We would like to thank the reviewer for their valuable comments and suggestions. We have modified the manuscript to include the proposed changes along with step-by-step answers to their suggestions. We would also like to inform the reviewer of a major addition in the manuscript which is the inclusion of 532 nm wavelength utilizing the PollyXT observations.

Reviewer #1

This paper presents, for the first time, estimations of particle number, mass, CCN, giant CCN (GCCN), and ultra-giant CCN (UGCCN) concentrations derived from polarization lidar observations of birch pollen, going beyond the traditional distribution and classification of aerosol types in the atmosphere. Although there are still many aspects that need to be improved when compared to in-situ measurements at ground level, this study is deemed necessary from the perspective of extending lidar technology and making new attempts.

Therefore, it is judged appropriate for this paper to be published in the respective journal.

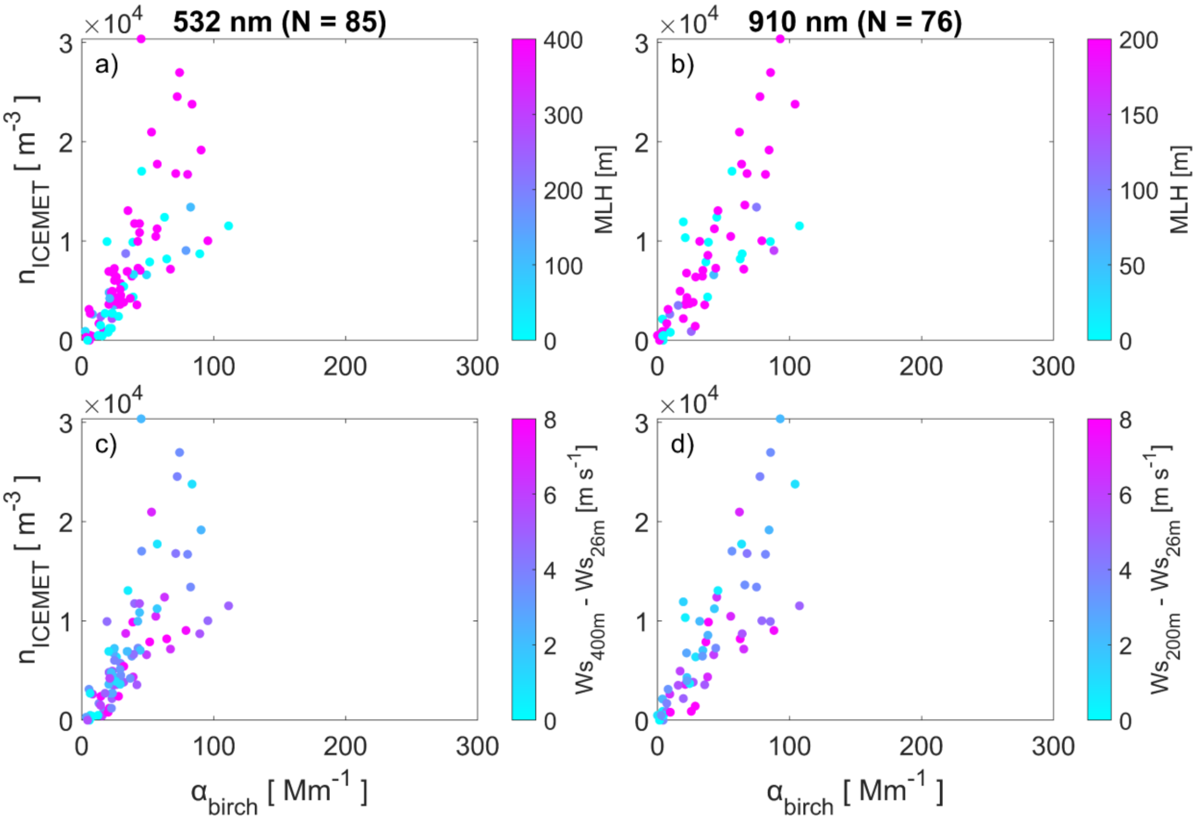
However, there is one important question. When discussing the particle size distribution and concentration, as shown in Figure 3, you compare the particle size of birch pollen using results obtained from the Burkard sampler and ICEMET. At this point, it is necessary to confirm whether the particle sizes reported by each instrument refer to aerodynamic particle size or geometric particle size. It seems that the particle size from the Burkard sampler is reported as the geometric particle size, but I am unsure about the particle size reported by ICEMET. If it is the aerodynamic particle size, it may require adjustments to compare the particle sizes derived from the two instruments.

