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Comment on acp-2021-305

Anonymous Referee #2

Referee comment on "Cloud activation properties of aerosol particles in a continental Central European urban environment" by Imre Salma et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-305-RC2, 2021

The manuscript "Cloud droplet activation in a continental Central European urban environment" by Salma et al. presents a comprehensive study of CCN characteristics of aerosol particles in the urban environment of a continental European city. The paper discusses on-line particle measurements, including CCN number concentrations, aerosol particle size distributions and meteorological data, as well as the CCN parameters derived from these measurements.

At the moment, the presented study is of rather limited scientific relevance and novelty as the potential for CCNC in aerosol-cloud interactions studies has been exhausted. The authors state that our knowledge about aerosol–water vapour interactions in the atmosphere is insufficient and use this as the motivation for their study; however, the authors do not acknowledge that the presented study does not result in significant improvements in our understanding of the aerosol-cloud interactions in the ambient atmosphere. At this point CCNC can no longer help us understand aerosol-cloud interactions and their effects on radiation and climate. The manuscript is a description of the aerosol CCN properties in an urban environment. This notion is not meant to change or take away from the paper; it is more meant as the direction of potential future work for the authors.

Having said that, the paper is of very good quality and written very well, and the authors do an excellent job at interpreting the data, presenting the results and discussing them in detail. The objectives and conclusions are clearly stated, and the paper makes great use of existing literature and puts its results in perspective. The paper is well-structured and provides the interested reader with a lot of information about CCN characteristics in an urban environment. Some of the results can be put more in perspective, and conclusions can be expanded a bit. However, I definitely recommend the manuscript to be published after the minor revisions suggested below are incorporated.

General comments

- The authors should put their measurements and results in a bigger perspective. The manuscript presents long-term measurements conducted at a single point. How representative are these measurements? Can they tell us anything about the aerosol effects on the cloud formation over urban environments? Considering the size or urban environments compared to, let's say, much bigger marine or forested environments, do we expect any effects of the urban aerosol population and its CCN properties on the actual ambient cloud formation?
- Conclusions section is fairly short and needs to be expanded. It would be particularly useful to focus on those *S*s found in a typical ambient atmosphere and summarise if and how urban emissions are expected to, at least theoretically, affect the cloud forming potential in urban environments. The authors could elaborate more on how their study compares to similar previously published literature about CCN properties in urban environments and draw conclusions about how their study complemented or added to the existing knowledge. I think it would also be important to notify the reader what else could be done in the future studies to increase the representativeness of single-point measurements and our knowledge of aerosol-cloud interactions.

Minor comments

- Introduction – please, give examples of *S*s that can be found in the ambient atmosphere.
- Lines 42-43 – the particle's ability to act as a CCN is primarily and overwhelmingly controlled by its size and to a much lesser degree by its chemical composition and the mixing state. Please, rephrase.
- Line 49 – it's not the CCN, but the droplets that alter the radiation. Aerosol particles also interact with solar radiation, but I think here the discussion is about the droplets.
- Lines 63-64 – "Long-term studies (of at least 1 full year) are required to understand [aerosol–water vapour interactions in the atmosphere under S conditions] and their consequences." Has your study done that? I think the statement is rather strong and not supported by your conclusions.
- Line 183 – could also be added? Or could also add what?
- Lines 187-203 – these paragraphs are slightly confusing, and I am not sure about their purpose. Why do you want to exclude nucleation mode particles? How does that affect the robustness of your statistics? The measurement location *is* in an urban and polluted environment, so I am not sure why there is a need to define such conditions based on the fraction of nucleation mode particles.
- Line 277 – what is meant by orientation?
- Lines 277-278 – we are not able to see from the table whether there were any extraordinary situations because the table shows values averaged over one year. I think the entire sentence would only make sense if seasonal meteorological values

would be shown.

- Lines 294-297 – what would cause such rapid concentration changes in an urban environment?
- I am not sure if SD is defined anywhere in the manuscript. Is it standard deviation? Or size distribution? What is RSD?
- Lines 388-411 and Figure 2 – how do the data points and the curve in Figure 2 compare to the curves and the parameterisation presented in Figure 4 of Paramonov et al. (2015)? Lines 394-396 present a very good argument. Is it known whether the considerable time variability of N_{6-1000} is driven by particular size bins? Or does it vary across all size bins? What drives such changes in an urban environment for nucleation mode particles and for those over 100 nm in diameter? This could be of interest since, indeed, both N and CCN seem to show a lot of variability.
- Line 414 – median *d*c decreased with *increasing S*
- Line 428 – "This confirmed that the water activation properties depend on the aerosol type." – yes, this is already well-known. If your "average diameters and CCN concentrations were larger than for" other sites, this means that a) your total particle numbers were higher and b) your particle population was, on the whole, less hygroscopic.
- Line 431 – the mean fraction
- Lines 460-461 – I believe chemical composition is size-dependent for all natural environments, not just urban ones.
- Lines 503-504 – "The changes were pronounced mainly for the laRger Ss", which are the least relevant for an ambient atmosphere. This means that these seasonal changes are not very likely to have any effect on the aerosol-cloud interactions.
- Lines 503-516 – I don't think it is reasonable to talk about monthly changes when there are no error bars with the data points. It doesn't seem like anything is really changing much throughout the year, and there is no need to try and look for such changes (lines 504-509).
- Line 558 – should say "March and April" as the campaign ended in April 2020.
- Figure 5 – your measurements were form April 2019 to April 2020. Why is the x-axis from March to February? The only March you measured was in 2020, towards the end of the campaign, but in the figure it appears as the first data point. Please, correct this. Having proper time series shown can also better demonstrate whether any changes occurred during the first COVID outbreak.
- Lines 558-561 – this could be expanded a bit more. In previous sections you talked about changes in total particle numbers during the first COVID wave. Please, elaborate more here on what happened to N_{CCN}, Dc and AF during the last weeks of the campaign.
- Line 564 – with *increasing* S

References

- Paramonov, M., Kerminen, V.-M., Gysel, M., Aalto, P. P., Andreae, M. O., Asmi, E., Baltensperger, U., Bougiatioti, A., Brus, D., Frank, G. P., Good, N., Gunthe, S. S., Hao, L., Irwin, M., Jaatinen, A., Jurányi, Z., King, S. M., Kortelainen, A., Kristensson, A., Lihavainen, H., Kulmala, M., Lohmann, U., Martin, S. T., McFiggans, G., Mihalopoulos,

N., Nenes, A., O'Dowd, C. D., Ovadnevaite, J., Petäjä, T., Pöschl, U., Roberts, G. C., Rose, D., Svenningsson, B., Swietlicki, E., Weingartner, E., Whitehead, J., Wiedensohler, A., Wittbom, C., and Sierau, B.: A synthesis of cloud condensation nuclei counter (CCNC) measurements within the EUCAARI network, Atmos. Chem. Phys., 15, 12211–12229, https://doi.org/10.5194/acp-15-12211-2015, 2015.

Thank you for an excellent paper and best of luck with the review process!