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## ***Interactive comment on “Notably improved inversion of Differential Mobility Particle Sizer data obtained under conditions of fluctuating particle number concentrations” by B. Mølgaard et al.***

**B. Mølgaard et al.**

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### **Answers to comments from referee 1**

Below, the comments from referee 1 are put in *italic* font, and our answers are in roman font.

1) *In Section 2.5.1 (Data from the SMEAR III station in Helsinki), the authors say that "At some wind directions, traffic emissions affect the sampled aerosol substantially" (lines 3-4). It would be informative to complement the results figures*

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*with wind direction and wind intensity plots. I checked the SMEAR project web page, and the wind information seems to be available. More in details, I would like to see the wind plots for the whole day of 2nd of March 2015 (to link with Figure 1), and a detailed one for the 2nd of March from 10:00 UTC+2 to 12:00 UTC+2 to be linked with Figures 2, 6 and 8-10. For me, the wind plots can be placed either in the manuscript or in the supplementary material.*

For that day wind data are available from two instruments. One of them was located about 200 m NNE of the DMPS on the roof of a building (about 26 m above ground level). The other one was at the top of a tower close to the location of the DMPS (32 m above ground level). We show data from both sources in Figures 1 and 2. These figures show that the wind came from around south-east, meaning from the direction of a main road. We will show similar figures in the supplement. For simplicity, the figures there will only contain data from the tower.

*2) I expect to see correlations between wind measurements and high UFP number concentrations (from CPC) in rush hours. I would also like to know if there are other cases during the two week of measurements, in which the authors found similar situations of the wind and high UFP number concentration (from CPC) especially in rush hours or in periods of intense traffic. If yes, I would like to know how their algorithm works and, if the results showed in the paper are an isolated case or not. For example, in Figure 1 at around 6:40 UTC+2 there is a yellow spot at the same  $Dp[m]$  of the light blue spot that you have considered in your discussion. Is this a similar case, in which the old algorithm performs worse than the new one?*

Yes, we observed a similar situation on 27 February and 3 March. Also on these days, the wind came most of the time from the major road, and the concentration was strongly fluctuating and relatively high. On 28 February and 1 March similar conditions were observed for some hours. The example based on data from around

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11:00 UTC+2h on 2 March is far from being an isolated case. Our algorithm generally performs much better than the old one when fluctuations occur. Specifically, answering your question about the yellow around 6:40 UTC+2 at 26 nm, the old algorithm fails in a similar way, and our new algorithm deals well with the fluctuations. The fluctuations which caused the old algorithm to fail occurred around 6:43 and are seen in Figure 3. Size distributions obtained with both algorithms are seen in Figure 4, and clearly the new algorithm gives much more realistic results.

3) *For a better comparison between the new and old algorithm, I would like to see Figure 6 complemented with an extract from Figure 1 with the same time intervals (10:30-12:00 UTC2), same  $D_p[m]$  and same color code for the concentrations.*

Good idea. Thanks. Figure 5 contains the extra panel. This figure will replace Figure 6 in the article.

*Minor comments:*

*Abstract:*

*Page 10284 line 11: "located in Helsinki" should be "located at an urban background site in Helsinki" (to be consistent with the Methods Section). Page 10284 line 14: "the overall agreement was good", please quantify this expression (correlation for the whole period is 0.98 for the new algorithm and 0.97 for the old one).*

We will make the suggested changes.

*Introduction:*

*Page 10285 line 24: "appears to be low (Fig. 2)" please add a link to the light blue spot (low concentration) in Figure 1, if I am correct.*

Yes, you have understood it correctly. We will make a clear reference to the light blue spot in the figure.

*Methods:*

*The authors used a stationary covariance function in a non-stationary process. They are aware of this limitation as discussed in the Result and Discussion Section (page 10299 lines 26-29), and they state that implementing a non-stationary covariance function with the desired features is not straight-forward. I agree in the difficulties of implementing such covariance function. However, for the future works, I would suggest the authors to test a covariance function based on the addition of a linear and rational quadratic functions. The sum of two functions allows to model the data as a superposition of independent functions representing different structures. The linear function is a non-stationary (it neither depends on the relative position of the two inputs nor their absolute location). The rational quadratic function can be seen as a sum of many squared exponential functions with different characteristic length scales and can accommodate several length-scales (see the Mauna Loa Atmospheric Carbon Dioxide example in Chapter 5 in Rasmussen and Williams (2006). Moreover, Duvenaud et al. (2013) proposed a grammar and an automated search for the covariance structure using different base functions.*

*Ref: Duvenaud, D., Lloyd, J.R., Grosse, R., Tenenbaum, J.B., Ghahramani, Z., 2013. Structure discovery in nonparametric regression through compositional kernel search. In: Proceedings of the 30th International Conference on Machine Learning, pp. 1166e1174.*

Thanks for your suggestion. We will consider this idea when developing the model further.

