



*Supplement of*

## **BAERLIN2014 – the influence of land surface types on and the horizontal heterogeneity of air pollutant levels in Berlin**

**Boris Bonn et al.**

*Correspondence to:* Erika von Schneidemesser (evs@iass-potsdam.de)

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The supporting online information document contains additional information on gas- and aerosol properties in different environments. A volatile organic compound (VOC) canister sample in the vicinity of a common air blower in action, which was performed by the Research Centre Juelich, is provided in addition to Table 5, too. The SOI are structured as follows:

- S1. Additional information on set-up of instruments, methods applied and comparability of the bicycle measurements with respect to the van
  - S1.1 Bicycle measurement set-up and calibration factors applied
  - S1.2 Results of bicycle and van based measurements at comparison tracks
- S2. Further information on second flight
- S3. Additional gas-phase related results of air pollutants
  - S3.1 Basic pollutants: CO, NO, NO<sub>2</sub> and O<sub>3</sub>
  - S3.2 Exemplary VOC sample in the vicinity of an air blower in use
- S4. Additional information on ambient particulate matter related results
- S5. Information about further results – temperature
- S6. Comparison of different measurement methods with reference ones in Neukölln

**S1. Additional information on set-up of instruments, methods applied and comparability of the bicycle measurements with respect to the van**

### **S1.1 Bicycle measurement set-up and calibration factors applied**

As stated in section 3.1 of the study, both particle instruments, i.e. the GRIMM1.108 and the DiSCmini, were located in a backpack or a pannier, which sampled ambient air by conductive inlet tubes. These inlet tubes (black silicone for the GRIMM, Tygon for DiSCmini, both ca. 50 cm in length) and the temperature sensor were fixed on the outside of backpack or pannier (Fig. S1.1). Losses from inlets and tubing were accounted for with correction factors provided in Table A2.



**Figure S1.1.** Photograph of the measurement set-up used by the cyclists. Instruments were either placed in a pannier at the rear with Tygon inlets about 1m above surface (left) or in a backpack of the cyclist with the Tygon inlets at about the same height (saddle).

Based on the particle measurements of the GRIMM instrument its software calculated six particulate mass values corresponding to different size ranges and corresponding to potential health effects: PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub> as well as PM(inhalable), PM(thoracic) and PM(alveolar). The final three health-related quantities estimate the particle number concentration for those size fractions making it to the throat/upper respiratory system, lung, and blood system, respectively (EN 481; European Committee for Standardization, 1993).

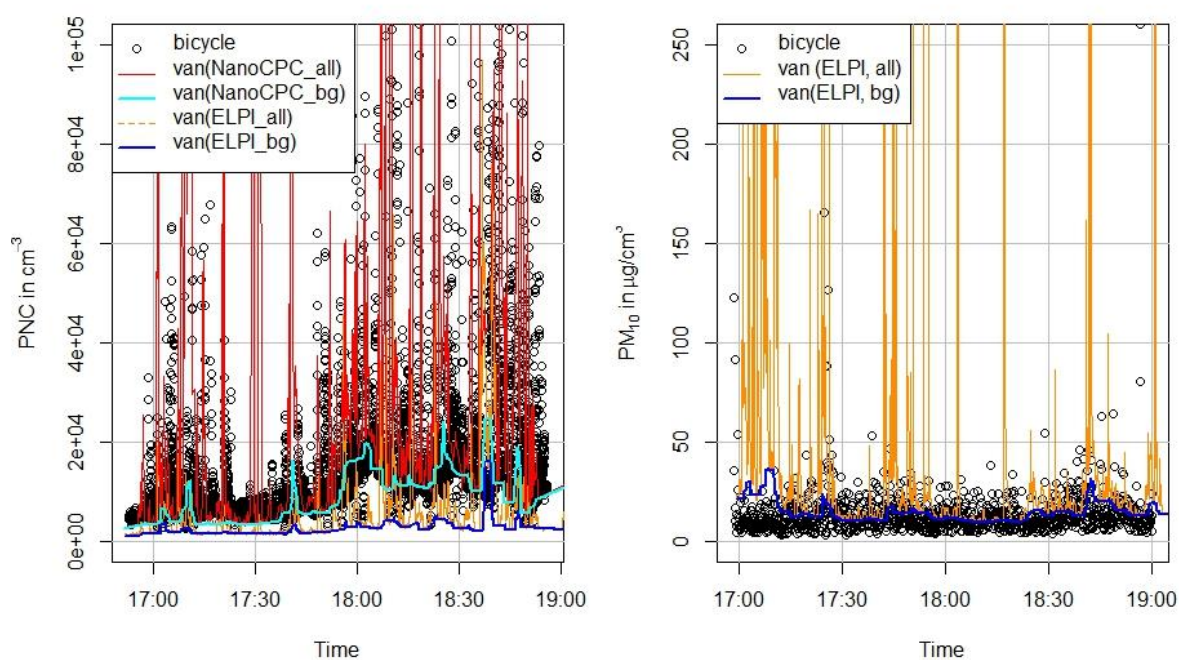
All particle instruments except the instrument were calibrated a month prior to the campaign in a controlled comparison experiment at TROPOS in Leipzig. Both instruments used on the bicycle measurement platform - DiSCmini and GRIMM 1.108 – were repeatedly operated in parallel with the suite of calibrated particle instruments (GRIMM 1.108, 5.403 and 5.416, and a TSI NSAM provided by the Federal Environmental Agency, Berlin) set up at the reference site in Neukölln. This was used for both instruments to obtain the calibration factors including the inlet losses listed in Table S1.1.

**Table S1.1** Correction factors and mean losses for the parameters of both bicycle instruments.

Instrument and parameter	Correction factor f	Mean loss
DiSCmini, tot. part. num. conc.	1.22±0.20	18.8±3.1%
DiSCmini, lung depos. surface area	1.15±0.13	13.0±9.0%
Grimm 1.108, PM10	1.24±0.46	19.3±7.1%
Grimm 1.108, PM2.5	1.24±0.29	19.6±4.5%
Grimm 1.108, PM1	1.29±0.12	22.6±2.1%
Grimm 1.108, PM(inhalable)	1.28±0.64	21.7±10.8%
Grimm 1.108, PM(thoracic)	1.25±0.47	19.7±7.5%

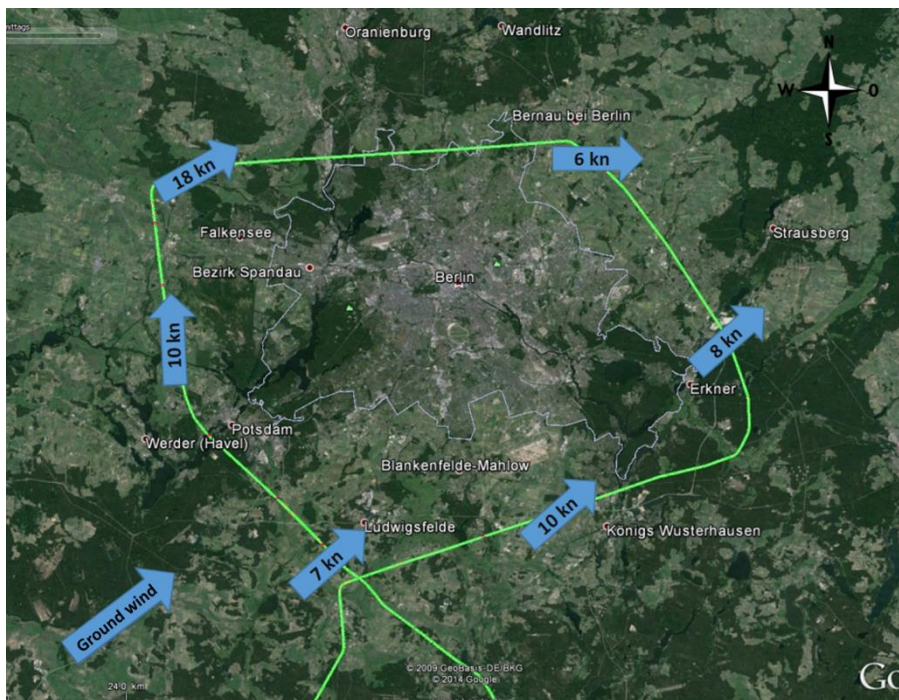
## S1.2 Results of bicycle and van based measurements at comparison tracks

Bicycle and van observations were directly compared during two 1.5 h tracks across Berlin. These focussed on particle number concentration, particulate matter and temperature only, as the bicycle measurements were not equipped for detecting gas-phase pollutants.

