Response to Anonymous Referee #1

The authors would like to thank Anonymous Referee #1 for his/her comments. Below, please find our response to each one of the referee's comments:

1) The structure of section 3 separates the DOD and profile evaluation from MACC and examines separately differences with CALIPSO at annual and seasonal scales. In principle this a reasonable approach. However as it is written and structured, the text has many repetitions accompanied by the same explanations. I would suggest to consider revising the structure of this section focusing eventually on the most interesting regions (or even merge regions in the discussion) and for each region then the authors could compare DOD and profiles at various time scales. This way they will avoid repeating the same discussion in different sections.

We thank the reviewer for his/her comment. We acknowledge that there were some repetitions and hence we did some changes in the text in order to improve this. However, we prefer to keep the basic structure of the manuscript with the discussion on an annual and seasonal basis separately as it is. The structure was thoroughly discussed by the co-authors when preparing the manuscript. We decided to do it this way as it makes it easier for the reader to find the information he/she needs. We first present the results for the annual patterns which is more generic and then go through a seasonal analysis which is more interesting for the more experienced readers in MACC and/or CALIPSO data. The sub-regions were selected not only with geographical criteria (close/away from the dust sources) but also in order to be consistent with previous studies in the area. The use of the specific sub-regions makes our results comparable to results from other studies (e.g. Tsikerdekis et al., 2017 where the LIVAS dataset is used for the evaluation of the RegCM regional climate model dust product) and hence we would prefer to include all of them in the discussion.

2) In addition, in the discussion many differences are attributed to possible modelling issues related to the assimilation or model parametrization in a very generic way, and the text as written lacks justification and seems speculative.

We thank the reviewer for giving us the opportunity to clarify this. The authors have gone through a detailed discussion about the reasons that might affect the bias between the reanalysis (model) and satellite-based data. We agree with the reviewer that one cannot be sure how the assimilation or the different parameterizations might affect the data quantitatively. As mentioned in the text and discussed in Ansmann et al. (2017) "…the uncertainties stemming from the complex parameterizations used by the model make it difficult to reach a solid conclusion about the observed overestimations and underestimations…". A different kind of analysis with simulations with and without assimilation of aerosol data and with the use of different model parameterizations could give some answers. A Monte Carlo approach might be useful in that case. However, this would be a good idea for a future focused study.

3) Figures 2, 3 and 5. The color scale used makes the figures hard to read, especially for values close to zero. The authors should consider choosing a different color scale.

We thank the reviewer for helping us to improve our figures. We updated the color bars by using brighter colors in Figs, 2,3,5 and 7. It is easier for the reader to discriminate the near zero values now.

4) Page 4 line 7. What do the authors mean by “if used properly”.

"Properly" means that one should focus on altitudes higher than 1 km as sea salt particles in the area are mostly accumulated within the marine boundary layer, generally at heights below 1 km. Hence, sea salt is expected to have an impact only at the lower levels of the natural aerosol profiles and one might claim that the natural aerosol profiles are equal to dust profiles. We acknowledge that this phrase might puzzle the reader here and hence we removed it in the revised version of the manuscript.

5) Section 2.1 It is not clear how the assimilation of MODIS data is associated with the dust product and the natural aerosol product. Please provide more information here because this info is later used in the discussion of the results.