*Page 10293 line 4: "This reconstruction may be inexact for particle counts above 40" here it is missing the unit and I think it should be \*below\* 40.*

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The unit is particles. Actually the present formulation is correct. The idea is that these integer particle counts are reconstructed by multiplying the concentration with the sampled volume. If this product is small it is always close to some integer. For instance, it could be 4.96, and in this case it is clear that the actual number of counted particles is 5. But if the product is ten times higher, i.e. 49.6, it is unclear whether 49 or 50 particles were counted. This only leads to minor inaccuracies.

*Results and discussion:*

*Page 10300 lines 7-9: "At 10 min resolution the correlation between the means from the two instruments was 0.984. For comparison, when processing the DMPS data with the old inversion algorithm, the obtained correlation is somewhat lower: 0.967". I do not think that the two correlation coefficients are statistically different.*

These two correlations may appear to be similar, but actually 0.967 is twice as far from 1 (perfect correlation) as 0.984. Such a difference in the correlations is hardly a coincidence. We will modify the text to make this clear.

*Conclusions: Page 10203 line 17: "suburban location" should be "urban background" to be consistent with the Method Section.*

Thanks for pointing this inconsistency out. We will make the change.

*Figure 4: I would color the train points of the two DMPSs differently. In the caption what does it mean "second axis"?*

This is a good idea. Second axis refers to the y-axis. Figure 6 in this comment (with the clarified caption) will replace Figure 4 in the article.

