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AMTD
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Interactive Comment

Interactive comment on "Surface matters: limitations of CALIPSO V3 aerosol typing in coastal regions" *by* T. Kanitz et al.

T. Kanitz et al.

kanitz@tropos.de

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Response on reviews for: 'Surface matters: limitations of CALIPSO V3 aerosol typing in coastal regions' (Kanitz, et al. 2014)

Response on RC C155, Comments from Franco Marenco

General:
It is well-known that the CALIPSO retrieval algorithms take into account the surface type as one of the basic criteria used to determine the aerosol subtype. Three decisions based on the surface properties are made in the CALIPSO decision tree:

(1) land vs. ocean; (2) snow/ice tundra vs. other type of surface; and (3) desert vs. other type of surface. Most aerosol classifications are possible both over land and over ocean (dust, polluted dust, biomass burning and polluted continental), whereas marine aerosol can only be selected over ocean and clean continental can only be selected over land. The aerosol subtype determines the lidar ratio, and hence the magnitude of the aerosol extinction coefficient. For a full description, see Omar et al (2009).

In the article by Kanitz et al, the effect of the land vs. ocean decision on CALIPSO retrievals is examined, in conjunction with the advection of marine aerosols over land. As expected, in this case a misrepresentation of the aerosols cannot be avoided, as the system is not allowed to use the marine subtype over land. The marine aerosol being the one that carries the lowest lidar ratio, the rather obvious consequence is that the extinction coefficient will be overestimated in this case. This could cause a bias in coastal regions.

Four hours of ground-based nighttime lidar data at Punta Arenas are compared to 1 minute of CALIPSO data. This site was chosen because it is influenced entirely by marine aerosols, and the region surrounding it can be subdivided into both land and sea areas, offering an opportunity to verify the effect of the switch in aerosol type at the coastline. Not surprisingly, CALIPSO's classification algorithm fails to represent the marine aerosols over land, and the layers receive a classification as polluted continental or biomass burning (in both cases with a lidar ratio 3.5 times larger).

In addition, four months of ground-based lidar data are compared statistically to AERONET, and the effect of changing the lidar ratio (LR) is tested, showing how the larger LRs can bring a bias in the lidar data. After this, one year of CALIPSO observations at Punta Arenas are used to estimate the frequency of occurrence of the different aerosol subtypes, showing that the aerosol classification shows an unreasonably infrequent selection of the marine subtype.

AMTD

7, C816–C824, 2014

After discussing Punta Arenas, the authors present four other similar patterns, in Mauna Loa, Tasmania, Ireland and Cuba. The effect of the discrepancies on solar radiation is also evaluated.

The research is of general interest, because CALIPSO is being used for global aerosol observations and climatologies, and the article is clearly written. I recommend its publication.

Specific comments:
1. Westerly advection at Punta Arenas is dominated by the synoptic wind (see the meteorological description in the paper, page 1338, lines 1-7), and is therefore not a 'sea breeze'. Replace this term with 'advection from ocean to land' (abstract and article text).
— adjusted in the abstract
'classification of sea–breeze–related marine aerosol over land' to 'classification of marine aerosol over land **that is advected from ocean to land**'
— adjusted in the text
'particle extinction coefficients over land within the sea breeze zone' to 'particle extinction coefficients over land within **the zone that is affected from advection from ocean to land,**'

2. Page 1335, lines 17-18: Ocean vs. land is not the only decision based on surface type in the aerosol classification scheme. Please briefly mention the other decisions based on surface type in the CALIPSO algorithms.
— adjusted in the text
'water/land' to '**e. g., snow and ice, desert, and water or land surface'**

3. Page 1338, lines 8-10: add 'and further downwind from Punta Arenas' after

AMTD
7, C816–C824, 2014

‘Atlantic coast’.
— adjusted in the text
’Rio Gallegos, Argentina at the Atlantic coast since November 2005’ to ’Rio Gallegos, Argentina at the Atlantic coast **, further downwind from Punta Arenas** since November 2005’

4. Page 1338, lines 20-21: the words ‘deficiencies’ and ‘corrupted’ are too negative. I suggest a less negative wording. These are well-known limitations of the instrument, and not corruption of the data.
— adjusted in the text
’had to deal with two deficiencies’ to ’had to deal with two **limitations** of the instrument’, and ’the bistatic system is corrupted by an incomplete overlap’ to ’the bistatic system is **affected** by an incomplete overlap

