Reply to comments on "In-situ aerosol measurements at the Arctic Sammaltunturi measurement station during the Pallas Cloud Experiment 2022" for Earth System Science Data

We thank both reviewers for the helpful and thorough comments on the manuscript. We think that both reviewers have substantially contributed to improving the manuscript. Below we address both reviewers in full and list the changes made to the manuscript.

Comments in quotes and *"italics"*, replies upright.

Comments and replies to Reviewer 1

Comment: "*Line 18. The reference citation shown as (e.g. Dusek et al. (2006) REF?) should be corrected.*"

Reply: Corrected.

Comment: "*Line 23. The statement of 'water vapor and clouds are way more important for the Earth's radiation budget than any non-condensable greenhouse gas' is kind of oversimplified which would possibly lead to a misleading that greenhouse gases are not important for the radiation budget. The authors are recommended to provide a little more detail on how water vapor, as the primary greenhouse gas, dominates the Earth's radiation budget, while non-condensable greenhouse gases act as critical forcings but not as important as water vapor and clouds.*"

Reply: This was also partly picked up by the other reviewer. The statement was indeed oversimplified and needs more elaboration. To explain this in the detail needed, not to mislead the uninformed reader, would however, have require a lengthy paragraph, so we decided to make do without the statement. The text was changed to: "These aerosol-cloud interactions (ACI) are important for the Earth's climate and increased knowledge about ACI will make future climate predictions clearer."

Comment: "*Line 79. Certain conditions like heavy snowfall, especially when accompanied by strong winds, could also reduce the visibility to below 1 km. Would this affect the measurement when the station is flagged as 'inside a cloud' when it's not?*"

Reply: Yes, it could and we would not know the difference simply from the visibility sensor we have. As the visibility sensor is about 6 m above ground level, wind driven snow is not a factor, but heavy snowfall could be. We added a sentence on this to the revised manuscript

as follows: However, it should be noted that heavy snowfall also can reduce the visibility to below 1 km.

Comment: "*Line 100. The citation Knutson and Whitby (1975) should be written as (Knutson and Whitby, 1975). Same for 'Flagan (1999)' in line 105.*"

Reply: Corrected.

Comment: "*Line 122. For' aerodoynamic', do you mean 'aerodynamic'?*"

Reply: Corrected.

Comment: "*Line 133-134. It should be written as 'the particle has to pass both of the laser beams and cause two large enough signals within a certain time window.'*"

Reply: The sentence was removed because of the comments by the other reviewer.

Comment: "*Line 158. With 'the subtraction is possible by regularly measuring particle free air', is there a companion instrument that is able to clear out the particles from the sample air in order to measure the particle free air? Or is it only a theoretical assumption?*"

Reply: The instrument saves the instrument's response from the particle free air measurements, which is done by the instrument automatically. There is a three way valve that connects a HEPA filter inline on a regular basis. The zero air measurements are then calculated, and subtracted, from the measurement comprising aerosol particles and gas molecules. The molecular scattering of air is well knows and can be calculated if the air pressure changes. The instrument does this automatically.

Comment: "*Line 174, should 'one wavelength instrument' be 'single wavelength instrument'?*"

Reply: Corrected.

Comment: "*Line 406, 'achieve the final data' should be 'obtain the final data' or 'acquire the final data'.*"

Reply: Done as suggested.

Comment: "*For Figure 6, it is recommended to modify the sizes of labels along the axis by enlarging the one along the x-axis while shrinking the one along y-axis. The label sizes in Figure 7 are more suitable.*"

Reply: Corrected.

Comment: "I would personally recommend that the authors add a brief and general summary of the components of the instrument and data format to the 'Summary' section.

The current subsection appears to be more of a directory while not providing much of actual 'key takeaways'.

Reply: We have added a paragraph on the key takeaways and potential use of the data to the revised manuscript. We have also summarized the data in the data set. We are not entirely clear on what the reviewer meant with summarizing the data format. The format of each instrument or the data format in general? We did not summarize the data format of each instrument, as that would have been too lengthy to fit in the summary section. We hope the reviewer is okay with this. We have listed the main components from each instrument in the summary section.

