

## ***Interactive comment on “Secondary new particle formation in Northern Finland Pallas site between the years 2000 and 2010” by E. Asmi et al.***

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We greatly thank and acknowledge the Referee #1 for their comments which helped us to improve and clarify the manuscript. We modified the manuscript according to the suggestions as detailed below. Referee#1 also suggested modifying the title to specify that the manuscript discusses NPF probability. This is a good idea, but we didn't manage to reformulate a better title so we will stay with the current one, which is very general.

P. 25711, lines 21-22. The phrase “estimates of aerosol cloud forming potential and associated climate effects” should be revised.

Answer: The phrase was revised as: “Uncertainties in particle formation processes are

C12526

translated into uncertainties in aerosol-cloud interactions and indirect climate forcing by aerosols.” We hope this is clearer.

P. 25711, line 25. One cannot solve a mechanism. Replace “unsolved” with poorly understood or any more appropriate word.

Answer: corrected

P. 25712, line 5. Add Vehkamäki et al. (2004) to the list and any other relevant paper from Northern Europe. A paper by Kristensson et al. (2008) also seems to be relevant. Kristensson et al., Characterization of new particle formation events at a background site in Southern Sweden: relation to air mass history. Tellus 60B (2008), 3. DOI: 10.1111/j.1600-0889.2008.00345.x

Answer: added

P. 25712, lines 26-27. This is a missed opportunity to promote the Pallas dataset. I would also like to see an explanation of the type of environment and why Pallas is different from other stations where long term datasets exist also in Northern Europe (e.g. Hyytiälä).

Answer: Thank you. We added a phrase where the Arctic location of Pallas is better promoted.

P. 25713, line 6. The measurements, plural.

Answer: corrected

P. 25715, line 1. Is there any particular reason why the weight decreased from 1 to 0.0769 during the 120 h? Is it common to do so? If so add a reference.

Answer: There is no particular reason for the chosen weighting procedure, nor there is probably not one right way to do it. We did not wish to weight the first trajectory point (120 h ago) with zero, but instead with 10/130. Using the chosen method, the most recent two days get a weight of 61 %. The NPF observed is likely to occur in

C12527

the proximity of the station, which we consider supports the use of weight. Another justification could be the increasing uncertainty in trajectory path with distance. We tried to be more specific in explaining the weighting procedure in the text: "For dividing the air masses into characteristic types, distance weighted fractions were used. It has been shown that NPF observed in northern Finland typically occurs in the proximity of the station (Hussein et al., 2009) and thus it is justified to give more weight to the nearest trajectory points. Here the weight was set to be a linear function of time such that the weight decreased from 1 to 0.0769 (10/130) during the 120 hours. This way, the sum of the weights given for the trajectory points at nearest 24 hours is 34 %, while the weights for the points at four following days are 27, 20, 13, and 6 %. Therefore, even if the trajectory path is over the ocean during the first three days (hours 48–120 backwards), the air mass can be classified as 61 % continental based on the most recent trajectory path. The division to characteristic types (marine, continental and mixed) is explained in detail in following section "air mass properties"."

P. 25715, line 15. Which stations are included in the "southern Nordic stations" is not clear.

Answer: We specified the southern stations referred (Hyytiälä, Aspöreten), and added also a study by Kristensson et al., 2008 showing results from southern Sweden Vavilhill station.

P. 25715, lines 22-23. A rephrasing like "highest value (> 0.5 cm<sup>-3</sup>s<sup>-1</sup>) were" might help the reader and the word "months" at the end of the sentence should be removed, as well as the word "overall" in the next sentence.

Answer: corrected

P. 25715, lines 24-25. The word "undiscovered" may lead the readers to think that there must have been a seasonal trend but it was not discovered. Depending on what the authors mean, perhaps replacing undiscovered by "lack of" or mentioning that the trend was not observed. Nevertheless, The authors should mention why we expect to see a

C12528

trend: previous studies or logical argument. The word "used" could also be removed.

