ar-2025-12: “AIDA Arctic transport experiment (part 1): simulation of northward transport and aging effect on fundamental black carbon properties”

Answers of the authors to Reviewer#1

While the reviewer’s comments are given in **black bold**, our answers are given below in blue letters. Additionally, we added the changes made in the revised manuscript in *blue italic letters*.

The work ”AIDA Arctic transport experiment (part 1): simulation of northward transport and aging effect on fundamental black carbon properties ” is well presented. The temporal evolution of BC and the influence of aging processes on the morphological transformations of BC throughout their atmospheric transport to the Arctic regions are systematically investigated through controlled experimental simulations employing realistic atmospheric parameters in the AIDA simulation chamber. The results demonstrate that aging processes coupled with Arctic-bound atmospheric transport induce transformative modifications to the physicochemical properties of BC and the methodology presented demonstrates the pressing need to bridge the gap between laboratory-based measurements and real-world scenarios. The compositional variability of organic and nitrate coating on BC particles during transport under summer and winter conditions is presented for the first time.

We would like to thank the referees for their detailed and constructive comments, which helped us to improve our manuscript. Here we provide some major considerations. Several reviewers noted an insufficient discussion on the ambient representativity of transport conditions, soot generation and coating species. This has now been addressed in more detail in both the Methods and Results sections, representing the major modification to the text. Reviewers also identified inconsistencies in the use of acronyms and abbreviations. These have been reviewed and corrected throughout the manuscript text and figures. The reviewer’s specific comments are addressed as it follows.

The discrepancy between AIDA measurements and ERA-5 data (Fig. 3) should be discussed. Could it be due to differences in methodologies used or varying in ambient conditions.

Since this point was raised by multiple reviewers we addressed it in detail.

a. Besides representing a major air transport pattern, the region of interest was chosen also because it shows a limited longitudinal variability in surface temperature, proving relatively stable atmospheric conditions. This was made clear at the end of Section 2.1.1 ”Region of interest”:
   … “Although other efficient transport patterns exist, this specific continental area is characterized by a reduced temperature variability (Przybylak, 2016), ensuring more homogeneous atmospheric conditions compared to the Atlantic and Pacific transport pathways.”…

b. To provide a better context to the reanalysis results, a short sub chapter was added in Section 3.1 “Northward transport conditions:

   … “These temperature and humidity profiles are consistent with general Arctic conditions, which typically feature stronger latitudinal cooling and more humid conditions near the surface compared to higher altitudes (Przybylak, 2016). The longer atmospheric lifetime of NO_2 during winter (Levy II et al., 1999) may be responsible for the higher NO_2/BC ratio in winter than in summer, in both low and high altitude scenarios. Although elevated NO_2 relative to BC concentration is a prerequisite for nitrate coating formation, the production pathways in the Arctic are strongly influenced by extreme environmental factors such as low

temperatures (Alexander et al.; 2020) and limited sunlight (Schaap et al., 2004), which affect both the efficiency and timing of nitrate formation. As concluded in the recent AMAP (2021) report, the limited horizontal and vertical coverage of NO_2 measurements does not allow for further comparison with ambient data." ...

c. Comparability of simulated and measured conditions. Considering that the estimated and observed temperatures were in close agreement, we focused on relative humidity and NO_2/BC ratio. The mismatch in RH may have affected gas-phase and aqueous-phase chemistry processes controlling the formation of coating-precursors and coating material. The most affected scenario would be WL, when RH values were underestimated by 10-15% during the entire duration of the experiment. The effect of NO_2/BC mismatch would be, however, dominant for the coating formation potential. In this regard, we might have introduced contrasting bias in the low altitude scenarios. We have added a short paragraph at the end Section 3.1 "Northward transport conditions" to explicitly discuss the implications of these discrepancies. The modified text in section 3.1 now reads:

... "The mismatch in RH may have affected gas-phase and aqueous-phase chemistry processes influencing the formation of coating precursors and coating material. As shown by the high values of the standard deviation of the NO_2/BC ratio measured in the AIDA chamber, the control of NO_2 concentration proved to be the most complicated. This technical difficulty led to non-systematic bias during the various experiments. As an example, we introduced contrasting bias in the low altitude scenarios. While the high NO_2/BC in SL might promote a higher degree of internal mixing in AIDA compared to CAMS, the depleted level of NO_2 might have hindered coating formation and internal mixing in WL. In summary, atmospheric conditions extracted from ERA-5 and CAMS revealed complex and heterogeneous transport conditions, which were well reproduced, day-by-day, in the AIDA chamber. Nonetheless, discrepancies between reanalysis and measured NO_2 levels might accelerate or hinder coating formation in a non-systematic way across the experiments." ...

d. Figure 3 was modified to accommodate the comments done by different referees. The modifications include: i) Addition of shading to represent the standard deviation of both reanalysis and measurements; ii) different colouring to improve readability; iii) adjustment of axis labels and legend.