The summary about the data set now reads as follows:

"*The measurements comprise size distributions of aerosol particles from 10 to 800 nm from a DMPS, and from 0.487 to 20.5 µm from an APS. Total particle number concentrations are reported from a CPC. Light-scattering coefficients are reported from an integrating nephelometer, and light-absorption coefficients from filter-based absorption photometers. Total CCN and size resolved CCN properties from a CCNc are also included in the data set. The size resolved CCN properties are in the form of κ-values and D50 diameters.*"

We left out the instrument names and models based on the other reviewer's comments.

<u>Comments and replies to Reviewer 2</u>

General Comments

Comment: "*The text contains numerous grammatical errors and language issues that significantly impact readability and scientific communication. Furthermore, several sentences convey similar information which creates redundancy. I strongly encourage the authors to conduct a thorough proofreading and structural refinement to enhance clarity and conciseness before resubmission (please also see my detailed comments below).*"

Reply: The grammar and language were substantially improved. Also, redundancy and repetition were addressed and removed, including all the detailed comments below.

Comment: "*The abstract contains repetitive and redundant sentences that reduce clarity and conciseness. Structural refinement is needed to eliminate these redundancies. Please, see my detailed comments in the "Specific comments" section below.*"

Reply: The abstract was rewritten based on the specific comments. Grammar and conciseness were improved.

Comment: "*The Background section fails to articulate specific PaCE2022 research objectives and explain how the datasets presented here contribute to those research goals. A more structured description would better demonstrate the significant value of this dataset.*"

Reply: The background section is now updated with the objectives of this work and how this will aid in the overall research goals for the Arctic climate. The text about the specifics of arctic amplification was removed for better cohesion, and a paragraph on how these data will aid the general research goals for Arctic clouds was added. It is now stated in the background section that the specific goal of this work, and the special issue, is to aid modellers in their efforts to beter represent low-level arctic clouds in their models, based on observed cloud properties and ambient aerosol and environmental data.

Comment: "*The In-situ instruments section requires comprehensive revision and reformulation. Currently, it provides extensive technical descriptions of well-established, standard atmospheric instruments that detract from the manuscript's primary focus on the datasets. I recommend restructuring this section to eliminate general instrument theory and focus exclusively on campaign-specific deployment details, including any instrument modifications made specifically for this study, and related methodological considerations. Standard operating principles should be replaced with concise references to established literature or manufacturer specifications. Redundancy with the Data Processing section should be avoided (for instance, the nephelometer model information (lines 339-341) is repeated unnecessarily. Such duplication should be eliminated through cross-referencing or consolidation of instrument specifications). I would be happy to provide specific comments on this section after the recommended revisions have been implemented.*"

Reply: The section was substantially revised, and instrument theory was rewritten to be both brief and kept at a minimum. The suggestion to focus on campaign-specific deployment details is not possible since all the instruments, except the CCN, are a part of the long-term measurements at the site. However, the text was changed to focus on site specific, instead of campaign specific, details whenever possible. We have not eliminated instrument theory, but kept it at a minimum. For most instruments, instrument theory is no longer than 6 lines of text in one paragraph. The authors hope this is satisfactory for the reviewer.

Comment: "*The Data Processing section should be comprehensively revised and streamlined to avoid redundancy with the Instruments section and improve overall readability. I recommend maintaining consistency in organizing each instrument's dataset description to ensure uniform structure across all I would be happy to provide specific comments on this section after the recommended revisions have been implemented.*"

Reply: The data processing section was comprehensively revised and streamlined as suggested. The sub-sections of the different instruments were also rewritten so that they have a more uniform structure between the different instruments. This improves the overall readability of this section of the manuscript.

The structure of the data processing for each instrument is as follows:

1 paragraph: Flowrates, (voltages), general setup (time resolution), etc.

2 paragraph: Calibration dates and methods, criterion for data disqualification, etc.

3 paragraph: How data post-processing to final parameter is done.

4 paragraph: Description of what is in the files, first data columns that are the same for all files are explained, then the primary quantity measured, and then last, the auxiliary data, such as temperature, pressure, and other instrument specific quantities. We kept the same sequence and wording across the different data files to make for easier reading.

