

Interactive comment on “Airborne measurements of new particle formation in the free troposphere above the Mediterranean Sea during the HYMEX campaign” by C. Rose et al.

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We thank Referee N°3 for his comments and suggestions that were very useful for improving the manuscript. We have addressed the comments point by point below. Also, 2% of the measurements previously classified as performed under non cloudy conditions in the first version of the manuscript were actually performed under undefined conditions regarding clouds. We now classify those 2% measurements as cloudy by default (i.e. filtered from our statistical analysis, for more safety). This leads to very minor deviations on some numbers of the manuscript.

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Comment 1: P8152, I10: To analyze the vertical extent is also a purpose of this study. This should be mentioned in this line as well.

Reply 1: This is now clearly mentioned: “The main purpose of the present work was to characterize the spatial extent of the NPF process, both horizontal and vertical.”

Comment 2: Please be more precise. Which processes?

Reply 2: These are mainly the processes which contribute to the production of gaseous precursors. This is now stated in the manuscript: “These observations suggest that nucleation events could be more influenced by local precursors originating from emission processes occurring above the sea, rather than linked to synoptic history”.

Comment 3: P8152, I17: How was the analyses of the vertical extent performed? It should be mentioned that vertical soundings have been used.

Reply 3: It is now mentioned that vertical soundings were used, and the expression “high altitude” was removed :” Vertical soundings were performed, giving the opportunity to examine profiles of the N5-10 concentration and to analyse the vertical extent of NPF. Our observations demonstrate that the process is favoured above 1000 m, i.e. frequently in the free troposphere, and more especially between 2000 and 3000 m, where the NPF frequency is close to 50 %.”

Comment 4: P8152, I18: “high altitude”, this term is used at several places in the text. For someone doing research in the boundary layer everything above 1000 m is “high”, but for someone doing research in the upper troposphere/lower stratosphere this is rather “low”. Therefore, I would suggest to write if possible above which altitude (e.g. above 100 m) or at “higher altitudes”.

Reply 4: It is true that the use of the term “high altitude” might be ambiguous. It was thus replaced by the suggested expressions.

Comment 5: P8152, I25: Why “could”?

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Reply 5: The use of “could” suggests that our conclusion regarding the particle GR is an hypothesis to explain our observations. Such caution is supported by the fact that our analysis of the particle GR is not based on numerical values that we can compare directly, but rather on the temporal evolution of average particle size distributions recorded at different altitudes. The use of “could” is also related to the fact that the number of SMPS size distributions included in the statistics is reduced for some altitude/time ranges (down to 29 above 3000 m at night).

Comment 6: P8153, l25: It should read “in” rather than “by”.

Reply 6: Correction was done.

Comment 7: P8157, l6: what is SD? As far as I remember the abbreviation has not been introduced yet.

Reply 7: P8157, l6: If we remember well we did not use the abbreviation in the manuscript that we submitted, but the expression “standard deviation”; maybe this was changed during the production process. The expression is explicitly written in the new version of the paper!

Comment 8: P8157, l14: I prefer trajectories six days backward in time. In my opinion three days are too short, but I know that it is common to use just three days.

Reply 8: Since the influence of air masses is mainly discussed regarding the occurrence of nucleation and the production of small particles (5 – 10 nm), we really believe that 3 days are enough, based on the life time of such small particles (also provided in the manuscript).

Comment 9: P8158, l21: “high” altitudes. Better to write above 1000 m.

Reply 9: Since Table A1 reports information for altitudes above 2000 m, “high altitudes” was changed into “above 2000 m”.

Comment 10: P8163, l28: “to be negative” Although there is nothing wrong with

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writing it this way, I would prefer that you write minus temperatures or temperature below zero.

Reply 10: Changed! “It is very clear that temperature is decreasing with altitude, especially above 3000 m where most of the temperatures are found to be below zero.”

Comment 11: P8165, l9-11: Something went wrong in this sentence. Please rephrase.

Reply 11: This sentence is now replaced by two shorter sentences: “During the time period 11:00 – 17:00 UTC, the size distributions are dominated by the nucleation mode. In fact, this mode includes 42% of the particles measured by the SMPS between 2000 and 3000 m, and 48% above 3000 m.”

Comment 12: P1865, l19-21: I have problems to follow how this suggest the speed of the particle growth. Could you be more precise and improve your explanations?

Reply 12: We have tried to improve our explanations. Here is the new version of the paragraph l17 – 21: “At night (17:00 – 05:00 UTC), the contributions of nucleation and Aitken modes to the total particle concentration are very similar between 2000 and 3000 m, being around 34% each, whereas above 3000 m the nucleation mode is dominant (46% against 36% for the Aitken mode). These observations suggest that between 2000 and 3000 m, nucleated particles are growing during the course of the day, leaving the nucleation mode, which thus includes a decreasing fraction of the total particle concentration, to reach the Aitken mode. In contrast, it is likely that above 3000 m, particle growth is not as fast, since the nucleation mode displays particle concentrations which remain on average higher compared to the Aitken mode, even in the evening. Again, this observation suggests that particle growth could get slower with increasing altitudes.”

Comment 13: P8167, l9: “first” obsolete?

Reply 13: Yes, removed!

Comment 14: P8167: Do I understand it correctly that you discuss size distributions

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that have been measured at the same day during different times? If yes, please write this more clearly. I think the reason for the decreasing coagulation sink with increasing altitude is due to the total number of particles you find in this altitude regions. Usually, as higher the total number of particles (with nucleation mode radii, like e.g. after a nucleation burst, is) as faster the coagulation.

Reply 14: No, here the GR was estimated from the shift of the nucleation mode seen on the average size distributions which are shown on Fig. 10, and which were calculated from the distributions recorded during the whole campaign, as explained at the beginning of section 3.2.1. It is true that “average” was not well used in our first sentence, which was changed to: “Particle GR were estimated from the shift of the nucleation mode diameter observed on the average SMPS size distributions between night time (17:00 – 05:00 UTC) and morning hours (05:00 – 11:00 UTC) for the altitude range 2000 – 3000 m (Table A1, Fig. 10)”. We also agree with the fact that decreased coagulation sinks are explained by lower particle concentrations. This is now clearly stated: “The results of this analysis are reported on Fig. 11, which indicates that particle life time increases with altitude. Such observation might be explained by decreasing total particle concentrations with increasing altitude, thus leading to lower coagulation sinks.”

Comment 15: P8168, I7: Again I would suggest to write above 1000 m instead of high altitude.

Reply 15: “high altitude” was removed. Comment 16: Figure 2: In the caption it could be added that the color coding of the trajectories corresponds to the sectors as given by the text colors. Reply 16: The figure caption was changed accordingly to: “Illustration of the air mass back trajectories calculation along the flight path (black points) for flight 39 (2012/09/23). The colour coding of the trajectories corresponds to the sectors as given by the text colours.”

Comment 17: Figure 15: Which mode is shown here? Or all four modes represented

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by the size distribution?

Reply 17: We do not have Figure 15 and we cannot find which figure is concerned by comment 17!

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 8151, 2015.

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