Anonymous Referee #2

General comments:

This paper presents a 3D multi-wavelength global aerosol and cloud optical climatology, LIVAS, based on multiple approaches. Such a database is useful and needed for the simulation, performance evaluation, and testing algorithm of future space lidar measurements. I suggest the paper is published after revisions are made.

In this study, the derivation of the factors that convert the CALIPSO backscatter and extinction measurements at 532 nm to other wavelengths is a key, where more discussion and work can be done. The LIVAS aerosol models are compared with the CALIPSO aerosol models. Comparisons are presented in Figures 2 and 7 and the authors conclude on page 2267 that "Overall, we found that the LIVAS and CALIPSO aerosol models agree only for the polluted continental aerosols, whereas for the rest of the aerosol types the LIVAS model to be closer to the ESA-CALIPSO measured value than the CALIPSO model." This conclusion does not seem to be fully supported by Figures 2 and 7. For the modeled lidar ratios at 532 nm for the four aerosol types (polluted continental, smoke, dust, and polluted dust) where the ESA-CALIPSO measurements are available (lower left panel in Figure 7), CALIPSO produces closer model values than LIVAS, except for 'polluted continental' where the CALIPSO modeled value is larger than the ESA-CALIPSO measured value only by 10

Although the ESA-CALIPSO measurements are not available at 1570 nm and 2050 nm that the authors can make comparison to, there seem to be other references that the authors can reference to. The two references given in below model the backscatter at 2.1 um for the space or air borne lidar application and the authors can make comparison with these studies.

1. Srivastava V, et al., Wavelength dependence of backscatter by use of aerosol microphysicsandlidardatasets:applicationto2.1-mm wavelength for space-based and airborne lidars. Appl. Opt. 2001; 40(27): 4759–69.

2. Wu D, et al, Simulation of coherent Doppler wind lidar measurement from space based on CALIPSO lidar global aerosol observations, Journal of Quantitative Spectroscopy and Radiative Transfer 122, 79-86.

We thank the reviewer for these suggestions. Unfortunately, the work of Srivastava et al. (2001) and Wu at el., (2013) do not provide optical data for aerosol types that have a direct correspondence to LIVAS aerosol types.

Minor comments

1. Page 2253, line 1: "The horizontal resolution of CALIPSO is. . .", the vertical resolution at 532 nm is 30 meters from the surface to 8.2 km.

This is correct; we thank the reviewer for pointing it out. We changed the MS accordingly: "The horizontal resolution of CALIPSO is 1/3 km while the vertical resolution is 30 m in the tropospheric region (between the surface and 20 km) and 180 m in the stratospheric region (between 20 and 30 km)."

2. Page 2253, line 11: "according to layer type and sub-type" can be deleted.

It is deleted in the MS.

3. Page 2253, line 13: ". . .using an assumed lidar ratio (LR) for each detected aerosol layer" is not really true. When clear air is available both above and below a layer, the transmittance constrained retrieval is applied in the CALIPSO standard data processing (see Young and Vaughan, 2009).

We included this in the MS, by changing the phrase to : "…using an assumed lidar ratio (LR) for each detected aerosol layer (the lidar ratio is calculated only in cases when clear air is available both above and below a layer (Young and Vaughan, 2009))".

4. Page 2254, line 1: "and two nighttime measurements per week with low background light in order to perform Raman extinction measurements", does this mean that the retrieval of extinction is not available for the daytime measurement? It would be useful to provide a list of primary parameters that EARLINET can measure during day and night.

The EARLINET products range for different stations and the respective parameters are given in Table 1 of Pappalardo et al., 2014. We provide in the new version of our MS the appropriate reference (Pappalardo et al., 2014)

5. Page 2256, line 25: "The definition of representative size distributions and refractive indexes for the CALIPSO aerosol types is not a straightforward task, mainly due to inaccuracies in the CALIPSO classification scheme" is hard to understand what this statement really means. There seem to be two issues involved – modeling aerosols and identifying aerosol type, which do not seem to necessarily correlate each other. Why the definition (modeling) of size distribution and refractive indexes are impacted by the CALIPSO classification. More explanations is needed.

What we mean to say here, is that since for LIVAS model we need to calculate the backscatter and extinction angstrom exponents (BAE and EAE) assuming that the CALIPSO aerosol types are representative of the aerosols observed, any inconsistencies in the CALIPSO classification scheme introduce inaccuracies in our results. We tried to clarify this by changing the paragraph in the MS: "The construction of representative size distributions and refractive indexes corresponding to the CALIPSO aerosol types is not a straight-forward task. Aerosol classification for CALIPSO is based on a threshold algorithm that takes into account the layer-integrated attenuated backscatter coefficient and an approximate particulate depolarization ratio as well as the surface type (either land or ocean; Omar et al., 2009). However, these properties do not provide all the information needed for unambiguously classifying the natural aerosol types and, as a result, misclassifications occur frequently (e.g. Burton et al., 2013). Since for LIVAS model we need to calculate BAE and EAE assuming that the CALIPSO aerosol types are representative of the aerosols observed, any inconsistencies in the CALIPSO classification scheme introduce inaccuracies in our results."