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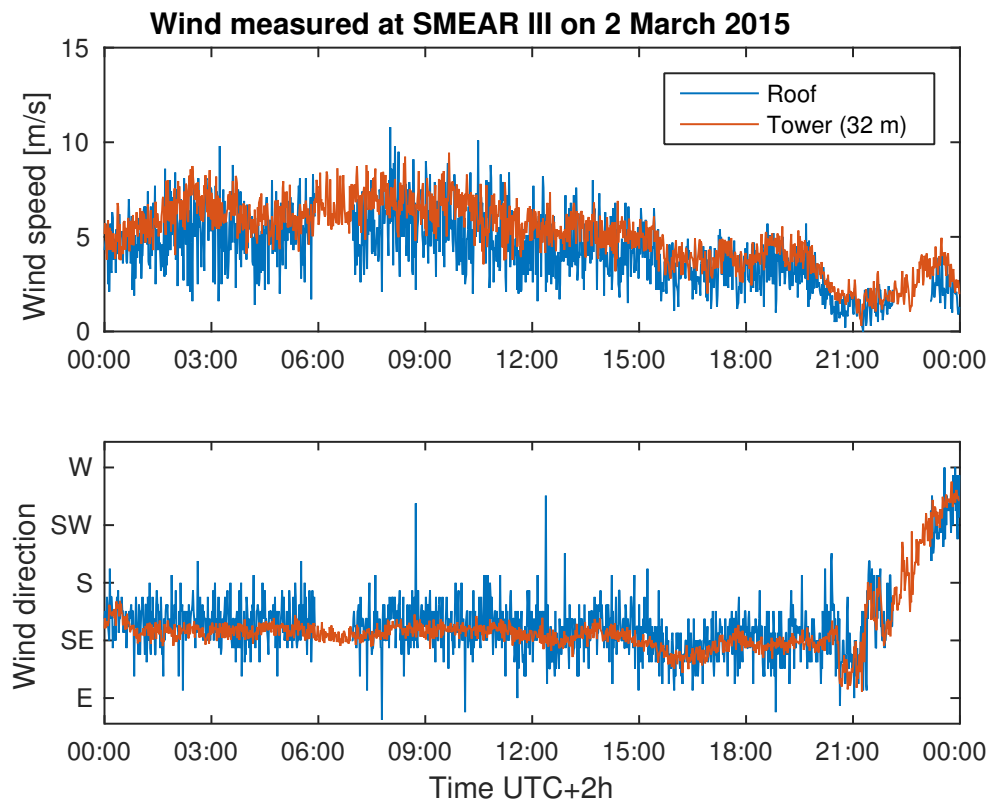
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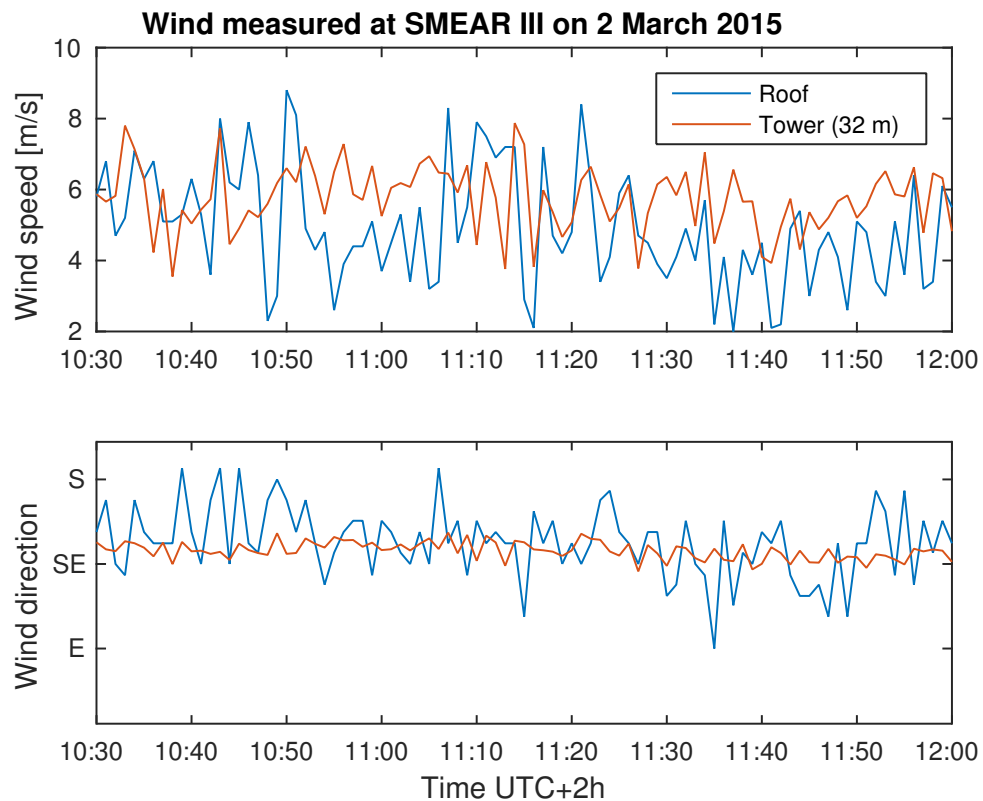
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**Fig. 1.** Wind on 2 March at SMEAR III.

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**Fig. 2.** Wind during the time interval 10:30 – 12:00 UTC+2h on 2 March at SMEAR III.

