Anonymous Referee #1
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> This paper using CALIPSO nighttime measurements to study how the dust aerosol properties change across the Atlantic Ocean. This paper provides some insights about how dust below and within the Saharan Aerosol Layer change across the Atlantic Ocean. However the reviewer believe the method used to study the effects of cloud on dust need to be refined. The authors need to elaborate on how they define the distance to clouds. Was it defined separately for dust layer below and above 2 km separately? Aerosols and clouds need to be in the same layer to study the effects of clouds on aerosol (or vice versa). Furthermore, CALIPSO only provide information along its pencil beam, therefore no information about cloud distribution is available on either side of the pencil beam. I recommend combine CALIPSO with imager for a more complete view of cloud field, which will provide a more truthful calculation of the distance from the CALIPSO beam might be misleading. This could be another reason for the unexpected increase of depolarization ratio near clouds shown in Figure 7.

We thank the reviewer for suggesting to refine the method that defines the distance to clouds and pointing out the possible errors caused by the off-track cloud effect.

In this paper, the distance to the cloud is defined as the horizontal distance to cloud, without taking into account the contributions of the vertical distance to cloud base or top. This horizontal distance is similar to the distance we can define in a 2D image in which no altitude information is available. We note that based on 2D imagery, near-cloud clear sky properties have been found significantly different from the properties far away from cloud (e.g. Koren et al, 2007).

This distance definition is identical for layers below and above 2 km.

This definition is a coarse but simple one to study cloud effects. Indeed, clouds and aerosols occurring at different altitudes have less significant interactions. This is particularly the case in regions E and M where most of the dust is at 2-5 km, well above most water clouds. For this reason, we separated dust into two groups: low dust (below 2 km) and high dust (above 2 km), and studied their near-cloud behaviors separately in Figure 7. A related discussion can be found in the revised manuscript at L9-15 on P13.

In short, we agree that a more refined layer selection would potentially reveal more detailed information. However, we think our coarse method is sufficient to reveal some basic features. In addition, as mentioned in the manuscript, earlier observations of the vertical structure of cloud effects on aerosols (Várnai and Marshak, 2011) indicate that cloud effects can extend to a rather large distance below the cloud layer, which also helps our coarse method to identify the main features of near-cloud particle changes.

Off-track clouds do impact the observations. However, simulations and the analysis of co-located MODIS data have shown that near-cloud backscatter and color ratio show qualitatively similar behaviors even when off-track clouds are considered, and that the effect of off-track clouds can be taken into account statistically through a scaling factor [Tackett and Di Girolamo, 2009; Várnai and Marshak, 2012]. As a result, we don't think that off-track clouds change the basic behavior of depolarization ratio and cause the unexpected increase near clouds. The influence of off-track clouds is discussed in L1-6 on P3 the revised manuscript.

Specific comments:

Figure 1. Percentage contribution of dust AOD to total AOD in Figure 1b would be more helpful for reader to see the contribution of dust to overall aerosol loading.

Good idea. The map of dust AOD percentage contribution to the total AOD is shown here in Figure R1, which replaces Fig1b in the revised manuscript.

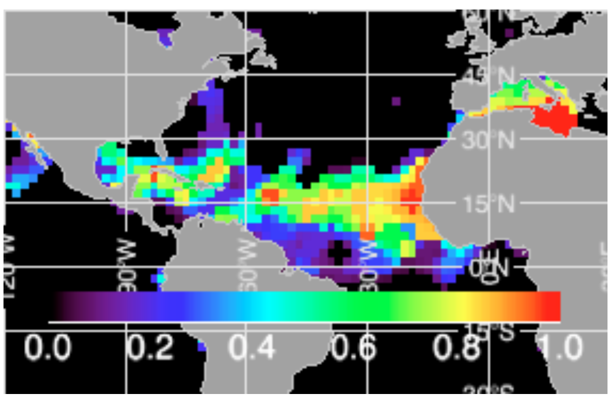

Figure R1. Ratio of median dust OD to the median overall AOD. To reduce the scatter, this map is filtered by a 3X3 median filter.

Figure 2b. The backscatter was the largest for region W, but why the dust AOD in W region didn't seem to be larger than AOD in M and E regions?

Thank you for pointing out that we did not make this point clear in the first version. In the first version, Figures 1b and 2b are not directly comparable and the discrepancy is only apparent. The main difference is that Figure 2b shows backscatter statistics conditioned upon dust occurrence, while the dust AOD contribution in the Figure 1b (in the first version of manuscript) is based on both dust and non-dust occurrences in a $2^{o}X2^{o}$ region. This difference can be large.

For completeness, let us also illustrate a hybrid approach that (similarly to Figure 2b) does not consider completely dust-free atmospheric columns, but (unlike

Figure 2b) does consider the dust-free portions of columns that include dust at some altitude. Assuming zero dust backscatter for the non-dusty segments,of dust-containing columns, we obtain the median dust backscatter profiles shown in Figure R2-1. Since the vertical integral of backscatter is related to AOD, Figure R2-2 shows the vertically integrated values of the three median profiles of Figure R2-1. It can be seen that the integrated value of median dust backscatter in dusty columns decreases towards west.

