

Interactive comment on “Eddy covariance measurements and parameterisation of traffic related particle emissions in an urban environment” by E. M. Mårtensson et al.

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We would like to thank the referee for the time she/he has spent to carefully read the manuscript and for the positive comments. The comments are no doubt important, and we will give our response below. We have done clarifications and corrections in manuscript.

1. Thanks. We have polished
2. See also the answer to referee 2. No model is yet developed and available to calculate the footprint for a complex area such as in the urban environment. When such a model is developed, we will use it. Still our opinion is that the source ar-

eas contributing to the fluxes can be called footprints when we discuss the origin of the flux. To meet the requirements of the referee, the N. Kljun's footprint model (<http://footprint.kljun.net/varinput.php>) has been tested. This model take into account the measurement height h , the standard deviation of the vertical wind speed σ_{wv} , friction velocity U^* , (these parameters do we have from the measurements), the boundary height BL height (we can only make a approximation) and the roughness Z_0 (a mean value are available for squares of $500 \times 500 \text{m}$). The model gives the distance where the contribution is largest X_{max} , and how large the contribution is within a specific distance, X_{75} representing 75% contribution. If we set BL height= 1000m, the contribution to 75%, $\sigma_{wv}=0.3 \text{m/s}$, $U^*=0.2 \text{m/s}$ and $Z_0=0.6 \text{m}$ the result is $X_{max}=868 \text{m}$ and $X_{75}=1732 \text{m}$. If instead $\sigma_{wv}=0.6 \text{m/s}$ and $U^*=0.5 \text{m/s}$ the result is $X_{max}=1202 \text{m}$ and $X_{75}=2395 \text{m}$.

Of course, the model shows that the footprint changes when the meteorology changes. The model agrees approximately with our previous estimates. Even if this model calculates somewhat lager footprints than we have assumed, it is difficult to say how significant this is. Furthermore, the highway is located in or close to the maximal contribution point. In addition, in all sectors the traffic activity upwind happens to be similar at different radius, resulting in a similar average traffic activity per time and space unit, and insensitivity to our choice of radius/footprint.

3. It is indeed not an easy task to estimate the surface layer height, or to validate that the measurements are made within the surface layer, over such an inhomogeneous surface as a modern city. What we had already done was to examine if the turbulent spectra follow similarity relationships. Indeed, they do in most cases. We now state this more clearly in the last sentence of section 3.2: "Analysis on spectra and co-spectra concluded that atmospheric turbulence at the sampling site obeyed similarity scaling laws for the surface layer and therefore the eddy covariance measurements represent surface layer exchange fluxes." (New formulation)

Further proof is that the $-5 < z/L < 2$ ($L = \text{Obukov length}$) for 70% of the data we finally

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use (this has been added to the text on page 5562). If we use only these 70% of the data the results does not change significantly, e.g. the EF_{fm} changes from 1.4 to 1.5. Data have been filtered for different stability, using only neutral stratification, and we got the same emission factor. Hence, since further data filtering does not change the results, we have chosen to keep using the larger data set, but present the results of the filtered data in the text as an estimate of the uncertainty due to these factors. Regarding the divergence problem: It is likely that our fluxes can be influenced by such effects. However, roughness as well as emission strengths vary on a scale equal to or even smaller than the footprint dimension. As we have included fluxes from various directions, with (depending on wind speed etc.) different radius, the effect of divergence is likely to cause an increased variance in the fluxes and in the end a less good precision of the emission factor estimate. The complexity may also partly cancel the problem: Consider when the footprint contain the highway in one part, with larger particle emissions, and blocks with houses and larger roughness, divergence due to roughness differences and emission differences act in opposite directions. It is outside the scope of the current manuscript to examine this very difficult problem in more details.

4. A comparison for six days (1 to 6 of April) have been done between the fluxes calculated over hours, half hours and the hourly averaged fluxes formed from two half hour fluxes (used in the paper). The hour-based fluxes agree fairly well, with a few exceptions, when compared in a scatter plot. These exceptions may be somewhat more frequent in the afternoons. In daytime, on the 4th and 5th day, the half hourly fluxes, varies considerably more than the hourly fluxes. It is likely that this is caused by secondary circulations in the convective boundary layer with a time scale <30 min, see for example Buzorius et al. (2001 Tellus 53B, 394-405), section 3.4. When comparing the hourly fluxes directly with a liner fit, the correlation $r=0.98$, the slope is 0.92, and the zero bias 3.6, (based on upward fluxes only). Hence, if the fluxes calculated over one hour is a better estimate of the true flux than the fluxes averaged to hours, due to larger eddies, this underestimation is only about 8% for our test period, and mainly confined

to a limited part of the data set. In addition, the hourly calculated fluxes results in a few extreme erratic values (like the large negative flux in the afternoon of the last day in the example period), probably due to problems with non-stationary low frequency variation from the diurnal cycles. We have included a short paragraph in the text to describe these additional results.

5. The uncertainty is a random error due to the stochastic nature of turbulence and it will not affect the final data interpretation and accuracy, and the 10% is a valid estimate of the order of magnitude. It is difficult to estimate this exactly and beyond the scope of this study. This uncertainty does not depend on if we measure gas or aerosols. Even if Rannik and Vesala measured at 23 m and our measurements are done at 118 m, both measurements are done within the surface layer and therefore the different heights will not influence the uncertainty.

6. Full sentences are: “Note, that the aerosol flux is better correlated with friction velocity U^* ($R=0.449$) than with the average aerosol number concentration ($R=0.439$) when all sectors are included. It means that at 118 m height the turbulence at the site is an important factor for the vertical flux exchange and confirms that deposition fluxes are probably less important (since they should be dependent on aerosol number). The average number concentration is instead strongly influenced by source regions located outside the footprint.”

Yes, of course the deposition flux depends on these parameters also. However, here we compare the correlation between the particle flux and other parameters measured at the tower. If we had then found a strong (negative) correlation between aerosol flux and number concentration, this would have been an indication of more significant deposition fluxes contributing to the measured net flux, but instead we found only a weak positive correlation. Based on this, the reflection made in the text is reasonable.

7. P. 5554 I.3-4 when energy decay with the lower frequency left of the peak Should be: when energy decay with the lower frequency to the left of the peak

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8. The number of data is reduced if a limit for U^* is applied, we made a test for fluxes when $U^* > 0.2$ m/s. The number of data is then reduced from 350 to 256. This filter takes away some of the nighttime data, many of these fluxes are small. The emission factor increase slightly to 1.5 and the bias F0 is now 24 and the correlation coefficient increase to $R=0.80$. Another possibility we have discussed and tested is to filter the data due to stability, for example only use data from neutral stratification. This will definitely take away nighttime data and as written in the text, the correlation increases, however, the emission factor remains the same. Some filtering techniques give a slightly larger emission factor. Our decision is to use the larger data set. The reason for this is that the larger data set represents a larger variation, and a better representation during periods of low traffic activity. If we disregard differences between the sectors, the low traffic activity are to some extent occurring more at nighttime, which could cause a bias. A paragraph with these results is included in the manuscript.

9. Table 1 w'T' in text and in the table should be: H

10. Fonts will be larger.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 5541, 2005.

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