$ ng m^{-3} corresponding to 11.4 ppbv.

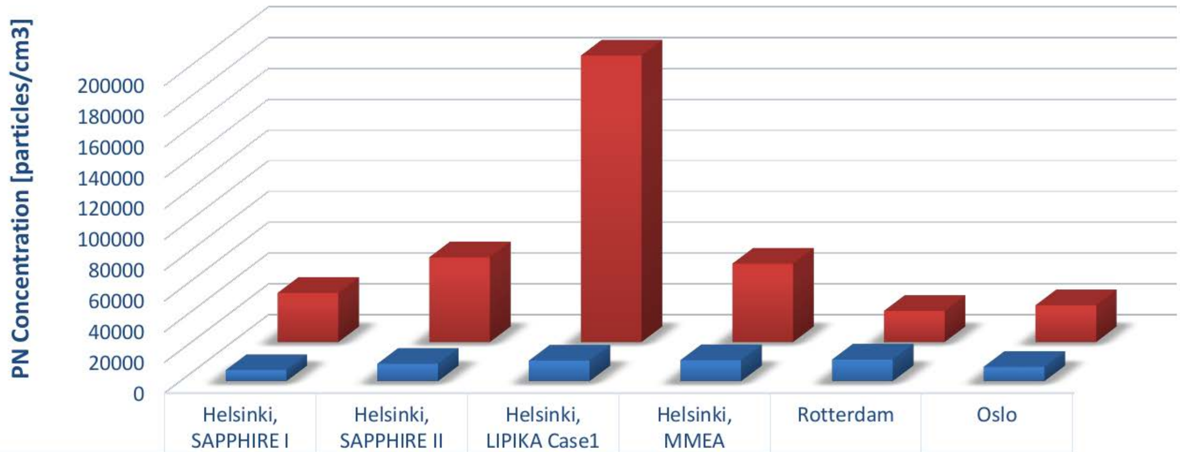
Assuming that 5−10% of the VOC's react to form condensable gas-phase products, a concentration range of 0.4−4.4 ppbv is obtained using the available VOC measurements. Based on this, initial concentrations of 0.25 ppbv C22 and 0.25 ppbv C28 were used in the reference case (all campaigns and dispersion conditions). In the sensitivity tests, initial concentrations of C22 and C28 (ratio 1:1) were stepwise increased by 0.5 ppbv in the range 1−4 ppbv. The effect of increased concentration of n-alkanes was tested for the campaigns in Rotterdam, Oslo (UFP-Oslo Tav and winter), and Helsinki LIPIKA. We note that n-alkane vapors were diluted by background air with zero n-alkane in the model calculation during travel of the air parcel away from the roadside.

Table S1: Meteorological and dispersion conditions during the campaigns at the traffic sites. Notation: WD = wind direction, WS = wind speed, Ta = ambient air temperature, RH = relative humidity, L^{-1} = inverse Monin-Obukhov length ($L^{-1}<0$ unstable; $L^{-1}=0$ neutral, $L^{-1}>0$ stable), H_{mix} = mixing height. Rotterdam data and mixing height data: ranges of 10th and 90th percentile; median in brackets. Helsinki LIPIKA and MMEA: Ta and RH data as mean and standard deviation. All other data is given as range of minimum to maximum value. Atmospheric stability data for Helsinki was extracted from the CAR-FMI model. Stability data for Oslo and Rotterdam was calculated based on temperature and wind speed at two heights from nearby met stations using traditional Monin-Obukhov similarity theory.

City/ campaign	WD [°]	WS [m/s]	T_a [°C]	RH [%]	L^{-1} [m^{-1}]	H_{mix} [m]	Dispersion
Rotterdam	97−280 (226)	0.1−5 (3.6)	10.5−17.8 (14.8)	43−88 (71)	1e-3−1e-1	50−359 (128)	Varied
Oslo, UFP-Oslo Tav	66−238	0.8−6.3	-14−10	42−97	-4e-1−2e-1	16−983 (77)	Varied
Oslo, UFP-Oslo Winter	65−86	0.6−3.8	-12− -8	69−93	0	204−902 (549)	Varied
Helsinki, SAPPHIRE, Case1	-90−30	<4	10−15	60−95	-5e-3−1e-2	55−1386 (220)	Downwind
Helsinki, SAPPHIRE, Case2	-90−0	<5	-15− -4	55-92	5e-4−1e-2	132−408 (205)	Downwind
Helsinki, LIPIKA, Case1	250−300	1.3−2.8	1.9±0.5	80±1	4e-4−8e-3	92−179 (149)	Downwind
Helsinki, MMEA	10−50	4−5	-9.7±0.7	68±4	2e-3−8e-3	115−174 (144)	Downwind

Table S2: Results from sensitivity tests for dry deposition using two deposition methods, KS2012 and H2012. Sensitivity runs were done for the campaigns in Rotterdam and Oslo UFP-Oslo Tav under moderate dispersion conditions. The contribution of dry deposition to percentage change of PN concentration (%) between roadside station and neighborhood environment after 30 minutes transport time. The result for KS2012 in case "Urban" corresponds to the contribution of dry deposition to PN change in the reference model simulation.