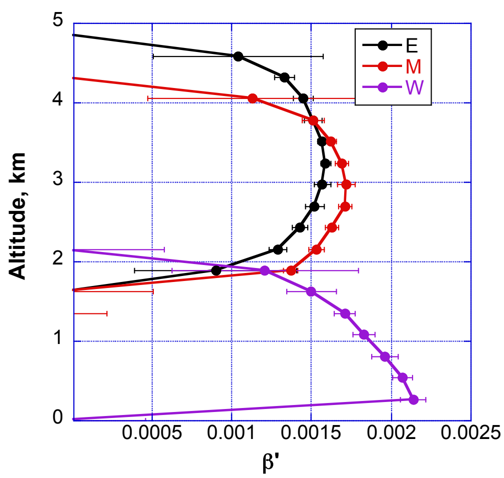

Figure R2-1. Vertical profile of median dust backscatter in the three regions, assuming zero dust backscatter for non-dusty segments of atmospheric columns that contain dust at some altitude. The calculations do not consider completely dust-free atmospheric columns. This profile is different from the backscatter vertical distribution conditioned on the dust occurrence, shown in Figure 2b of the paper.

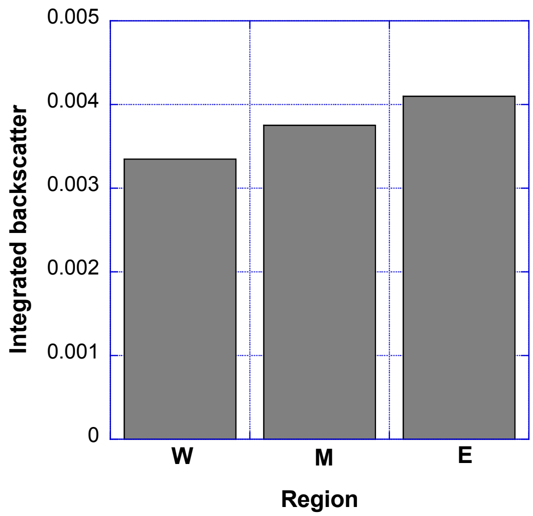

Figure R2-2, Vertically integrated values of the three median dust backscatter profiles in Figure R2-1. .

As the dust transport across the Atlantic Ocean, the backscatter and color ratio increase. Authors explain this is due to the fading of the SAL during the westward transport. But the reviewer would argue the sedimentation speed of large particles is greater than that of small particle. Therefore the fraction of small particles would increase as the dust plume transports across the Atlantic Ocean, which would result in decreasing of color ratio. Authors need to further examine the causes of the westward increases of backscatter shown and color ratio.

Thanks for these insights. We have revised our manuscript using the results for the dust particulate color ratio and depolarization ratio, in addition to their volume counterparts.

The dust particulate color ratio, in which molecular scattering and gas attenuation contributions have been removed, shows a slight decreasing trend westward (here "slight" means the amount of increase/decrease is just a little more than the error range that is indicated by the size of error bars). This result (shown in the Appendix of the revised paper) does not look counter-intuitive anymore with respect to size-dependent sedimentation. However, our results on volume or particulate properties under clear skies (section 3.2) show that color ratio does not vary significantly westward. Therefore, the westward increase or decrease of color ratio is likely due to the effects from clouds. We have updated the related issues on color ratio in the revised manuscript such as in L5-6 on P1, L3-6 on P7, L17-18 on P7, L21-26 on P8, L1-3 on P10 etc.

Also, the revised manuscript mentions (L3-5 on P7) that the relationship between particle size and color ratio is complex when particles are non-spherical.

Regarding backscatter, our results under clear skies (section 3.2) show that backscatter varies insignificantly westward at altitude above ~ 2 km. Therefore, the westward increase of backscatter (in Figure 2) is likely due to the effects of clouds. But we found that under clear skies the backscatter below ~2 km is larger in W than E. This bigger dust backscatter below ~2 km under clear skies in W is very likely because of the stronger wind speed westward observed using MERRA monthly data of the same month and year. The stronger wind can generate higher concentrations of marine aerosols mixing with dust. We have updated the results on backscatter in the revised manuscript accordingly (L25-31 on P7, L1-5 on P8 and L1-3 on P10).

Reference:

Koren, I., L. A. Remer, Y. J. Kaufman, Y. Rudich, and J. V. Martins (2007), On the twilight zone between clouds and aerosols, Geophys. Res. Lett., 34, L08805, doi:10.1029/2007GL029253.

Várnai, T., and Marshak, A.: Global CALIPSO observations of aerosol changes near Clouds, IEEE Rem. Sens. Lett., 8, 19-23, 2011

Várnai, T., and Marshak, A.: Analysis of co-located MODIS and CALIPSO observations near clouds. Atmos. Meas. Tech, 5, 389-396. doi:10.5194/amt-5-389-2012.

Tackett, J. L., and Girolamo, L. D.: Enhanced aerosol backscatter adjacent to tropical trade wind clouds revealed by satellite-based lidar, Geophys. Res. Lett., 36, L14804, 2009