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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Use of the CALIOP vertical feature mask for evaluating global aerosol models" *by* E. P. Nowottnick et al.

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This work incorporates some very good ideas on using the CALIPSO aerosol classification to evaluate a global aerosol model (here the MERRAero model). Some points in the analysis though need some elaboration before the paper is published in AMT. First, it should be explicitly stated that the CALIPSO VFM is not constructed for aerosol classification, but for estimating the lidar ratio used in the CALIPSO backscatter and extinction retrieval. In terms of aerosol classification, the CALIPSO VFM is of good accuracy only for the dust type. The recent validation effort of Burton et al. (2013) (using collocated airborne High Spectral Resolution Lidar (HSRL) measurements during 109

CALIPSO under-flights) shows an agreement of 80% for dust particles and 62% for marine, 54% for polluted continental, 35% for polluted dust and only 13% for smoke. Include this result in the general context of your work and use it in the discussion of your conclusions.

We thank Reviewer #3 for their comments and suggestions. In our Introduction we state the purpose of the CALIOP VFM: "The practical application of the CALIOP VFM is to assign an appropriate lidar ratio for each detected aerosol layer in order to compute aerosol extinction profiles from the attenuated backscatter signals, extinction being more directly comparable to model fields than attenuated backscatter (Omar et al. 2009)." We also cite Burton et al., 2013 and include their results in our Introduction and Conclusions as justification for focusing on the dust component of the VFM.

Individual points for revisions are provided below.

Page 1405, lines 19-22, "Despite. . . timescales": I am not aware of any work on using CALIPSO VFM to evaluate global aerosol models, but the CALIPSO VFM has been evaluated in various studies. Please mention at least the work of Burton et al. (2013) (Burton, S. P., Ferrare, R. A., Vaughan, M. A., Omar, A. H., Rogers, R. R., Hostetler, C. A., and Hair, J. W.: Aerosol classification from airborne HSRL and comparisons with the CALIPSO vertical feature mask, Atmos. Meas. Tech., 6, 1397-1412, doi:10.5194/amt- 6-1397-2013, 2013.), including their conclusions presented in the beginning of this review. Moreover, you should change appropriately your conclusions.

In our introduction we now cite Burton et al., 2013: "Recently, Burton et al. (2013) evaluated CALIOP VFM aerosol typing using High Spectral Resolution Lidar (HSRL) under-flights and good agreement (80%) between CALIOP and HSRL typing for desert dust aerosols, however, there was significantly less agreement between CALIOP and HSRL for other aerosol types.". . ." We focus our analysis to July 2009 over and downwind of the dust laden Sahara, which is dominated by the VFM aerosol type (desert dust) that had best agreement with AERONET (Mielonen et al., 2009) and HSRL (Burton et al., 2013)."

Additionally, we cite additional studies that have evaluated the VFM and clarify that as far as we know, we are the first to use the VFM to evaluate a global model on monthly time scales.

Page 1417 lines 3-13, "Downwind. . . (r2=0.584)": It does not seem that MERRAero AOD is of high accuracy. What is the impact of this? Please comment.

At our comparisons to AERONET downwind, the observations are displaying diurnal variability that is not captured in MERRAero, as MERRAero benefits from twice-daily MODIS observations at nearly the same time. We was verified by comparing daily averaged AERONET and MERRAero AOT, which led to an improved correlation. Despite missing this diurnal variability, which reduces r2, the MERRAero captures the timing of passing aerosol events at both locations.

Page 1417 lines 14-16, "In Fig. 3. . . by CALIOP": In Figure 3 the latitude range (0o -40o) does not include higher latitudes where we expect bigger variability. Provide a better test by extending the latitude range of the comparison in Figure 3 and discuss the results.

We have extended our latitude range to 10S-50N. Comparing CALIOP and MERRAero at this latitude range, we find that MERRAero transports slightly more dust to the north and south when compared to CALIOP. We include these findings in the manuscript.

Page 1418 lines 6-15, "Figure 3... North Atlantic": The high extinction values of CALIPSO Level 3 extinction product at low altitudes have been evaluated from Amiridis et al. (2013) (Amiridis, V., Wandinger, U., Marinou, E., Giannakaki, E., Tsekeri, A., Basart, S., Kazadzis, S., Gkikas, A., Taylor, M., Baldasano, J., and Ansmann, A.: Optimizing CALIPSO Saharan dust retrievals, Atmos. Chem. Phys., 13, 12089-12106, doi:10.5194/acp-13-12089-2013, 2013.). Include their findings here and change your conclusions accordingly (change them also in page 1430, lines 4-14: "Vertically. . .

marine aerosol.")

We cite Amiridis et al., (2013) in Section 3.3: "Recently, Amiridis et al. (2013) found that these low-level 'dust' features are related to the CALIOP feature detection and averaging scheme, which cannot separate non-dust aerosol layers from dust layers if they are located at the same altitude and will classify the entire altitude range as desert or polluted dust."

and modified our Conclusions: "Vertically. . .. This finding is consistent with Amiridis et al., (2013) and highlights the importance of correctly identifying aerosol type when converting the backscatter to extinction via the lidar ratio."

