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Interactive Comment

Interactive comment on "Mode resolved density of atmospheric aerosol particles" *by* J. Kannosto et al.

J. Kannosto et al.

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Comments for the Referee #2

We would like to thank the referee for his/her constructive comments and several helpful remarks. Here we refer to them point by point.

Specific comments:

Ref: p. 7268, Fig. 1. What is "guide for the eye" based on? The two lowest values by Ristimäki et al. (2002) seem too low, but all other open circle values are similarly close to the bulk value as the new values (black dots).

The guide for the eye fitting is based just to the visual estimation. It is plotted to show the trend in density values: as the size decreases also the density values decreases. This is due to the inaccuracy in the lowest part of the 1st impactor stage cut off curve.



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The inaccuracy was revealed when the impactor was re-calibrated. We have tried to clarify this in the text.

Ref: p. 7268. Could you add a little more information about the "detection limit" of the method? What kind of simulations is the detection limit based on? ... Could you provide a table with the minimum number concentrations required, and the minimum total current required in the ELPI measurement so that a 20% contribution of the nucleation mode yields reliable density values?

In simulations first the "input" DMPS distributions were generated based on measured Hyytiälä data: the distributions consisted of 3 lognormal modes in the size range of nucleation, Aitken and accumulation modes. After that, the density values ranging from 0.5 to 2 g/cm3 were given to each mode. Then the ELPI currents were simulated by means of size distributions, given densities and ELPI instrument functions (i.e. impactor kernels and charger efficiency). The simulations were made by adding 5 % noise to ELPI currents and DMPS distributions. After that the density of each modes were found by using the simulated currents and DMPS size distribution data. We added the explanation in the text. We also added the table as the referee proposed.

Ref: p. 7296, lines 14/15: What criteria are used to detect the two type of errors, i.e. what is defined as improbably high/low density values?

We added the following explanation in the text: "This can be recognized as one mode receives an improbably high density value (dp> 7 g/cm3), while the other one receives an improbably low one (dp< 0.2 g/cm3). The mode swapping cases were sorted from the resulted density values. After that each case was checked separately by calculating the resulted aerodynamic mode sizes."

Ref: p. 7269, lines 19/20: Is the addition of 5% noise component a realistic representation of the measurement errors you expect from the ELPI instrument?

The noise level was estimated from zero currents of ELPI (i.e. currents corresponding

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the signal measured by using filtered air). The zero current were measured every day. The noise as well as the electrometer zero drift was less than 5% in each channel.

Ref: p. 7270, second section: Are the measurement ranges of the SMPS, DMPS and ELPI instruments given as diameters or radii? Can you state the lengths of the inlet lines? In lines 15 and 17, I suggest to use "about" instead of "ab".

The measurement ranges are given in diameters. We added this into the text. We also added the more detailed description of the inlet lines. The "ab" is replaced with "about".

Ref: p. 7271, line 5: You state that you recorded a particle formation episode on May 8. This is surprising given the low total number concentration and the temporal evolution of the size distribution in Fig. 2.

Classification of days is made by methodology explained in Dal Maso et al. 2005. Shortly about the criteria: new particle mode have to be formed and it have to be present for a time span of hours. New mode has to be below 25nm. New mode shows signs of growth, if growth is very week the new particle formation event belongs to event class 2. Total number concentration is not a criteria for the classification. Detailed description can be found in already mentioned Dal Maso et al. 2005. May 8th has strong accumulation mode present, which acts as a sink for newly formed particles and consequently nucleation mode is very weak. The day has also partly cloud cover and this prevent strong event from happening. Never the less May 8th still fulfils the criteria to be a new particle formation event.

The figure in the paper is very compressed for a day by day analysis, we advice referee to see detailed data for the particular day from: http://www.atm.helsinki.fi/~junninen/trajShow.php?day=8&month=5&year=2005&arrh=100&bt=96&screen=trajShow&varID Interactive Discussion

Ref: p. 7272, lines 1 / 2: I cannot see that the modes are more clearly distinguishable on the aerodynamic axis in Fig. 3b.