Specific comments are welcome if the reviewer wants to be more specific on the revised manuscript.

Comment: "*I recommend including a table that summarizes calibration activity dates performed during PaCE2022 that may have affected data availability.*"

Reply: The only instruments where the calibration takes some time to do is the CCN and nephelometer. The CCN is presented as daily files instead of high time resolution data (< 10 minute time resolution) so the CCN data gap due to calibration is not visible in the data. The nephelometer calibration takes about one hour, which is now mentioned in the text. The authors do not think that it is therefore necessary to have a table of gaps in the data due to calibration which is in the order of 5 – 15 min per instrument in a three months data set. We can produce such a table in detail if the reviewer insists.

Comment: "*The summary section is very limited and doesn't address potential applications and future research directions. I recommend substantially expanding this section to clearly articulate how the presented datasets can be leveraged by the scientific community and integrated into broader atmospheric studies, thereby strengthening the manuscript's impact and value to the field.*"

Reply: The summary section was expanded substantially to be more clear on how these data (all the data in the special issue) could improve current model capabilities focusing on Arctic clouds and the aerosol-cloud interactions. The following text was added to the summary section:

“Climate models would benefit substantially from expanded in-situ observations that characterize the full ACI pathway, including aerosol size distributions, chemical composition, hygroscopicity, CCN activity, and cloud microphysical properties. Such measurements are particularly important in the Arctic, where low aerosol concentrations and persistent mixed-phase clouds create a highly aerosol-sensitive environment (Mauritsen et al. 2011). Improved observational constraints can reduce uncertainties in simulated cloud radiative effects, ACI feedbacks, and Arctic amplification, thereby enhancing confidence in future climate projections. Coordinated observations of particle number size distributions, CCN spectra, cloud droplet number concentrations, ice crystal populations, and boundary-layer dynamics can provide critical constraints for aerosol activation schemes and mixed-phase cloud microphysics representations (Schmale et al., 2021). This special issue provides such a data set.”

References added:

Mauritsen, T., Sedlar, J., Tjernström, M., et al., 2011. An Arctic CCN-limited cloud-aerosol regime. Atmospheric Chemistry and Physics, 11, 165–173.

Schmale, J., Zieger, P., and Ekman, A. M. L., 2021. Aerosols in current and future Arctic climate. Nature Climate Change, 11, 95–105.

Comment: “*Problems with instruments should not be mentioned in incomplete sentences but should be properly discussed with appropriate technical detail. For example, could you please clarify what "bit nosy" means in lines 363-365? Did this issue affect data quality?*”

Reply: The sentence was clarified with precise numbers of the noise limits. Other instrument problems were also clarified.

Specific comments

Abstract section

Comment: “*Please streamline the following sentences to improve clarity and eliminate redundant phrasing: Sentences 1 (line 2-3) and 2 (line 3-4) both describe that the paper presents aerosol measurements and instrument descriptions - this could be consolidated into a single, clearer statement Sentences 3 (line 4) and 4 (line 4-6) both introduce PaCE2022 and could be streamlined by integrating their key information*””

Reply: The sentences were streamlined and combined as suggested to provide key information in a more concise manner.

Comment: “*Sentences 5 (line 6-7), 7 (line 9-10), and 8 (line 10-111) all address data availability and repository information with overlapping messaging that could be*

consolidated into a single, clear data availability statement. Sentence 6 (line 7-9) "this data paper will also act as a future reference" is redundant with " for future publications”"

Reply: The sentences were combined and edited as suggested.

Comment: "*Line 3: "This data paper, describes" - unnecessary comma*"

Reply: The sentence was removed when revising the manuscript due to the general comments listed above.

Comment: "*Line 5: "described in this paper and are complementary" - should be "described in this paper are complementary" Line 7: "All data from the campaign resides" - should be "reside'"*"

Reply: Done as suggested.

Background section

Comment: "*Line 13: "Aerosol particle suspended in air" - should be "Aerosol particles suspended in air'"*"

Reply: Corrected.