Page 1420, lines 24-29, "Comparing. . . (Fig. 4b – feature C)": The presence of clouds and the subsequent attenuation of the CALIPSO signal in parts of this scene is very prominent. The cloudy profiles should be excluded from the analysis, since the attenuation of the signal is possible to introduce uncertainties in the layer identification and the aerosol typing from CALIPSO. If you choose to keep the profiles, please provide a proper justification.

In Figure 5 we only plot cloud and subsequent attenuated profiles for a more complete depiction of the scene, as omitting these profiles would introduce large gaps in the VFM. In our large-scale monthly analysis, however, we omit all cloudy profiles as suggested. We have also modified the text to discuss how including cloudy profiles could impact layer identification: "In an effort to avoid cloud attenuation impacts on layer identification, we only consider cloud-free VFM profiles that contain aerosols for our monthly analysis."

Page 1420, line 29 and page 1421, lines 1-10, "Comparing... biomass burning": At higher altitudes the MERRAero estimated particulate depolarization ratio does not follow not only the CALIPSO volume depolarization ratio but also the MERRAero extinction coefficient. Furthermore, the MERRAero estimated particulate depolarization ratio of feature "A" seems to be much higher than the corresponding one from CALIPSO (this interpretation is by looking at the CALIPSO volume depolarization ratio, since the CALIPSO estimated particulate depolarization ratio is not provided in the figures). In order for this comparison to be more straightforward, you should include two figures for both CALIPSO and the MERRAero particulate depolarization ratio for this scene. This way any sources of discrepancy will be more obvious to the reader. Please comment and justify the discrepancies.

For these figures, we are plotting CALIOP L1B total attenuated backscatter and volume depolarization ratio that we compute from the perpendicular/parallel signals. Because the particulate component is not provided in these files, we plot the MERRAero volume depolarization ratio for a more consistent comparison between MERRAero and CALIOP for this case.

Page 1423, line 29 and page 1424, line 1, "These differences. . . types": They have to do also with the microphysical properties considered for the different aerosol components from MERRAero versus the ones considered for each aerosol type from CALIPSO. Please include this remark.

This is a good point. We have added to the text: "While MERRAero and CALIOP Sa and SSA values are sensitive to assumed physical and optical properties, their differences also highlight the challenge of mapping MERRAero aerosols to the CALIOP aerosol types."

Minor revisions: Page 1410, lines 10-15, "It should be noted. . . (Omar et al., 2009)": Include also the error reported for the particle depolarization ratio CALIPSO product from Tesche et al. (2013) (Tesche, M., Wandinger, U., Ansmann, A., Althausen, D., Müller, D., and Omar, A. H.: Ground-based validation of CALIPSO observations of dust and smoke in the Cape Verde region, J. Geophys. Res., 118, 1–14, doi:10.1002/jgrd.50248, 2013.)

We cite this study in our Introduction as one that has evaluated the CALIOP VFM, however, when mimicking the CALIOP VFM algorithm we use the estimated particu-

late depolarization ratio rather than the particulate depolarization ratio as discussed in Omar et al., 2009.

Page 1413, lines 14-16, "Therefore. . . by 30% for our analysis": Increasing the depolarization ratio by 30% is somehow arbitrary. Moreover, since the dust depolarization is not reproduced well, you should make a comment on what happens with its backscatter and extinction coefficients.

Reviewer #2 also made this point. We scaled our depolarization ratio to match observed depolarization ratios for Saharan dust, as we suspect that we do not correctly represent dust non-sphericity in our spheroid model. We have used observation-based refractive indices for dust that have been shown to compare well with MODIS, AERONET, and CALIOP observations (Colarco et al., 2014a). Our use of non-spherical particles yields a realistic lidar ratio (40 Sr) despite the need to adjust our depolarization ratio. If we had used a spherical model for dust, we would have less backscatter and subsequently a lower lidar ratio ($\sim$20 Sr) and would have to assume a depolarization ratio for dust. So, while it is unfortunate that we cannot directly simulate observed dust depolarization ratios using our non-spherical dust model, our dust optical model produces realistic extinction to backscatter ratios.

Page 1423, lines 8-12, "For example. . . respectively": In Table 2 the percentage is 75%, is this a mistake?

No, this is the fraction required from a single aerosol species or aerosol mixture to be mapped to a CALIOP VFM type. For example, in order to flag marine we require that sea-salt contribute at least 75% to the total extinction as we consider another aerosol present if there is a contribution that exceeds 25%.

Page 1423, lines 23-26, "In Table 3. . . Omar et al., 2009)": This is not true for dust. Omar et al. (2009) used the discrete-dipole approximation technique to calculate the optical properties of dust particles. Please correct.

Thank you. We have noted this in the text.

Page 1426, lines 17-18, “In an effort... analysis”: As indicated for Figure 4 as well, you should maybe consider excluding the cloudy profiles from your analysis, since the attenuation of the signal is possible to introduce uncertainties in the layer identification and the aerosol typing from CALIPSO.

For our monthly analysis we now exclude cloudy profiles and have modified the text: “In an effort to avoid cloud attenuation impacts on layer identification, we only consider cloud-free VFM profiles that contain aerosols for our monthly analysis.”

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 1401, 2015.