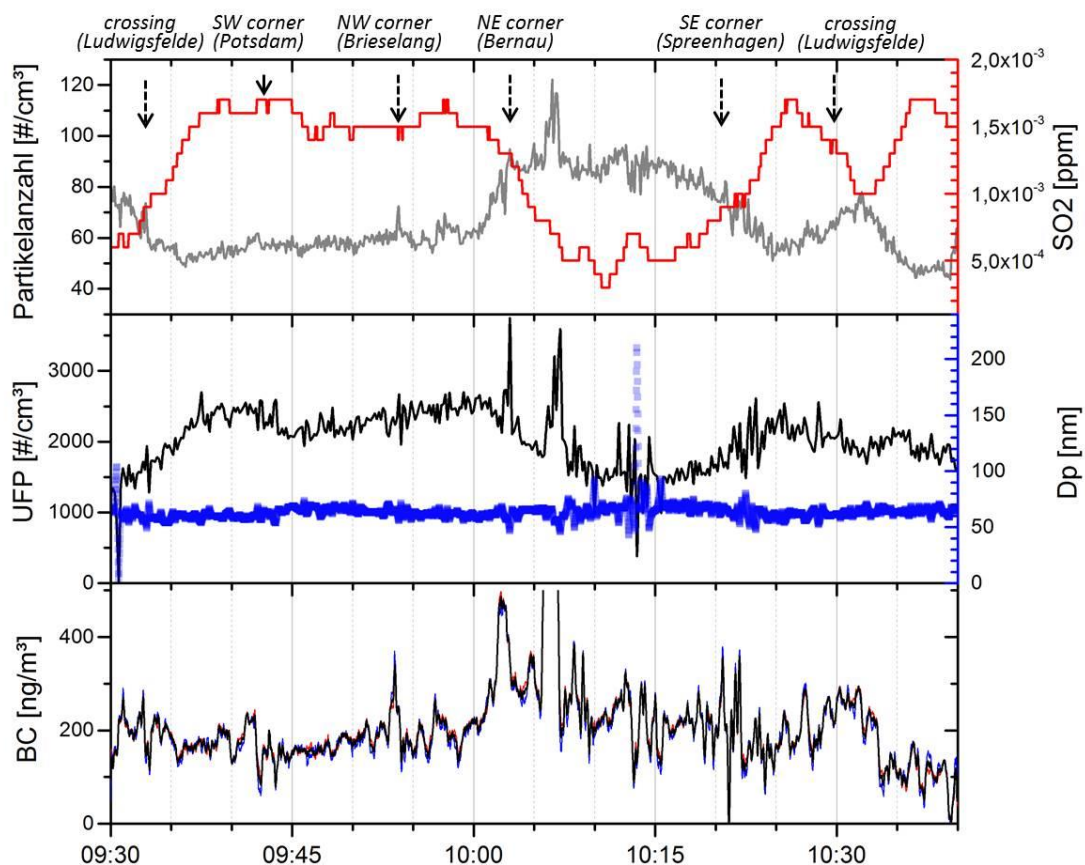




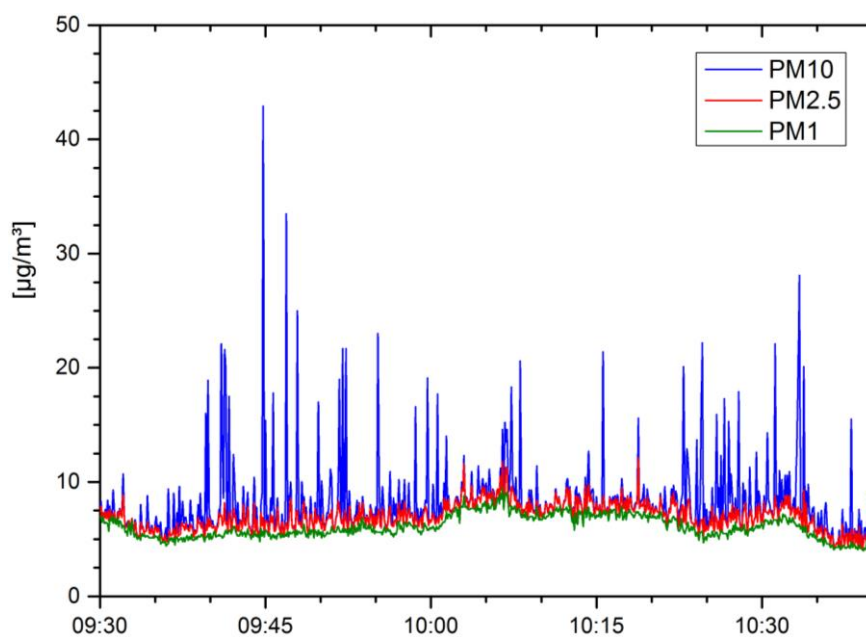
## S2. Further information on the second flight



**Figure S2.1.** Flight track (green line) displayed with wind directions and speeds during the observations at around 500 m (1700 ft) altitude.

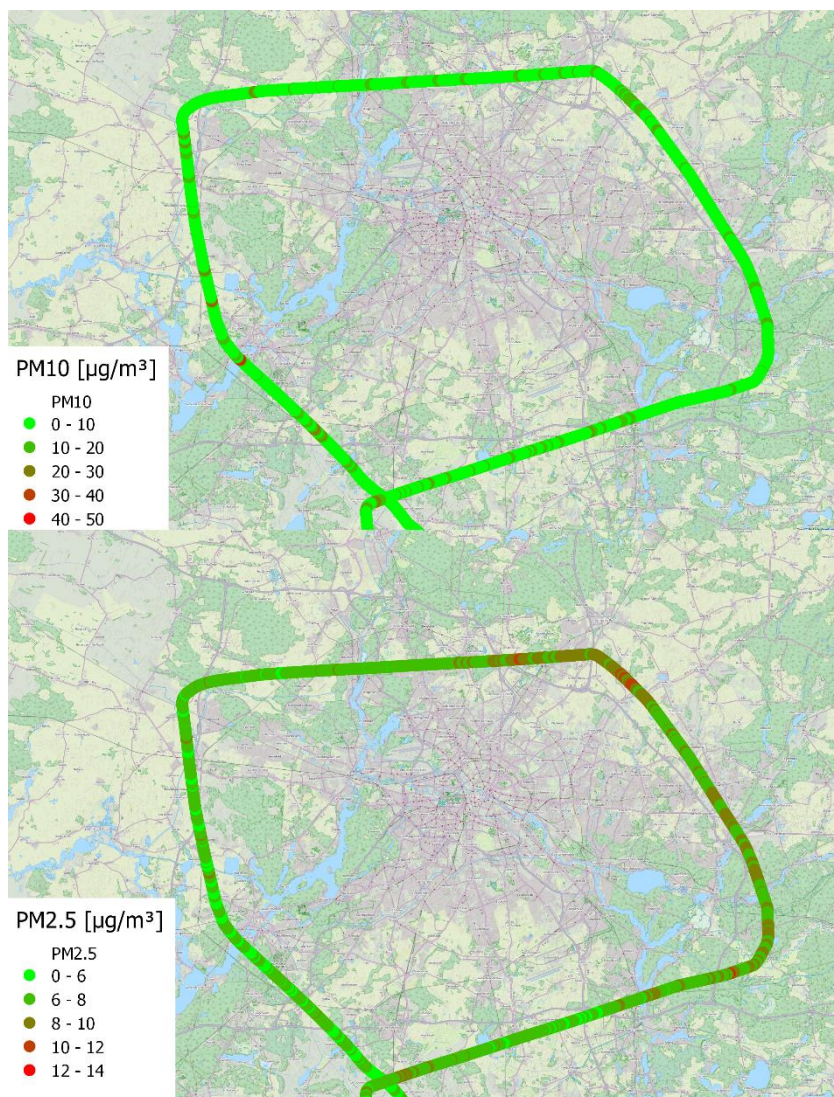


**Figure S2.2** Particle parameters measured during the Oct. 10 flight around Berlin. Particle number concentration and sulphur dioxide (SO<sub>2</sub>), UFP and UFP-diameter, Black Carbon (from top position towards bottom) as measured at a constant altitude of around 500 m (1700 ft).





**Figure S2.3.** Total particle mass (PM) values for different upper cut of diameters provided in  $\mu\text{m}$  measured during the flight on the 10<sup>th</sup> of October 2014.



**Figure S2.4.** Spatial distribution of PM<sub>10</sub> (top) and PM<sub>2.5</sub> (bottom) flight measurements on the 10<sup>th</sup> of October 2014.

### S3. Additional gas-phase related results of air pollutants

#### S3.1 Basic pollutants: CO, NO, NO<sub>2</sub> and O<sub>3</sub>

**Table S3.1.1.** Absolute CO characteristics (van measurements, baseline) at different surface usage types. The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-” indicates areas, which have not been tested by the method. Values are presented in ppb<sub>v</sub>.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>176</b>	<b>201</b>	<b>243</b>	<b>223.9</b>	<b>171237</b>
<b>(Neukölln): UBA</b>						
Urban	block build.	127.8	145.3	165.8	151.6	16501
Urban	single build.	119.6	131.9	149.5	145.6	60257
Industry		134.1	152.7	178.9	164.8	10900
Com.+transp		149.7	163.6	183.3	173.8	4243
Green spaces		130.0	143.7	160.6	186.4	10907
Agriculture		119.8	127.4	135.8	128.5	7877
Dec. forest		115.1	130.0	141.6	133.6	6124
Con. forest		115.3	120.5	140.0	127.9	4508
mix. forest		121.6	131.1	142.1	133.1	1300

**Table S3.1.2.** Relative CO burden characteristics (van/van (background) measurements) at different surface usage types divided by the reference concentration in Berlin-Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban - block build.	0.72/0.60	0.90/0.67	1.51/0.75	/1.75/0.67	16501
Urban - single build.	0.64/0.57	0.78/0.64	1.25/0.70	1.46/0.65	60257
Industry	0.72/0.59	0.93/0.66	1.57/0.74	1.68/0.70	10900
Com.+transp.	0.82/0.62	1.30/0.67	2.34/0.75	2.29/0.70	4243
Green spaces	0.70/0.57	0.97/0.64	2.04/0.77	2.08/0.80	10907
Agriculture	0.63/0.59	0.69/0.63	0.93/0.68	1.11/0.64	7877
Dec. forest	0.56/0.52	0.70/0.57	1.07/0.67	1.03/0.61	6124
Con. forest	0.54/0.52	0.65/0.56	0.88/0.63	0.88/0.58	4508
mix. forest	0.57/0.52	0.71/0.58	1.15/0.66	1.29/0.61	1300

**Table S3.1.3.** Absolute NO characteristics (van measurements) at different surface usage types. The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-“ indicates areas, which have not been tested by the method. Values are presented in ppb.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>0.8</b>	<b>1.3</b>	<b>2.9</b>	<b>3.1</b>	<b>11869</b>
<b>(Neukölln): UBA</b>						
Urban	block	6.9	32.3	106.4	86.8	1473
	build.					
Urban	single	4.2	22.7	88.6	81.4	5958
	build.					
Industry		13.3	45.8	142.0	111.9	1021
Com.+transp.		23.6	65.4	124.8	96.8	415
Green spaces		13.9	46.7	208.1	142.8	975
Agriculture		0.8	6.4	25.8	27.8	822
Dec. forest		1.3	10.8	38.4	30.9	654
Con. forest		1.5	5.0	28.3	28.0	561
mix. forest		2.5	11.0	46.3	43.7	136

**Table S3.1.4.** Relative NO characteristics (van measurements) at different surface usage types divided by the reference concentration in Berlin-Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	- 2.8	15.4	60.4	74.4	1473
Urban single build.	- 2.4	16.6	73.2	80.1	5958
Industry	7.4	25.7	72.3	76.3	1021
Com.+transp.	12.9	33.9	84.5	62.0	415
Green spaces	7.9	31.7	112.7	134.7	758
Agriculture	0.8	6.2	24.3	31.5	822
Dec. forest	1.0	9.1	33.4	34.4	654
Con. forest	1.5	8.0	29.9	45.8	561
mix. forest	2.4	10.5	33.5	43.8	136



**Table S3.1.5.** Absolute NO<sub>2</sub> characteristics (van measurements) at different surface usage types. The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-“ indicates areas, which have not been tested by the method. Values are presented in ppb.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>6.7</b>	<b>9.4</b>	<b>14.1</b>	<b>11.8</b>	<b>12419</b>
<b>(Neukölln): UBA</b>						
Urban	block build.	9.2	23.9	85.3	8.8	1473
Urban	single build.	5.8	18.1	63.2	8.1	5958
Industry		12.7	30.3	97.0	8.4	1021
Com.+transp.		20.6	56.0	148.0	5.3	352
Green spaces		9.5	29.8	108.2	7.5	758
Agriculture		1.5	5.2	23.5	3.2	732
Dec. forest		2.6	7.6	31.0	3.3	654
Con. forest		3.4	9.3	26.0	2.9	561
mix. forest		2.2	18.0	44.1	4.7	136

**Table S3.1.6.** Relative NO<sub>2</sub> burden characteristics (van measurements) at different surface usage types divided by the reference concentration in Berlin-Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-” indicates areas, which have not been tested by the method.