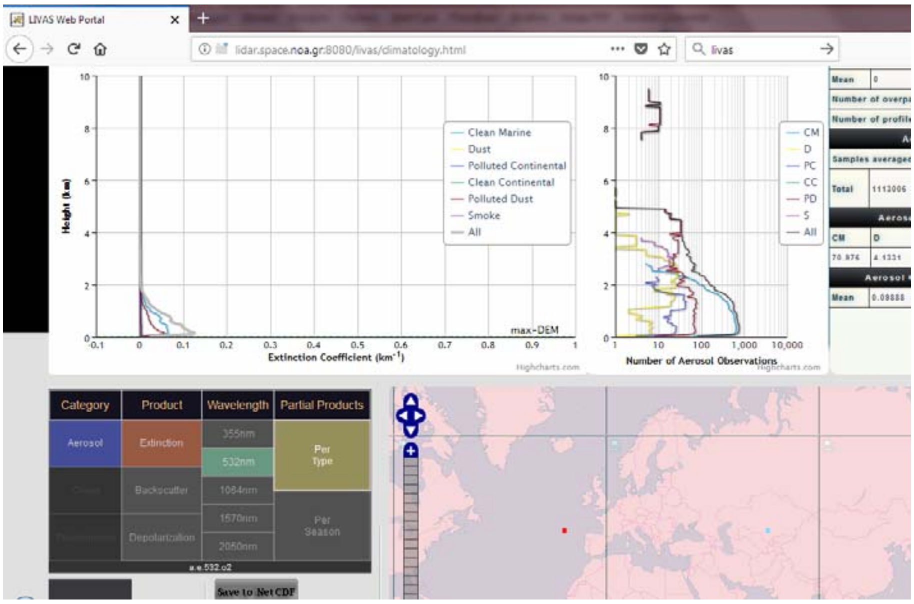
A detailed explanation of how the aerosol data assimilation works within MACC is given in the fourth paragraph of Sect. 3.1.1. *"…The control variable of the assimilation is the total aerosol mixing ratio calculated by adding the mixing ratios of all species. The AOD550 is calculated from the single species, summed, integrated and then compared to the observations. Through the 4D-Var assimilation algorithm increments in total aerosol mixing ratio are obtained. Those increments are redistributed to all species proportionally to their fractional contribution to the total mass. It has to be noted that the model does not take into account ammonium nitrate aerosols which represents a large component over the greater European area (Giordano et al., 2015). As a result the model will most of the time underestimate AOD relative to the observations and hence the assimilation system will tend to increase the other aerosol components to give the correct AOD overall. Probably, the system allows the presence of dust even at tiny concentrations and so dust always receives a small contribution during the assimilation even when there should be no dust in the atmosphere…"*

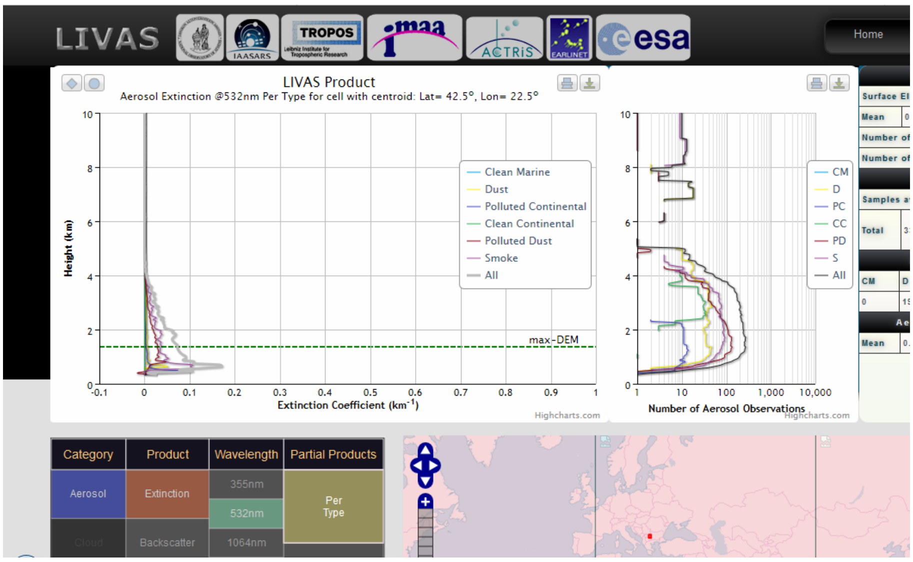
6) Section 2.3 (page 5, line 30). Why the authors interpolate the model levels to 399 LIVAS levels and then regrid vertically with 300m resolution instead of first converting LIVAS to the 60 MACC layers and directly average then vertically over the four 1800-meter layers? Why did they choose 1800m? The authors should justify better why they think this way they obtain more robust statistics.

