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Comment on acp-2022-605

Anonymous Referee #1

Referee comment on "Influence of air mass origin on microphysical properties of low-level clouds in a subarctic environment" by Konstantinos Matthaios Doulgeris et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-605-RC1, 2022

In the study "Influence of air mass origin on microphysical properties of low-level clouds in a subarctic environment" by Doulgeris et al. microphysical cloud properties measured during eight Pallas Cloud Experiments in the Finnish subarctic region are analyzed with respect to their air mass origin based on the Lagrangian particle dispersion model FLEXPART.
The scientific approach is valid and the manuscript is structured in a clear and concise way.
However, two main deficits regarding the scientific relevance and thus the scientific quality of the study as described in the general comments would require major revisions.

General comments

1. Scientific relevance

The study is based on a large time series of measurements campaigns that have been conducted in a subarctic mostly pristine region adequate for the analysis of aerosol cloud-interactions (ACI). A clear statement is missing on how the presented results may advance the current state of the art. The dependence of cloud microphysics on the air mass origin (Twomey effect in continental air masses vs. marine air masses) and that cloud droplets are prone to grow in warmer air is known already from other studies (cited in the manuscript l.346). Also the introduction is not clearly leading to a research hypothesis or research question. Modifications in the Introduction and discussion of results as well as in the abstract and conclusions are required to specify the scientific relevance of the study in the context of existing literature. The identification and further interpretation of results that add new findings to the existing body of knowledge would be helpful for the ACI community and further studies.

2. Scientific approach

Cloud properties are analyzed according to their air mass origin in 5 predefined source regions. Cloud properties strongly depend on the air mass characteristics including humidity, wind speed, temperature etc. at different altitudes. Including air mass characteristics (e.g. from ERA5 reanalysis) in the analysis to understand differences in Nc, MVD, ED as started in Fig. 8 would make results more interpretable and scientifically

relevant.
Also the approach of using predefined source regions is questioned as this classification may result in similar/mixed air mass characteristics as shown for the Eastern/Southern and Arctic/Western air masses in Fig. 8. More intuitive would be an automatic classification (grouping) based on the air-mass origins or pathways.

Specific comments
l. 106: Do you have information on the cloud type, is this mainly fog or low stratus? This may imply different processes.

l. 123: Latitude and longitude is missing in Fig. 1.

l. 201: Delete "model" as this can be mixed-up with numerical models.

l. 207: it is not specified if the PES belongs to an aerosol type or Nc or which emission inventory is used to calculate the PES. If solely air mass trajectories are calculated backwards what is the PES referred to? Please provide more details on the FLEXPART model settings and assumptions here.

l. 244: Subtitle 3.1 should be bold as 3.2 and 3.3.

l. 245: The main message of the figure is not mentioned and should include something like: It shows the seasonal range of temperatures from on average XX°C in September to -XX°C in November and its interannual variability.
Fig. 5 (also Fig. 7): Is there a reason to present each year separately? If not I suggest in accordance with the main message of the figure to present only one average line together with the standard deviation and include data gaps in the data section. This also applies to Fig. 7 and would increase clarity of the figures as 4 panels can even be summarized in one panel (4 lines - 4 regions). Data gaps and instrument specifications can be moved to the data section.

l. 271: anthropogenic aerosols: Is this an assumption, provide a reference?

l. 275: Fig. 6 a) What is the meaning of the cyan color? If not necessary please remove it. If it is representing a range please indicate it in the legend.

l. 275: Fig. 6 b) Symbols (stars and circles) representing different Nc measurements are difficult to distinguish. Would recommend either summarizing campaigns sorted by PES

and CAS/FSSP (4 symbols per air mass) or summarizing it even further only by PES. If this is no option, increasing maker size and distance between campaigns would improve clarity.

l. 284 CAPS --> CAS? (as in the legend of 6b), please check usage throughout the manuscript.

l. 395-396 Fixed vertical position, but different layers? Something is missing: "…cases that we sampled WITH different layers".

l. 409 Fig 10 a and b. I cannot see the difference between CAS and FSSP in the plot. If the difference is not important for conveying the message that MVD/ED is not dependent on the position of the probe I would skip the legend entry. This figure could be improved by using a scatter density plot (2-D histogram) and regression line.
Further, If there is no dependence between MVD/ED and position of the probe, is this something still relevant for the main message of the paper and would it require a figure plus subsection? If the answer is no I recommend skipping it or putting it in the supplementary.

l. 428: to be representative or considered as representative

l. 429: Why are clouds more frequent when air masses originate from Southern and Eastern regions?

l. 440: What kind of measurements are needed?