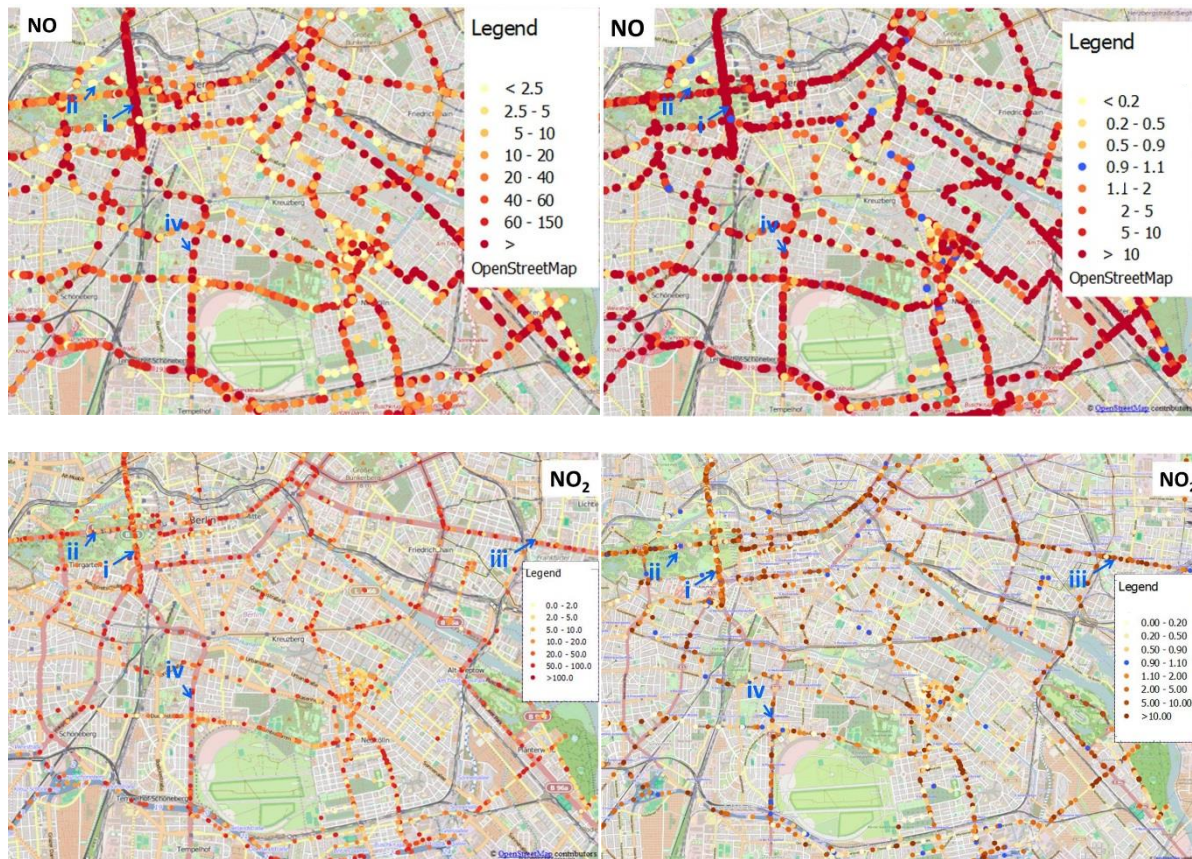
<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	- 0.6	1.6	6.3	8.8	1473
Urban single build.	- 0.4	1.3	5.1	8.1	5958
Industry	0.7	2.1	6.6	8.4	1021
Com.+transp.	1.0	2.6	6.6	5.3	352
green spaces	0.7	1.7	7.3	7.5	758
Agriculture	0.2	0.7	2.9	3.2	822
Dec. forest	0.2	0.5	2.5	3.3	654
Con. forest	0.2	0.7	2.1	2.9	561
mix. forest	0.2	1.6	3.4	4.7	136

**Table S3.1.7.** Absolute ozone burden characteristics (van measurements) at different surface usage types. The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-“ indicates areas, which have not been tested by the method. Values are presented in ppb.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>19.6</b>	<b>29.0</b>	<b>39.7</b>	<b>30.6</b>	<b>50158</b>
<b>(Neukölln): UBA</b>						
Urban	block build.	15.5	25.6	33.7	24.9	6549
Urban	single build.	17.8	28.7	37.5	28.6	24503
Industry		11.7	21.7	34.1	24.0	4145
Com.+transp.		13.2	18.9	26.4	20.6	1692
green spaces		14.7	21.6	34.6	25.1	3684
Agriculture		31.0	37.8	46.1	37.5	3267
Dec. forest		18.3	25.7	37.5	28.0	2667
Con. forest		17.7	22.7	38.6	27.4	2099
mix. forest		17.5	27.3	43.8	30.0	548

**Table S3.1.8.** Relative ozone burden characteristics (van measurements) at different surface usage types divided by the reference concentration in Berlin-Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	- 0.5	0.7	0.9	0.7	6549
Urban single build.	- 0.5	0.7	0.9	0.7	23907
Industry	0.4	0.6	0.8	0.6	4145
Com.+transp.	0.5	0.6	0.8	0.6	1692
green spaces	0.5	0.6	0.8	0.6	3684
Agriculture	0.7	0.9	0.9	0.8	3267
Dec. forest	0.5	0.7	0.8	0.7	2667
Con. forest	0.4	0.6	0.8	0.6	2099
mix. forest	0.5	0.7	0.9	0.7	548



**Figure 3.1.1.** Mobile measurement data (left) and relative (right) graphs of nitrogen monoxide (NO, top) and dioxide (NO<sub>2</sub>, bottom) observed by the measurement van. Mobile measured values are displayed in ppbv. Colours indicate the heterogeneity of the parameters, of the range (mobile measured values) and the variation with respect to reference value.

### S3.2 Exemplary VOC sample in the vicinity of an air blower in use

**Table S3.2.1** Canister sample analysed for VOC compositions in the vicinity of an air blower in use adjoined with the results for the reference site at Nansenstraße. An ozone scrubber was applied in front of the inlet to prevent sampling losses and artefacts. All values are provided as mean volume mixing ratios in pptv. Elevated anthropogenic compounds with respect to vegetated background area concentration ( $>\text{average}+2\text{STD}$  of the two smaller mixing ratios of vegetated areas) are marked in bold. Underlined numbers mark biogenic compounds exceeding the average of the two smaller mixing ratios for anthropogenic dominated areas + 2 standard deviations. “b.d.” abbreviates *below detection limit*.

<i>Compound</i>	<i>Locations affect by both emission types</i>	
	<i>air blower</i>	<i>Nansenstraße (see Tab. 5)</i>
	<i>1 sample</i>	<i>14 samples</i>
ethene	<b>33487</b>	<b>465±263</b>
ethyne	<b>40003</b>	286±239
ethane	<b>5642</b>	<b>1686±1514</b>
propene	<b>20445</b>	251±64
propane	<b>991</b>	<b>825±613</b>
propyne	<b>2574</b>	73±28
acetaldehyde	<b>108</b>	<b>336±139</b>
2-methylpropane	<b>1888</b>	<b>504±441</b>
methanol	1244	<b>4996±3082</b>
1-butene / i-butene	<b>22974</b>	<b>300±412</b>
1,3-butadiene	<b>1777</b>	43±11
n-butane	<b>9867</b>	b.d.
trans-2-butene	b.d.	16±3
cis-2-butene	<b>1025</b>	<b>74±38</b>
1,2-butadiene	<b>120</b>	<b>33±7</b>
ethanol	<b>546</b>	333±189
3-methyl-1-butene	b.d.	52±6
2-methylbutane	<b>27819</b>	465±178
acetone	1002	<b>10721±24004</b>



1-pentene	<b>265</b>	35±8
2-propanol	b.d.	44±14
2-methyl-1-butene	<b>1544</b>	b.d.
n-pentane	<b>1883</b>	242±106
isoprene	<b><u>1012</u></b>	266±159
trans-2-pentene	<b>490</b>	<b>28±13</b>
cis-2-pentene	<b>230</b>	22±9
propanal	b.d.	54±24
2-methyl-2-butene	b.d.	11±8
acetic acid methylic ester	b.d.	b.d.
1,3-pentadiene	b.d.	14±4
cyclopentadiene	b.d.	35±14
2,2-dimethylbutane	<b>8847</b>	117±111
2-butanol	b.d.	<b>117±156</b>
1-propanol	b.d.	<b>342±377</b>
cyclopentene	b.d.	<b>39±11</b>
methacrolein	b.d.	<u>80±37</u>
cyclopentane / 2,3-di-methylbutane	<b>9838</b>	<b>275±316</b>
2-methylpentane	<b>10049</b>	232±112
methylvinylketone	b.d.	<u>102±</u>
butanal	b.d.	133±56
1-hexene	b.d.	<b><u>113±68</u></b>
3-methylpentane	<b>5651</b>	<b>73±40</b>
2-methyl-1-pentene	b.d.	14±3
n-hexane	<b>373</b>	<b>127±99</b>
trans-2-hexene	b.d.	<b>110±53</b>
cis-2-hexene	b.d.	<b>107±21</b>
1,3-hexadiene (trans)	b.d.	<b>53±10</b>
methylcyclopentane	b.d.	<b>49±13</b>

2,4-dimethylpentane	<b>8355</b>	54±28
methylcyclopentene	b.d.	14±5
benzene	<b>420</b>	<b>303±238</b>
1-butanol	b.d.	28±14
cyclohexane	<b>6705</b>	39±23
2-methylhexane	<b>432</b>	36±14
2,3-dimethylpentane	<b>1169</b>	23±14
3-methylhexane	<b>363</b>	82±34
pentanal	b.d.	11±2
cyclohexene	b.d.	18±4
1,3-dimethylcyclo-pentand (cis)	b.d.	11±5
1-heptene	b.d.	17±10
2,2,4-trimethyl-pentane	<b>47404</b>	28±15
heptane	b.d.	32±11
2,3-dimethyl-2-pentene	b.d.	b.d.
octene	b.d.	b.d.
methylcyclohexane	b.d.	27±15
2,3,4-trimethylpentane	<b>16235</b>	20±14
toluene	<b>16253</b>	<b>407±237</b>
2-methylheptane	b.d.	25±17
4-methylheptane	b.d.	14±9
3-methylheptane	b.d.	17±13
hexanal	b.d.	<b>72±46</b>
acetic acid butylic ester	b.d.	b.d.
n-octane	b.d.	28±23
dimethylcyclo-hexane isomer	b.d.	b.d.
ethylbenzene	b.d.	76±40
m/p-xylene	<b>235</b>	151±97
heptanal	b.d.	22±14

styrene	b.d.	57±40
1-nonene	b.d.	b.d.
o-xylene	<b>124</b>	64±38
n-nonane	b.d.	21±4
i-propylbenzene	b.d.	<b>30±70</b>
α-pinene	b.d.	<u>31±26</u>
n-propylbenzene	b.d.	20±13
m-ethyltoluene	b.d.	31±26
p-ethyltoluene	b.d.	24±14
1,3,5-trimethylbenzene (1,3,5-TMB)	b.d.	<b>46±55</b>
sabinene	b.d.	b.d.
o-ethyltoluene	b.d.	36±24
octanal	b.d.	13±5
β-pinene	b.d.	15±8
1,2,4-trimethylbenzene / t-butylbenzene	b.d.	<b>63±37</b>
n-decane	b.d.	22±8
1,2,3-trimethylbenzene (1,2,3-TMB)	b.d.	<b>120±296</b>
limonene	b.d.	b.d.
eucalyptol	b.d.	b.d.
indane	b.d.	b.d.
1,3-diethylbenzene	b.d.	13±11
1,4-diethylbenzene	b.d.	<b>522±1380</b>
butylbenzene	b.d.	b.d.l.
n-undecane	b.d.	10±13
n-dodecane	b.d.	26±24
n-tridecane	b.d.	b.d.

