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Discussions

Interactive comment on "Modelling street level PM₁₀ concentrations across Europe: source apportionment and possible futures" *by* G. Kiesewetter et al.

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We thank Dr. Lutz for his constructive comments and many helpful suggestions on how to improve the manuscript. Below we provide detailed point by point replies to the questions. Referee comments are quoted in *italicised* font.

Page 3, para 2: It might be useful to also mention the AQ objectives based on the AEI, i.e. the national exposure reduction target and obligation, which is based on the urban background PM2.5 levels averaged over all larger cities for every EU Member State. [...]

We will take up this suggestion and mention the AEI in the introduction. Since this manuscript restricts itself to PM10 concentrations we do not plan to include PM2.5 estimates here; however, another manuscript is currently under review for Atmos. Environ. where PM2.5 is addressed more explicitly.

Page 3, para 3: I think the value of the paper could be better reflected in the introductory section by elaborating a bit more the context as described above. [...]

This is a good suggestion an will be taken up in the revision of the manuscript.

Page 3 line 17 and Page 27, line 29: There is now a 2013 version of EEA's report available. Hence, I'd suggest citing that, including the web URL.

Thanks, this will be done in the revised manuscript.

Page 3, line 20: Better use the term "reduction commitments", instead of emission ceilings, because the latter is less self-explaining and formally correct anyway.

Point taken, will be changed in the revised manuscript.

Page 5, line 20: It would be good to provide an uncertainty range for the 30μg surrogate, or at least a number for the probability for more than 35 excess days in the event that the annual average is 30μg.

See Fig. 1 in this comment which is derived from monitoring data in 2009, essentially remapping the data in Fig. 1 in the manuscript for this purpose. Stations are analysed in 2μg/m^3 bins of annual mean PM10 here, and the fraction of stations complying with the daily mean limit value is calculated within each bin. In fact, the derived likelihood distribution for meeting the limit value on daily exceedances corresponds nicely to the margins for compliance set in the paper. Below annual mean 25 μg/m^3, all stations meet the daily mean limit value, then the curve drops sharply (65% at 30 μg/m^3). At 35 μg/m^3 the chances for meeting the limit value are less than 10%, and above 40 μg/m^3 no stations are found to comply with the daily limit. We will mention this in the revised manuscript.

Fig. 2: It would facilitate understanding the figure if you added a horizontal line indicating the margin between "regional/Rural" and "urban" background.

Will be done in the revised manuscript.

Page 8, line 4: add "to derive an urban concentration increment"

Will be done in the revised manuscript.

Page 8, line 5-7: At least for larger urban areas, there is NO3 formation even within the urban domain. [...] it would be good to mention it in the discussion of the uncertainties. Perhaps it could be considered (for any future update of the approach) taking this aspect into account by adding a term in Equation (3) dependent on NOx emissions in the subgrid m ?

This is a very interesting suggestion indeed. We will mention it in the uncertainties section. The interactions between the different precursors of secondary PM formation would complicate the approach a bit (this complication is presently avoided), but indeed this option could be explored for future improvement of the model.

Page 8, line 26: I'd also add orography as a factor influencing the Beta-values and thus the dispersion in the boundary layer (see Map in Fig. 3, looking especially

at the UK, AT and SW-Germany, where mountainous regions correspond well with elevated beta-numbers.)

Agreed, will be done in the revised manuscript.

Page 9, line 10: It would be helpful for the reader to know the resolution also in Km x km

Will be added in the revised manuscript. At 45N, this corresponds to about .75 km (lon) x 1.1 km (lat) resolution.

Page 10, line 21: add "national total tailpipe emissions of"

In fact, for this step, we do not distinguish between tailpipe and non-exhaust emissions (mainly brake abrasion for the PM2.5 fraction discussed here). The idea is that the PM2.5 increment is related to the total PM2.5 emissions, regardless of their exhaust or non-exhaust origin.

Page 11/12, Section 2.3: It could helpful to refer to Fig. 2 (and the colours of the bars in there) when explaining the different steps here. To my opinion, Fig 2 really helped understanding the whole approach. So, linking the description closer to that figure would make it easier for the reader to follow what is being done to model the total roadside pollution.