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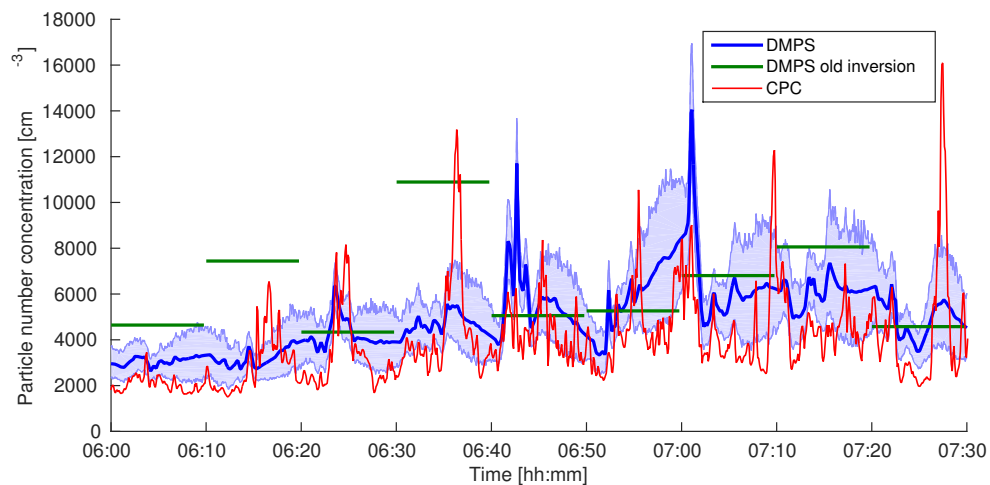
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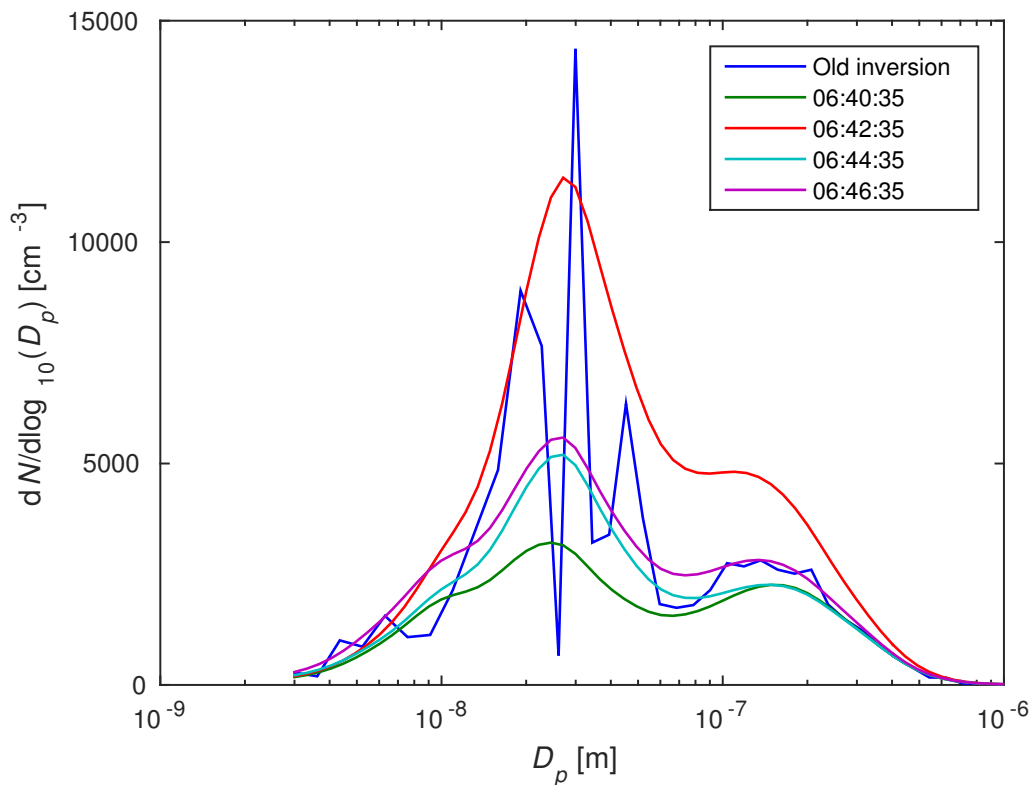
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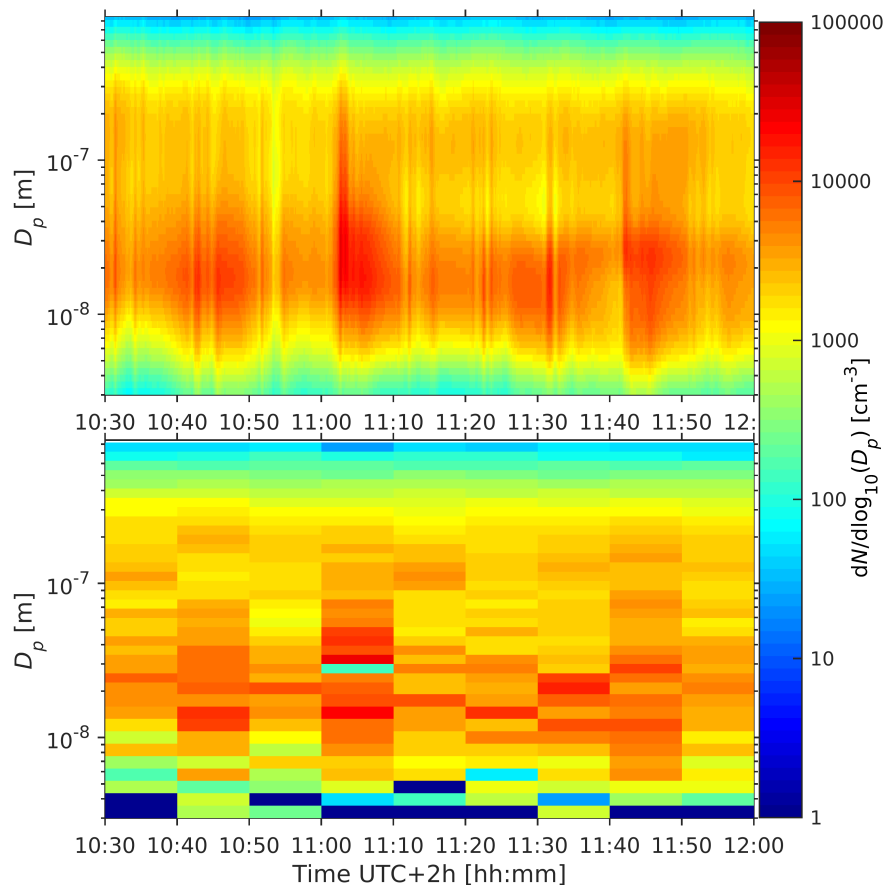
**Fig. 3.** Particle number concentrations in the morning of 2 March 2015 at SMEAR III.