#### S4. Additional information on ambient particulate matter parameters

**Table S4.1.** Absolute particle number burden characteristics (bicycle/ van (background) measurements) at different surface usage types. The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-“ indicates areas, which have not been tested by the method. Values are presented in particles per cm<sup>3</sup>.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>	<b>5930</b>	<b>7793</b>	<b>10466</b>	<b>8697</b>	<b>2892</b>
<b>(Neukölln): UBA</b>					
Urban block build.	8589/7555	13050/10114	21155/13390	25862/11356	55132/21646
Urban single build.	6021/4550	9490/6181	15405/10078	17044/8861	139597/81293
Industry	6269/7201	8629/10614	16226/16710	17330/14488	9966/13784
Com.+transp.	5785/9219	8251/13780	13101/18850	13361/17069	4367/5637
green spaces	4972/6441	7563/8853	11684/16500	13212/14828	18913/13644
Agriculture	-/2967	-/4869	-/7072	-/7200	0/10576
Dec. forest	3613/3846	4991/5466	8394/9169	8657/24740	38485/8806
Con. Forest	3646/3501	5802/4993	10619/5658	12192/14630	28726/7020
mix. forest	3828/3501	6059/5093	10523/7685	11686/11860	7215/1810

**Table S4.2.** Relative particle number burden characteristics (bicycle/ van (background) measurements) at different surface usage types divided by the reference concentration in Berlin-

Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	-	1.05/0.97	1.58/1.42	2.52/2.19	3.23/1.71	55132/21646
Urban single build.	-	0.73/0.68	1.09/0.97	1.87/1.43	2.05/1.24	139597/81293
Industry		0.66/0.98	0.98/1.51	1.83/2.04	1.80/1.92	9966/13784
Commerc.+transp.		0.98/1.07	1.39/1.47	1.88/2.09	1.92/1.82	4367/5637
Green spaces		0.57/0.82	0.83/1.11	1.34/1.85	1.47/1.70	0/10576
Agriculture		-/0.42	-/0.80	-/1.09	-/1.16	38485/8806
Dec. forest		0.58/0.47	0.76/0.80	1.18/1.21	1.28/3.06	55132/21646
Con. forest		0.55/0.40	0.85/0.69	1.49/0.90	1.83/1.89	139597/81293
mix. forest		0.61/0.42	0.91/0.77	1.57/1.09	1.75/1.66	9966/13784

**Table S4.3** Absolute particle mass (PM<sub>10</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in µg/m<sup>3</sup>. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup>

percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>		<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>12.7, 11.5</b>	<b>16.6, 16.0</b>	<b>22.0, 22.4</b>	<b>18.2, 18.2</b>	<b>4928, 3317</b>
<b>(Neukölln):</b>						
<b>BLUME, UBA</b>						
Urban	-	6.9/17.4	13.6/32.8	22.7/74.7	24.3/75.6	8260/21801
block build.						
Urban	-	7.9/18.6	15.0/34.3	25.2/69.4	29.0/67.9	19143/82502
single build.						
Industry		13.6/19.6	23.9/35.9	36.5/72.2	30.7/73.9	1464/14047
Com.+transp.		7.4/39.5	13.6/53.4	23.7/77.9	20.1/84.1	478/5613
Green spaces		4.2/16.4	9.2/31.1	16.1/59.7	18.8/73.2	2470/12976
Agriculture		-/17.8	-/29.5	-/46.0	-/48.3	0/10788
Dec. forest		2.8/19.1	5.9/38.0	10.4/71.4	8.9/58.2	1842/8874
Con. Forest		3.2/17.8	7.1/38.3	12.6/70.9	12.7/52.7	3410/7078
mix. forest		3.4/15.8	7.8/32.7	13.5/65.9	13.8/53.6	620/1820

**Table S4.4.** Relative particle mass (PM<sub>10</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.



<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban - block build.	0.47/0.83(1.14)	0.79/1.08(1.75)	1.42/1.47(4.75)	1.65/1.85(5.53)	7813/21801
Urban -single build.	0.47/0.91(1.06)	0.78/1.11(1.58)	1.36/1.54(3.79)	1.89/1.58(3.83)	15758/82502
Industry	0.64/0.72(0.94)	1.13/1.07(1.56)	2.00/1.63(3.87)	1.71/1.50(4.15)	1172/14047
Com.+transp.	0.46/1.00(1.40)	0.74/1.22(1.83)	1.44/1.41(2.79)	1.31/1.32(3.34)	478/5613
Green spaces	0.27/0.83(1.02)	0.53/1.03(1.42)	0.98/1.29(2.85)	1.43/1.35 (3.92)	2470/12976
Agriculture	-/0.89(0.97)	-/1.02(1.20)	-/1.24(2.22)	-/1.13(2.49)	0/10788
Dec. forest	0.20/0.83(1.07)	0.45/1.20(1.94)	0.78/2.24(4.20)	0.67/1.73(3.57)	1842/8874
Con. forest	0.23/0.84(0.96)	0.53/1.10(1.93)	0.89/2.67(4.40)	0.87/1.83(3.39)	3410/7078
mix. forest	0.30/0.83(0.91)	0.62/1.05(1.62)	1.08/1.65(3.87)	1.18/1.57(3.33)	620/1820

**Table S4.5.** Absolute particle mass (PM<sub>2.5</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in µg/m<sup>3</sup>. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
<b>Reference (Neu- kölln): UBA</b>	<b>5.7</b>	<b>8.0</b>	<b>12.9</b>	<b>10.6</b>	<b>3317</b>
Urban block build.	4.0/15.1	6.7/26.8	10.0/40.6	8.0/34.8	8260/21801
Urban single build.	4.4/15.8	6.8/27.2	10.6/39.4	8.9/35.2	19143/82502
Industry	6.8/19.1	9.8/32.1	15.1/47.1	12.1/39.5	1464/14047
Com.+transp.	3.9/38.2	6.1/49.5	8.1/66.2	6.6/56.2	478/5613
Green spaces	2.3/15.7	4.6/27.7	6.9/40.5	5.6 /37.3	2470/12976
Agriculture	-/15.7	-/28.2	-/33.0	-/28.1	0/10788
Dec. Forest	2.0/14.7	3.3/24.9	5.2/35.2	4.0/27.3	1842/8874
Con. Forest	2.1/15.7	3.6/23.0	6.0/31.1	4.9/25.5	3410/7078
mix. forest	2.5/14.2	3.7/23.1	5.7/34.6	4.6/26.8	620/1820

**Table S4.6.** Relative particle mass (PM<sub>2.5</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
Urban - block build.	0.62/1.81	0.85/2.47	1.15/4.41	0.99/4.17	7813/21801
Urban - single build.	0.57/1.69	0.81/2.26	1.08/3.28	1.00/3.11	15758/82502
Industry	0.83/1.37	1.15/2.23	1.57/4.16	1.26/3.43	1172/14047
Com.+transp.	0.55/2.10	0.74/2.67	1.08/3.54	0.93/3.55	478/5613
Green spaces	0.36/1.71	0.57/2.20	0.78/3.59	0.68/3.30	2470/12976
Agriculture	-/1.32	-/1.71	-/2.32	-/2.13	0/10788
Dec. forest	0.25/1.77	0.43/2.41	0.64/3.25	0.48/2.78	1842/8874
Con. forest	0.26/1.88	0.49/2.41	0.72/3.49	0.54/2.75	3410/7078
mix. forest	0.34/1.31	0.54/2.23	0.72/3.10	0.60/2.69	620/1820

**Table S4.7.** Absolute particle mass (PM<sub>1.0</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in µg/m<sup>3</sup>. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference (Neu- kölln): UBA</b>	<b>3.3</b>	<b>5.5</b>	<b>10.4</b>	<b>8.1</b>	<b>3317</b>
Urban block build.	2.7/14.4	4.9/23.9	7.0/34.3	5.7/29.6	8260/21801
Urban single build.	2.8/14.8	4.5/23.9	6.2/33.5	7.2/29.5	19143/82502
Industry	4.7/18.8	7.2/29.1	10.6/40.3	9.2/34.4	1464/14047
Com.+transp.	2.4/33.8	4.3/42.6	5.8/55.9	4.4/47.9	478/5613
Green spaces	1.5/15.3	3.1/25.3	4.8/35.8	3.6/31.8	2470/12976
Agriculture	-/15.0	-/27.4	-/30.7	-/25.4	0/10788
Dec. forest	1.5/14.1	2.0/18.9	2.9/28.2	2.6/22.3	1842/8874
Con. forest	1.5/14.9	2.1/18.1	3.7/22.3	3.3/20.7	3410/7078
mix. forest	1.7/14.0	2.3/18.6	3.4/28.4	2.9/22.3	620/1820

**Table S4.8.** Relative particle mass (PM<sub>1.0</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
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Urban block build.	-	0.68/2.49	0.95/3.52	1.21/5.60	1.04/5.11	7813/21801
Urban single build.	-	0.62/2.09	0.92/2.78	1.14/4.23	0.99/3.74	15758/82502
Industry		0.87/1.70	1.24/2.68	1.60/5.23	1.33/4.08	1172/14047
Com.+transp.		0.61/2.45	0.83/3.05	1.10/3.94	0.92/3.68	478/5613
Green spaces		0.39/2.28	0.63/2.96	0.77/4.74	0.63/4.06	2470/12976
Agriculture		-/1.53	-/1.93	-/2.86	-/2.52	0/10788
Dec. forest		0.27/2.52	0.47/3.05	0.66/3.95	0.49/3.34	1842/8874
Con. forest		0.28/2.33	0.53/3.18	0.73/3.88	0.55/3.32	3410/7078
mix. forest		0.35/1.51	0.59/2.89	0.73/3.90	0.58/3.21	620/1820

**Table S4.9.** Absolute particle mass ( $PM_{inhalable}$ ) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in  $\mu g/m^3$ . Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
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Reference (Neu- kölln): UBA		13.5	18.5	26.1	20.8	3317
Urban	-	7.5/17.0	14.9/31.9	28.0/69.2	53.9/68.2	8260/21801
block build.						
Urban	-	8.6/18.1	16.9/33.1	30.9/63.3	65.9/61.9	19143/82502
single build.						
Industry		14.7/19.3	28.5/35.1	52.8/68.2	53.8/35.1	1464/14047
Com.+transp.		7.8/38.7	15.0/52.1	30.5/75.4	36.5/78.6	478/5613
Green spaces		4.4/16.1	9.9/30.3	18.4/56.6	35.5/66.6	2470/12976
Agriculture		-/17.4	-/28.9	-/43.8	-/44.4	0/10788
Dec. forest		2.9/18.4	6.2/36.2	11.5/64.6	12.3/52.6	1842/8874
Con. forest		3.3/17.4	7.5/35.6	14.0/64.0	20.3/47.8	3410/7078
mix. forest		3.5/15.5	8.2/31.3	15.2/60.6	19.7/48.7	620/1820

**Table S4.10.** Relative particle mass ( $PM_{inhal}$ ) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.

surface type		25 <sup>th</sup>	median (50 <sup>th</sup> )	75 <sup>th</sup>	mean	no. of data
Urban	-	0.43/0.98	0.75/1.51	1.51/3.83	3.44/4.34	7813/21801
block build.						



