Acp-2023-30: “Airborne investigation of black carbon interaction with low-level, persistent, mixed-phase clouds in the Arctic summer”

We would like to thank the referee and the editor for their comments. While the reviewer’s and editor’s comments are given in black bold, our answers are given below in grey letters. Additionally, we added the **changes made in the revised manuscript in grey bold letters**.

Public justification (visible to the public if the article is accepted and published):
I would like to thank the authors for incorporating the suggestions made by both reviewers. The revised version looks pretty good and it is almost ready for publication; however, there are some minor comments that need to be properly addressed before I can accept the manuscript.
As following, we addressed the comments of the reviwer#2 and the editor. The major changes include:1) a full revision of grammar and syntax; 2) replacement of rBC with BC terminology, 3) implementation of colouring for colour-blindness in figures.

Answers of the authors to Reviwer#2:

1, It is recommended to have the grammar of the entire text polished by a professional translation agency, for example:
Line 15: "a cloud nucleus"
Line 21: ", below,"
Line 21: "the increase in size"
Line 23: "a BC"
The grammar was verified by a native English speaker.

2, Line 101: It is mentioned here that there were 22 aircraft missions, but later in the text, it is clarified that only 17 missions' data were used. To avoid confusion, it is not necessary to mention 22 missions.
Modified accordingly.

3, Line 130: In line 121, it is stated that LWC is calculated based on the size distribution, but here it is mentioned that LWC is measured by SID-3. This may lead to ambiguity.
Modified as:
… “The mass fraction of ice water (IWF) was calculated from the IWC estimated by the CIP, and the LWC estimated by the SID-3.” …

4, Line 140: The use of "rBC" to represent BC measured by SP2 has a specific meaning according to Petzold et al. However, many subsequent studies on SP2 did not use this notation. This study did not extensively discuss the distinction between BC and rBC, nor did it discuss any differences in their interaction with clouds. Therefore, it is not recommended to use "rBC" instead use "BC" directly.
The term “rBC” has was replaced with “BC” in the text, figures and tables. The following sentence was added in Section 2.2.3:
… “The term refractory black carbon (BC) is used to identify the insoluble carbonaceous matter that vaporizes at temperatures around 4000 K, and that is measured with a laser-induced incandescence

technique, including the SP2 (Petzold et al., 2013). To facilitate the reading, the term BC is used instead of rBC to identify all measurements performed with the SP2 and presented hereafter." …

5, Line 153: There is a grammar issue with this sentence. It should be rewritten.
The sentence now reads:
… "To estimate the rBC mass concentration outside the SP2's detection range, the rBC mass size distribution measure by the SP2 may be fitted with a lognormal fit (e.g. Laborde et al., 2013; Zanatta et al., 2018)." …

6, Line 336: "...the results discussed as following are extremely uncertain..."

Line 433: "...unable to confirm nor to exclude the..."
The paper contains some unnecessary phrases and uses the term "might" extensively. It is important to be cautious with vague conclusions in academic papers.
The text was revised to limit the use of vague sentences.

Answers of the authors to the editor

1. There is a need to be consistent in the use of BC and rBC along the text.
We revised the use of rBC and BC along the full manuscript, as also suggested by Reviewer#2.

L17: Change "ACLOUD" with "Arctic CLoud Observations Using airborne measurements during polar Day (ACLOUD)"
Modified accordingly.

L42-43: What do the authors mean with "its atmospheric layer"
We mean the atmospheric layer where BC is suspended. The statement was modified as:
… "causing a net warming of the local atmospheric layer (Flanner, 2013)" …

L44, L83, L85, L106, L238, L436, L457, L459: "black carbon" should be "BC"
Modified accordingly.

L63: Add a reference after "schemes"
Added Holopainen et al. (2020).

L68: "lac" should be "lack"
Modified accordingly.

L71-73: The following text is unclear "If nucleation scavenging of aerosol particles from the below-cloud layer might represent the dominant activation mechanism in the Alaskan Arctic (Earle et al., 2011; McFarquhar et al., 2011), Igel et al. (2017) showed"
The former long sentence was distilled in two parts:
… ". Nucleation scavenging of aerosol particles from the below-cloud layer represents the dominant activation mechanism in the Alaskan Arctic (Earle et al., 2011; McFarquhar et al., 2011). On the other hand, Igel et al. (2017) showed" …

L81: "riming and Wegener" should be "riming and the Wegener"
Modified accordingly.

L88: “1) presence” should be “1) the presence”
Modified accordingly.

L89: “mechanisms; 3) impact” should be “mechanisms, and 3) the impact”
Modified accordingly.

L93: fix “(AC)3”
Fixed as $(AC)^3$

L103: “26 June” should be “26 June 2017”
Modified accordingly.