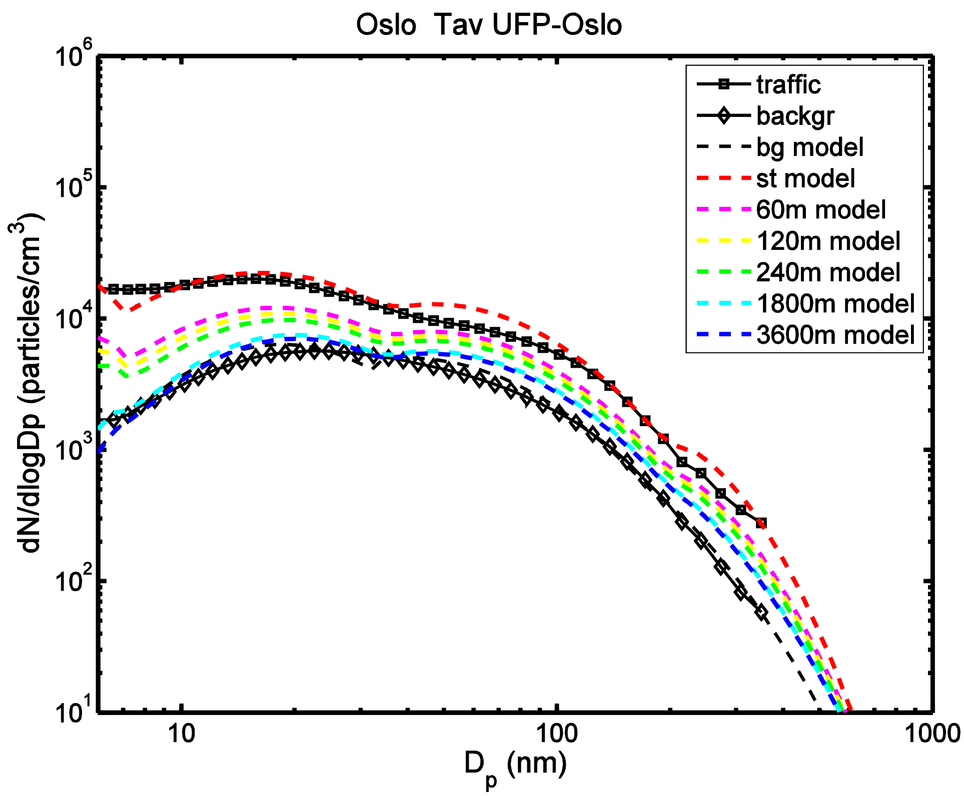
Case	Surface type	Rotterdam (KS2012)	Rotterdam (H2012)	Oslo UFP-Oslo Tav (KS2012)	Oslo UFP-Oslo Tav (H2012)
Urban	Street and building	4.3	2.6	2.6	1.2
Low friction	Street and building	4.2	0.5	2.5	0.3
High roughness	Street and building	4.3	12.8	2.6	4.2
Green area without trees	Grassland	3.0	0.6	1.8	0.3
Green area with forest	Deciduous forest	2.0	13.9	1.2	4.5



	Helsinki, SAPPHIRE I	Helsinki, SAPPHIRE II	Helsinki, LIPIKA Case1	Helsinki, MMEA	Rotterdam	Oslo
Total PN Urban Bg	7200	11300	13400	13700	14100	9300
Total PN Roadside	32000	55100	186100	51000	20300	24000

Figure S1: Total PN concentration (in particles cm^{-3}) as measured campaign average at the roadside traffic station (red bars) and at the urban background site (blue bars) for all campaigns included in this study.