Urban single build.	-	0.42/0.93	0.75/1.36	1.48/3.05	3.68/3.07	15758/82502
Industry		0.58/0.82	1.18/1.38	2.59/3.28	2.73/3.36	1172/14047
Com.+transp.		0.41/1.25	0.67/1.63	1.54/2.45	2.10/2.80	478/5613
Green spaces		0.24/0.87	0.49/1.24	0.99/2.39	2.46/3.14	2470/12976
Agriculture		-/0.87	-/1.09	-/1.92	-/2.06	0/10788
Dec. forest		0.14/0.90	0.33/1.59	0.59/3.29	0.65/2.83	1842/8874
Con. forest		0.16/0.82	0.39/1.58	0.68/3.42	1.01/2.68	3410/7078
mix. forest		0.21/0.76	0.46/1.37	0.84/3.08	1.18/2.66	620/1820

**Table S4.11.** Absolute particle mass (PM<sub>thoracic</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in µg/m<sup>3</sup>. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25th</i>	<i>median (50<sup>th</sup>)</i>	<i>75th</i>	<i>mean</i>	<i>no. of data</i>
<b>Reference (Neu- kölln): UBA</b>	<b>12.3</b>	<b>17.0</b>	<b>23.6</b>	<b>19.2</b>	<b>3317</b>

Urban block build.	7.2/16.9	14.3/31.7	24.7/66.8	27.4/64.0	8260/21801
Urban single build.	8.2/18.1	16.1/32.6	27.2/60.7	32.7/58.8	19143/82502
Industry	14.2/19.3	25.9/34.8	39.8/66.3	33.8/64.0	1464/14047
Com.+transp.	7.7/38.6	14.4/52.0	26.2/74.8	26.0/76.0	478/5613
Green spaces	4.4/16.1	9.7/30.1	17.3/55.2	20.9/63.1	2470/12976
Agriculture	-/17.3	-/28.8	-/42.7	-/42.2	0/10788
Dec. forest	2.9/18.2	6.2/35.5	11.1/61.7	9.5/49.7	1842/8874
Con. Forest	3.3/17.3	7.5/34.6	13.4/61.2	13.8/45.3	3410/7078
mix. forest	3.5/15.5	8.1/30.7	14.5/57.8	15.1/46.1	620/1820

**Table S4.12.** Relative particle mass ( $PM_{thor}$ ) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>		<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	-	0.46/1.06	0.78/1.60	1.46/3.88	1.77/4.39	7813/21801
Urban single build.	-	0.46/0.99	0.78/1.45	1.39/3.13	2.02/3.11	15758/82502

Industry	0.63/0.88	1.15/1.46	2.06/3.40	1.78/3.39	1172/14047
Com.+transp.	0.44/1.32	0.74/1.71	1.47/2.56	1.36/2.96	478/5613
Green spaces	0.26/0.95	0.53/1.32	1.00/2.49	1.51/3.38	2470/12976
Agriculture	-/0.92	-/1.13	-/1.94	-/2.18	0/10788
Dec. forest	0.16/0.99	0.36/1.70	0.63/3.40	0.54/2.86	1842/8874
Con. forest	0.17/0.89	0.42/1.67	0.72/3.51	0.73/2.72	3410/7078
mix. forest	0.23/0.83	0.50/1.46	0.86/3.17	0.98/2.68	620/1820

**Table S4.13.** Absolute particle mass (PM<sub>alveolic</sub>) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types provided in µg/m<sup>3</sup>. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>	<b>8.2</b>	<b>11.5</b>	<b>16.1</b>	<b>13.6</b>	<b>3317</b>
<b>(Neu-kölln):</b>					
<b>UBA</b>					

Urban block build.	5.3/16.6	9.2/31.1	13.9/62.1	11.8/58.3	8260/21801
Urban single build.	6.1/17.7	9.9/31.9	15.5/54.9	13.5/53.9	19143/82502
Industry	9.9/19.2	13.5/34.6	20.1/62.6	16.4/59.2	1464/14047
Com.+transp.	5.1/38.5	8.9/51.3	13.0/73.0	10.4/71.7	478/5613
Green spaces	3.4/16.1	6.6/29.9	10.2/52.6	9.2/58.0	2470/12976
Agriculture	-/17.1	-/28.7	-/41.2	-/39.5	0/10788
Dec. forest	2.6/17.7	4.7/34.0	7.4/55.5	5.8/45.1	1842/8874
Con. Forest	2.9/17.1	5.3/32.3	8.7/54.4	7.2/41.1	3410/7078
mix. forest	3.2/15.4	5.6/29.6	8.4/53.0	7.4/42.2	620/1820

**Table S4.14.** Relative particle mass ( $PM_{alveol}$ ) burden characteristics (bicycle/van background (van all) meas.) at different surface usage types divided by the corresponding concentrations in Berlin-Neukölln. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>		<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
Urban block build.	-	0.56/1.44	0.81/2.14	1.17/5.04	1.06/5.58	7813/21801
Urban single build.	-	0.53/1.36	0.79/1.98	1.11/3.93	1.12/3.89	15758/82502

Industry	0.78/1.15	1.06/1.92	1.45/4.46	1.25/4.24	1172/14047
Com.+transp.	0.53/1.73	0.73/2.23	1.14/3.21	1.01/3.53	341/4875
Green spaces	0.34/1.31	0.57/1.80	0.82/3.33	0.87/4.05	1961/9598
Agriculture	-/1.14	-/1.41	-/2.37	-/2.53	0/9488
Dec. forest	0.21/1.38	0.40/2.34	0.63/4.26	0.48/3.61	1842/8874
Con. forest	0.24/1.30	0.48/2.31	0.73/4.39	0.56/3.48	3410/7078
mix. forest	0.30/1.22	0.54/2.03	0.80/4.08	0.68/3.37	620/1820

**Table S4.15.** Absolute lung depositable surface area (LDSA) characteristics (bicycle) at different surface usage types in  $\mu\text{m}^2/\text{cm}^3$ . The 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points are provided as columns. “-“ indicates areas, which have not been tested by the method. Values are presented in particles per  $\text{cm}^3$ .

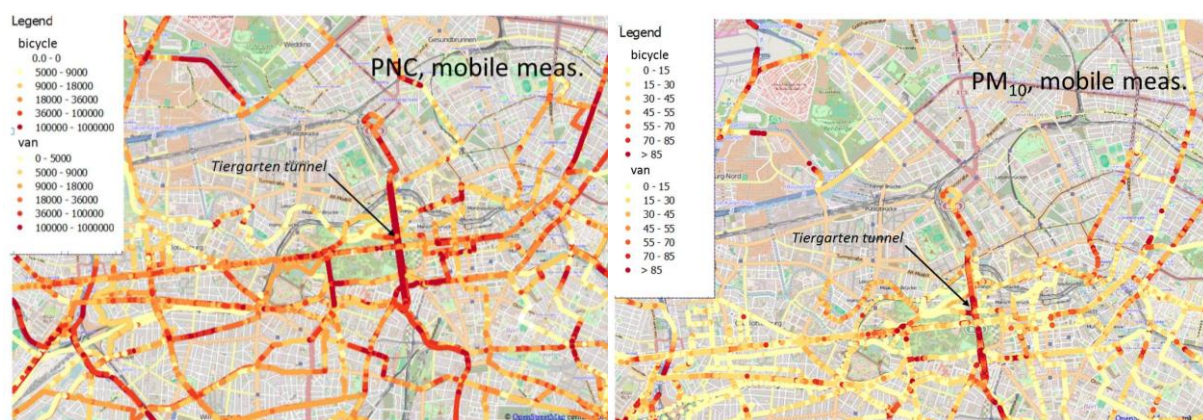
<i>surface type</i>		<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
<b>Reference</b>		<b>24.3</b>	<b>25.8</b>	<b>33.5</b>	<b>28.8</b>	<b>37632</b>
<b>(Neukölln): UBA</b>						
Urban	block	23.3	33.1	51.0	49.6	55132
build.						

Urban build.	single	16.5	24.7	38.2	34.3	139597
Industry		16.5	25.8	41.6	37.4	9966
Commerc.+transport		12.5	15.4	21.1	21.5	5335
Green spaces		12.7	19.1	32.3	28.2	18913
Dec. forest		9.8	15.0	22.1	20.6	38485
Con. forest		12.6	17.5	27.8	24.3	28726
mix. forest		11.8	15.6	23.7	22.4	7215