Referee is correct! We removed the fig. 3b.

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Ref: p. 7273, lines 2-4: With regard to the accumulation mode particles, was the absolute number concentration of the relative mode contribution too low for a successful density analysis?

The relative concentration of the accumulation mode was too low. We clarified this in the text.

Ref: p. 7273, Fig. 4: You state that the Aitken mode density values reached their maximum on May 14. Looking at fig. 4, the values seem even higher on May 15 and 18. In addition, maybe you could add the time series of wind direction and relative humidity to fig. 4.

Again, referee is correct: the highest density values were recorded between 14th and 18th May. We changed the text. We also added the time series of RH, wind direction and net radiation (fig 5)

Ref: p. 7273/7274, Fig. 5: You briefly refer to Fig. 5a on p. 7274. Could you add few more words explaining fig. 5? For example, explain the concentration spikes in the evening and night on May 4.

The spikes are clear local pollution episodes. NOx, CO2 have peaks at the same time and O3 has negative peak. Since the peaks are very sharp and air mass back-trajectories are not passing by any close industrial facilities we believe that these spikes are very local most likely caused by a tractor or a truck. However, more detailed source apportionment of these peaks is not possible with only aerosol and standard gas data and is also out of scope of this paper.

Ref: p. 7274, table 1: Are the present values in Table 1 daily arithmetic means or median values, or maximum values? The potential temperature values are surprising. What is the difference between column pairs labelled UV_A, UV_B and net radiation? Are you confident that the presented NO mixing ratios 13 ppt and 0.4 ppt can be resolved with the NO measurement technique used?

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There was an error in table labelling: the column labelled "Potential T" should be labelled "Potential temperature gradient". This is now corrected. UV-A ultraviolet radiation in wavelength range 0.32 - 0.40 um in units W/m2 UV-B ultraviolet radiation in wavelength range 0.28 - 0.32 um in units W/m2 Net radiation is the difference between the incoming and outgoing radiation, wavelength range is 0.30 - 40 um in units W/m2

Referee has a point; our instrumentation is on the very edge of detection limit. Noise of the raw signal is around 20 ppt, however by averaging over 30min noise to signal ratio improves considerably and noise becomes 2 ppt and detection limits with S/N = 3 becomes 6 ppt. This is valid only during this measurement period, the instrument is measuring at the site continuously and it has long time drifting which we try to compensate but this increases error. However, this is not the case during this campaign.

Ref: p. 7274, Fig. 6: Could you explain why the error bars of the accumulation mode density values are much higher than the error bars of the Aitken mode in Fig. 6c.

The relative errors of the accumulation and Aitken mode density values are of the same order of magnitude. The Aitken mode density values are ~2 times lower than the accumulation mode density values, thus the absolute values of the errors are also lower. This is why also the error bars of Aitken mode density values are smaller.

Ref: p. 7274, line 21: "when density levelled at 1.0 g/cm3": Could this levelling-off be due to the fact that the GMD reaches the size limit of the mode?

In the density calculation method itself, we don't limit the mode GMD. The GMD values are gained by fitting the lognormal modes is measured DMPS distribution. The density values resulted from density fitting method are given as a function of mode GMD. In the density data analysis we have grouped the density values into different modes according to the mode GMD. Thus the size limit of the mode does not influence on the results.

Ref: p. 7257, lines 3-9: Based on your results and previous studies, could you expand

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a little on potentially relevant condensing species? In the conclusions, you refer to studies where the density of condensing species ranges from 0.5 to 1,9 g/cm3. Your density values seem to indicate that condensing vapors with densities on the lower end of this range are dominant in Hyytiälä. What species could be most important?

The density value alone can not, unfortunately, give sufficient information for identification of individual species. Thus we wish not to speculate too far. And obviously this is the subject of the further studies.

In addition, all technical corrections that the referee suggested have been done.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 7263, 2008.

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