A



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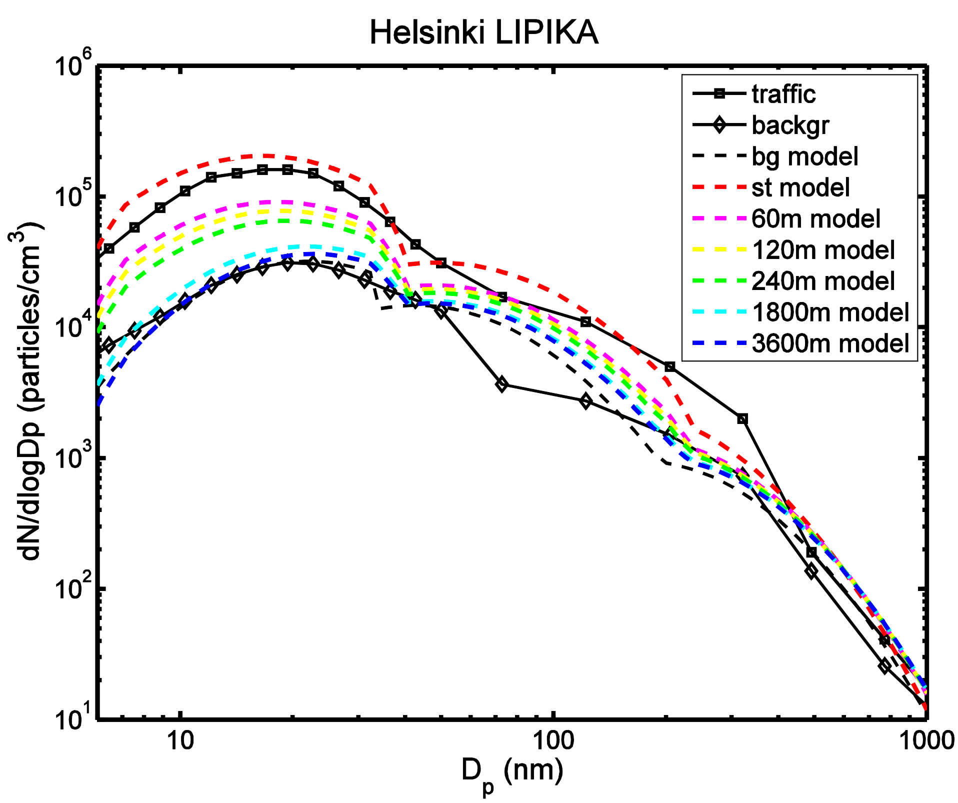

Figure S2: Continued.

C

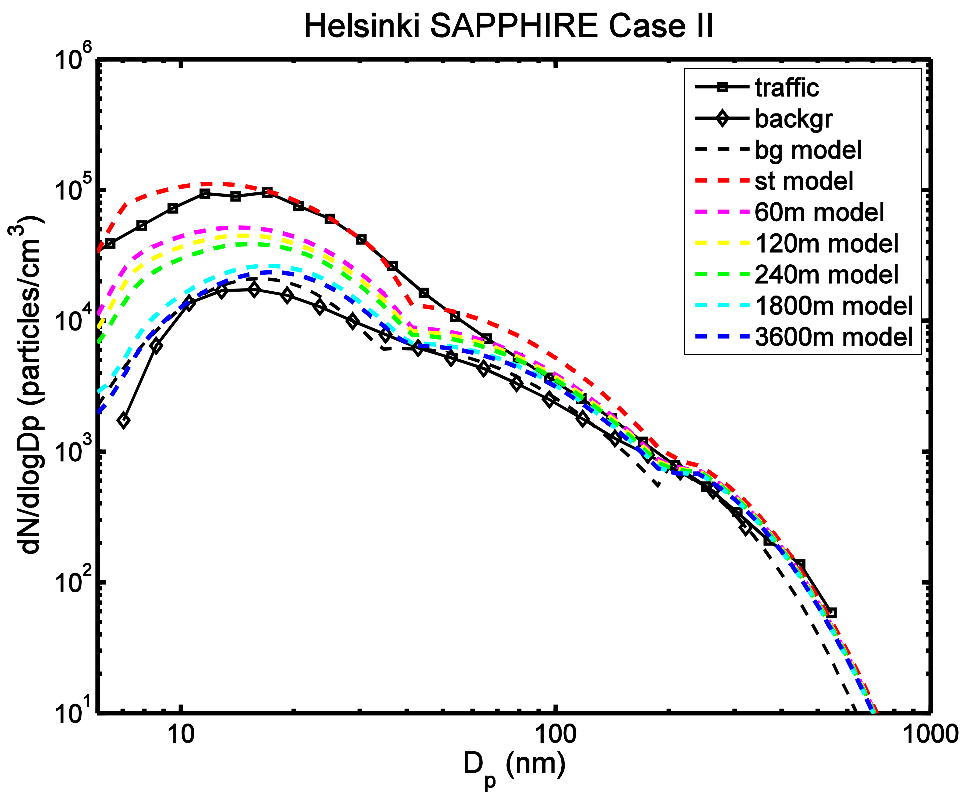

Figure S2: Size distributions (dN/dlogDp in particles cm^{-3}) downwind of roads in selected campaigns: A) Oslo UFP-Oslo Tav, B) Helsinki LIPIKA, and C) Helsinki SAPPHIRE Case II. The plots show the measured distribution at roadside (black squares connected by line), the measured distribution at urban background (black diamonds connected by line), the initial model distribution (roadside: dashed red line, background: dashed black line) and the modelled distributions (resulting for moderate dispersion conditions) at distances of 60, 120, 240, 1800, and 3600 m, respectively. Size distributions are shown with a lower size cut-off at 6 nm.

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