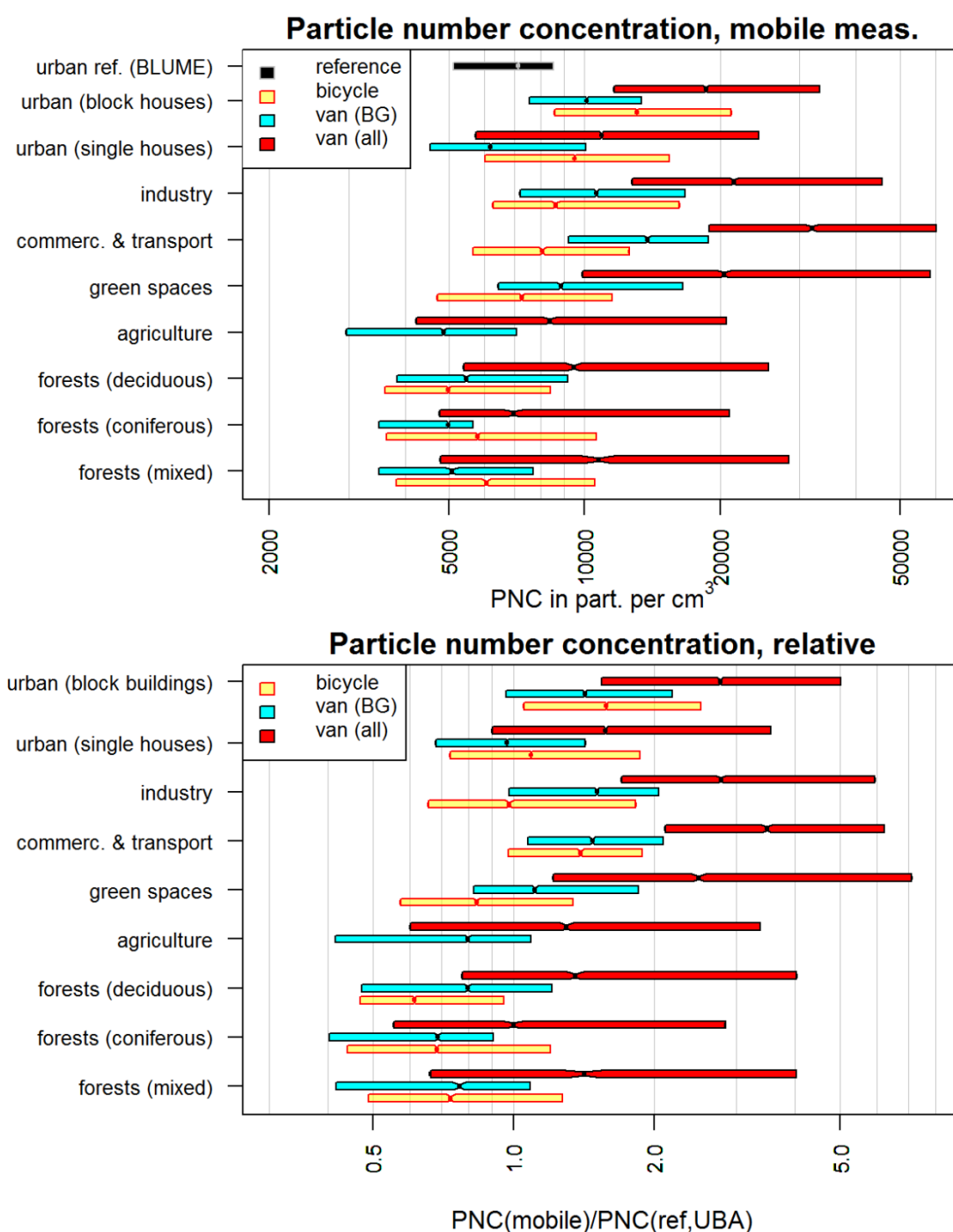
**Table S4.16.** Relative LDSA characteristics (bicycle) at different surface usage types divided by the reference concentration in Berlin-Neukölln. Listed are the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentiles, the mean values and the number of data points. “-“ indicates areas, which have not been tested by the method.

<i>surface type</i>	<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
Urban - block build.	0.86	1.15	1.76	1.77	55132
Urban -single build.	0.65	0.92	1.44	1.32	139597

Industry	0.73	1.13	1.72	1.52	9966
Com.+transp.	0.61	0.71	0.89	0.91	5335
green spaces	0.50	0.71	1.01	0.97	18913
Dec. forest	0.49	0.63	0.84	0.81	38485
Con. forest	0.49	0.68	1.07	0.96	28726
mix. forest	0.51	0.67	0.98	0.94	7215



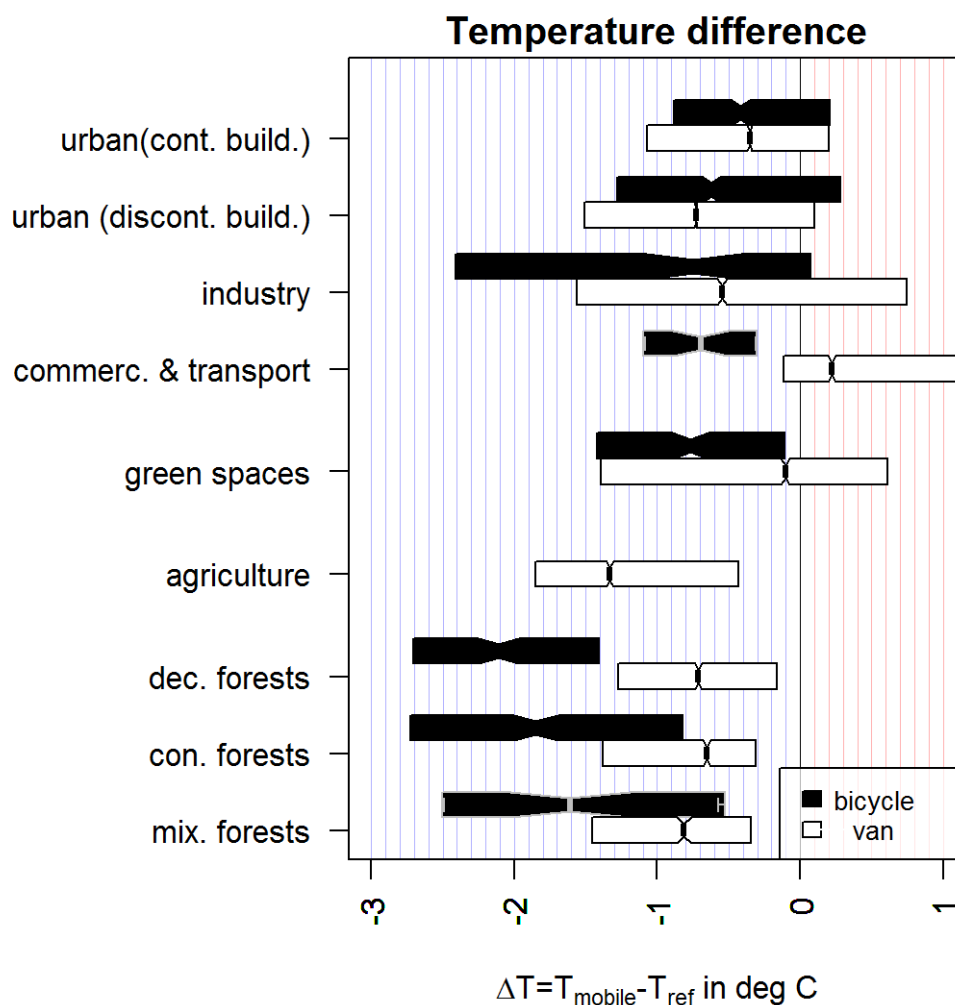
**Figure S4.1** Zoomed heterogeneity of particle number (left) and mass (PM<sub>10</sub>, right) concentrations in the center of Berlin displayed in absolute measured values. This figure is an extension of Fig. 8.



**Figure S4.2** Boxplots of particle number concentration ratios for different land surface types (CORINE) and different observation platforms compared to the measurements in Berlin-Neukölln. The boxplots range from the 25<sup>th</sup> to the 75<sup>th</sup> percentile with notches from the 45<sup>th</sup> to the 55<sup>th</sup> percentile centered on the median.



## S5. Information about further results – temperature



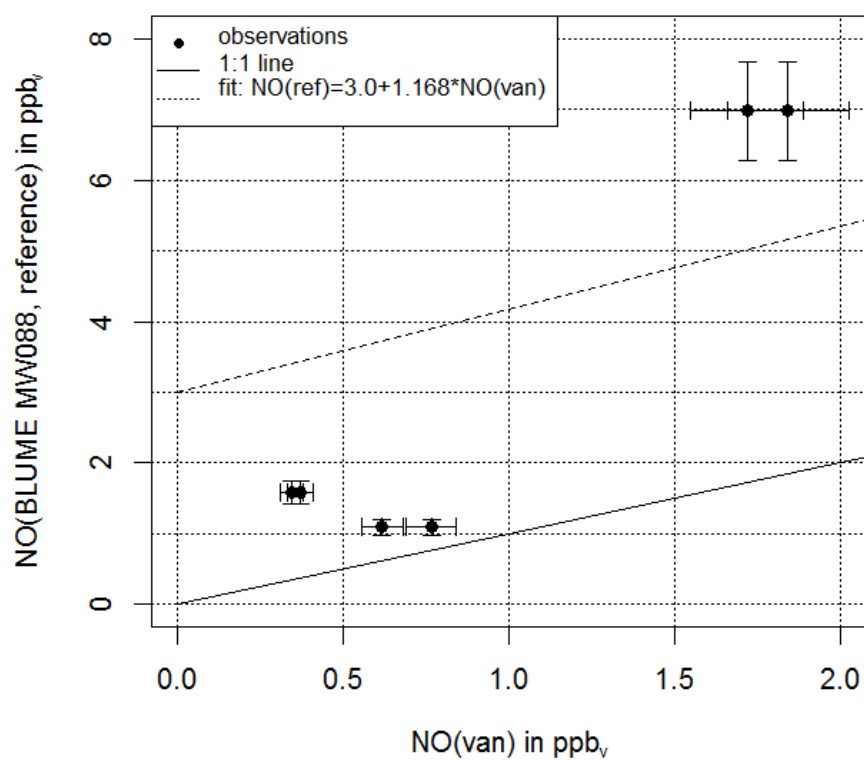
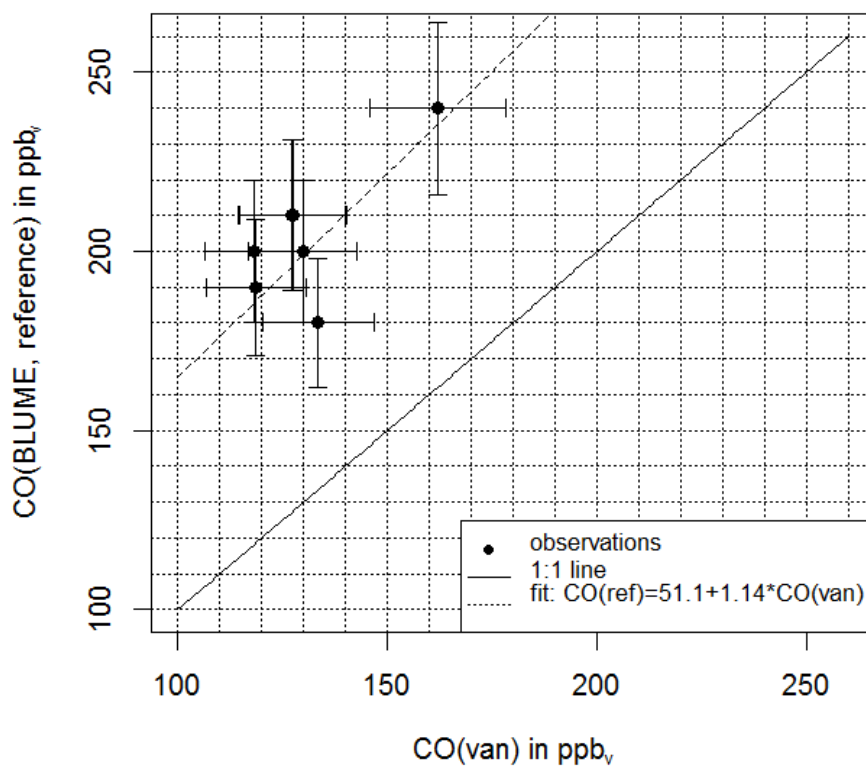
**Figure S5.1** Boxplot of temperature differences for different land use types and different observation platforms compared to the measurements in Berlin-Neukölln. Displayed is the range between the 25<sup>th</sup> and the 75<sup>th</sup> percentile with a notch from 45<sup>th</sup> to 55<sup>th</sup> percentile. Grey borderlines of bars represent categories with insufficient data values, missing bars no data by the corresponding method.