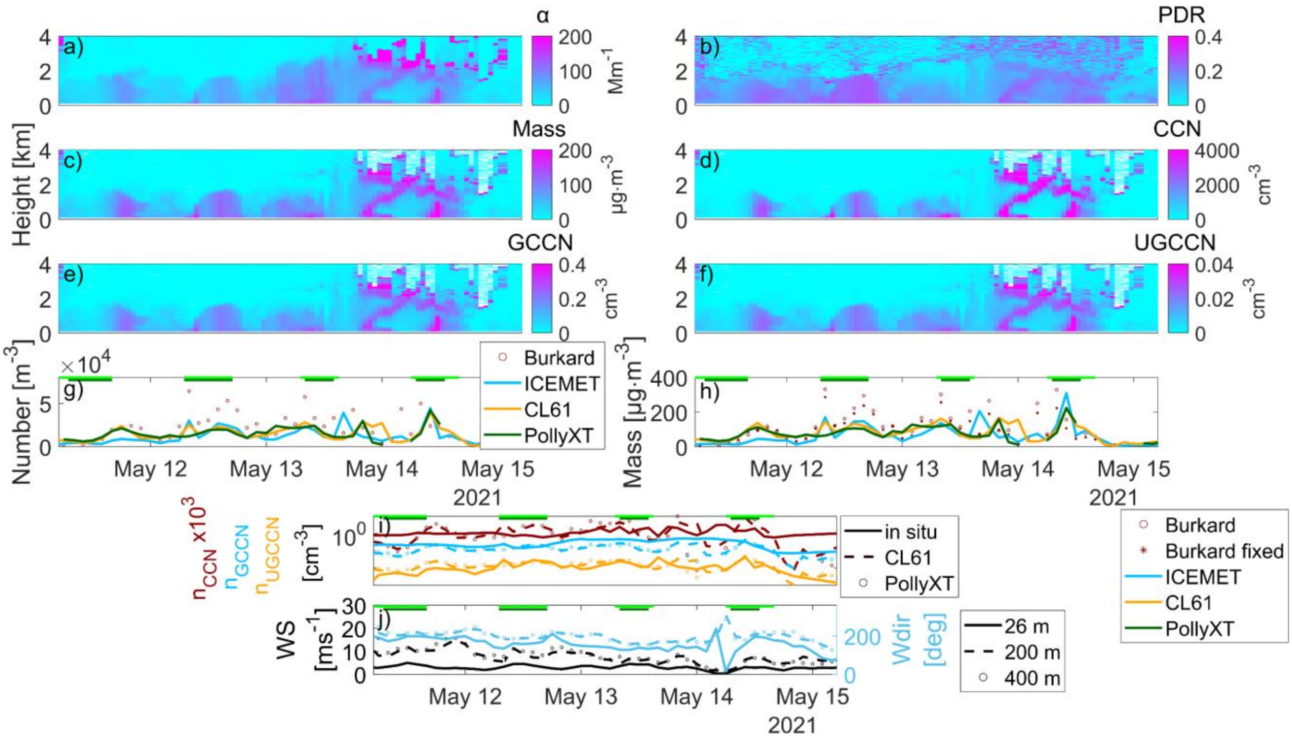
The reviewer raises a valid question. Both instruments report the geometric particle size. In the Burkard sampler, the pollen particles stuck on the tape and later are analyzed under the microscope. During this procedure, the tape is cut and mounted between two glasses submerged into a solution of gelvatol, ion exchanged water, glycerol and lactic acid to preserve the sample. In ICEMET, the particles are illuminated by a short laser light pulse and the resulting hologram is digitally sampled by a digital image sensor and the digital hologram is then numerically analyzed to calculate the size of the particles. The pulse length of the laser used is 50 ns, which is enough to freeze the moment of the objects to less than one pixel size in the hologram up to 30 m/s speed (Kaikkonen, Molkoselkä and Mäkynen, 2020). We have added the following sentence in Sect. 3.1.1 to support further the discussion: ‘Also, both instruments sense the geometrical particle diameter, and therefore their diameters are directly comparable.’