5. Section 2.2: The data analysis methods are unclear. Ideally, with a Raman lidar you would retrieve extinction and backscattering simultaneously and independently. However, lidar specialists are aware that the method may have limitations in daylight, and that other methods (e.g. Fernald-Klett) may have to be used at times. Some of the sentences suggest something like this, e.g. page 1339, line 5-6 stating that extinction is evaluated from backscattering using a lidar ratio (whereas for a Raman lidar it should be the other way around, and a LR should not need to be assumed). Clarify how the data are processed, and how this ‘appropriate’ LR is determined. Moreover, if the ground-based lidar permitted an evaluation of the LR of the marine aerosols, it would be very interesting to compare it against CALIPSO’s assumed LR of 20 sr.
— In our comparison with CALIPSO, we did not depend on the Raman technology. We used all available measurements during overflights of CALIPSO (day and night). For a consistent treatment of the data, we used the Fernald-Klett method to retrieve the AOT for Fig. 5 for all measurements to discuss them with the respective Klett-Fernald-

AMTD
7, C816–C824, 2014

solution applied to the data of CALIOP.
In addition, we compare the profiles of extinction coefficients of CALIPSO as determined over land and over ocean, which does not depend on the ground-based measurements.
However, in the frame of ALPACA lidar observation during nighttime were also analyzed with the Raman method and showed low lidar ratios in the upper PBL, indicating the presence of marine aerosol (note, the incomplete overlap in the lowest 400m prohibits the direct determination, see Sec. 2.2). Nevertheless, more appropriate observations for an overall comparison of the lidar ratios as used in the CALIPSO algorithm exist, e.g., Burton et al. (2012) and Groß et al. (2013).

— adding these references in the text
Section 1: 'and smoke (SP=70sr)(**details of the aerosol type identification in Fig. 2** Omar et al., 2009; Lopes et al., 2013). **These aerosol types and their lidar ratio have been subject of numerous field campaigns (e. g., Burton et al., 2012; Gross et al. 2013).**'

Burton et al. (2012): Aerosol classification using airborne High Spectral Resolution Lidar measurements - methodology and examples, Atmos. Meas. Tech., 5, 73-98, doi:10.5194/amt-5-73-2012, 2012.
Gross et al. (2013): Aerosol classification by airborne high spectral resolution lidar observations, Atmos. Chem. Phys., 13, 2487-2505, doi:10.5194/acp-13-2487-2013, 2013.

6. Page 1339, line 1: this sentence appears to be completely decorrelated with the rest of the paragraph.
— In Sec 2.2 we first describe the general capabilities of the instrument. Then, we introduce the two deficiencies during ALPACA. One is the necessary assumption in the PBL because of the overlap, the other one is the very low aerosol content, which

caused a too low SNR in the 355-nm channels and the 532-nm inelastic channel for a statistical investigation.

7. Page 1340, line 1: list all the CALIPSO aerosol subtypes.
— The aerosol subtypes are listed with the respective lidar ratios on page 1335, lines 18-21 (initial submission).

8. Page 1340, line 5: CAD score threshold should be -90 rather than 90 (probably a typo).
— typo corrected in the text

9. Page 1340, line 6: ‘contains particles’, change to ‘is likely to contain aerosols’:
(1) be possibilistic on the fact that the CAD score does a good job, and
(2) clouds also contain ‘particles’ (droplets), therefore ‘aerosols’ is more appropriate.
— substituted in the text as recommended

10. Page 1340, line 22: as before, replace ‘particle-free’ with ‘aerosol-free’
— substituted in the text as recommended

11. Page 1341, line 4: ‘gave’ ! ‘will show’; lines 6 and 7: ‘are’ ! ‘will be’; line 9: ‘we finish’ ! ‘we will finish’; line 12: ‘is presented’ ! ‘will be presented’.
— substituted in the text as recommended

12. Figure 3c-d and page 1342, line 3: the circumstance of aerosols below clouds should be tested at the stage of the initial data quality check. It would be advisable to discuss how the cloud affects the uncertainty on the underlaying aerosols.
— The effect of clouds was investigated and discussed before, e.g., Yang et al. (2012) and Varnai et al., 2013. In page 1342, line 3 (initial submission) we describe the observation in general. Later on in line 15, we point out that we only deal with

AMTD
7, C816–C824, 2014

cloud-free signals. We wanted to avoid further complicated discussions that have to consider the effect of clouds.