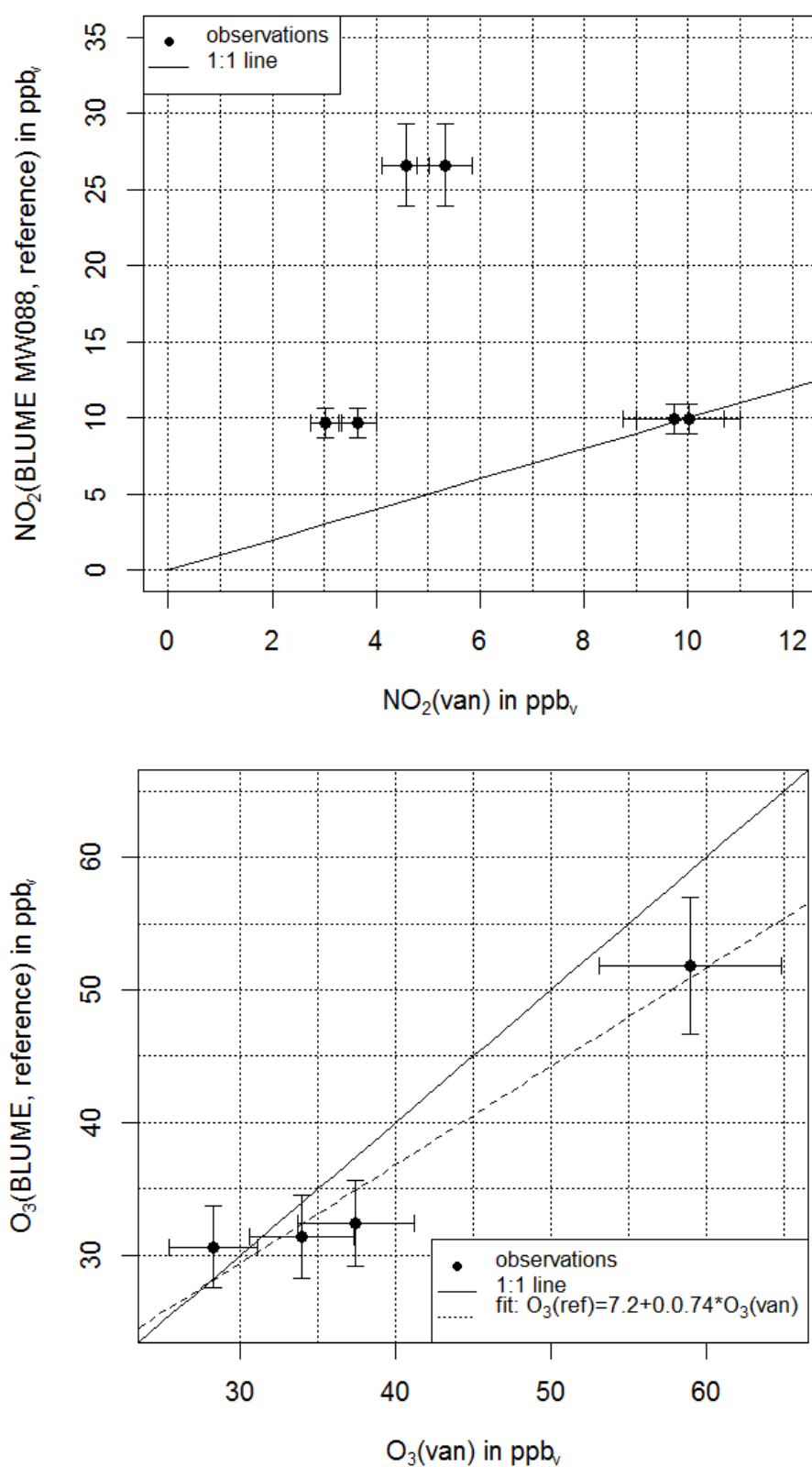
**Table S5.2.** Changes in air temperature between mobile measurements and the reference site in Berlin-Neukölln (BLUME). Values are provided as  $\Delta T(\text{“bicycle”})/\Delta T(\text{“van”})$  both in degrees C. The value is negative if the mobile measurement recorded cooler values.

<i>surface type</i>		<i>25<sup>th</sup></i>	<i>median (50<sup>th</sup>)</i>	<i>75<sup>th</sup></i>	<i>mean</i>	<i>no. of data</i>
Urban	-	-0.9/-1.1	-0.4/-0.4	0.2/0.2	-0.2/-0.4	8260/17570
block build.						
Urban	-	-1.1/-1.5	-0.5/-0.7	0.4/0.1	-0.2/-0.7	19143/62395
single build.						
Industry		-2.4/-1.6	-0.7/-0.6	0.1/0.7	-1.4/-0.5	1464/10830
Com.+transp.		-1.0/-0.1	-0.6/ 0.2	-0.3/1.2	-0.7/0.8	478/4871
green spaces		-1.4/-1.4	-0.8/-0.1	-0.1/0.6	-0.6/-0.3	2987/10404
Agriculture		-/-1.9	-/-1.3	-/-0.4	-/-1.0	0/9035
Dec. forest		-2.7/-1.3	-2.1/-0.7	-1.4/-0.2	-1.9/-0.6	2096/5497
Con. Forest		-2.7/-1.4	-1.9/-0.7	-0.8/-0.3	-1.5/-0.6	4141/3482
mix. forest		-2.5/-1.5	-1.6/-0.8	-0.6/-0.4	-1.4/-0.7	1153/1153

## S6. Comparison of different measurement methods with reference ones in Neukölln

### S6.1 Ozone





**Fig. 6.1.1.** Comparison for CO, NO, NO<sub>2</sub> and O<sub>3</sub> at the stationary reference site. Note, while long term stable compounds match best, small scale and temporal variable gases such as NO do not. Any of the mobile instruments was calibrated a priori to the campaign and BLUME instruments earlier the year.