6. Page 2257, line 9: "Although the proposed classification is assumed to correspond to the independently derived CALIPSO aerosol types, this is not true for all cases, mainly due to the different nature of AERONET sunphotometer measurements versus CALIPSO lidar measurements used for the categorization." Once again, two issues – how to develop aerosol models that are most representative of the natural aerosol types and how to identify these aerosol types, which should be discussed separately.

Our intention here was to provide reasoning for not using the CALIPSO aerosol model for calculating LIVAS BAE and EAE. The reason is that the CALIPSO aerosol model, irrespectively of whether or not is representative of the aerosols observed, does not correspond always to the CALIPSO aerosol types. We tried to put this across by adding the following phrase at the end of the paragraph: "This is the reason we do not use it for the calculation of LIVAS BAE and EAE." The two issues mentioned by the reviewer (the development of the aerosol model for CALIPSO and the CALIPSO classification itself) are thoroughly analysed in the next paragraph included in our MS.

7. Page 2258, line 22: "more than 500 aerosol layers. . ." correspond to how many CALIPSO orbits?

We have chosen more than 500 well identified layers from different aerosol types. Each one corresponds to one CALIPSO overpass.

8. Page 2260, line 23: "We considered that the non-spherical particles of dust and polluted dust have the same aspect ratio distribution . . ." for the coarse mode only, non-spherical particle only, or entire size range?

We used the same aspect ratio distribution for the entire size range. We make this clearer in the MS by changing the phrase to: "We considered that the non-spherical particles of dust and polluted dust over their entire size range have the same aspect ratio distribution…"

9. Page 2261, line 14: "The dataset is not constrained with ESA-CALIPSO as in the AERONET-Omar approach." it would be useful to clarify for what wavelengths here or somewhere in this section.

We clarified it by changing the phrase to: "The dataset is not constrained with ESA-CALIPSO as in the AERONET-Omar approach for the UV/VIS wavelengths."

10. Page 2261, line 18: OPAC Section, it would be useful to refresh readers' memory about why this approach is necessary and for what wavelengths it is applied.

We added in the section: "Since for the clean continental aerosol there is little to no information from AERONET and EARLINET we have to rely on models to derive LIVAS BAE and EAE."

11. Page 2262, section 3.1.3: in this section, the LIVAS aerosol models (which appear to be the AERONET-CALIPSO models) are evaluated again ESA-CALIPSO database and AERONET-Omar aerosol models. One sentence on page 2262 states "We believe that the discrepancies in backscatter spectral dependence observed for most of the aerosol types in the AERONET-Omar approach are most likely due to the fact that AERONET lacks the capability to directly measure in the backscattering direction." I am confused here. Were the AERONET-CALIPSO approach by Schuster also based on the AERONET retrieval? Was there any other retrieval and/or measurement used in the development of AERONET-CALIPSO models? It would be helpful to clearly point out the difference between the AERONET-Omar and AERONET-CALIPSO approaches (models).

Just to clarify, the LIVAS aerosol model is the same with the AERONET-CALIPSO model only for dust, polluted dust and smoke types (see Table 1 the column "approach used").

We agree with the reviewer that the text is somewhat confusing. It is true that both AERONET-Omar and AERONET-CALIPSO approaches utilize AERONET data, the difference between the two methods is the selection of the AERONET data. For this reason we changed the MS accordingly (page 2263, line 2): "The approach shows a relatively better agreement with ESA-CALIPSO compared to the AERONET-Omar approach, especially for the backscatter-related conversion factors, maybe due to better filtering of the AERONET data used in the calculations for the AERONET-CALIPSO approach (Figure 2). Overall though, we believe that the discrepancies in backscatter spectral dependence observed for most of the aerosol types are most likely due to the fact that AERONET lacks the capability to directly measure in the backscattering direction. Comparisons found in the literature between Raman-lidar-measured and photometer-retrieved lidar ratio, support this argument (e.g. Mueller et al., 2007)."

12. Page 2263, line 2: ". . ., we choose the AERONET-CALIPSO approach for the calculation of their conversion factors. The approach shows a relatively better agreement with ESA-CALIPSO compared to the AERONET-Omar approach, especially for the backscatter-related conversion factors (Fig. 2)." better agreement for backscatter only, isn't it? Should the *selection of the model/approach be based on backscatter or extinction? It is useful to discuss this somewhere in the paper.*

The LIVAS database is adapted to lidar space applications, thus our main focus is the conversion of the backscatter measurements.

13. Page 2263, line 8: "ESA-CALIPSO provides intensive properties for mixtures of dust with polluted continental, smoke and marine aerosol separately" I think this is really interesting and the right way to go!

