Atmos. Chem. Phys. Discuss., 7, S4279–S4285, 2007
www.atmos-chem-phys-discuss.net/7/S4279/2007/

Atmospheric Chemistry and Physics Discussions

ACPD

7, S4279–S4285, 2007

Interactive Comment

Interactive comment on "Contribution of mixing in the ABL to new particle formation based on some observations" *by* J. Lauros et al.

J. Lauros et al.

Received and published: 22 August 2007

We are grateful for the comments which have improved our work.

General comments

We have improved the manuscript as suggested by referee #1. In addition, we have added clarifying statements, e.g. in section 4.1.

Many factors affect new particle formation and it still is unknown which of those are deciding. These factors also affect each other, e.g. synoptic and mesoscale meteorology. The focus of this paper is the effect of mixing on new particle formation in the boundary layer and we believe sources and synopticscale meteorology are out of the scope of this paper. However, we have referred to prevailing synoptic conditions (now in the end of the section 4.1) and discussed on sources (in sections 4.2 and 4.3).

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We have utilized 30-minute data and aimed to simulate effect of maximum lift created by micro and mesoscale systems. We do not see that it is reasonable to mention separately meteorological mechanisms or discuss if observed mixing is generated by mesoscale (e.g. vortex rolls) or smaller microscale eddies. By mentioning micro- and mesoscale, we want to point out that this is not a synopticscale study.

Referee #1 is correct that we do not show that the growth of nanoclusters is the bottleneck for particle formation rather than their nucleation. However, our results support results presented by Hirsikko et al. (2005) and Kulmala et al. (2006), who have shown that 1) nanoclusters exists but 2) grow only if the conditions are favorable.

Specific comments

Abstract Page 7536, l. 11: " Humidity and heat flux may also be good indicators for particle formation" is based on the logistic regression study, section 4.4: "Almost as successful results were produced by $\exp(CS_{z_i})$ with $-\overline{w'\theta'}_{z_i}$ or RH_{z_i}."

Page 7537, l. 26: We rephrased: ...if observed mixing affect significantly on particle formation and utilized...

Page 7537, l. 28ff We added a statement: The surface conditions do not predict particle formation in all cases when it could be possible at more favorable conditions at elevated altitudes (discussed in Sect. 4.2).

Page 7538, l. 17: The actual organic vapor is unknown but the enthalpies of vaporization for atmospheric organic compounds are typically below 170 $\mathrm{kJ\,mol^{-1}}$. The used value corresponds more likely mono- and dicarboxylic acids than PAHs.

We rephrased: In this study $\Delta H_{os} = 170$ $\mathrm{kJ\,mol^{-1}}$ which is a reasonable value for mono- and dicarboxylic acids (see e.g. Strader et al., 1999).

Page 7539, l. 9: We rephrased: ...at any level z_1 (m), it can be derived for another altitude z_2 as...

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Page 7539, l. 15 We added a table which includes the variables. We added a statement, p. 7540: ... The measurements are summarized in Tab. 1. We added a statement, p. 7542: ... dz_i/dt from the sodar measurements and γ from Tikkakoski soundings.

Page 7539, first paragraph: We rephrased and added an explanation for event days: ...82 event days. The classification to event and nonevent days was based on visual analysis of particle data and following criteria for event days were used: a new mode had to start growing from nucleation mode size range and the mode had to grow and exist hours (Dal Maso et al., 2005)... The time periods cover 490 days altogether but we were able to observe the boundary layer growth in sodar data only on 100 days.

Page 7539, l. 24: We have removed "Our study based on..." as it is unnecessary. The paragraph was rewritten.

Page 7540, l. 15 We added a statement: ...We estimated values of variables at the top of the ABL and for this we needed to know the mixing height. The strength of backscatter...

Page 7540, l. 25: Even if the measurement level is located inside the surface layer in some cases, we believe that this is the best and also adequate estimate of temperature change in the ABL for the used slab-model. Therefore we have not paid attention to study how often the measurement level is located above the surface layer.

Page 7541, formula 2 and Page 7541, l. 5: Here w is the vertical velocity and θ_s the potential temperature at the surface. The primes refer to fluctuations from temporal means.

Page 7541, l. 15: Done, please see our answer to *page 7539, first paragraph*.

Page 7541, l. 19: We rephrased: However, we assumed that the conditions were similar in the vicinity of the sodar and the mast/tower. We ignored the spatial and

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altitude difference because the difference is negligible especially due to the used time resolution.

Page 7541, l. 20: We prefer to retain the description of the model and especially Fig. 2 because the section helps to understand the results, which are discussed in Sect. 4.4.

We rephrased: ...or jump model. The model has been introduced by several authors (e.g. Stull, 1988). The principle of the model is described shortly here and it is illustrated in Fig. 2.

Page 7543, l. 16 ff We believe that some readers are interested in how particle distributions were defined in the paper. We removed the well-known definition for total energy.

Page 7544, l. 7: We added brackets.

Page 7543, l. 10: We removed the formula.

Page 7544, formula 7 We replaced Eq. 7 with Eq. 10 and reformulated the paragraph: The probability of an event $p(y=1|\boldsymbol{x})$ can be presented by a continuous function which takes values between 0 and 1:

$$p(y=1|\boldsymbol{x}) = \frac{1}{1+\exp\{-(\beta_0+\boldsymbol{x'}\boldsymbol{\beta})\}} \tag{1}$$

Here $\boldsymbol{x}$ is the vector of variables, β_0 is the intercept and $\boldsymbol{\beta}$ the vector of slope parameters. The method is called binomial logistic regression and it has been utilized to study which variables could describe the new particle formation probability.

