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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Roll vortices induce new particle formation bursts in the planetary boundary layer" *by* Janne Lampilahti et al.

Anonymous Referee #3

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General Comments

This study presents evidence from field data of the formation of aerosol particles from volatile organic compounds (New Particle Formation, NPF) due to the transport of boreal forest air to the upper regions of the atmospheric boundary layer by the convective boundary layer rolls. This is a relevant topic that deserves to be studied and understood, since it can have direct impact on the estimation and modeling of aerosols in the atmosphere, which are relevant for air quality, weather and climate. This study presents a dataset that shows clear evidence of the relationship between convective rolls and NPF. However, the manuscript needs some improvement in terms of the scientific writing. Due to its relevance, I suggest (1) improvements to the scientific presentation of the study, and (2) some additional analysis and discussion that can help future studies

on the development of better measurements and models for this phenomenon.

- Introduction: it is too short and some important information is lacking. For example, it needs more details on what is NPF (how it is defined, range of particle sizes of interest, where it comes from), why it is important (where it is used, where it is not used but should be used) and what are the mechanisms in which ABL dynamics might influence NPF. It would be important to describe in details what is already known about the relationship between NPF and convective rolls, what is not known (or never observed in field data), and what will be investigated here exactly. Why convective rolls, but not convective conditions in general? With this information the reader should be convinced about the relevance of this study. Right now this description (and consequently the motivation) of the study is superficial, only someone in the field will recognize its importance. It is important to convince the general audience as well. Some interesting information that should be in the intro is mentioned in the Conclusion section and in the caption of Figure 10.
- Methods: the section already starts with "Zeppelin measurements", without introducing the reader with the big picture of the methods of the study. It would be useful to start with a overall description (type of data, location, overall goal with each type of data, etc). After situating the reader, then go to the details. All the details needed to reproduce the analysis should be given. Some information is described in the results section (or in the caption of figures), some is missing (see details below). I'm very confused about the different particle size ranges mentioned in different moments of the manuscript. It there a range of interest?
- Results: these results are very interesting, but they are too focused on the measurements of particles, but not on the atmospheric conditions. Maybe the gas and meteorological data at the surface could be used to provide quantitative information about the roll-induced NPF? It would be interesting to characterize the roll

days with their micrometeorological variables, and to try to better identify the differences between the days with and without NPF. If this is not possible, it should be addressed in the manuscript, with a discussion of what should be done in future field studies in order to provide better quantitative data that can be used to model this phenomenon.

Specific Comments

- l. 25: “the small clusters and particles originating from these bursts grow in size similar to particles typically ascribed to regional scale atmospheric NPF”. The difference between regional scale NPF and rolls induced NPF should be made clearer.
- l. 40: “In observational studies enhanced nucleation mode particle concentrations have been observed in turbulent layers in the lower atmosphere. For example inside the residual layer (Wehner et al., 2010) and in the inversion capping a shallow mixed layer (Platis et al., 2015; Siebert et al., 2004).” It is not clear how these two layers would favor the development of NPF, compared to other ABL conditions.
- l. 40: what is “nucleation mode particle”?
- l. 43: “Other airborne measurements have found significant horizontal and vertical variability in the number concentration of nucleation mode particles within the BL.” Can you expand on that? What level of variability? Anything measured within the ABL has variability, what makes this one worth pursuing?
- l. 49: “Convection in the planetary BL often organizes into counter-rotating horizontal roll vortices or rolls that extend to the top of the boundary layer”. What is the horizontal and time scales of these rolls? How can they be identified by

micrometeorological variables? This is relevant to evaluate if the measurements are appropriate. Why this specific type of convection is more relevant for NPF than others?

