Response to reviewers: paper acp-2011-581 (Redemann et al.)

We would like to thank reviewer #2 for their suggestions for improvements to our manuscript. Both reviewers recommended publication of our paper, one after "significantly expanding the discussion part", the other after minor revisions. We found a limited number of parallels between the two reviewers' suggestions. Incorporating the majority of recommendations from each reviewer resulted in significant improvements to our manuscript. Detailed responses to all reviewers' comments are given below. We are providing responses to both reviewers below, because our responses to one of the reviewers often cross-reference responses to the other.

We hope that our manuscript is now acceptable for publication in ACP.

Best regards,

Jens Redemann (for the co-authors)

Referee #2: Specific comments on minor improvements

1) P 22991, line 20. A short description of the screening method of Oo and Holz should be added. It will bring understanding to the method used in the manuscript. Are there other screening methodologies which could be applied?

<u>Response:</u> The screening method of Oo and Holz was not scientifically different. Instead, it was a different method of selecting the data, which caused them to look at a different subset of the MODIS and CALIOP AOD data. We apologize for the confusion and have clarified this in the text.

2) P 22991, line 23. Technical description in the title of 2.1 section should be removed. *Response: Done.*

3) P 22991, line 26. What is the meaning of product MYD04_L4? <u>Response:</u> We have added explanatory text: "The MODIS aerosol product (MYD04_L2 in the MODIS data product catalogue) is derived....".

4) P 22992, line7. Why is this limit value set to 0.0025 ? Comment should be added on it because this criterion is often used in the study.

<u>Response:</u> This value was an ad hoc choice for the separation of clear and cloudy pixels in MODIS. This choice is described in Martins et al., 2002.

5) P 22992, line 16, MODIS AOD uncertainty and also CALIOP uncertainty should be given in a table with the evolution of these uncertainties where bigger analysis area is considered. It will help interpreting the statistics on the AOD difference (Fig 4) and the longitudinal distribution (fig. 5 and 6).

<u>Response:</u> The MODIS AOD uncertainty is a function of AOD and has been stated for over-land and over-ocean retrievals. We see no need to repeat them in a table. The CALIOP uncertainties were explained in the new text added in response to referee #1 comment 9) and 10).

6) P 22993, line 18. The entire paragraph (up to page 22994 line 20) qualitatively describing the uncertainties of CALIOP and the improvement from V2 to V3 are not necessary. It doesn't help the reader. It should be summarized to essential quantitative values leading to build up the AOD comparison. See previous remark.

<u>Response:</u> We believe that a summary of the potential shortcomings of the CALIOP extinction algorithm is very useful to the reader, as not every reader will want to go and read the reference we provide. We would prefer to keep this paragraph.

7) P 22995, line 18. The paragraph on the box size evaluation should be shortened giving the statistics on the chosen one and a small comment on the other size.

<u>Response:</u> Spatial sampling has been identified as one of the main reasons for discrepancies of aerosol and cloud retrievals when comparing data from different satellite sensors. We feel strongly that the detailed discussion is warranted.

8) P 22996, line 23, the MODIS symbol colour explanation should be given in the legend. It will help the reader to understand the figure 1. Moreover this FMF differentiation is never discussed in the text. Remove this FMF indication or add comments if it is a valuable parameter for the study.

<u>Response:</u> We added the definition of FMF to the figure caption and discussed the implications in the text: "A large FMF indicates that the aerosol is dominated by fine mode particles with diameters less than one micrometer, often indicative of particles produced from anthropogenic sources. Small FMF points to a dominance of large particles, but often times indicates a possible cloud contamination as well."

9) P 22997, line 3 to line6. It should be checked if all of these statistical parameters are discussed in the paper. If not they should be removed from the list and from the tables or further discussed. Moreover the simple mathematical expression of each evaluated statistical parameter should be added in the text with the reason on the choice of these statistical parameters. It is convenient for the reader to have this information in order to better understand the results presented in the manuscript.

<u>*Response:*</u> We checked that all statistical parameters discussed are also used in the text.

10) P 22997, line 26. "Mean difference from Modis AOD,... are smaller for V2 than V3". A reasonable explanation on this behaviour should be given.

<u>Response:</u> We agree and have added the following explanation: "We speculate that this result is caused by competing factors. The steps taken in between CALIOP V2 and V3 certainly reduced the cloud contamination, lowering the mean V3 AOD. At the same time other steps taken, for example the extension of extinction profiles all the way to the ground in low transmission cases, likely increased the mean V3 AOD. The better agreement between CALIOP V2 AOD and MODIS is hence serendipitous.".

11) P 23001, line 1. Presenting the results in a figure (figure 3) is not the adequate format. A table will be more convenient to highlight the results. Moreover, information or values not discussed in the text should be removed. Otherwise each values presented in the table should be discussed or commented.

<u>*Response:*</u> See response to comment 22) below. These results are also provided in tables and we explain now where to find them.

12) P 23002, line 13. "as well as differences in the aerosol type....". How is this information linked to Caliop AOD evaluation? Is this sentence necessary?

<u>Response:</u> We have added a remark that explains how the aerosol type affects the CALIOP retrieval:"... as well as differences in the aerosol type identified by the CALIOP aerosol classification scheme, the latter affecting the choice of lidar ratios in the CALIOP retrieval."