— adjustment in the text (Sec. 3.1)
Particle backscatter coefficients from CALIOP level 2 data for cloud-free signals were selected for the scene shown in Fig. 3d **to avoid an effect from cloud contamination in the data (Yang et al. 2012, Varnai et al. 2013)**.

Yang et al., 2012, Effect of CALIPSO cloud aerosol discrimination (CAD) confidence levels on observations of aerosol properties near clouds, Atmos. Res., 54, 742-753, doi:10.1016/j.atmosres.2012.03.013
Varnai et al., 2013, Multi-satellite aerosol observations in the vicinity of clouds, ACP, 13, 3899-3908, doi: 10.5194/acp-13-3899-2013.

13. Figure 3c and page 1342, line 10: it seems that the boundaries of the marine aerosols extend to more than just the region showing a water surface. This should however be impossible in CALIPSO. Please explain.
— In general, the distance of the applied horizontal averaging in the CALIOP data algorithm has to be considered ("within the distance of the horizontal averaging in the CALIOP data algorithm off the water surface“, page 1344, line 18-20, initial submission). Thus, it is possible that aerosol layers characterized as marine aerosol can overlap the sharp border from water to land surface.

— adjustment in the text
Section 3.1.: " from land to ocean **, and in consideration of the spatial averaging in the CALIOP data**“

14. Page 1343, line 20: ‘Fig. 5c’ ! ‘Fig. 5d’
— typo corrected

AMTD
7, C816–C824, 2014

15. Page 1345, lines 1-3: provide a comment on the unreasonable result regarding aerosol classification at Punta Arenas. As presented now, this paragraph shows interesting data on what aerosol subtypes are detected. Moreover, it is clear from other parts of the paper that you would expect marine aerosols for most of the time. But you have not added any sentence linking the two, and pointing to this discrepancy. This makes it unclear.

— added to the end of the section

"**The statistical analysis shows a high contribution of continental aerosols to the general aerosol content in the surrounding of Punta Arenas, although the intensive and permanent ocean-to-land advection would let expect a reasonable contribution of clean marine aerosol in this area.**"

16. Page 1346, line 17: 'SARE' ! 'SARE, determined using libRadtran'

— inserted in the text

shows the SARE**, determined using libRadtran** of the boundary layer

17. Page 1348, line 11: 'a case study' ! 'this case study'

— substituted as recommended

18. Page 1348, lines 22-23: could an aerosol transport model be usefully exploited for the CALIPSO aerosol subtyping, and thus for avoiding these abrupt changes of the LR at the coast line?

— This is a general comment looking from water to land surface and also from land to water surface. An aerosol transport model might be able to show how far marine aerosol can be advected onshore, but also to show how far continental aerosol can be advected offshore in the free troposphere and entrained down in the MBL.

The proposed aerosol subtype mixed-marine aerosol could be found over land, but also over water, e.g., off the west coast of northern Africa close to the Sahara to

AMTD

7, C816–C824, 2014

represent a mix of Saharan dust and marine aerosol in the marine boundary layer (Gross et al., 2011). Note, in mixed layers of dust and marine aerosol the approximated particle linear depolarization ratio decreases. In this case, CALIPSO would determine polluted dust (Omar et al., 2009) that represents more efficient absorbing aerosol as most probably observed. The applied lidar ratio would be higher than the lidar ratio for pure dust (55>40sr), although it should be in between the lidar ratio for marine aerosol (20sr) and pure dust (40sr).

Gross, S., et al. (2011), Characterization of the planetary boundary layer during SAMUM-2 by means of lidar measurements. Tellus B, 63: 695–705. doi: 10.1111/j.1600-0889.2011.00557.x

19. Page 1348, line 26: please describe the mixed marine aerosol type that you are proposing, and how it is to be determined in the CALIPSO decision tree.
— The mixed-marine aerosol type has to represent a mix of continental aerosol (e.g., smoke, polluted continental), and marine aerosol. The occurrence of this aerosol type might be connected to the groundtrack of the laser beam and its distance to the border of water/land surface. However, the CALIPSO science team is more capable to find the best solution.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 1333, 2014.

AMTD

7, C816–C824, 2014

Interactive Comment