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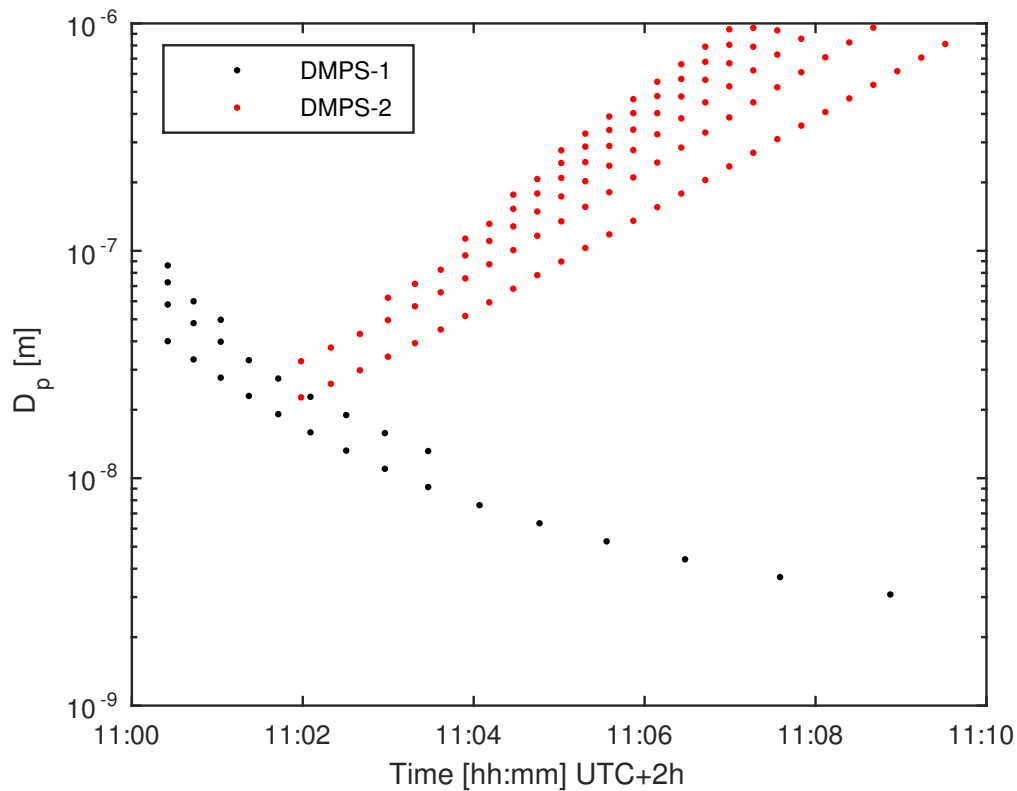
**Fig. 4.** Size distributions obtained with the old for the scan between 6:40 and 6:50 UTC+2h on 2 March 2015, and with the new algorithm for various times during that scan.

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**Fig. 5.** Upper panel: Expected size distributions on 2 March between 10:30 and 12:00 UTC+2h. Lower panel: Size distributions for the same period obtained with the old inversion algorithm. The ticks on the time

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**Fig. 6.** Training inputs for the scan on 2 March between 11:00 and 11:10. For clarity we put  $D_p$  instead of  $u$  on the vertical axis (y-axis).

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