

We thank the reviewers for their insightful feedback. We have substantially revised the manuscript as a result. Mainly, we revised and coordinated almost all of the figures and improved upon the writing quality of the text based on the suggestions provided. We also revised the source classifications and redid any calculations resulting from such changes, all of which are reflected in the manuscript.

Reviewer 1

This study analysed the airborne observations during ACME-V campaign along the North Slope of Alaska in the summer of 2015 and found that summertime Alaskan Arctic was not pristine as suggested by previous evidence, but was with higher aerosol loading and trace gas concentrations than measurements even in Arctic haze. Local oil extraction activities, central Alaskan wildfires, and to a lesser extent, longrange transport enhanced the aerosol and trace gas concentrations in Alaskan Arctic during summertime. Quantifying aerosol loading and sources in the Arctic is challenging. The aircraft observations presented in this study is therefore an important contribution to the field, but the analysis and writing quality of this manuscript is really poor. I recommend publication in ACP after major revisions and substantial improvements.

Major comments:

1. The analysis of the data was a little superficial and I suggest the authors dig deeper. For example, in Figs. 3, 7 and 9, the data were color coded by flight numbers, which does not provide any valuable information. They already classified the flights into several air mass types as shown in Table 2 and Fig. 10. I think analysis based on different air mass types would provide more information than the current flight numbers used in the manuscript. In addition, Figs. 2, 3 and 4 discussing the impacts of oil extraction was based on data during the whole campaign. I suggest select the period during which these sources dominate would be better to illustrate their contributions.

We agree with the reviewer that the data colored by flight number is not useful and redundant to Table 2 and Figure 9 (was Figure 10). We want to note that the analysis in the manuscript is intended as an overview and presentation of the unique dataset to show the influence of the sources in the Prudhoe Bay area. More detailed studies are currently undergoing the planning phase to elucidate aerosol sources in a more specific manner. However, in an effort to conduct a deeper analysis based on air mass types, we tied in the source classifications more thoughtfully throughout the discussion and respective figures. For clarity and consistency, we revised most of the figures to show all data and those data classified by the air mass types. Much of the text for section 3.1 and some of the text in section 3.2 was updated to reflect the source-specific analysis in the figures. Specifically regarding the figures, we:

- *Revised the color scheme in Figure 9 (was Figure 10) for each source; now all source colors are consistent throughout all of the figures.*
- *Changed the color scales in Figures 2 and 5 (was Figure 6) to reflect the approximate source colors.*
- *Removed the panels colored by flight number entirely from Figure 3 and colored the data impacted by Prudhoe Bay in blue (all other data in grey).*
- *Combined Figures 3 and 4 into the new Figure 3.*
- *Changed the color scale in Figures 4 and 7 (were Figures 5 and 8) to match fires source color.*
- *Revised Figures 6 and 8 (were Figures 7 and 9) show the vertical profiles and/or correlations for all data and those data impacted by fires and all sources, respectively.*
- *Kept the spatial averaged maps to show, qualitatively, the spatial variability in the parameters and to demonstrate the locations impacted by Prudhoe Bay and the fires. However, the color scales now reflect the assumed sources.*

With regard to the last point (restricting the oil extraction analysis to the periods during which those sources dominate), it is important to note that this signal is continuous and was encountered by almost all flights as they traversed the Prudhoe Bay area. Therefore, we felt that it was appropriate to highlight the specific signal of these emissions in contrast to the background signal encountered during much of the rest of the flights at altitudes below 500 m.

2. The manuscript was poorly organized, making it really hard to follow. For example, in Sect. 3.1, figures were discussed back and forth. Fig. 2 c and d were discussed after Fig. 4. In the same section, the idea that ‘high concentration of small particles are restricted within 50 km of Deadhorse’ has been discussed several times (P6,

L21–26, P7, L14–16, and P7, L24–25). In Sect. 3.2, discussions of different species were also jumped back and forth. For instance, aerosols were discussed in P8, L15–19, P8, L25–29 and P9, L21–25. Background concentrations of CO and enhanced CO were discussed back and forth in P9, L1–14. In Sect. 3.3, the second paragraph discussing air mass types along the flights does not belong to this section, which is supposed to discuss the contribution from long range transport. Long range transport deserves more analysis.

We went through and reorganized to ensure the figures are discussed in an orderly manner and prevent redundancy in ideas presented. We also added a paragraph describing the classifications of sources in more detail, which helps elucidate the long-range transport analysis. However, we disagree that the second paragraph in section 3.3 does not belong. The focus of the paper is on the abundant local and regional sources (which may be increasingly important in a dynamic Arctic environment), while long-range transport is secondary. Our study and previous studies have indicated that this is not an important source in the summer as compared to the winter/spring. The purpose of this section is to discuss the contributions from all sources compared to one another. A more detailed analysis of long-range transport would require extensive air mass trajectory analysis in addition to other remote sensing or modelling techniques to accurately evaluate long-range sources; this is outside the scope of our manuscript. To reflect the secondary importance of long-range transport, we removed ‘long-range transport’ from the title.