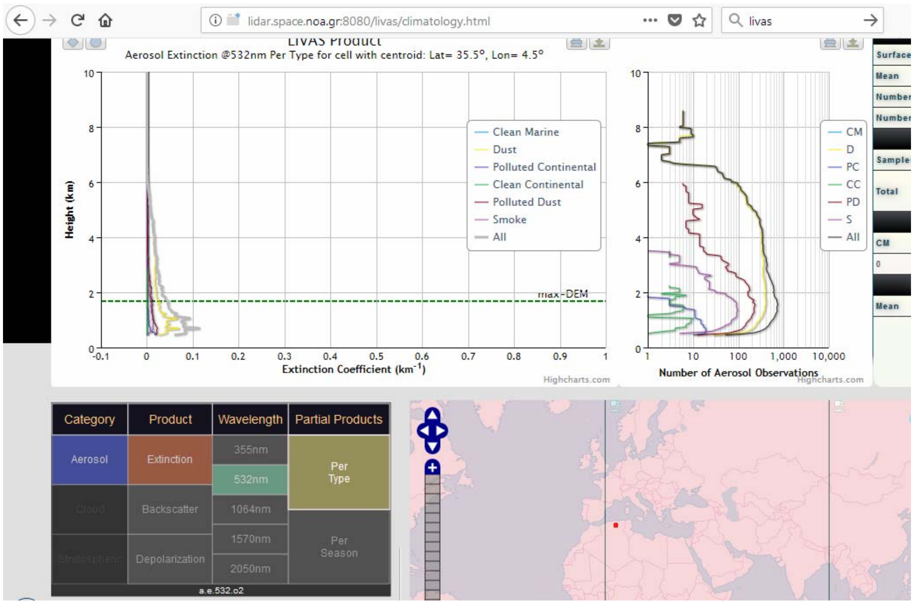
We thank the reviewer for giving us the opportunity to clarify this. The data from LIVAS are much more detailed as they report an extinction coefficient every 60 m for heights below 20 km. The MACC data characterize much broader vertical layers. The authors decided to bring the model data closer to the observations than doing the opposite. By interpolating the MACC data to the LIVAS levels we preserve the detailed vertical features from LIVAS which would not otherwise be possible. These data are available for future use; however, they are difficult to be used in figures. Therefore, we decided to average on a 300 m basis following Cuevas et al. (2015). In fact the vertical interpolation procedure we followed is similar to the interpolation suggested by Cuevas et al. 2015). To generalize our results we then chose four 1800 m layers. 1800 m allows for covering the first 9 km where this study focuses following also the reasoning of Marinou et al. (2017). The first layer starts from 1200 m and hence we manage to avoid contamination from sea salt particles.

7) Section 2.3 (page 6, lines 7-15) Are there any estimates how much is the contribution of marine aerosols in the natural aerosols above 1km?

We thank the reviewer for his question. It depends mostly on the region. Over the ocean, the contribution is dominant as expected; however, over continental regions, the contribution is nearly zero. We present here three different figures for three different sites from the LIVAS climatology which can be found on http://lidar.space.noa.gr: 8080/livas. As shown in Fig. 1, over the oceanic region, marine aerosols have some contribution above 1km (most of it resides below) while for the other two regions the contribution of marine aerosols is near zero regardless the height. In addition, in Fig. 1 the clean marine component is found to be close to polluted dust component below 1 km. Similar results are shown in Nabat et al. (2013) (fig. 9). For the oceanic region shown here the clean marine extinction above 1200 meters (layer 1 lower boundary) is ~50% of the extinction below this height.




LIVAS
Home
LIVAS Product
Aerosol Extinction @532nm Per Type for cell with centroid: Lat= 42.5°, Lon= 22.5°
Height (km)
Extinction Coefficient (km⁻¹)
max-DEM
Clean Marine
Dust
Polluted Continental
Clean Continental
Polluted Dust
Smoke
All
Number of Aerosol Observations
CM
D
PC
CC
PD
S
All
Category
Product
Wavelength
Partial Products
Aerosol
Extinction
355nm
532nm
1064nm
Backscatter
Per Type


lidar.space.noa.gr:8080/livas/climatology.html
livas
Aerosol Extinction @532nm Per Type for cell with centroid: Lat= 35.5°, Lon= 4.5°
Height (km)
Extinction Coefficient (km⁻¹)
max-DEM
Clean Marine
Dust
Polluted Continental
Clean Continental
Polluted Dust
Smoke
All
Number of Aerosol Observations
CM
D
PC
CC
PD
S
All
Category
Product
Wavelength
Partial Products
Aerosol
Extinction
355nm
532nm
1064nm
1570nm
2050nm
Backscatter
Depolarization
Per Type
Per Season
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