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Reply on RC2

Patrick Chazette et al.

Author comment on "Mesoscale spatio-temporal variability of airborne lidar-derived aerosol properties in the Barbados region during EUREC⁴A" by Patrick Chazette et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-706-AC3>, 2021

The authors would like to thank the reviewers for their valuable comments which helped improving the quality of the manuscript. Our point-by-point responses to the reviewer's comments appear in bold below. The text modified in the revised version of the MS and included in the response appears in quotes.

Reviewer 2

The manuscript is well in the focus of ACP and should be published after mainly minor revisions.

General comments:

In the introduction and the discussion findings of the approx. last 10 years on Saharan dust are completely missing. Large research projects and campaigns were conducted focusing on the beginning of dust transport (e.g. SAMUM – which focuses also on wintertime conditions), as well as after long-range transport towards the Caribbean (e.g. SALTRACE, NARVAL-II). A large number of studies were published using data from these studies that should and could be connected to the findings of this manuscript. Those studies were also dealing with wintertime dust transport, mixtures of dust and biomass burning aerosols, downward mixing of dust, and on the relation of Saharan dust layers and relative humidity. Those studies should be mentioned in the introduction and discussed in relation to the findings described in this manuscript.

We agree. This is now addressed in the revised version of the MS. We have rewritten the beginning of the introduction to take the suggested studies into account with a discussion on the seasonal transport (and the difference between wintertime and summertime dust and BB transport). The part of the text related to the transport of smoke and the importance of dust-BB mixtures in the atmosphere composition is now introduced earlier in the Introduction, i.e. after the 1st sentence. To comply with similar comments made by Referee #1, we have included a number of references pertaining to SAMUM, SALTRACE and NARVAL.

Specific comments:

In the abstract information on what characterized the two distinct periods with significant aerosol content should be given. How is the heterogeneity connected to the highly variable relative humidity field?

The second part of the abstract has been modified to take into account the referee's comment. As the role of humidity is one hypothesis among others, we do not include it in the abstract. It is indeed too speculative.

Introduction: A differentiation between summertime and wintertime transport should be made. The main dust transport towards the Caribbean is happening in summertime (which is also mentioned in the manuscript). The Saharan Air Layer seems to be quite undisturbed close to the source and during long-range transport during the summertime transport. A number of publications (e.g. Weinzierl; Haarig; Groß; Gutleben; ...) described the summertime dust transport to the Caribbean. In contrast, during wintertime the dust is located at lower altitudes and frequently mixed with biomass burning aerosols (e.g. SAMUM-II related publications: Ansmann; Tesche; Groß; ...). Additionally, biomass burning might be transported to the Caribbean from the South American continent (Haarig).

Agreed. This is now accounted for in the Introduction as mentioned above.

Calibration of the lidar signal: How stable is the system constant when pressure and temperature change during flights? How do system settings affect the system constant?

We did not note any variation in the lidar calibration constant as a function of pressure for flights below 5 km a.m.s.l., as the cabin is pressurized. The temperature in the cabin was also stable during the flights. These two aspects have been added. As explained, the most important factor affecting the system constant is the transmission of the aircraft window, the variability of which could be assessed from the reflection of the laser beam from its surface.

Observation periods: The detailed information on the different observation periods should be given together to get a better overview of the different aerosol situations. The different observation periods should be described in a bit more detail. Which aerosols / mixtures were the dominant one? Or why were these periods chosen for a detailed description?

The selected periods are presented at the beginning of Section 3 and representatively sample the whole airborne campaign in terms of aerosol loads. At this stage, the reasons for this choice are roughly explained. The choice is confirmed as the observations and modelling are presented. A strong confirmation of this choice is given in subsection 4.4 by the CAMS modelling which is shown to be consistent with the spaceborne observations in subsection 4.2. We have added the sentence "It is worth noting that the selected observation periods are representative of the main aerosol situations, with rather contrasting relative contributions of aerosol compositions" in subsection 4.4 to emphasize the representativeness of the selected flights.

Is the vertical profile derived from the ascends and descends? Can you give a bit more information?

Profiles include both. We have added the sentence "It should be noted that the vertical profiles include the ascent and descent parts of the flights."

Page 6, line 31: Do you mean vertically homogeneously distributed? I do not see it for horizontally...

Yes, it is for the vertical. The correction has been done.

Page 7, lines 8: How do you link the horizontal relative humidity field to the particle's horizontal heterogeneity? Might it also be the other way around? As described in Gutleben

et al., 2020, Saharan dust transport is associated with transport of embedded water vapor. To link relative humidity and aerosol heterogeneity one needs to have information about the water vapor / relative humidity field, and on the type of particle. To better describe the vertical distribution and the connection to possible convective processes a consideration of the atmospheric stability would be helpful (e.g. inversions, stability).

Yes, more information is needed to properly study the links between water vapour and the optical properties of aerosols. In this part of the text, we only state the causes that could explain the observed heterogeneity and humidity is one of them, as well as sources diversity and vertical mixing by convection.

Page 11, lines 14: To connect changes in relative humidity to changes in the optical properties, information on the relative humidity distribution is needed. Furthermore, e.g. dust aerosols are not hydrophil. Thus, relative humidity should not affect the intensive optical properties. What about biomass burning aerosols? What kind of mixtures do you consider?

As before, it is hypothesised that RH may influence the variability of LR and PDR. It is also said that LR varies little with RH and that the observed variability may also be related to different aerosol natures. This does not exclude an effect of RH, but it is difficult to quantify at this level. We have added an explanation in subsection 4.2 where the 2 main aerosol components are presented via CAMS modelling:

"The simultaneous presence of dusts and biomass burning aerosols may explain the heterogeneous character observed above. This does not exclude a role of relative humidity as explained by Kim et al. (2009) for the winter period in West Africa. They have shown that the biomass burning aerosol plumes advected over long distances are associated with significantly higher relative humidity values than the dust plumes. These two plumes may co-exist at different altitudes or be mixed as in our case. This mixture may not be homogeneous."

It is true that it is often said that dusts are hydrophobic, but this is not necessarily the case in a mixture of aerosols, as in our case, where nitrates can be positioned on the aerosol surface. For this study, we cannot discuss this aspect because no aerosol chemistry measurements were performed.

Figure 5: Capture is missing the date information.

Yes, the date information has been added in the figure caption.