13) P 23002, line 14. The figure 4 is an important issue of this study. Some supplementary analysis and remarks should be added on the bias difference between over land and over ocean AOD difference. This difference does not strongly depend of the period of the year. Comparison of the width of the distribution AOD difference with individual Modis (Caliop resp.) AOD evaluation for typical AOD values (low and high) and this for over land and over sea AOD evaluation will perhaps differently highlight the results. Comment on the bias of Caliop AOD evaluation based on optical extinction numerical integration procedure could also help interpreting the statistics. It is well known that different numerical integration procedures (trapeze, weighted,...) rise to different small errors, which can be in the range of the bias. Some of these comments could be added in the discussion section.

<u>Response:</u> We tested the impact of our choice of integration methods for calculating CALIOP AOD and found no significant difference in our results when using the method of "integrating discrete functions via spline interpolation (see http://numericalmethods.eng.usf.edu/topics/ discrete_data_integration.html.

14) P 23002, line 20. Explanation on graphic line format should be in the graphic legend. <u>Response:</u> The line formats are explained in the figure caption. We left them out of the legends as a space-saving measure, because they would need to be repeated 8 times for the eight figures.

15) P 23003, line 11. A reference on the long range transport of biomass burning particles should be given.

<u>Response:</u> We added a reference to Matichuk et al., 2008.

16) P 23003, line 13. The title "discussion" is not appropriate because the section includes more conclusion remarks and outlook than discussion. Quantitative discussion should be added in this section and a new section summarizing the finding could be added in the manuscript.

<u>Response:</u> We feel that quantitative discussions have been provided in section 3, and agree to change the title of section 4 to "Conclusions".

17) P 23004, line 13. Example of the rms values should be given. It will perhaps help interpreting the systematic bias sensors AOD difference and give insight for future work on screening procedure.

<u>Response:</u> A minimum rms difference caused by aerosol spatial variability depends on the spatial variability itself, which is unknown. We would prefer to not have to speculate about the exact value of such an rms difference.

18) P 23004, line 20. The conclusion seems to be severe because, as mentioned in the manuscript, the large width of AOD difference statistics is also related to Modis AOD evaluation. Moreover, this large rms difference is limited to AOD estimation over land. The discussion on this rms difference should be enhanced.

<u>Response:</u> We simply meant to say that an rms difference of 0.1 or larger makes it difficult to combine the retrievals from the two different sensors (say backscatter profiles from CALIOP and AOD from MODIS) for further processing. We have clarified the intent of our statement by adding: "An rms difference of this magnitude points to the fact that there is limited probability that individual measurement pairs from the two sensors can be used in combination to make further deductions about aerosol type or origin.".

19) P 23005, line 15. As previously highlighted the discussion should be enhanced because the work presented in this manuscript is important for the scientific community. Elements of discussion could be better organised relating the different topics: methodology (sensors AOD evaluation, screening, statistics on the AOD difference, geographical distribution,...) and ending with a general statement.

<u>Response:</u> Adding the responses to both referees' comments has significantly added to the substance of this section. Given that our manuscript is already longer than 40 pages, we would like to refrain from adding more material.

20) Fig.1. Explanation of the different colours of dots and boxes should be given. The size of each Modis, Caliop V2 and V3 screening box should be clearly indicated in the legend. It will render the figure more comprehensive. Only one Modis V2 box is necessary, the second one adds complexity in the figure.

<u>Response:</u> We deleted one of the two CALIOP V2 40x40km boxes, thereby reducing the overall figure size. The figure caption was changed to refer the reader to the relevant section of the manuscript for explanations of symbol colors.

21) Fig.2. The text in the figures should be minimized on indication of parameters discussed in the text. It is not a necessity to indicate the fitted parameters, which are summarized in the table. FMF should be defined in the legend.

<u>Response:</u> All text has been removed from Figure 2, except the equation for the fit line, which was not provided elsewhere in the paper. FMF is now defined in the figure caption (see response to comment #8 above).

22) Fig. 3. The content of this figure should be presented in a table.

<u>Response:</u> The results in this figure are already given in Tables 2-9 (rows entitled comparison #3). We added the following sentence in the text to clarify: "Consequently, the numerical results shown in Figure 3a can be found in Tables 2-5 and the results in Figure 3b are given in Tables 6-9 (in the rows entitled "comparison #3"). "

23) Fig. 4. The legends of the different line type and colour are not correct or are not correctly assigned. The legend of the x-axis is scientifically not correct because a difference is plotted in state of sensors name difference. "AOD difference" will be more adequate. Same remarks for the other figures presenting the AOD difference.

<u>*Response:*</u> The x-axis labels in Figures 4, 5 and 6 have been changed to respond to this comment and now read "AOD difference (MODIS – CALIOP)".

24) Fig. 5. "and over-lean". It seems that "over-land" will be more adequate. Plotting the standard deviation of the AOD difference, if it is possible, will help the interpretation of the latitudinal distribution. Same remark for Fig. 6. *Response: Change made.*

25) Fig.6: define "foc" and "flc" either in the legend or in the text. *Response: The terms are now defined in the figure caption.*