14. Page 2263, line 21: "These findings indicate that the CALIPSO smoke classification may not correspond to real smoke presence, thus the properties of this CALIPSO classification category may not be comparable with real smoke detections by ESACALIPSO. Thus, we prefer to use the calculations for CALIPSO smoke coincidences (AERONET-CALIPSO approach), ignoring the ESA-CALIPSO smoke statistics." confusing. Is this because the classification of the ESA-CALIPSO database is based on the CALIPSO standard classification which can be wrong for smoke? Note that even though CALIPSO can misclassify smoke, it does not mean the CALIPSO smoke model is not acceptable. The logic here is not very convincing.

We need to clarify here that the ESA-CALIPSO classification scheme is not based on CALIPSO classification scheme, but on the aerosol optical properties measured with the lidar as well as atmospheric state parameters and source-receptor calculations through air-mass transport models.

What we intended to say here is that we consider the ESA-CALIPSO smoke model closer to real smoke, whereas the one provided from CALIPSO is most probably closer to an "unknown type", considering the findings presented in Burton et al. (2013), where the CALIPSO classified smoke was not in correspondence with airborne HSRL classifications. For this reason we cannot use the ESA-CALIPSO data to evaluate the BAE and EAE for the conversion of the CALIPSO data for this "unknown type". We clarify this more in the MS by changing the phrase to: "These findings indicate that the CALIPSO smoke classification may not correspond to real smoke presence. For this reason, it may not be comparable with real smoke detections by EARLINET used for ESA-CALIPSO classification model, which is based on source-receptor analysis based on model simulations of air mass advection over the stations, together with the aerosol optical properties measured by the lidar that are used for aerosol characterization. Thus, for the smoke type we avoided to use the ESA-CALIPSO smoke statistics."

15. Page 2264, section 3.1.4: please see my general comments. This section discusses intensively on the spectral properties calculated and measured. It should also discuss in more detail about the lidar ratios calculated at 532 nm and explain why the AERONET-Omar approach can produce lidar ratios at 532 nm closer to the measurement than LIVAS does.

Also simulations should be done to examine the dependence of the scattering calculation on the refractive index.

LIVAS aerosol model is focused on producing BAE and EAE consistent with ESA-CALIPSO measurements. This is because, as shown in Figure 7, the CALIPSO aerosol model fails to do so, especially for the backscatter. The lidar ratio is not used in LIVAS and it is only provided here for reasons of completeness. We highlight this in the MS by adding (page 2266, line 19): "We need to highlight here that our focus in evaluating LIVAS model is the BAE and EAE consistency with the ESA-CALIPSO measurements. The lidar ratio and effective radius are not used in generating LIVAS database and are only provided here for reasons of completeness. More work is needed to develop an aerosol model oriented for space-borne lidar applications."

16. Page 2267, line 26: "In brief, we classify stratospheric features as Polar Stratospheric Clouds (PSCs) when the temperature is lower than 198 K, while features of higher temperatures are classified as stratospheric aerosols. The separation is applied only for stratospheric features at latitudes greater than 54N and less than -54S, while for the latitudes in between, the stratospheric features are considered as aerosols." I think it is highly risky to classify stratospheric aerosol this way. I would expect more cloud layers than aerosol layers in the stratosphere that can be detected by the CALIPSO feature finding algorithm.

We agree with the reviewer. A lot of work has been done on the PSC/aerosol stratospheric feature classification and has been published by Pitts et al., (2009). In order to achieve a reliable classification in the stratosphere, more information is needed in terms of meteorological parameters, as suggested also by Pitts et al. This is a very crucial comment that should be taken into account for the next LIVAS version and optimizations planned for the future. We added a sentence in our MS to make this clear, specifically: "This classification is not considered reliable enough and has been included in LIVAS in order to provide only a rough estimate of the stratospheric aerosol loads detected by CALIPSO. More efforts will be needed in the future for achieving a trustworthy separation of different stratospheric features. As proposed by Pitts et al. (2009), the utilization of L1 CALIPSO product in synergy with L2 may provide a more reliable discrimination."

17. Page 2271, line 13: "The map provides only positive biases (absolute values)" can be changed to "The map provides only the magnitude of biases" or something like that.

We changed the phrase to: "This map provides only the magnitude of biases…"

18. Page 2273, line 16: "This can be attributed to errors introduced due to the extrapolation of the AERONET AOD in the IR (note that we use AERONET AOD measurements at 440, 670, *860 and 1020 nm), and/or to uncertainties introduced by the LIVAS conversion scheme in the IR." What about the AERONET-Omar models? It would be interesting to take a look.*

Indeed, this would be interesting to investigate, but unfortunately, requires processing the 4-year database of ~10TB from the beginning and this is difficult to be implemented for this MS.

19. Page 2275, line 3: "However, the LIVAS aerosol model found to be more consistent with ESA-CALIPSO but also the relative literature than the one used by CALIPSO for the VIS-UV spectral region." Is it only true for backscatter conversion factors?

Yes, the reviewer is right. We revised as: "However, the LIVAS aerosol model found to be more consistent with ESA-CALIPSO but also the relative literature than the one used by CALIPSO for the UV-VIS spectral region, especially for the BAE."