## Response to Anonymous Referee #3

The authors would like to thank Anonymous Referee #3 for his/her comments. Below, please find our response to each one of the referee's comments:

1) 3.1.1, p8: different hypothesis are given in order to explain the respective overestimation and underestimation of the dust load in the datasets in the different regions. First, the fraction of fine and coarse particles that could permit to the dust to be transported further from the sources if the dust are considered as too fine in the model. It might be interesting to compare these fractions of fine/coarse mode with some climatological value given by the AERONET retrievals at some key stations (even though this won't say how, in the column, varies this fraction).

We thank the reviewer for his/her comment. Unfortunately, extinction data are not available from MACC for the single species/bins. Only mixing ratios in different species/bins have been saved. From those it would be indeed possible to calculate the extinction and then the DOD taking into account the optical properties for dust that were used in the MACC model. However, that would require a lot of post-processing of the raw data which might be a task for a future study. This would also fit future developments of the satellite-based dataset used here (coarse/fine mode retrievals).

2) 3.1.1, p8: another hypothesis given by the authors is the limited sensitivity of CALIOP, as mentioned especially daytime, for detecting small amount of dust. Do you think that the statistics would be significantly different using only night-time Lidar data?

We thank the reviewer for giving us the opportunity to clarify this. We are currently not sure if the statistics would be significantly different between day and night datasets as this depends on both the model and the satellite-data.

In LIVAS clear-sky dust product, similar values are observed above Europe for the day and night means. On the contrary, slightly smaller mean seasonal values are observed during daytime above the northern part of Africa and in particular between [20ºN, 30ºN]. For that reason, we might see somehow different statistics between the model and the observations in a day/night inter-comparison.

In addition, the new version 4 of CALIPSO product, with a new enhanced calibration approach, is documented to provide more accurate retrievals. In particular, V4 night-time calibration coefficients coincident with HSRL measurements were found to agree within ~1.6%±2.4% in V4, reduced from 3.6%±2.2% in V3 (Kar et al. 2018). Furthermore, from preliminary studies in our group, we know that the new V4 product includes layers that were undetected in V3 and we are still investigating their contribution in the total dust load.

We acknowledge that a future extension of this work with the new V4 and with daytime / nightime separation could add on this work and provide feedback on which part of the documented differences are due to the model and which due to the satellite.

Reference:

Kar, J., Vaughan, M. A., Lee, K.-P., Tackett, J. L., Avery, M. A., Garnier, A., Getzewich, B. J., Hunt, W. H., Josset, D., Liu, Z., Lucker, P. L., Magill, B., Omar, A. H., Pelon, J., Rogers, R. R., Toth, T. D., Trepte, C. R., Vernier, J.-P., Winker, D. M., and Young, S. A.: CALIPSO lidar calibration at 532 nm: version 4 nighttime algorithm, Atmos. Meas. Tech., 11, 1459-1479, https://doi.org/10.5194/amt-11-1459-2018, 2018.

3) 3.2.1: regarding the annual profiles, there is no mention about the associated uncertainty. Is it available from LIVAS product, and what is the confidence in the layer 4 observations (overestimation of the model) when one knows that CALIOP sensitivity is limited when the extinction is small?

We thank the reviewer for giving us the opportunity to clarify this in the revised manuscript. The associated uncertainty of LIVAS profiles is described in detail in Marinou et al. (2017). We rephrased the document in the end of section 2.2 in order to include the uncertainty of the product.

Regarding the confidence in the layer 4 observations affected from the limited sensitivity of CALIPSO in small extinction layers, we quote the recent publication of Tackett et al. (2018):

*"Several researchers have recently sought to characterize the optical depths of the aerosol layers undetected by CALIOP using collocated observations (Kacenelenbogen et al., 2011; Sheridan et al., 2012; Rogers et al., 2014; Thorsen and Fu, 2015; Toth et al., 2018) or independent retrievals (Winker et al., 2013; Kim et al., 2017). Exactly how these undetected layers affect the level 3 mean extinction is difficult to estimate given that the resulting underestimate depends on the magnitude of missing extinction and the frequency of non-detection. Answering this question is a topic for forthcoming level 3 aerosol product validation".*

Following the reviewer's comment we added a sentence in the document, in the end of section 2.2 stating that the documented bias of LIVAS product (-0.03 in comparison with AERONET and -0.02 in comparison with MODIS) may be attributed to the undetected aerosol layers of CALIPSO.

*"…The correction leads to an $AOD_{532}$ absolute bias of ~-0.03 compared to spatially and temporally collocated AERONET observations above Europe and North Africa while the corresponding biases for the standard CALIPSO product are much higher (~-0.10) (Amiridis et al., 2013). The bias is lower (~-0.02) when compared against spatially and temporally collocated MODIS satellite data.* ***This bias may be attributed to the undetected aerosol layers of CALIPSO (Kim et al. 2017).*** *In addition, the use of a new methodology for the calculation of the pure dust extinction from dust mixtures and an averaging scheme that includes zero extinction values for the non-dust aerosol types allow for further improvement of the LIVAS pure dust product (Amiridis et al., 2013).* ***The uncertainty of the LIVAS pure dust product, it is discussed in detail in Marinou et al. (2017). Overall, the uncertainty of the LIVAS dust seasonal profiles is < 54 % close to the surface and at high latitudes and < 20 % at high altitudes and for latitudes up to 45ºN.*** *"*

Reference:

Tackett, J. L., Winker, D. M., Getzewich, B. J., Vaughan, M. A., Young, S. A., and Kar, J.: CALIPSO lidar level 3 aerosol profile product: version 3 algorithm design, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-97, in review, 2018.

4) Technical corrections

We thank the reviewer for his suggestions. We have taken into account each one of them. The missing letters have been added to the subfigures in Fig. 3, the gray area has been removed from Fig. 8 in order to be consistent with Fig. 6 and the averaging period has been added in the caption of Fig. 2 stating that *"All the panels in this and the rest of the figures of the manuscript refer to the period 2007-2012*.".