Answer: Undiscovered was replaced by "missing". The phrase was corrected not to give a wrong impression of expected seasonal variability. The rephrased sentence is: "The missing seasonal variability in particle formation rates is in line with previous studies from Northern Finland. . ."

P. 25716, 2nd paragraph. In Fig. 3, there are NPF events occurring during the polar night, so in these cases, an error on the growth rate does not explain that the event takes place before sunrise. Please acknowledge the presence of those events in the text.

Answer: Yes, good remark. We added a sentence "In late autumn, few class II events were also detected during late polar night. These events suggest that NPF can, in rare cases, occur also in the absence of solar radiation."

P. 25717, line 11. "[...] along with the corresponding values for the NPF starting times trajectories". This should be rephrased, it is difficult to know if the authors are talking about the starting time of the NPF or the that of the trajectories and what is what.

Answer: Yes, rephrased: "Table 2 presents the seasonal frequencies of air mass types along with the corresponding values during NPF:"

P. 25722, lines 14-17: "Connection of NPF frequency with GR might suggest that in the lack of sufficient vapour concentrations events are both rare and weak (i.e. GR is low), and do not thereby inflict significant climatic effects." This is only for class I events. Is there any chance that class I events are biased in a way that class II events would perhaps yield more CCN?

Answer: In some cases, the connection between event frequency and GR could be explained by the "survival probability" of the particles. If the GR is too low, the particles might be lost before we can detect them (at 7 nm). Probably most of the class II events are similar as class I events, but are classified as class II rather due to air mass changes

C12529

in our measurement point. In other words, we can not follow the growth because we are not measuring the same air mass all the time. However, some of the class II events can be totally different, e.g., events which are very local (in which case we do not observe continuous growth). Resolving the climatic effects of this type of events would require Lagrangian study.

P. 25723, line 22: typo: events "where" (not were) no new CCN Answer: corrected

P. 25724, line 7: The authors could easily remove "part of the year". Answer: corrected

P. 25724, line 26: through, not trough. Answer: corrected

P. 25725, line 29: "defined"? Did the authors mean "found"? Answer: more so, corrected

P. 25726, line 2: "unsolved"? Did the authors mean "solved" or "resolved"? Answer: changed to resolved

P. 25726: Can the authors use this study to say something about what happens above the boundary layer in such environments?

Answer: This study is limited to boundary layer conditions. Studying the results together with those of close-by stations, and following the back trajectory path and altitude, it's true that some conclusions on upper boundary layer or free tropospheric particle formation and growth could be deduced.

References:

P. 25727, line 17. The paper can be found under the name Buenrostro Mazon, which seems to be the author's last name. Answer: true, corrected

P. 25728, line 25. The accent is missing on Kurtén. Answer: corrected

Aalto P. is sometimes P. and sometimes P.P. Are these two different persons? Answer: Yes they are, but in some publications only one P is written in author list.

C12530

P. 25730, lines 31-32: Two names are missing letters. Answer: corrected

P. 25731, line 21: It should be Prevot, A. S. H. Answer: corrected

P. 25731, line 25: Dal Maso in two words. Answer: corrected

P. 25731, line 32: O'Dowd (with an apostrophe) Answer: corrected

P. 25732, line 2: O'Dowd, C., Monahan, C., (apostrophe, and first and last name inverted for the 2nd author) Answer: corrected

P. 25732, line 5: Plass-Dülmer Answer: corrected

P. 25732, line 29: atmospheric should not be plural Answer: corrected

P. 25733, line 8: Kivekäs does not have an initial. Answer: corrected

P. 25733, line 27-28: From Merikanto to Salminen, the initials go with the wrong name. Answer: corrected

Table 1. Caption: The GR units are missing their closing bracket. Answer: corrected

Table 2. Caption: Please mention that the frequencies are percentages, either in the caption or the table itself. Answer: added

Table: Even though this is against the ACP general guidelines, it may be easier for the reader to read the table if there were vertical lines in between the seasons. Table: I recommend that the authors add the number of cases in parentheses also for the "All" column. This way, the readers can calculate the number of days in summer where the air mass was of marine origin, for example.

