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Interactive Comment

Interactive comment on "Dispersion of traffic-related exhaust particles near the Berlin urban motorway: estimation of fleet emission factors" *by* W. Birmili et al.

W. Birmili et al.

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Thank you for your comments to the manuscript. For clarity, your statements will appear in italic face, and our response in standard face.

We were able to positively consider all your comments, see below.

Section 3.2 / Figure 3, the 'amazingly similar' structure of the size distributions in the background and distant background points more towards a regional phenomenon than to a local source (the plume from the highway should be substantially diluted between the two stations). This regional event could be the general background pollution in the city or even some 'regional nucleation event' Have such been observed during the measuring period?

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Interactive Discussion

Discussion Paper

In fact we observed no clear event of secondary particle formation and subsequent growth in Berlin during the entire measurement period. On the one hand, 2005 was a rather cool and rainy summer. On the other hand, we know from previous experience (Leipzig compared to Melpitz, Augsburg compared to Hohenpeissenberg, Helsinki compared to Hyytiälä — the latter are observations by the University of Helsinki group) that urban areas feature a lower number of particle formation events compared to rural environments, probably due to the higher pre-existing particle surface area as well as a changed boundary layer dynamics.

The shape we see in Figure 3 could therefore represent sources upwind the two measurement sites (background and distant background, 1 km apart). Whether these sources are primary or secondary is not clear. They seem, in any case, far enough upwind (wind direction was north; at least a few km) so that we encounter the same aerosol at the background and distant background sites.

We reformulated the text as follows: "Figure 3 shows the diurnal evolution of the particle number size distribution at the three urban measurement sites on Tuesday, 12 July 2005. One can clearly see the influence of traffic emissions at roadside, which features by far higher number concentrations than the background and distant background sites. The winds came from the north, thereby collecting pollution aerosol along the motorway (Fig. 1). The concentrations at roadside show the greatest traffic-induced signal between 04:00, i.e. the onset of motorway traffic (Fig. 2), and 12:00 h on this day. Although the two background sites are separated by a few major streets over a distance of about one km the evolution of their number size distributions in Fig. 3 appears amazingly similar. The coincidence of individual aerosol plumes detected around 03:00, 06:00, 11:00, 13:00, 17:00, and 22:00 h in Fig. 3b-c illustrates the high spatial homogeneity of particle size distributions in the urban background around the motorway. It is clear that these plumes do not originate from the motorway but from sources that far enough upwind to be visible in the measurements at both background sites."

Sections 4.1 and 4.4 are suggested to keep in the chapter on Dispersion modelling;

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switching 4.3 and 4.2 seems more logical.

The sections were moved according to your suggestion. The final structure of the manuscript is now as follows:

1 Introduction

2 Experimental methods

3 Modelling technique

3.1 3-D dispersion modeling

3.2 Vehicle emission factors

4 Field observations

5 Dispersion modelling results

5.1 3-D Simulation results

5.2 Validation of wind parameters

6 Experimental vehicle emission factors

6.1 Fleet emissions on weekdays

6.2 Weekend effects and lorry/passenger car split

6.3 Emission factor size distributions

7 Discussion

8 Conclusions

Section 4.4 p.15556 l.12-16: The higher wind speeds in the simulations especially at the background side might be result of the too small roughness in the model. Fig. 1 indicates some trees that might substantially reduce the wind speed locally. The authors should discuss in the validity and consequences of the uniform assumed roughness

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(0.1 m) in the model.

You are right. This is now appropriately discussed in the text: "The comparison of simulated and experimental wind speeds in Fig. 9b yields similar conclusions. The ratio between modelled and measured wind speed was between 2.1 and 4.2 for the background site: The model systematically overestimates the real wind speeds. Here, our conclusion is that the generally assumed roughness length of 0.1 m might not be appropriate for the surroundings of the background site. Although the wind sensor was located 6 m above the ground, adjacent trees existed around the site — not represented by the model, which likely reduced the overall wind speeds locally."

Figure 5.1 The analysis of the emission factors from background only (Figure 10b) could be skipped or should at least regarded as a kind of 'test' and discussed in the context of much higher uncertainties due to the much weaker signal in the measurements, much higher uncertainties in the model results and the assumption on the moving 24h minimum as background measure.