Ok, we will try to draw a closer link to the figure in the revised manuscript.

Page 15, line 15: The systematic difference between the gravimetric reference method and automatic techniques is not limited to TEOM instruments. Also Beta-attenuation monitors show lower values and need to be corrected by a factor of about

20% depending on the local environment.

Correct. As in the case of TEOM observations, however, we assume that necessary corrections have been applied by national authorities, so we do not adjust the base year data that are provided by Airbase. Only in the case of French TEOM observations we applied corrections to the pre-2007 data to construct a consistent time series for the trend validation.

Page 15, line 22: When referring to "successful local measures" I suggest not to limit it to reducing "dust suspension", as the dust binding mentioned here isn't very (cost-)effective, especially in heavily trafficked roads. I'd rather point to measures like LEZ, traffic management and economic measures to promote clean transport modes, some of which have proven beneficial impact both on tailpipe and non-exhaust emissions (due to a shift in transport modes away from car traffic like in Berlin, where car traffic volumes decreased by 10% within a decade thanks to some sort of sustainable transport policy)

Correct: Dust binding and road surface cleaning might only be relevant for roads with very high dust or sanding levels. Otherwise, measurements indicate that improving a worn road surface can reduce resuspension by a factor 6 to 11, and using porous instead of concrete asphalt might reduce by a factor 2. In addition, reducing traffic volume and smoothing traffic flow, controlling the share of (old) HDV (not equipped with a particle filter) will all help, though quantification remains a challenge. We will enhance the discussion in the revised manuscript.

Page 18, end of Section 4: I suggest adding a sentence like "...and to estimate the remaining compliance gap left by future EU policy scenarios, which is supposed to be closed by additional measures on national level and local level, such as economic incentives for clean technology, traffic management, access restrictions, etc." This

further highlight the advantage of being able (thanks to the presented methodology) to express the resulting improvement from emission control scenarios (also) in the form of compliance with the limit values.

Thanks for this suggestion, will be done in the revised manuscript.

Page 19: I don't know whether the chosen station from Paris is the same as "Boulevard peripherique", which was part of AIRPARIF's source apportionment study, lasting from Sept. 09 to Sept 10. [...] The large coarse part calculated there might be overestimated, because (as rightly stated on page 11, line 12 : : :) the resuspension per vehicle decreases with growing traffic volume numbers, and NOx emissions (used for the parametrisation of the coarse fraction) per vehicle tend to be higher there because of the higher speed driven on motorways. This would explain the higher share of PM coarse in the modelled traffic increment (almost 50%) in comparison to what was measured during AIRPARIF's campaign (38%, comparing Fig. 26 with Fig. 53 in their report).

Thank you very much for this detailed comparison. That is a nice test how our modelling compares to a specific situation. We can learn about sensitivities and uncertainties:

- The stations are indeed not identical (nor the time periods, as Dr. Lutz rightly points out), but comparable. Both are located at sub-urban highways. In fact, the station was chosen as an example for a station with an extremely high local traffic increment, in contrast to the station in Warsaw shown directly below which shows a similar total PM10 concentration but completely different source contributions, in particular no roadside increment at all.
- Though a difference exists between our estimated share and the measured ratio of PMcoarse to PM10 for the local street component, we would like to point out

that the 46% is in fact not much higher than the 38% measured for this highway site and probably within the uncertainty range – considering the number of simplifications of our modelling, including e.g. the emission inventory. Therefore, we would rather like to take this as a confirmation for the quite good performance of the model even at a single site, which is clearly at the margin of the model's capabilities (as noted in the manuscript, e.g. p 18335 l 15ff, we cannot expect that the model reproduces each station perfectly well but at least the main characteristics).