L104: “08 June” should be “08 June 2017”
Modified accordingly.

L107: “25 June” should be “25 June 2017”
Modified accordingly.

L110: “humidity and temperature” should be “humidity (RH) and temperature (T)”
Modified accordingly.

L121: “concentration (NDro) of liquid droplets” should be “concentration of liquid droplets (NDro)”
Modified accordingly.

L136: “27-29 June” should be “27-29 June 2017”
Modified accordingly.

L136: “13-17 June” should be “13-17 June 2017”
Modified accordingly.

L146: “differential mobility analyser” should be “scanning mobility particle sizer”
Modified as
… “differential mobility analyser (DMA;” …

L206: “SP2” should be “The SP2”
Modified

L237: Should “BC” be “rBC”?
Modified accordingly.

L247-248: Replace “-5.8 - -3.9°C” with “-5.8 to -3.9°C)”
Modified accordingly.

L256: “of Arctic boundary layer impacted cloud presence” is unclear
Modified as:
… “representative of Arctic boundary layer influenced by cloud presence.” …

L259: Replace “where no” with “where neither”
Modified accordingly.

L268: Should “showed” be “shown”?
Modified accordingly.

L281-284: This part is unclear.
The sentence was modified as:
… “The size distribution of free-tropospheric rBC observed during ACLOUD is not uncommon in the Arctic spring and summer (Raatikainen et al., 2015; Taketani et al., 2016; Kodros et al., 2018; Zanatta et al., 2018; Schulz et al., 2019; Ohata et al., 2021). However, none of these previous Arctic studies ever reported rBC size distributions similar to below-cloud conditions.” …

L285: I am not sure “All told” is appropriate.
Modified in “overall”

L299: I think “fund” should be “found”
Modified accordingly.

L315: I think “enriching” can be change by “increasing” or “enhancing”
Modified accordingly.

L336: Replace “as following” with “below”.
Modified accordingly.

L347: “observation” should be “observations”
Modified accordingly.

L374-376: This part in unclear.
The sentence was modified as:
… “First, these results confirmed that larger and more hygroscopic rBC particles are usually enriched in cloud residuals (Motos et al., 2019). Second, the values above unity shown in Error! Reference source not found.**, indicating an absolute enrichment of larger rBC-residuals compared to above-cloud and below-cloud, suggested the formation of these larger rBC as the result of in-cloud processing.” …**

L393: “The liquid water content” should be “LWC”
Modified accordingly.

L394: “The ice water content” should be “IWC”
Modified accordingly.

L427-431: This part is unclear.
The sentence was modified as:
… “Due to the low transmission efficiency of large drizzle drops in the CVI inlet, we were unable to verify the correlation between the diameter of rBC residuals and the concentration of drizzling drops. However, below-cloud release via evaporation (Igel et al., 2017) of rBC-agglomerates formerly contained in drizzling drops, and its reactivation at cloud-bottom (Solomon et al., 2015) might

contribute to the presence of larger rBC-residuals at cloud-bottom (Error! Reference source not found.**) and explain the similarity between in-cloud and below-cloud size distribution (**Error! Reference source not found.**b,c).” …**

Table 1: “this study. Including” should be “this study, including”
Modified accordingly.

Figure 1. I suggest to change BC to rBC in the entire figure.
Modified accordingly.

Figure 3: “rBC in cloud sampled behind the CVI inlet, otherwise behind the total inlet.” This has to be grammatically improved.
Modified accordingly.

Figure 4: A), B), and C) labels are missing on the panels.
Modified accordingly.

Figure 4: “Liquid droplets measured with the SID-3 probe in the 10-45 µm diameter range. rBC residuals sampled behind the CVI inlet or behind the total inlet and measured with the SP2 in the 73-575 nm diameter range.” This has to be grammatically improved.
Modified

Figure 5: “rBC residuals sampled behind the CVI inlet, rBC particles sampled behind the total inlet. All rBC measured 840 with the SP2 in the 73-575 nm diameter range”. This has to be grammatically improved.
Modified accordingly.

Figure 6. “Median and interquartile range calculated for in-cloud equidistant 845 normalized altitude (Zn) steps of 0.25. Liquid droplets measured with the SID-3 probe in the 5-45 µm diameter range. Ice crystals measured with the CIP probe in the 75-1550 µm diameter range. rBC residuals sampled behind the CVI inlet and measured with the SP2 in the 73-575 nm diameter range.”. This has to be grammatically improved.
Modified accordingly.

Figure 7. “rBC residuals sampled behind the CVI inlet and measured with the SP2 in the 73-575 nm diameter range.”. This has to be grammatically improved
Modified accordingly.

References

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