Fine, this analysis is now only briefly mentioned in the text.

Section 5.1 p.15559. The drop of the emission factor around 13:00 might be caused by the additional dilution due to thermal instability during the sunny days. The model considers neutral temperature profile and might therefore underestimate the dilution, this again leading to lower emission factors. The authors might check the influence by comparing the diurnal variation of the emission factor on cloudy and sunny days and discuss the validity of the assumed neutral profile.

Thank you for your suggestion. We consequently checked the influence of solar radiation. Data on solar radiation was only available as daily sums, but this was fine enough to divide the data set into two subsets corresponding to "sunny" days (12.4 ± 1.7 hours of sunshine, a total of 13 workdays was considered), and "cloudy" days (4.5 ± 3.5 hours of sunshine, a total of 12 workdays). Both sub-sets include only data from the favourable wind sector 330–150°, i.e. northerly and easterly winds.

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A result is that sunny and cloudy days do not differ significantly in terms of observed concentrations before 12:00, but significantly after. On sunny days, the experimentally observed number concentration increment c dropped by a factor of 2 (50500 to 24600 cm^{-3} between 10:00 and 14:00) on sunny days, while it stayed approximately constant on cloudy days. The traffic density was, as expected, practically the same in both sub-sets. The wind speeds were generally higher during sunny days, but the main increase in the diurnal pattern wind speed happened already before 11:00. During midday, the wind speed itself did not change drastically. As a consequence, the observed decrease in number concentration increment c propagated well into the emission factor E.

Our conclusion is, in line with your suggested explanation, that the vertical stratification is more instable during the sunny days, and leads to an additional vertical dilution not accounted for by the model, which assumes a neutral temperature profile. Since this conclusion belongs to the novel aspects in our paper, we decided to illustrate these findings by an additional Figure, and the corresponding text description.

Section 5.3 /conclusion It is a bit surprising or not plausible that the two lognormal modes together (1.5+3.3)e14 km-1; give more than the double of the average emission factor (2.1 e14 km-1). Check this for consistency regarding the assumed equation, selection etc. Part of the reason could be the lower cut-off at 10nm, but this should be discussed and maybe the value for the nucleation mode for $>$10nm should be given as well.

Thank you. In fact, we erroneously used a wrongly scaled data subset when computing the modal parameters. The true values are 0.78 (0.1) and 1.30 (0.2) for the numbers of the soot and nucleation modes, respectively. For particle volume they are 0.074 (0.01) and 0.002 (0.001). All the values are now generally limited to the size range covered by observations (10–500 nm). This is now also mentioned in the text.

Technical corrections: Figure 7. The A100 in black is very hard to distinguish from the *other gray areas, maybe another colour could be used.*

We see no other way to represent the A100, which is a black-and-white Figure. As a solution we modified the Figure caption as “3-D model domain with the A100 motorway in black.”.

Figure 8 caption and Table 4 uses ’C’ for the road side while the text and the Figure itself ’R’ is used; this should be harmonised.

Thank you for your observation. This was corrected.

Figure 11. Why does the Weekdays curve not agree with the Eq.8 curve in Fig 10a? Both the shape of the curve and the absolute values of the emission factor do not match?! For the red and blue curves the colour changes between the thin and thick sections, this is probably not the intention.

Your observation is correct. In fact, Figure 11 was erroneously based on the wrong data set, which included the full original data regardless of wind direction and wind speed. The corresponding data points were therefore recalculated and the Figure reproduced with the correct values. Any changes in the results were also corrected in the entire text. Also, the layout of the Figure was changed so that statistically more solid values (weekday) appear as a line, and the weekend values as individual data points.

Figure 12. The soot mode has in the figure legend an emission factor of 1.5 e12 veh-1 km-1 while in several places in the text and tables 1.5 e14 veh-1km-1 is used. This should be harmonised.

This refers to mistakes mentioned above. The values are now corrected according to those indicated in the large overview Table. Also, the values are now generally limited to the size range covered by observations (10–500 nm). The Figure was further improved by dashing the lognormal fits outside that size range.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 15537, 2008.

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