Page 7545, l. 1: The abbreviation $Pmet$ has been used already after Eq. (1) and it means the effect of meteorology through the manuscript. We added a statement: ... Eq. (1), the effect of meteorology P_{met} and condensation sink CS.

Page 7545, l. 4: We removed “on”.

Page 7545, l. 24: We added a statement: Strong mixing on event days may be connected to cold fronts. It could be interesting to study if synoptic conditions explains the mean difference in mixing strength.

Page 7546, l: We completed: ...measured during BIOFOR (Biogenic aerosol formation in the boreal forest) campaign...

Page 7546, l. 6: We believe that the synoptic conditions are outside of the topic of this paper. The expected conditions were described in the begin of section 3. We moved this part to the end of the paragraph on page 7546 and rephrased: They concentrated on situations with a cold outbreak. The synoptic conditions could often be similar in our cases, as our data was confined to meteorological situations typical for a clear sky continental boundary layer, with a transition from stable to unstable conditions in the morning, followed by increasing turbulence and convection.

Page 7546, l. 7 Replaced the title by "Theoretical change of saturation ratio"

Page 7546, l. 8: We replaced observe by assess.

Page 7546, l. 13: We removed the sentence and rephrased: We studied separately the effect of temperature, humidity and expansion of an air parcel on CS on 29 March 2003 and the results are presented in Fig. 5a.

Page 7547, l. 13 The range is theoretical but covers the typical conditions. We rephrased: ...(chosen to be 240$\leq \overline{\theta} \leq$300 K and 400$\leq z_i \leq$2400 m as these cover most of the local situations)

Page 7547, last paragraph $\rightarrow$ *7548* We wrote "saturation ratio" instead of S_{os} to use less abbreviations. However, we prefer to present every case and corresponding results in current way. We added some statements to clarify the basic idea of this section. We believe these changes improved the section. We thank the reviewer for these educational comments.

Page 7548, l. 1 The following equations: We rephrased: ...would modify the following Eqs. (2) and (3)...

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Page 7548, l. 9 We rephrased: The theoretical study based on surface observations showed that...

Page 7548, l. 18: We rephrased the paragraph, hopefully this clarifies: The wind velocity varies during 30-min measurement period. Instead of the mean vertical velocity $\overline{w}$ we used a higher value $\overline{w}+\sigma_w$, where σ_w is the standard deviation of wind velocity. If the velocity follows a normal distribution, the distribution predicts that w is $\overline{w}+\sigma_w$ or higher during 5 min of measurement period.

Page 7548, l. 25 We did not expect anything but the larger the term $< P_{met} - CS >$ is the more favorable the result is. The result endorses the hypothesis that new particle formation is connected to vertical mixing, even if the values are negative. As mentioned in the paper, a smaller source is needed on event days than on nonevent days for a positive change in saturation ratio.

We rephrased:...Even on the event days the effect of temperature lapse does not overcome the effect of condensation sink on saturation ratio. The mean total effect is negative and the saturation ratio decreases, instead of increasing. Even if $P_{\rm met}$ does not exceed the effect of CS on the event days, convection has...

Page 7548, l. 27 and Page 7549, l. 2: The value of source depends on initial saturation ratio and saturation vapor concentration. We can give a value of relative source strength which is needed on (non)event days on average.

We removed *much*, rephrased and added a statement: ...the relative source strength $Q/(C_0 S_{os})$ (...), but normalized by the saturation ratio) that would be needed on average to get a positive change of saturation ratio and hence possible aerosol formation to about 1–2$\times 10^{-3}$ s^{-1} on event days. The required relative source on nonevent days is correspondingly over 6×10^{-3} s^{-1}.

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Page 7549, l. 27: We added a statement: The size of data set decreased from 100 to 80 cases due to missing mast and tower data on 20 days.

Page 7550, formula 10: Please see above, answer to *page 7544, formula 7*.

Page 7550, formula 11: We prefer to have the example for readers who are not familiar with logistic regression models.

Page 7550, l. 24: We added a statement in section 3.4: The accuracy of a regression model raises if the number of variables is increased. On the other hand, this leads to a more complicated but not necessarily significantly better model.

Page 7552, l. 13: Sources of organics are important at the surface but their effect on saturation ratio decreases when altitude increases. In this study, we have concentrated on effect of mixing.

The event and nonevent day observations are real. On the other hand, we have simulated entrainment velocity and know that dilution is proportional to this. It is not realistic to assume that there is no dilution, but we do not need to simulate it to draw conclusions.

We expanded the discussion: ... . In the future it would be interesting to study how the saturation ratio profile behaves when the effect of vertical mixing, sources and condensation sink have been simulated simultaneously.

We added a statement on page 7551: The event observations depend on real mechanisms in the ABL, e.g. entrainment and dilution. Even if our model does not include the effect of dilution, we know that this is correlated with simulated entrainment velocity and can draw conclusions based on this... despite the fact that it could be expected that the probability increases due to decreasing preexisting particle concentration if entrainment velocity increases.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 7535, 2007.

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