Kaikkonen, V.A., Molkoselkä, E.O. & Mäkynen, A.J. A rotating holographic imager for stationary cloud droplet and ice crystal measurements. *Opt Rev* **27**, 205–216 (2020). https://doi.org/10.1007/s10043-020-00583-y

Additionally, although it was mentioned that wind direction and wind speed were measured using a Doppler lidar, no results related to these measurements are presented in the paper. There is only a reference stating that it was used to identify the mixed layer and that data below 200 m were not used in the analysis. When comparing lidar measurements with in-situ measurements, as in Figure 7, it seems necessary to check whether meteorological conditions, especially wind speed or diffusion coefficients at different altitudes, had any effect. In this context, Doppler lidar data could be utilized.

The MLH was selected as an indicator of similar aerosol conditions between the ground and the 200m level. The MLH was estimated using a threshold in the Turbulent Kinetic Energy (TKE) dissipation rate profile which is informative of the intensity of turbulence for a given flow. Having said that, whether the aerosol size distribution is similar between the surface and the 200m height level is multi-dimensional and it depends on the particle size and wind conditions. An indicator of whether pollen is distributed equally in the vertical direction would be the shape of the particle depolarization ratio (PDR). Unfortunately, this information is missing close to the surface and conclusions relying on the shape of the PDR profile can be made for heights above 200 m. The graph below shows similar information to figure 5 for the number concentration and birch extinction coefficient but without filtering the MLH nor the dust/bc cases. We can see that the MLH presents an efficient way to facilitate comparisons between the two height levels (panels a) and b)). Furthermore, data points following linear relationship present, on average, smaller wind speed difference between the surface and the elevated layer compared to those with similar wind speed conditions between the two height levels (panels c) and d)). Note that we have added PollyXT observations, therefore, the same information is additionally presented at 532 nm where the observations are available above 400 m due to the overlap limitation of that instrument. The highest birch concentration on site, is represented with the topmost point in all four panels. It was observed by Burkard instrument during the 12th of May 2021 at 8 UTC (7-9 UTC). We see that in 532~nm this point deviates from the linearity, and it can be due to the transitioning of the boundary layer which resulted to averaging heterogeneous aerosol layers together with the wavelength sensitivity to the aerosol particle size population. To this direction, we have added to Fig.7 the wind speed-direction at three levels (surface, 200m and 400m), the times that the mixing layer height was above the 200m (400m) height level as light green bar (dark green bars) as indicated by the HALO Doppler lidar and enhanced the discussion by adding the following sentences. 'In fact, the smaller the wind speed difference between the surface and the elevated layer is the better the agreement between these two height levels. In turn this implies that, during unstable atmospheric conditions, higher discrepancies between the lidar- and in situ-estimated quantities are anticipated, due to the long temporal averaging of non-uniform aerosol layers together with the sensitivity of the specific wavelength to the aerosol particle size distribution.' The updated figure 7 can be also found below.

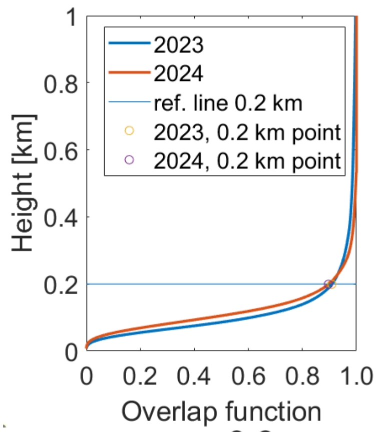

532 nm (N = 85)
910 nm (N = 76)
a)
b)
c)
d)
n_{ICEMET} [m^{-3}]
$\times 10^4$
MLH [m]
$Ws_{400m} - Ws_{26m}$ [$m\ s^{-1}$]
$Ws_{200m} - Ws_{26m}$ [$m\ s^{-1}$]
α_{birch} [Mm^{-1}]

