Interactive Comment (D. Winker)

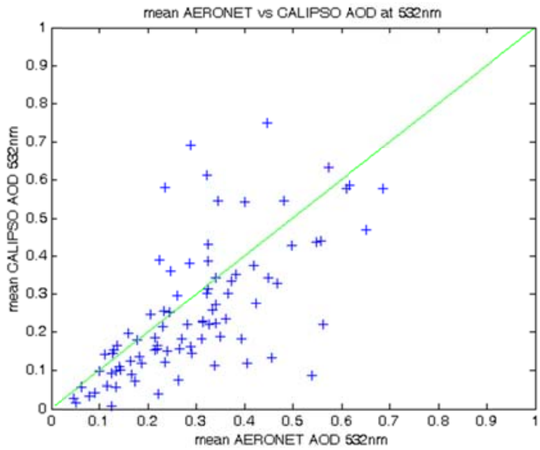
We would like to thank D. Winker for his comments and for sharing his knowledge and his views on our work.

"There are many interesting aspects to this paper, including the application of the method of Tesche et al (2009) to separate the component of extinction in dust mixtures due to dust and the development of a specialized regional Sahara dust data product. I'm concerned, however, about the impression this paper gives that aerosol lidar ratio is the only source of error which needs to be considered in CALIOP dust AODs.

Schuster et al. (2012) also partition the CALIOP data by aerosol type, finding a bias in AOD which can apparently be attributed to dust AOD. Schuster et al. also assumed the differences are due solely to the choice of lidar ratio assigned to the Dust type. A more recent paper (Omar et al., JGR, 2013, doi:10.1002/jgrd.50330) looks at CALIOP Aeronet comparisons in more detail and finds a number of sources of discrepancies, including the failure to correctly detect aerosol layer base (or failure to detect the aerosol at all), and misclassification of aerosol type. These error sources can be dominant. The behavior of the relative bias in Figure 1 at AOD below 0.5 looks more like an artifact due to layer detection than to incorrect lidar ratio, which would tend to produce a constant relative bias".

In the new version of our manuscript we acknowledge the possible sources of CALIPSO-AERONET discrepancies mentioned by D. Winker and presented in Omar et al. (2013). A revised analysis has been performed for the AERONET comparison section to take into account the potential artifacts. Data processing is now restricted to more conservative filtering techniques based also on the comments raised by Reviewer#2. The new constraints aim to remove "bad" aerosol detections and cloud contamination in the CALIPSO L2 product and moreover to account for consistency in the CALIPSO L2 product for scenes used, by removing aerosol inhomogeneity and cloud contamination as far as this is possible. We have to mention here that, in our paper, we chose only pure dust scenes - namely overpasses that are dominated by dust without being interrupted by cloudiness or bad aerosol detections. This has been done with a number of CALIPSO flags and by visual inspection of the final scenes. Regarding aerosol misclassification, we think that the high quality depolarization signatures provided by CALIPSO is sufficient to characterize at least dust, although we will agree with D. Winker that misclassifications may still occur, but most probably for other aerosol types. However, since dust should be distinguishable in relation to other types, a comparison for dust should be feasible. This is the same rationale that allows the provision of a Level 3 dust CALIPSO product.

The new relative biases provided for the filtered dataset (see Figure 1) strengthen the impression that the LR should be the major source of error for CALIOP dust AODs over the Sahara. Regarding the work of Omar et al. (2013), if we follow our revised methodology over Saudi Arabia, we get the comparison presented in the following Figure.



These results are very similar to those presented in Omar et al. (2013). It should be born in mind that the study regions of our work and Omar et al. (2013) are different (the authors in this work concentrated only on Arabian desert, thus their results cannot be compared with our study region). It is our general belief that CALIPSO provides consistent with AERONET AODs for Arabian dust, due to the lower LRs for this area. This is also supported by recently published data by Mamouri et al. (2013) that provides further evidence that the LRs of Arabian dust are much lower than those of Saharan dust.

"Dense dust layers which are detected on single shots and therefore classified as clouds by the current Level 2 algorithms (frequently seen over the Mediterranean) also lead to an underestimate of AOD".

This is a case that we had not considered at all and we wish to thank D. Winker for sharing his knowledge of this issue. In our analysis, we use only cloud-free CALIPSO columns and thus it is hoped that this effect should not have a significant impact on our reported results.

"Omar et al. also noticed the possibility of significant cloud contamination in even Level 2 Aeronet AODs".

The possible cloud contamination in AERONET measurements is most probably minimized by the use of the Level 2 product. Moreover, we acknowledge that only cloud-free CALIPSO scenes are used in our analysis and thus we don't believe that clouds are the reason for observed discrepancies in the combined CALIPSO-AERONET dataset used here. Besides, we get similar to AERONET behavior for the MODIS comparison, where we apply highly conservative cloud-filters for MODIS cells. The reason for AERONET cloud biases is most probably related to thin cirrus clouds which usually appear on larger scales and would be well detected by CALIPSO.

"Nevertheless, adjustment of the lidar ratio as a way of accounting for the net effect of all the error sources has merit in this particular application. The authors should acknowledge, however, that this may be compensating for other sources of error and may improve the agreement in AOD at the expense of biasing the extinction profile".

We acknowledge the possible contribution of other sources of error in the revised version of our manuscript. However, we believe that their impact should be small and that, for the region under study, the lidar ratio is the major factor responsible for the CALIPSO underestimation. This is demonstrated in the manuscript by making comparisons using two different and independent sensors (AERONET, MODIS) and by applying a large number of rather conservative filters and consistency checks.

"Applying S=58 to the retrieved aerosol backscatter implies a multiple scattering factor of 0.7. This is similar to the multiple scattering factor for cirrus particles – which are much larger than dust particles – and seems unrealistically small. This is a topic requiring further research which would benefit from some direct validation".

We agree that more research is needed on estimating the multiple scattering factor for dust. At the moment there are strong indications from SAMUM measurements and from Wandinger et al. (2010) paper that particles of effective radius ~6 μm can cause multiple scattering factors of the order of 0.7. Such factors may account for the difference between the 40 and 58 sr LR, in particular when the bias is observed only in the extinction but not in the backscatter profiles. In any case, the value of 0.7 may, in reality, be small for dust. However, the particular value is just a result coming from the need to justify the difference between possible ground-based LR overestimation and/or CALIPSO LR underestimation. Other factors may be responsible for the 40 sr assumption of CALIPSO for dust. We prefer in our work to use the direct measurement of 58 sr, since there is strong evidence that this optimizes the product when compared with other sensors.

"Regarding some of the other comparison studies cited:

Version 3 had major changes to aerosol products relative to Version 2, so the results shown in Kittaka et al are not very relevant to the quality of the Version 3 product.

Regarding the discussion of Ma et al. (2012), I hesitate to cite papers in discussion as they are not yet reviewed and subject to change. Ma et al compute average AOD from the 5-km AOD and find larger biases than in Winker et al (2013), where AOD is computed from the averaged extinction profiles. As mentioned by Anonymous Reviewer #2, calculation of AOD by integrating 5 km columns and then averaging tends to be biased low due to data removed by filtering and screening. AOD calculated from the average extinction profile is more representative and tends to agree better with MODIS AOD".

We agree. The Kittaka and Ma references have been removed. The AODs reported in our work are now calculated by integrating averaged extinction profiles.