Comment: "*Line 14: " by scattering and/or absorbing solar radiation" – could be " by scattering and/or absorbing it”"*"

Reply: Done.

Comment: "*Line 18: "to a lesser extent the aerosol particles chemical composition" should be "to a lesser extent by the aerosol particles chemical composition”"*"

Reply: Corrected.

Comment: "*Line 18: "e.g. Dusek et al. (2006) REF?" - incomplete reference formatting*"

Reply: Corrected.

Comment: "*Line 22-23: please, clarify this statement and provide references*"

Reply: The sentence was rephrased based on the other reviewers comment. The sentence now reads: "These aerosol-cloud interactions (ACI) are important for the Earth's climate and increased knowledge about ACI will make future climate predictions clearer."

Comment: "*Line 24: "The Arctic is a particularly vulnerable" - should be "The Arctic is particularly vulnerable*"

Reply: Corrected.

Comment: "*Line 27-29: please, clarify this statement and provide references"*

Reply: The sentence was removed for better cohesion in the background section.

Comment: "*Line 28: "snow and sea ice is replaced" - should be "are replaced*"

Reply: The sentence was removed.

Comment: "*Line 31: "happening in Arctic" - should be "happening in the Arctic*"

Reply: The sentence was removed.

Comment: "*Line 40: "those factors were found to be limiting" - perhaps better as "these factors limit*"

Reply: Corrected.

Comment: "*Line 40: "Our previous research" – what does it refer to?*"

Reply: The sentence was rephrased for better clarity. The previous research refers to the list of articles at the end of the sentence.

Comment: "*Line 43: "subarctic aerosol up to" – perhaps replace with "subarctic aerosol properties with consequences on CCN…*"

Reply: Corrected.

Comment: "*Line 45: "This paper is a data description paper" – redundant use of "paper""*"

Reply: The sentence was removed when the section was rewritten.

Comment: "*Line 48: "The duration of the PaCE 2022 campaign was from 15 September 2022 to 15 December 2022" - Awkward phrasing should be "The PaCE 2022 campaign ran from..." or "took place from..."*

Reply: Corrected.

Comment: "*Line 50: Brus et al. (2025) reference could not be verified. Please confirm this citation is correct*"

Reply: The overview paper was withdrawn from ESSDD as it needs to be the last paper in the special issue. We will make sure that the reference is correct prior to final submission.

Comment: "*Line 53: This section would benefit from a reference describing Pallas station (e.g. Lohila et al. 2015, Preface to the special issue on integrated research of atmosphere, ecosystems and environment at Pallas or similar comprehensive site description)"*

Reply: This is true. Thanks for noticing. The reference was added.

Comment: "*Line 54: redundant use of "located*"

Reply: Corrected.

Comment: "*Line 55-56: redundant use of "station*"

Reply: Corrected.

Comment: "*Line 57: the summary table of the instrument should be introduced in the section describing the instruments not here"*

Reply: The table was moved to section "2.2 In-situ instruments" as suggested.

Comment: "*Line 59: "measuring through" – conceptually incorrect, instruments don't "measure through" inlets. The verb tense is also incorrect*"

Reply: The sentence was changed to "The in-situ aerosol instruments at the Sammaltunturi station were connected to one of two aerosol inlets"

Comment: "*Line 63-64: The inlet design is detailed in Weingartner et al. (1999), this sentence is unnecessary and should either be deleted or consolidated with the previous sentence.*"

Reply: The sentence was removed.

Comment: "*Line 67-68: the two sentences would benefit from some structural refinement to enhance clarity and conciseness*"

The sentence was changed to: "The $PM_{2.5}$ inlet is a total suspended particle (TSP) inlet from URG Corp. (USA) which is directly attached to a $PM_{2.5}$ cyclone (MesaLabs BGI $PM_{2.5}$ Sharp Cut Cyclone). The inlet is heated to prevent clogging by snow or ice."

Comment: "*Line 78: remove "also""*"

Reply: Done.

Comment: "*Line 81-85: the two sentences would benefit from some structural refinement to enhance clarity*"

Reply: The sentences were refined.