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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Vertical and horizontal distribution of regional new particle formation events in Madrid" *by* Cristina Carnerero et al.

Anonymous Referee #1

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In this study, new particle formation (NPF) in Madrid during July 2016 is investigated from ground-based measurements of aerosol particle size distributions at three different locations in the Madrid area combined with vertical profiles at one location. The authors frequently observe ultrafine (UF) particles appearing in the morning followed by growth which they define as NPF events. On several days, such NPF events are observed simultaneously at the three different locations which leads to the conclusion that the NPF events are regional. From the analysis of the vertical profiles, the authors conclude that the UF particles are produced close to the surface and transported to higher altitudes within the mixed layer. New particle formation in urban locations have been investigated rather intensively in previous years. However, as the authors state in the introduction, rather few of the previous studies on urban NPF have included mea-

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surements in the vertical dimension. Therefore, I think the topic of this manuscript is suitable for publication in ACP. The manuscript is well structured and mostly well written. However, there are a few issues that the authors need to clarify, and possibly reassess, before publication.

Specific comments

1.) My first comment is related to the definition of primary aerosol particles in an urban location. A quite large part of the Introduction is spent on what fractions have been primary particles and originating from NPF in earlier studies in urban environments. Furthermore, since you claim that you can distinguish NPF events from primary emissions in this study, I think it should be more clear exactly how you define these two processes. In the Introduction, in lines 18-20 on page 2, you discuss production mechanisms of ultrafine particles from traffic: "condensation of semi-volatile phases vapor species that creates new UFP during dilution and cooling of engine exhaust emissions near the source". After that you write "most studies consider them as primary", "or quasi-primary particles". How do you define these particles, that form by nucleation in the tailpipe or a second after exiting? I guess you define them as primary, but I think that should be clear.

2.) Comment 1) leads to the question how you know that the regional NPF events are not "primary aerosol particles" formed by nucleation in the tailpipe or soon after exiting. Such emissions of 6-11 nm particles (Kittelson et al., 2006) dominate the number emissions. Furthermore, such emissions from thousands of cars in the Madrid area would likely look like a regional NPF event, since the emitted particles will grow by condensation in the atmosphere. One argument against this hypothesis, that the particles are primary, is the fact that your formation rates and number concentrations of 9-25 nm particles peak at noon when BC levels are at minimum. On the other hand, condensational growth is strongest at noon or in the afternoon since photochemical production of condensable vapors is dependent on solar radiation. Therefore, even though primary emissions are likely highest in the morning and evening rush hours,

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the likeliness that the emitted nano-particles grow into the 9-25 nm interval (which you refer to as ultrafine particles and for which you present the diurnal cycle in Fig. 5a) may be highest at noon or in the afternoon. I think you need to strengthen your arguments and definitions here when you refer to the events as “regional NPF events”. Also, could you add diurnal cycles of number concentrations associated with the PSM data to Fig. 5a?

3.) Following up on Comment 2), in Sect. 3.2.1 you equate the occurrence of “10 nm particles” with NPF. Could these particles not just as well be primary?

4.) Page 5, lines 22-23: Why did you choose the number concentration in the 9-25 nm interval in Eq. 4 for your definition of the formation rate? Why do you not use your PSM data for the formation rates?

5.) I do not follow the conclusion written in the abstract on lines 37-39: “The vertical soundings demonstrated that ultrafine particles (UFP) are transported from surface levels to higher levels, thus newly formed particles ascend from surface to the top of the mixing layer”, or that the fluxes are “bottom-up” as written on page 9, line 28. As far as I can tell, Fig. 10 (which is a very nice figure by the way) only shows that the particles are produced inside the mixed layer (not the residual layer). The mixed layer of course grows during the day, but how can you tell whether the particles are being produced close to the surface or at the top of the mixed layer (or both)?

6.) Regarding shrinkage in lines 1-2 on page 7: Could evaporation be a reason for the shrinkage as well?

7.) Page 7, lines 30-31: “For these stations the observed median growth rates were 7- 8 nm h-1”. These values are very close to the average growth rate of 7.3 nm h-1 reported from Bakersfield, a polluted location in California (Ahlm et al., 2012). Please also add this reference to the studies of NPF events in urban environments in lines 25-30 on page 2.

8.) Page 9, line 8. It seems this is the first time you discuss Fig. 3 so perhaps you should change the order of the figures.

9.) I suppose the black dots in Figs. 7-9 represent the fitted log-normal modes, but please add that information to the figure captions.

10.) You don't draw any conclusions from Fig. 9 so perhaps that figure is not necessary.

References

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