- l. 55: “and the overall effect of rolls on aerosol particle formation is unknown”. Is it completely unknown? Can you be more specific on what is known, what is unknown? You have cited papers that discuss this.
- l. 68: “We used the positively charged particles and the data was averaged to 4 min time resolution”. Why? Is that equivalent to the total concentration of particles?
- l. 72: “The data was corrected for diffusional losses in the one meter long, 37 mm inner diameter, inlet tube and converted to standard conditions (293.15 K and 1 atm).” How? Can you provide at least a reference, so that someone could reproduce what was done exactly?
- Sec 2.1: it is not clear after this section if the zeppelin data is only profiles or if there are measurements fixed at a given height.
- l. 89: “Particle number concentration in the 3-20 nm range was calculated by subtracting the total particle number concentration measured by the Scanning Mobility Particle Sizer (SMPS) from the number concentration measured by the Ultrafine Condensation Particle Counter (UCPC).” Not clear what that means. Why are you interested in this range only? The SMPS is mentioned in Table 1 as measuring between 10-400 nm. No information about UCPC is given. This description is not clear.
- l. 91: “The SMPS starts to lose accuracy in terms of spatial distribution of the aerosol particles due to its 2 min averaging period when the horizontal scale becomes less than 4 km.” How does that apply to your study? Is this scale

comparable to the phenomenon that you are investigating? Is this relevant? What about the other instruments used?

- l. 93: “A turbulence probe, capable of measuring the 3d wind vector, was only installed at the end of the 2015 campaign.” This sentence is completely lost here. What is this going to be used for? And how? Any details on this instrument? Measurement frequency, probe model, post processing?
- Sec 2.2: it is also not clear after this section if the airplane data used is only profiles or if there are measurements fixed at a given height.
- l. 122: “The CPC had a 10 nm cutoff size” what is the measurement range? what is CPC?
- l. 132: what is Aitken mode?
- Sec 2.4: Is there an exact quantitative criteria for NPF days, or was it selected by inspection only?
- l. 147: What is the time interval used? What size ranges are used? How is the coagulation sink obtained? It is important to provide all information from the data to the results presented.
- Sec. 2.8: I did not see the use of the ABL height in the results section.
- l. 193: “Figure 2 shows a frequent observation in the measurement data:” which data?
- Results section: why is the particle range size different in different analysis (for example figs 4 and 5, or between conditions (i) and (ii))
- l. 208-216: this paragraph should be in the Methods section.

- l. 228-229: which statistic test was performed? All information necessary to reproduce your results should be given.
- l. 229-232: can you verify in the data what micrometeorology conditions characterize NPF and non-NPF days?
- l. 235: “This timescale is associated with mixing throughout the convective BL” did you calculate it? Compared with references?
- l. 238-244: instead of Table 3, it would be useful to show plots related to the estimation of GR. Also, what is the particle range size of your GR estimate?
- Figure 8: “and power spectra of the wind components from the station’s mast showed that the rolls were moving over the site” this would be interesting to see, maybe it could be added to this figure as a third panel?
- The analysis in Figure 9 is not clear to me. It needs to be better explained in the methods and results section, not only in a figure caption. All the details needed to reproduce your results should be presented.
- Figure 10 is more appropriate for the introduction than conclusion. A good description of the physical process that motivates this study is in the caption of the figure, and it would be important for the reader to know about these things since the beginning.

Technical Corrections

- l. 40: “In observational studies, enhanced” (add the comma)
- l. 52: “(Buzorius et al., 2001; Nilsson et al., 2001)” you don’t have to cite the same thing twice on the same sentence.

- l. 55: “However direct observations (...)”, rephrase.
- l. 67: what is “mobility diameter”?
- l. 79: “while the airspeed was kept at 20 m/s” not clear what that means
- Table captions: remove the word “Explanations:”
- l. 85: Table 1 also mentions the Zepelin data, why is it mentioned only in the Airplane section?
- l. 96: “such that the aircraft was either descending, ascending or staying level”, maybe rephrase as “measurements performed during descending, ascending...”
- l. 98: “The measurement airspeed was 36 m/s”, again, not clear.
- It goes from section 2.4 to section 2.8
- l. 143: why no equation number?
- l. 221: “station. Whereas” change to comma
- I don’t think Table 2 is necessary, the statistics are sufficient.
- l. 225: “roll-indcued”
- Table 3: as Table 2, I don’t think this is necessary. It should be presented the statistics, but the information for each individual day is not necessary for the understanding of the study. If you decide to keep these tables, maybe put them in an appendix or supplemental material.
- l. 265: equation number

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