Response to the Anonymous Referee #2 comments for the manuscript "Exceptional high AOD over Svalbard in Summer 2019: A multi-instrumental approach" by Sara Herrero-Anta et al. in AMT

First of all, we would like to thank the time and effort of the referee for their detailed review of the manuscript. Reviewer comments (RC) are in bold font and author comments (AC) are in italic font.

Author's answer to Anonymous Referee #2

RC: The paper "Exceptional high AOD over Svalbard in Summer 2019: A multi-instrumental approach" by Herrero-Anta et al. is a thorough study of an episode of enhanced aerosol at Svalbard during summer 2019. It combines observations of several instruments to identify aerosol characteristics. Further, modelling with FLEXPART is used to identify the different sources of the aerosol.

Overall, the paper presents a comprehensive, logically structured study, it is well written, and is of interest to the broad readership of ACP.

The paper is therefore recommended for publication in ACP after addressing my minor comments as detailed below.

My main comment is that in some places discussion of some features in the data is missing.

AC: SPECIFIC (MINOR) COMMENTS:

RC: (1) Fig.2: Please comment! Why is there a peak of AOD with strong standard deviation in the reference record between 1 and 15 July? Is this a repetitive event each year? Or is this peak attributable to a specific event? If yes, which?

AC: Yes, this is due to an extreme event observed on 10 and 11 July 2015, when AOD (500 nm) up to 1.0 were measured.

This has been included in the capture of Figure 2 in new version of the manuscript: "The high reference values observed on 10 and 11 July are due to an extreme event that occurred in 2015.

RC: (2) Fig.4: For the S1 event, beta_sca is only enhanced at GAL, but not at ZEP, while beta_abs is enhanced at both sites. Do you have any explanation for this?

AC: It is not that they Bsca was not enhanced, but that, unfortunately we did not record Bsca at ZEP exactly at the time. We also do not have data from GAL on event S2 and CS1.

RC: (3) l.301-311, about Fig.5: ZEP discussion is missing! Here you should also comment about the PNSD at ZEP, which does not show a clear bimodal structure during the surface events, and the distributions peak at sizes between Aitken and Accumulation mode.

AC: Thank you for the remark. We have included a short discussion in the new version of the manuscript:

"The PNSD at ZEP does not show a clear bimodal structure for either of the events. In these cases, the peak of the distribution lies between the Aitken and Accumulation modes, generally showing higher concentrations than GAL during events S1 and S2. Therefore, the surface events were perceived slightly differently at the two sites."

RC: (4) l.324-325: What about the other layers seen by KARL? There is a more intense layer at 13km that is not seen by CALIOP. Why? Is this an issue of the CALIOP sensitivity?

AC: We did not mentioned it but actually CALIOP also sees some extinction around 13-14~km in most of the profiles. As vertical and temporal resolution of CALIOP and KARL are very different we do not expect a closer agreement. Basically, a ground-based lidar perceives the temporal evolution, a quick satellite the spatial evolution of aerosol layers. In the new version of the manuscript we also have updated the discussion and Figures following other reviewer comments:

"Unfortunately KARL measurements are only available for four days in the summer of 2019 due to cloudy conditions and safety regulations of the instrument. The layers observed with KARL were temporally quite constant on each day (See Figure S4 in the supplement), therefore, the daily averaged backscatter profiles have been calculated. These are shown in Figure 7. It is observed and increased backscatter between 10 and 16 km a.g.l. with several layers through August, but in 17 September the backscatter slowly decreases and becomes more homogenous with height. Only one of these days corresponds to a day identified with aerosol event, 11 August (Event C3). During this day, a high backscatter coefficient at 532 nm up to about 0.8 M m − 1, with several layers, is observed throughout the entire troposphere, as well as in the stratosphere up to nearly 16 km a.g.l.. Particularly, the layer just around the around 10 km a.g.l. observed with KARL correlates very well in altitude with the increased backscatter profile measured by CALIOP in the same date In CALIOP it is also observed some extinction around 14 km a.g.l., which correlates with the stratospheric layers observed with KARL. Since the vertical and temporal resolution from both instruments is very different, we do not expect a closer agreement."

RC: (5) l.447-449: Thin cirrus clouds are hard to detect by ground based and space based instrumentation. Could thin (subvisible) cirrus clouds also contribute to negative values of delta-DNI?

AC: Optically very thin clouds can be difficult to detect even from ground-based sun-photometers, so this is a complex problem not only for ΔDNI. Thin clouds (but also not so thin clouds) can have contributed to the negative values and to the variability of ΔDNI.

However, the tendency observed from July to August and September must be due to the aerosol presence. In particular, the first event correlates very well with the moment at which we start to observe only negative ΔDNI.

This effects of clouds were already mentioned in the manuscript: "The large standard deviation observed shows the complexity of this analysis, with multiple conditions (mainly variation in aerosols and clouds) sometimes playing roles in opposite directions. However, in general, the negative sign of ΔDNI is a good proxy for the effect of the decrease in the direct component of solar radiation."

RC: TECHNICAL COMMENTS:

(1) l.28: levels.Lisok -> levels. Lisok

(2) l.52: Siberian wildfires -> smoke of the Siberian wildfires

(3) Table 1: abbreviations of several parameters (e.g., DNI, DIF) are only given later in the text. This should be mentioned in the table caption.

(4) l.148: can be also be -> can also be

(5) l.161: to Reference Upper-Air Network (GRUAN) -> to the Global Climate Observing System (GCOS) Reference Upper-Air Network (GRUAN).

(6) l.171: from zero to the unit, being small -> from zero to unity, with small

(7) caption of Fig.2, l.2-3: Sentence "Long-term daily means ..." can be deleted because same info is given at the end of the caption.

(8) caption of Fig.2, l.5: with errors bar -> with error bars

(9) l.253: one maxima -> one maximum

(10), (11) l.254: main maxima -> main maximum second maxima -> second maximum

(12) l.259: This longer radii -> These larger radii

(13) p.11, last line: longer -> larger

(14) l.277: next mean values: -> following mean values:

(15) Table 3 and text on p.13: Here you use B_abs and B_sca instead of beta_abs and beta_sca. Please use consistent notation throughout!

(16) caption of Fig.5: the are only -> there are only

(17) l.303: With respect GAL observations -> Regarding GAL observations

(18) l.331: is shown -> are shown

(19) l.361: row)is -> row) is

(20) Caption of Fig.10: red line -> magenta line

(21) Caption of Fig.11: With respect the sources -> With respect to the sources

(22) Caption of Fig.12: with respect the reference -> with respect to the reference

(23) l.495: Ship born -> Ship borne

(24) l.503: under request to the authors -> under request to the authors.

AC: Thanks for the detailed review, all the technical comments have been addressed in the new version of the manuscript.