## S6.2. Particulate mass comparisons for different measurement techniques

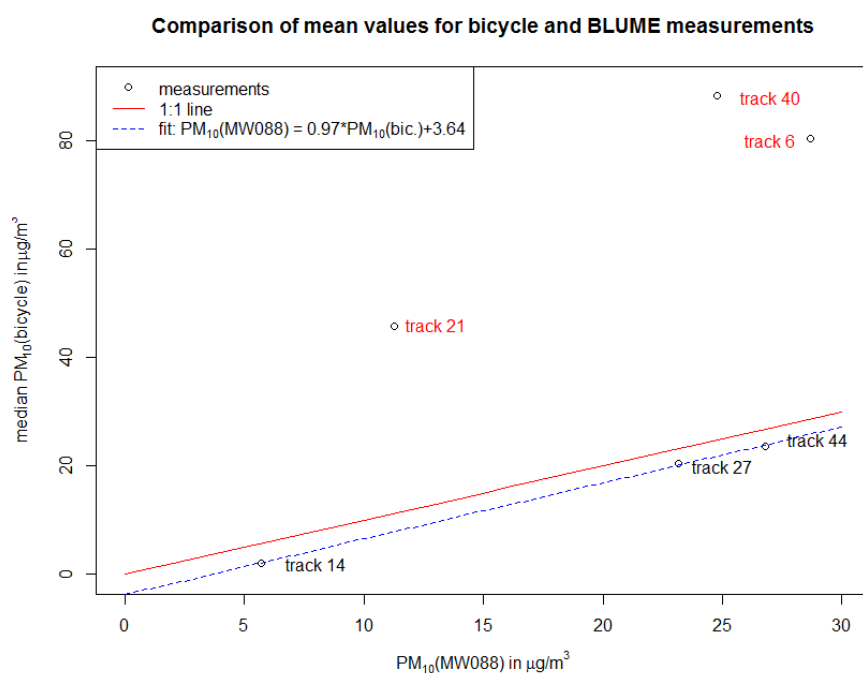
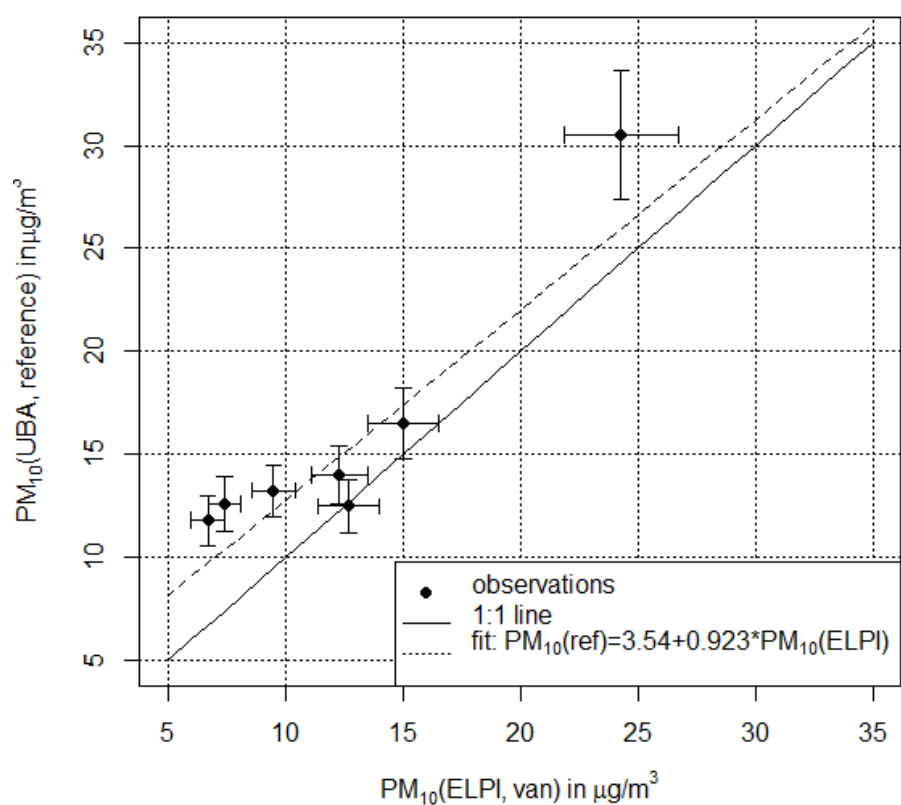
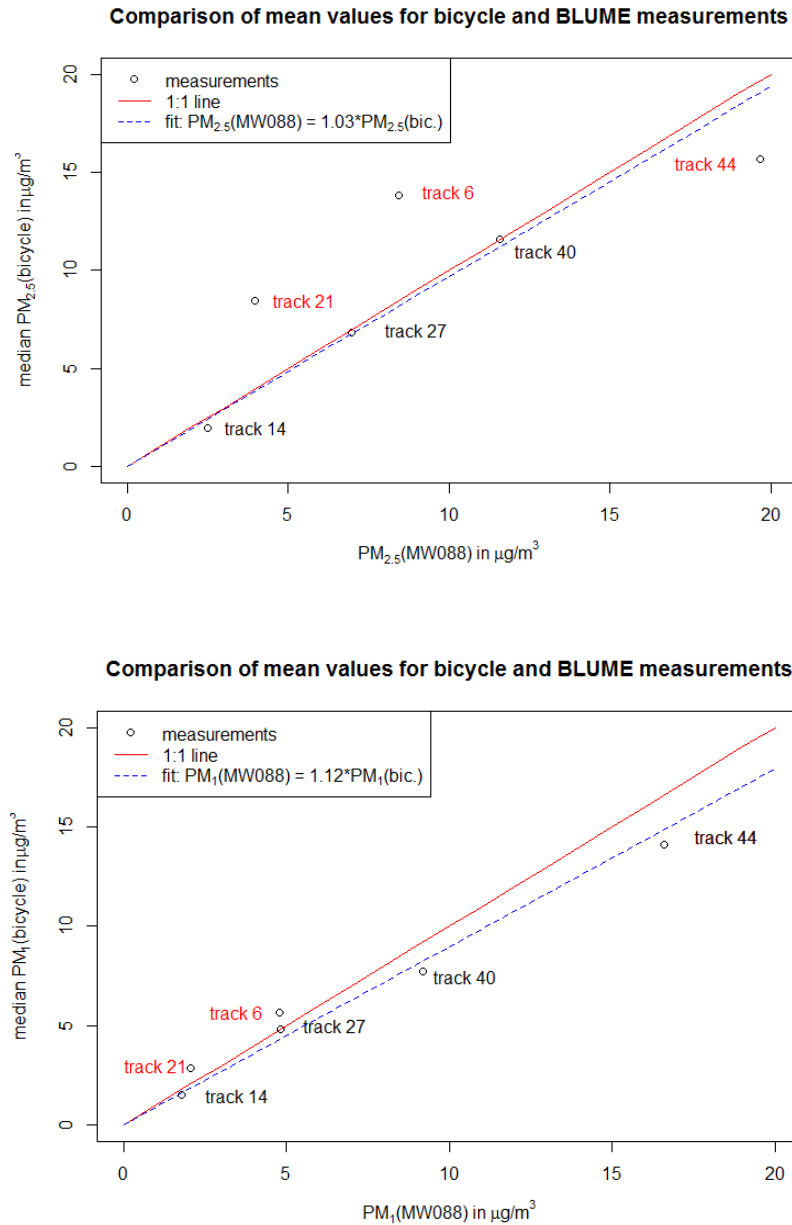
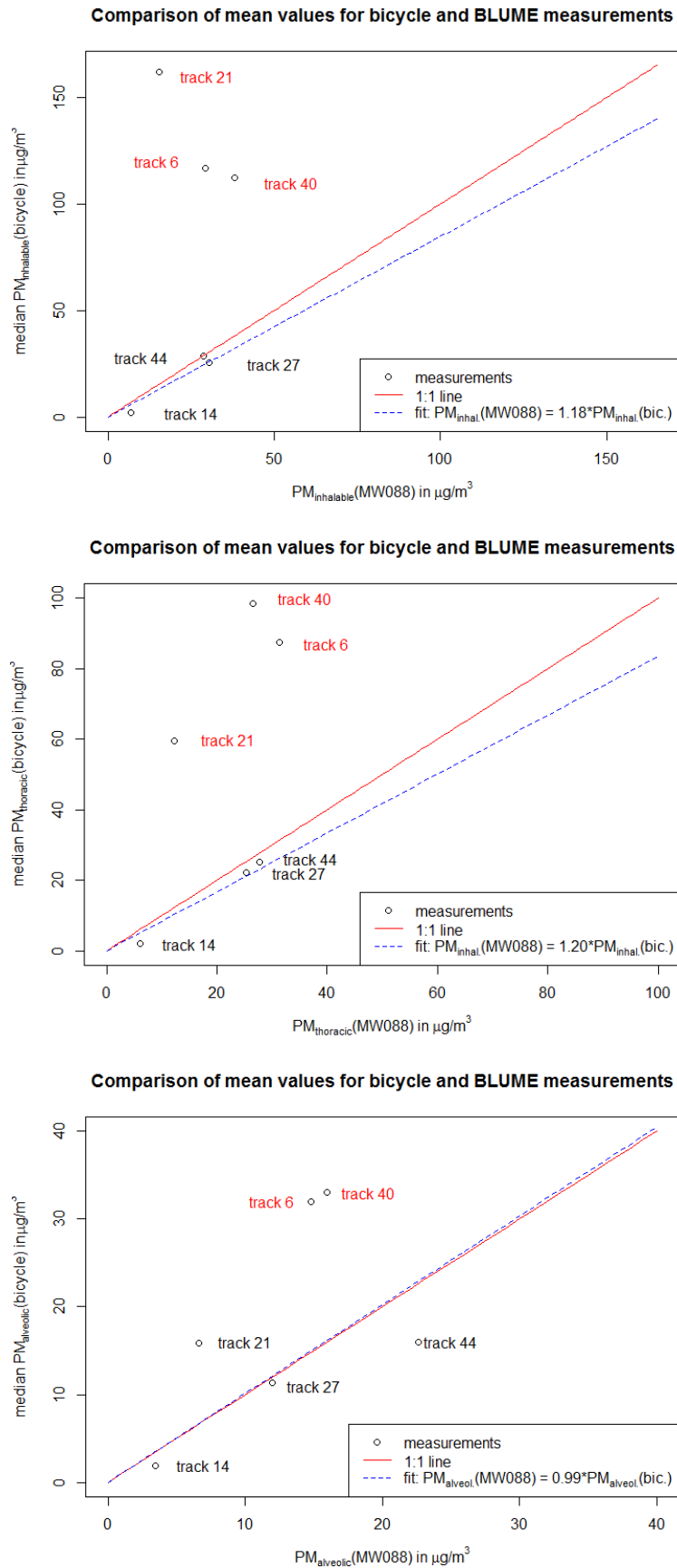


Fig. 6.2.1. Comparison of mobile observed  $PM_{10}$  values (top: van, bottom: bicycle based) with 30 min averages at the reference site. Three short stops (no. 6, 21 and 40) of the cyclists seem to be notably affected by short term local pollution of very large particles.

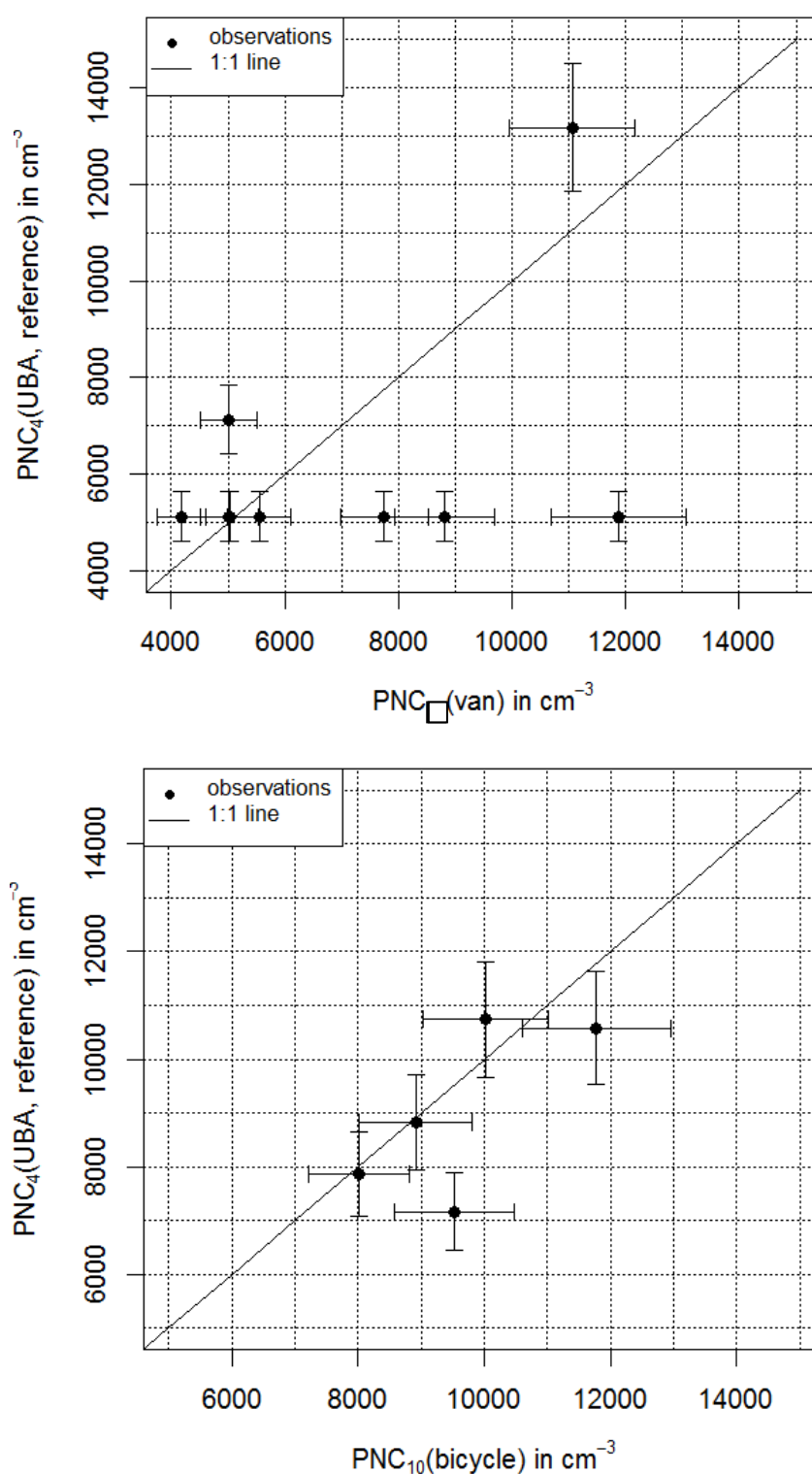


**Fig. 6.2.2.**  $\text{PM}_{2.5}$  and  $\text{PM}_1$  comparison as for  $\text{PM}_{10}$  in above Figure 6.1.1 but for bicycles only. Other values than  $\text{PM}_{10}$  for van measurements were not available. In here affected bicycle track measurements hardly apparent. Effect predominantly on largest sizes.



**Fig. 6.2.3** Health related parameterized PM value comparison as for  $PM_{10}$  in above Figure 6.2.1 but for bicycles only. Other values than  $PM_{10}$  for van measurements were not available.

### S6.3 Particle number concentration (PNC)



**Fig. 6.3.** Particle number comparison with reference site measurements, top: van, bottom and bicycle based measurements with different lower cut-off diameters, i.e. van: 3nm and bicycle: 10 nm.