For the figures, we revised so that they are in order when first presented, however, we do refer back to certain figures when discussing different parameters. For Prudhoe Bay, we organized the discussion such that we focus on each measurement parameter (i.e., nucleation mode aerosol and rBC) at a time, which is why we go back and forth between Figures 2 and 3. For the fires, we discussed rBC and CO back and forth because they are related, correlate strongly, and thus both used as tracers for the fires. For both sections, we now show and discuss HYSPLIT first to qualitatively provide spatial evidence of the sources, then discuss how the measurements support the source modeling.

3. Another problem of the paper is the sloppy style of writing and the use of the English language. For instance, the tense was wrong in numerous places. To name a few, P1, L 22–44, P3, L16, and P3, L30. The references were not always written in the correct format. ‘... and colleagues (year)’ should be ‘... et al. (year)’. The acronyms were not properly used (e.g. ‘rBC’ and ‘black carbon’, ‘CO’ and ‘carbon monoxide’ were used back and forth; AMSL and MSL were not spelled out when they were used for the first time; ARM and AOD were spelled out twice). A lot of ‘and/or’ were used. Please double check and delete ‘and’ or ‘or’. I also list a few other problems in the ‘Minor comments’ section, but all these I’ve pointed out are only a few of the language problems in the manuscript. I suggest a much more careful checking of the manuscript and a substantial improvement of the language.

We cleaned up the writing style throughout the manuscript and made sure we corrected wrong tense usage, citations, and acronym consistency and definitions.

4. In section 3.2, please compare the fire activity in summer 2015 with climatology to illustrate how representative the summer is.

We now state that it is the second largest number of acres burned since records began in 1940 based on the findings of Partain Jr., J. L.; Alden, S.; Strader, H.; Bhatt, U. S.; Bieniek, P. A.; Brettschneider, B. R.; Walsh, J. E.; Lader, R. T.; Olsson, P. Q.; Rupp, T. S.; R.L. Thoman, J.; York, A. D.; Ziel, R. H., An Assessment of the Role of Anthropogenic Climate Change in the Alaska Fire Season of 2015. Bulletin of the American Meteorological Society 2016, 97, (12), S14-S18.

5. Axis labels of Fig. 7b are wrong.

Fixed.

Minor comments:

1. P2, L22: ‘to discover’ is inappropriate here. Revise please.

Changed to ‘to conclude’.

2. P2, L25: ‘during their Aug–Sep 2015 study’ -> ‘during Aug–Sep, 2015’

Done.

3. P2, L29: 'exists' -> 'locates'

Changed to 'is located'.

4. P2, L31: revise 'provides the ability to ...'

We removed this sentence and instead combined with the second sentence in the paragraph to, "This site is located in the northwest region of oil extraction activities in Prudhoe Bay, making it an ideal location to determine the potential impacts of emissions from such activities on the relatively pristine Arctic atmosphere."

5. P2, L33: 'long-range transported aerosol from lower latitudes' -> 'long-range transport from lower latitudes'

Done.

6. P3, L1: 'insight' -> 'insights'

Done.

7. P3, L2–3: please provide proper references

Done.

8. P4, L23: CO₂ were also discussed.

Changed to 'aerosol, CO, and CO₂'.

9. P5, L6: particles -> particle

This should be particles.

10. P5, L23: 'landing the Deadhouse' -> 'landing in the Deadhouse''

Changed to 'landing at the Deadhorse'.

11. P5, L30–33: please show these locations in related figures.

These are already shown in Figure 4 (was Figure 5) as indicated in the caption. However, we changed the color of the location markers to make them more evident.

12. P6, L17–18: please clarify which data were used.

Clarified that these are thermal anomaly data.

13. P6, L19: '&' -> 'and'

Done.

14. P6, 31: those vapours does not nucleate, the secondary products are. Please clarify.

Done.

15. P8, L31: Please provide concentration values in standard summertime and springtime.

We removed this part of the sentence because the SP2 measures refractory black carbon, and the values in most studies from the North Slope are either equivalent black carbon, or modeled black carbon. Thus, they may not be directly comparable due to possibly slight variations in sampling techniques.

16. P9, L4–5: please clarify whether it is active flaming or smoldering.

We already stated that the MCE value indicated active flaming, but changed ‘versus’ to ‘instead of’ for clarity.

17. P10, L9: what are the tracers?

We added ‘CO and rBC’ at the end of this sentence.

18. P19: Figure 2. [mass m-3] is not a unit

This is the unit defined by the HYSPLIT manual. It is an arbitrary unit. We now describe this in more detail in section 2.4 (was section 2.3).

19. P22: Figure 5. Move the colour bar to the bottom of the figure.

Done.