

## Comments on “Investigating the Frequency and Inter-Annual Variability in Global Above-Cloud Aerosol Characteristics with CALIOP and OMI”

### General comments:

The authors have made some sincere efforts to address the questions and comments I raised. I feel the manuscript is improved considerably. In particular, the comparison of ACA frequency between MODIS-OMI and CALIOP based retrievals is now solid and pretty comprehensive. However, I still feel the authors haven't adequately addressed what are the reasons for the differences between the two techniques. There are still quite a few speculations in this part without solid proofs, which can be further improved. Overall, I think the revised manuscript is worthy of publication, although a few technique points (in particular the one about MODIS cloud fraction) should be clarified before acceptance.

### Detailed comments:

- 1) One of the major conclusions from the manuscript is that the “cloudy-sky ACA frequency differences between the OMI-MODIS- and CALIOP-based methods are mostly due to differences in cloud detection capability between MODIS and CALIOP as well as QA flags”. But it is made largely based on statistical results. It would be much more convincing if some level-2 images from CALIOP and/or MODIS can be shown to support the argument. For instance, it is speculated that the misidentification of heavy dust as cloud by MODIS could be an importance reason for the abnormal high ACA frequency over North Africa. The argument would be more convincing if the authors can identify and show one or two cases from level-2 data, i.e., CALIOP vertical feature mask image side by side with MODIS observations. In general, I think it is a good idea to add some level-2 cases (could be supplementary materials) to support the argument regarding the “cloud detection capability between MODIS and CALIOP”.
- 2) Line 76: CALIOP is no longer the “lone” space-borne lidar. The Cloud-Aerosol Transport System has been in operation since early 2015. See <http://cats.gsfc.nasa.gov/>
- 3) Line 167: it is very important to note that in MODIS operational product the fraction of successful retrieval (i.e., cloudy pixel with valid >0 COD) is significantly smaller than the total cloud fraction. This is because in collection 5 product pixels with broken clouds and highly heterogeneous pixels are excluded all together from optical thickness retrieval (a process called “clear-sky restoral”). In the latest collection 6 product, the clear-sky restoral process is removed. However, there are still a significant fraction of cloudy pixels that have *failed* cloud property retrievals (i.e., cloudy but no COD retrieval). A recent paper by [Cho *et al.*, 2015] did a comprehensive analysis of such pixels. It may help the authors better understand this issue. Please clarify which version of MODIS cloud product is used in the paper and whether the cloud fraction means real cloud fraction or successful retrieval fraction.
- 4) Figure 2A: please also use different line styles in addition to color to distinguish lines for the sake of color blind readers.
- 5) The MODIS cloud fractions in Figure 7 F and L seem too low to me. See my comments above about successful retrieval vs. total cloud fraction. Please also see Figure 2 in [King

*et al.*, 2013]. You need to clarify what is the definition of MODIS cloud fraction in the paper (i.e., Table 1)

- 6) [Toth et al.2013] is missing from the reference list.
- 7) Previous studies, e.g., [Holz et al., 2008], found pretty good agreement between MODIS and CALIOP cloud fraction retrievals, certainly not so large as shown in Figure 7. Please comment.

#### References:

Cho, H. M. et al. (2015), Frequency and causes of failed MODIS cloud property retrievals for liquid phase clouds over global oceans, *Journal of Geophysical Research-Atmospheres*, 120(9), 2015JD023161–n/a, doi:10.1002/2015JD023161.

Holz, R. E., S. A. Ackerman, F. W. Nagle, R. Frey, S. Dutcher, R. E. Kuehn, M. A. Vaughan, and B. Baum (2008), Global Moderate Resolution Imaging Spectroradiometer (MODIS) cloud detection and height evaluation using CALIOP, *J. Geophys. Res.*, 113(D8), D00A19, doi:10.1029/2008JD009837.

King, M. D., S. Platnick, W. P. Menzel, S. A. Ackerman, and P. A. Hubanks (2013), Spatial and Temporal Distribution of Clouds Observed by MODIS Onboard the Terra and Aqua Satellites, *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING*, 51(7), 3826–3852, doi:10.1109/TGRS.2012.2227333.