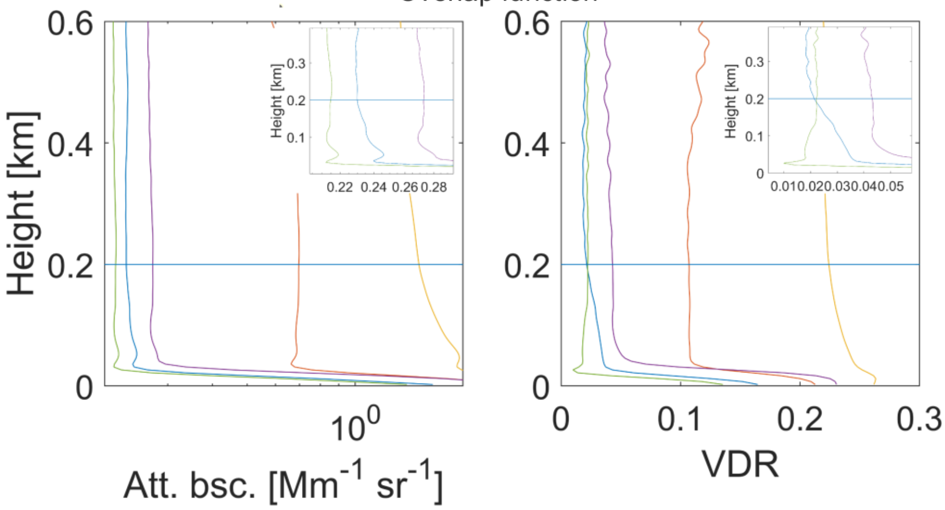

α
PDR
Mass
CCN
GCCN
UGCCN
Height [km]
Mm^{-1}
$\mu g \cdot m^{-3}$
cm^{-3}
Number [m^{-3}]
Mass [$\mu g \cdot m^{-3}$]
Burkard
ICEMET
CL61
PollyXT
Burkard fixed
May 12
May 13
May 14
May 15
2021
n_{CCN} x10^3
n_{GCCN}
n_{UGCCN}
[cm^{-3}]
in situ
CL61
PollyXT
WS [ms^{-1}]
Wdir [deg]
26 m
200 m
400 m

Other revisions or questions are as follows:

1. The CL 61 instrument is said to have a full overlap at 300 m, but in the study, data measured at 200–250 m are analyzed. Please provide an explanation for this.

The 300 m is the height where the laser beam is mirrored in the field of view of the instrument. For quantities that are determined from signal ratios such as the depolarization ratio, the height of complete overlap is not as essential as for the separate detection channels, for example the attenuated backscatter coefficient. At 200 m height about 89-90% of the beam is mirrored (see figure below) and it is a compromise for having as close to the ground observations for the calibration of the lidar and assure quality assured signals. The overlap functions presented here are from 2023 and 2024 observations as the overlap function was not stored in the files in 2021 data. To this direction, the graph below shows five 1h temporally averaged profiles of the attenuated backscatter (att. bsc) and volume depolarization ratio (VDR) up to 0.6 km in height. The 200 m level is marked with a horizontal line. The 5 profiles are during clear skies with varying aerosol load and as minimal aerosol structure in the vertical direction as possible. A nested zoomed view is presented for the first 3 cases for the abovementioned quantities. We can see that there are structural similarities in the shape of the signal regardless of the aerosol load below 200 m. There are two local maxima present at about 50 m and 140 m. The VDR is less affected by these and information below 200 m can be possibly used for either optical property on a case-by-case scenario (e.g. for the high aerosol load case (yellow)). Below the selected height, information should be used with cautious and additional corrections may needed to be applied to derive useful information. Such corrections are outside of the scope of this paper.





2. The lowest observation altitude for the Doppler lidar is indicated, but the highest observation altitude is not. Please also indicate the highest observation altitude.

Thank you for your comment. We have added the following text to the manuscript: 'The minimum usable range of the instrument is 90m, as the lower range gates are affected by the outgoing pulse, and the maximum range is 9.6km above ground level'