- Nevertheless there might be systematic differences due to the site characteristic as a (sub)urban highway. It may be that the model underestimates the exhaust PM at the highway site (and hence overestimate the non-exhaust=coarse share). Our explanation is slightly different from Dr. Lutz's, as follows: The PM2.5 increment is calculated proportional to NOx increment, times the ratio EF-PM/EF-NOx. That ratio is higher at highway driving conditions (higher speeds and higher heavy duty vehicle share) compared to the ratio at inner city sites. NOx emissions increase with speed for diesel cars, but strongly decrease for HDV (e.g. HBEFA 3.1). Hence, when moving from an inner city site to a highway traffic site we have typically two competing effects for NOx, while PM increases. For a numeric example compare APART 2009 (PM10-Emissionsfaktoren von Abriebspartikeln des Strassenverkehrs, EMPA 2009, Tables 1.1 and 1.2). Hence, for the same increment in NOx we are likely to underestimate the resulting PM2.5 increment at a highway location. The PMcoarse increment is diagnosed as the residual to the observed PM10 increment, hence a low calculated PM2.5 increment results in a too high PMcoarse increment.
- A test for the above reasoning can be made by taking national average emission factors instead of the emission factors for urban driving conditions used for the PM2.5 increment calculation. The difference is not large but in the example of the Paris A1 station, this increases the PM2.5 increment to 58% and decreases

the coarse increment to 42%, correspondingly.

It might be of interest to add somewhere here or in the following section 5.2 that the AQ Directives allows to neglect the contribution from winter traction sanding when assessing compliance with the PM10 limit values.

Will be done. Unfortunately we do not specify this contribution explicitly in the model.

Fig 7: Substitute in the legend above the first bar the term "domestic" by "national", so that it's consistent with the naming of the legend on the right side

Correct, will be done.

Page 25, line 27/28: I'd suggest adding road and tire abrasion. Concerning the last sentence of the paragraph ("targeted measures...") I don't think that it merits mentioning dust binding and enhanced road cleaning as generally useful. [...] I'd suggest pointing (also) to traffic management and planning measures as a means to shift motor traffic to cleaner transport modes, following the logic that less road traffic produces less PM emissions.

See reply to comment on Page 15, line 22 above. Dust binding and road surface cleaning may be mostly relevant for roads with very high dust or sanding levels, e.g. in Nordic countries. Improvement of the road surface may help, and we agree that traffic management measures should be mentioned here.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 18315, 2014.

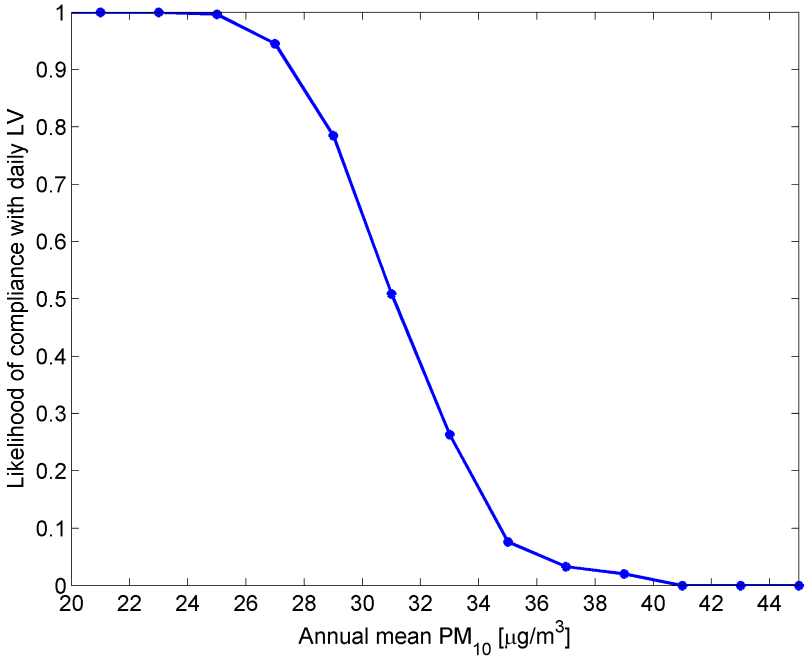

Fig. 1. Fraction of stations in compliance with the daily mean limit value for different annual mean PM10 levels, as derived from Airbase observations in 2009 (as for Fig. 1 in the ACPD manuscript).