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Reply on RC1

Janne Lampilahti et al.

Author comment on "Zeppelin-led study on the onset of new particle formation in the planetary boundary layer" by Janne Lampilahti et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-282-AC1>, 2021

This paper presents measurements of new particle formation above ground using a Zeppelin in two different environments in Europe, in northern Italy and in Finland. This is an excellent set of measurements demonstrating that these events take place uniformly in the boundary layer in both locations. The paper is well written and should be published after the authors address the following issues.

Major issues

(1) The major weakness of the paper is that it does not even mention the results of the other Zeppelin flights and the ground measurements during the two campaigns. I do appreciate the in depth analysis of the case studies, but it is not clear if they represent what happens most of the time in these two areas or if they are very special days. I think a section summarizing the results of all flights and their similarities (or differences) with the case studies discussed is needed.

ANSWER: The detailed measurements with NAIS and APITOF were only available from the nucleation layout flights. These included 5 flights in Italy and 6 flights in Finland. The NPF event was fully captured on only some of those days, which leaves us with the case studies.

Even though the time of the year and meteorology represent a situation when NPF usually happens in Po Valley and Hyytiälä, we acknowledge that the case studies may not represent the typical case of NPF. We will try to emphasize this more in the introduction and conclusions, stating that the results are from case studies.

Studying the average profile from the roughly 30 flights in Po Valley and Hyytiälä using the SMPS data and comparing it to other measurements is probably best done in a separate manuscript.

(2) Despite the presence of relatively high levels of sulfuric acid in the residual layer above the Po Valley there was no NPF there (Figure 4c). This is an interesting observation that deserves some discussion and discussion. I understand that the Zeppelin was not measuring the concentrations of gas-phase pollutant during this flight but my

understanding is that the authors have some measurements during other flights in the campaign. What was different in the RL? They suggest that may be there was not enough ammonia there. However, the presence or lack of VOCs is probably worth some discussion using the observations of VOCs in that region during other flights in the campaign.

ANSWER: We added the following piece of discussion about VOCs:

"In addition oxidized VOCs are important for aerosol particle growth (Ehn et al., 2014). VOCs were measured on board the Zeppelin in Po Valley in 2012 and the results showed higher VOC concentrations close to ground Jäger (2014). This may at least partly explain why we measured increased concentrations of intermediate ions in the RL but they did not grow to larger sizes in any significant quantities."

(3) I was surprised by the measured spatial extent of NPF in Hyytiälä. According to the measurements it is taking place in a relatively narrow area of 30-40 km around the station and not over scales of 100s of kilometers as it has been sometimes assumed. However, there is little discussion of what is happening in this relatively narrow corridor that leads to NPF and what is missing outside it and NPF is not happening. To be more provocative are all of these NPF observations over the years in Hyytiälä referring to something that is quite limited in space and covers only a small fraction of the boreal forest?

ANSWER: We studied this phenomenon further in a separate paper that was published in 2020 and found that these narrow zones of NPF seem to be related to locally enhanced NPF caused by organized convection in the BL, more specifically roll vortices (Lampilahti et al 2020).

(4) There is little discussion of the measurements of the composition of the smallest particles during these flights.

ANSWER: The composition of the particles in the sub-20 nm range could not be determined with the instruments on board. With the APiTOF we were able to detect [HSO₄-] ions and used it as an estimate for sulfuric acid in the gas phase as this only required one or two distinct peaks that were relatively easy to spot. However due to low signal and changes in pressure, other interesting compounds like organic molecules could not be reliably detected and this data was not included in the manuscript.

Minor points

(5) I had some difficulty with Figure 3b (SO₂ in Hyytiälä) and Figure 3c (CS in Hyytiälä) until I realized that the y-axis includes negative concentrations. I strongly suggest starting these axes from zero. Also does the N axis in Figure 3c start from zero or from another value?

ANSWER: Changed the axis to start from zero

(6) The legend of Figure 3 should mention that these are ground measurements.

ANSWER: We added this to the caption.

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