Review of the manuscript:

Aerosol particle formation in the upper residual layer by

Janne Lampilahti et al, submitted to ACP, second revision

The manuscript improved compared to the initial submission. However, unfortunately flight patterns (GPS locations) for the case studies are still not included and even the altitude graph was omitted. As well in situ data on water vapor respectively relative humidity wind speed and direction are missing.

The vertical advection proved to be highly relevant for ground based nucleation mode particle events as well as horizontally advected nanoparticles (line 369-375). The two, vertical and horizontal, advection processes of particles, produced or transported elsewhere, seem to dominate the appearance of nucleation and Aitken mode particles at the SMEAR II site in Hyytiälä. It is, however, not supported by data that the nanoparticles really are produced above Hyytiälä. They appear during the day, but this might just be due to a change in wind direction. It's definitely not the same air mass in the morning and at noon.

A particle formation in the upper residual layer, and the process of mixing residual layer air and free tropospheric air, is still a highly speculative hypothesis which could not be confirmed by any data neither within the current study, nor within any other investigation in the recent literature. As some of the main components for nucleation identified in the last 20 years, sulphur and ammonia or amine compounds, are rather emitted from similar or even the same anthropogenic sources. An external mixture plus water vapor from two individual transport processes above and below an inversion layer seems to be less likely a source for nucleation.

That particles of all sizes are transported along inversion layers in a stratified atmosphere is well known. That holds for Saharan dust as well as for nanoparticles co-emitted from major anthropogenic potential nucleation mode particle precursor sources. Decoupled from the planetary boundary layer containing low volatility VOC's, such particles are not expected to grow significantly, but changes in size distributions may occur due to changing ambient conditions like temperatures and humidity. A more detailed meteorological investigation including horizontal transport and a GPS location information (missing in the current manuscript) of the current data thus could be the key to identify the sources for nucleation mode particles or their precursors within the current data set.

Some further questions arose:

Timing:

In the original version in Fig 4 the aircraft altitude was plotted against the time between 11:30 and 14:00 Fig. 3 caption says 09:30 to 12:00 UTC. However 11:30 and 14:00 is the EET and vertical flux is at – 0.06 at 13:00 EET

In the new manuscript (version 5) the vertical profile is now between 12:00 and 13:20 UTC and the vertical flux - 0.06 is now still at 13:00, but now the time is given in UTC.

Location:

In the new manuscript (5) the altitude graph of Fig. 4 is no longer available. While for a statistical summary a rough average vertical pattern would be sufficient (Fig. 2), for the case studies a more

detailed altitude profile or better a three dimensional plot with the GPS position is needed. Where has the aircraft been during the 15 and 30 min horizontal flight legs? Where and how far from Hyytiälä were the profiles flown? This information is important to understand, whether and how the vertical profiles are related to the ground based data from SMEAR II. For comparison, Väänänen et al presented several time particle hotspots 15 km north and south of Hyytiälä and a local minimum just above the SMEAR station. Thus the spatial information is important.

Data:

1) Why are there no 1.5 – 3 nm data included in Fig. 4, May 19, 2017?

2) In the May 2 ascend there are enhanced particle numbers in the PSM channel (1.5 – 3 nm) above 2200 m up to 2700 m reaching about 2200 cm^{-3} at 2700 m and 3-10 nm were ~ 200 – 300 cm^{-3}. 20 minutes later 1.5 – 3 nm particles went down to nearly 200 cm^{-3}. Top of the mixed layer is below 2000 m (Panel C), HYSPLIT maximum ML altitude 1750 m. How can this behavior of the smallest particles be explained despite the still high radiation levels and further growth of the MBL until 14:00 UTC? The text claims that the PSM might have problems with the altitude, line 193. How reliable are these high elevation data? The commercial Airmodus PSM is specified only down to 900 hPa. Can this limiting weakness of the PSM be the reason for the unexpected particles at very high altitude levels?

3) Typical speed for a Cessna 172 descend is 500 ft min^{-1} or ~ 150 m min^{-1} resulting in a vertical resolution of 300 m. What is the reason for the rapid descend, keeping in mind that the SMPS has a time resolution limit of 2 minutes. What is the rationale for the 15 min horizontal pattern during the descend? The Cessna 172 has more endurance than the 2.5 h and 10 – 15 additional minutes would improve the vertical resolution.

4) Time resolution for the SMPS is 2 min according to the text, line 121. That should be 40 size distributions within the whole flight profile (12:00 – 13:20). However, resolution in Fig 3B is only ~6 minutes. This lower time resolution would be a severe restriction for airborne profile measurements.

5) Can the size distributions be extended with the 1.5 to 3 nm and 3-10 nm measurements as in Väänänen (2016). As figure 3 was changed to 1.5 – 3, 3 – 10 and > 10 nm these data should be available.