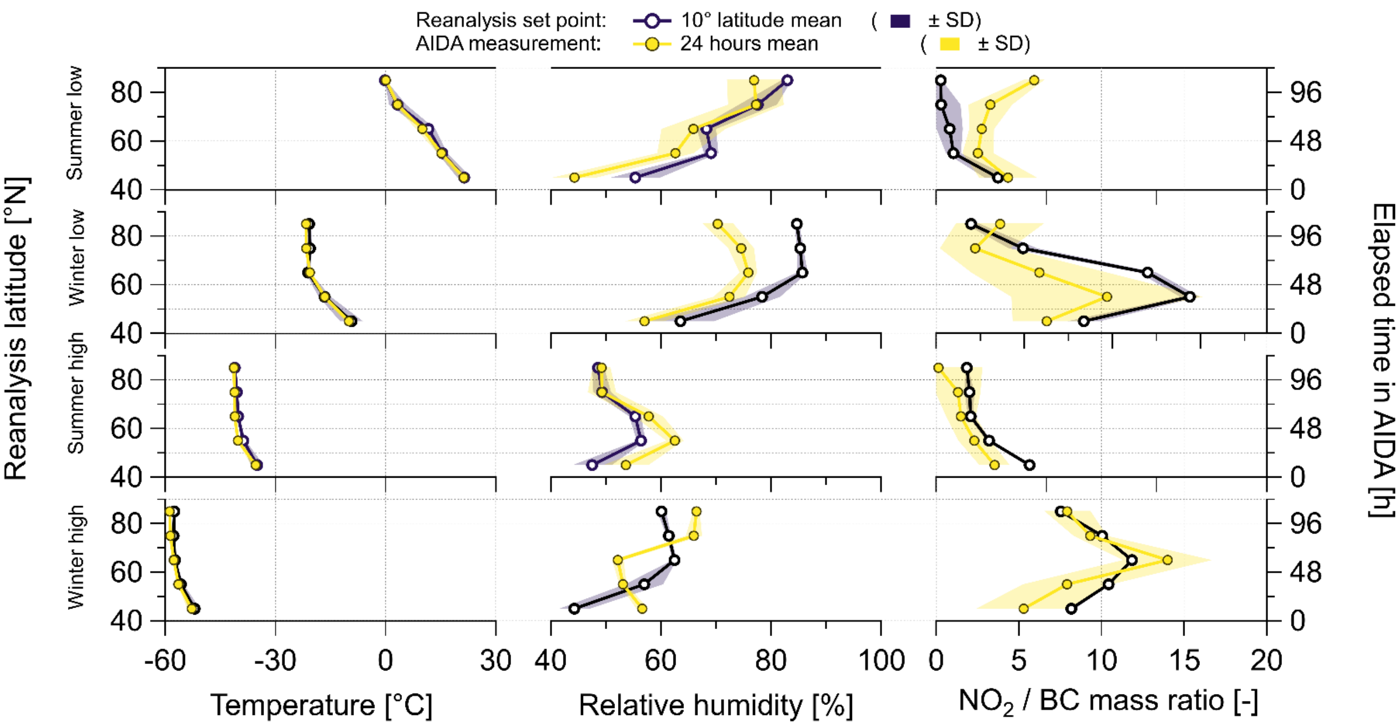

Figure 3 Left axis: Latitudinal profiles of temperature and relative humidity extracted from ERA-5 and of NO_2/BC mass ratio extracted from CAMS in the region of interest (40-90°N and 60-140°E). Mean and

standard deviation (SD) calculated for equidistant latitude bands 10° wide. Right axis: temporal variability of temperature, relative humidity and NO_2/BC ratio measured in the AIDA chamber. Mean and standard deviation (SD) calculated over 24 hours.

Technical comments

In the abstract norward should be replaced with northward

The mistake was corrected.

replace twentyfour with 24 in line 200

The issue was addressed.

rewrite the sentence after Eq. 7 line 375

The Sentence was indeed awkward. It was modified to improve readability as:

… "For each particle selected by the DMA-APM-SP2 system based on its mobility diameter and mass, it was possible to estimate the volume equivalent coating thickness (ΔD_{ve}; Equation 7). Assuming that the particle core is spherical and surrounded by a concentric, spherical coating layer, ΔD_{ve} was defined as the half of the difference between the total particle diameter $D_{ve\text{-}P}$ and the rBC-core diameter $D_{ve\text{-}rBC}$:" …

References

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