Reviewer: Abhay Devasthale (abhay.devasthale@smhi.se)

Alfaro-Contreras et al analyze CALIOP and OMI data sets to investigate frequencies and trends in above-cloud aerosol (ACA) events. In the process, they derive baseline values of above-cloud AOD from CALIOP and Aerosol Index from OMI that can be used (albeit subjectively) to distinguish background noise. The ACA frequencies are then investigated using both these approaches. Overall, I think the manuscript is well written and is easy to follow logically. Scientifically, the manuscript has potential to be published in ACP after improvements. I have some comments/suggestions that authors may like to consider. I will keep it short and to the point.

We thank the reviewer for his/her constructive suggestions and comments.

Specific comments:

1) The first thing that came to my mind: why is the synergy between CALIOP and OMI is not used to further improve the work by Devasthale and Thomas (2011) that was based alone on CALIOP rather than focusing again on CALIOP separately? Considering how deep authors are into these data sets and analysis, it feels like a missed opportunity not to exploit their synergy. For example, OMI is very good in separating absorbing and non-absorbing aerosols. So wouldn't it be scientifically more insightful to do a pairwise comparison of CALIOP and OMI to at least separate smoke and dust ACA using aerosol typing from both CALIOP and OMI? After all, the radiative impact of absorbing and non-absorbing aerosols over clouds could be quite different.

Response: This is a nice suggestion. It was our intention initially. However, due to the row anomalies that affect the OMI aerosol products, OMI AI are not available along the CALIOP overpasses after 2008. This makes a pairwise comparison less feasible for the full data record. Still taking the comment, we have performed a pairwise comparison between OMI-MODIS and CALIOP analyses for the period from June 2006 through November 2008. From this collocated data set, we have further explored the observed differences between CALIOP and OMI-based ACA cloud-sky ACA differences due to cloud detection, QA settings and absorbing vs non-absorbing aerosol, which is now included in Section 4.2.

2) Authors subdivide their CALIOP data into summer and winter half years. I think it would be rather interesting, not least to bring out strong seasonality in aerosol and cloud distributions, to analyze and discuss four seasons separately (DJF, MAM, JJA, and SON). As shown in Devasthale and Thomas (2011), ACA has a strong seasonal character. The aerosol plume heights and their spatiotemporal distribution over clouds (esp. in the regions of dust outbreaks and biomass burning) differ strongly over four seasons. I can understand that authors may have had statistical robustness of samples or brevity (of space) in their mind when dividing the year into two seasons, but this is also an area where they could complement CALIOP using spatial relevance of OMI.

Response: This is a good suggestion. We do agree that certain characteristics pertaining to ACA (i.e., aerosol and cloud distributions as well as aerosol plume height) have a strong dependence on seasonality as the reviewer suggested. However, CALIOP data are rather scarce, and by dividing a year into two halves as opposed to four seasons, we hope to increase the spatial and temporal sampling, as well as the signal to noise ratio of the study.

A second area of concern is that the traditional 3 month seasons split major aerosol features. For example, using Jun-July-August as distinct from Sept-October November perfectly bisects the biomass burning season for the three top regions. Similarly, Dec-Jan Feb versus March-April-May, begins to split Asia. By using bi-seasons, we can capture entire aerosol seasons in their entirety which fits better with a long term trend analysis. We Thus, we thus would like keep this part of the study unchanged.

3) *I am not sure what we could learn from the ACA trend analysis using just 7-8 years of data, except the fact that OMI trends could be spurious. I would rather remove this section altogether and focus on points 1 and 2 mentioned above, or at least compress that section. The authors themselves show that (in Figs. 8, 12 and 13) the interannual variability in aerosols and clouds for such short period is high, casting doubts on the interpretation and statistical significance of trends. I think investigating ACA frequencies using CALIOP and OMI has enough scientific merit to stand on its own rather than having add-on trend analysis.*

Response: This is a good point. As 7-8 years of CALIOP data is not sufficient we have changed the term from “trend” to “inter-annual variability”. However, we believe the temporal knowledge of variation in ACA events are worth reporting as no previous attempts have been made on this issue to our knowledge. Thus, we have not removed this section from the study. For example, several clear sky aerosol trend analyses suggest that increasing trends in AOD are found over India and Middle East. Increase in ACA frequencies are also found for the two regions from this study. Although these results are not statistically significant, it is worth noting.

4) Page 4176, lines 10-20: For climate monitoring, one needs to have sufficiently long time series and enough samples as well. But authors seem to confuse between the two (or at least it not clear to me based on how it is expressed). Agreed that passive sensors like OMI could fill spatial gaps compared to CALIOP, but the time series is nonetheless short for climate monitoring.

Response: This is a nice suggestion. We have changed the term from “trend” to “inter-annual variability”, consistent with the reasoning above.

5) When I first saw Fig. 1 without reading the corresponding text (which I agree is my mistake), I thought it probably shows a nice statistic on cloud heights during ACA events and that it is predominantly low level clouds that are capped by aerosols and that this is contrasted against average cloud height for all clouds (right column). But when I starting reading the corresponding text, the context was completely different, which threw me off a little bit. Fig. 1 is *actually shown to argue that CALIOP cannot see super thin sub visual aerosol layers (AOD<0.01). I would rather see this figure with a positive note. I can't help but ask if these "missed" sub visual aerosol layers radiatively matter?*

Response: Thanks for the suggestion. To avoid confusion, we have removed figure 1 from the paper based on the comment as well suggestions from another reviewer.

Technical comments:
There is virtually no discussion on what kind of quality control was applied to CALIOP, OMI, and MODIS datasets during analysis. There could be devil in the details. CALIOP data comes with a number of quality flags and CAD score (cloud aerosol discrimination). As we have shown in Devasthale and Thomas (2011), the ACA frequency could be quite sensitive to these flags. In your case the varying selection of these quality flags could easily introduce or explain the differences in observed ACA frequencies from CALIOP and OMI. It is probably worth checking sensitivity to these flags as well.

Response: This is a very good point. Section 2 refers to Alfaro-Contreras et al. (2014), which describes in further detail the QA applied to our data sets. From the OMI aerosol products, the OMI algorithm flags were applied to eliminate sun-glint contaminated regions and the path length, described further in Yu et al. (2012), is constrained between values of 3-7. For the MODIS cloud products, only scenes found to have a cloud fraction of 1.0 (100 % cloudy) with medium confidence or higher. For the CALIOP aerosol layer data set, we required that integrated layer AOD for the column be greater than 0 found to be of high or medium confidence, from the CAD score and Fearture Classification Flag. Additionally, this AOD layer was required to be above a cloud of COD > 0 derived from the cloud layer data set. The only restriction set on the CALIOP cloud layer data set is that the cloud optical depth be greater than zero regardless of the QA (we have added a new section, Section 4.2, to explore the effects of the QA flags as well). We have added some discussion in the text.

In addition, as suggested, we have added a whole new section (4.2) which studies the difference between OMI-MODIS- and CALIOP-based methods using collocated MODIS, OMI and CALIOP data and explores the sensitivity of QA flags to the cloud-sky ACA frequencies in details. Thanks for the suggestion.

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