Answer: We agree, and added the vertical lines. But we think the number of "All" cases do not fit into the table. They could be easily calculated by the readers. In fact, the information on e.g. prevalence of marine air masses in summer is equally presented by the percent numbers given.

Figure 2. I think it would be nicer to see the observed starting time of class I events as

C12531

well, to allow comparison with the class II events' starting times.

Answer: They were added in Figure 2.

Figure 5. The NPF-proxy is said to be divided by 1000 in the caption, yet we can see that numbers on the x-axis are between 0 -  $5e104$ . If so, why not divide by another 10000? Should there be units for the proxy?

Answer: Yes, we added the units in x-axis and scaled it to go from 0 to 50.

Figure 9. Caption: Please precise that the lines are the CS for all days (event, nonevent and undefined days).

Answer: added

Figure 10. The equation should be described explained. What is BE (I assume Biogenic Emissions)? Moreover, in Table 2, the authors use the limit of 70% of the time spent over a marine origin for the air mass. In the caption, we learn that for this figure, they use 50%. Why did the standard change between Table 2 and Figure 10?

Answer: Explanation on equation was added. It is a good question, why 50% was used here. The method presented by Tunved et al. for calculating the biogenic emissions is very much dependent on the time over land. Because the trajectories, and temperatures on the bath of trajectory, get more uncertain the more far away from the measurement point we are, we wanted to limit the analysis to recent marine air masses. By taking only the marine air masses, the overall picture remains similar, but the scale of x-axis goes only up to about 6000 – 7000, instead of 11000 as in here. We decided to add the most marine part of the mixed air masses to make the decrease of nucleation probability with increasing CS clearer.

Figure 11. I did not find very clear the meaning of the "trend" bars in this figure. Try to be clear about it in the caption. And please replace "replaiced" with "replaced".

Answer: added, corrected

C12532

Figure 12. Please explain how to interpret these boxes in the caption. What is the meaning of the red line, the boxes, and the whiskers?

Answer: Explanation added: "The boxes show upper and lower quartiles, and median with red line. The whiskers extend from minimum to maximum. "

Figure 13. Caption: Please insert "NPF start" and "NPF end" into quotation marks to increase the readability. Figure: Are the units of the y-axis okay? Also, I did not fully understand this figure. Please explain what each bar means in more detail in the caption. For example, the readers may wonder why NPF end is not the sum of NPF start and the CCN contribution of the NPF event.

Answer: inserted. The units of y-axis were  $sm^{-3}$ , while they should have been, of course,  $cm^{-3}$ . We added following explanation in figure caption: "Bars "CCN Cont.", "CCN Mixed" and "CCN Marine" present the median concentration of >80 nm particles (CCN80) in continental, mixed, and marine air masses, respectively, and include all: event, undefined, and no-event days. Note that most events occur in marine air masses. "NPF start" bars show the median of mean concentrations of CCN80 in the beginning of the event, before the growing mode exceeds 80 nm. "NPF end" bars show the median of mean concentrations after the mode has grown to over 80 nm size, until the end of the event." So the bars "CCN Cont, mixed and marine", rather present the "typical" CCN80 numbers in each type of air mass. The numbers in the beginning of the event "NPF start" and end of the event "NPF end" can be compared with these to estimate if the nucleated particles cause the typical CCN values to increase (it seems so during spring and autumn) or rather maintain the typical CCN80 concentrations (it seems so during summer). Of course, the statistics in this are not excellent, and quantitative estimates of atmospheric CCN increase by NPF using point measurements are not even possible. However, in some cases, the results can serve as qualitative guidelines.

Please also note the supplement to this comment:

C12533

<http://www.atmos-chem-phys-discuss.net/11/C12526/2011/acpd-11-C12526-2011-supplement.pdf>

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 25709, 2011.

C12534