

Comments on “Global Dust Optical Depth Climatology Derived from CALIOP and MODIS Aerosol Retrievals on Decadal Time Scales: Regional and Interannual Variability” by Song et al.

General comments:

Dust is an important aerosol type in the atmosphere and has significant impacts on environment and climate. Satellite is a very useful tool to detect dust aerosol as it can provide dust distribution of large spatial coverage with long-term duration. A unique lidar platform (CALIOP) can further provide the vertical distribution of dust aerosol. This study provides a 13-year global dust optical depth (DAOD) climatology derived from CALIOP and MODIS observations and presents some interesting results for global dust spatial distribution and temporal variations. The authors also investigate the reasons for the recent decline of dust activities in East Asia. The results demonstrate the reliability of the two datasets the authors have developed.

However, the authors seem to mention a lot of uncertainties in the dataset and it seems there is no answer for a better DAOD. I personally would like to see more convincing quantitative comparison of these two datasets, such as which one is better and it is possible to suggest a more reliable global DAOD. I suggest the authors make more clear conclusions relative to the comparison.

Major comments:

Section 2 and 3: I am curious about the systematic difference between CALIOP and MODIS. In my understanding, the main reasons may be in the algorithms used to generate the product and the difference may be minimized if calibrated to the same data sources. I am wondering if there is some way to minimize the difference between different dataset. The authors seem to mention a lot of uncertainty and it may be helpful to separate the contributions from these factors. First, is it possible to compare the two dataset at the same time and close location (although the sample number may be small)? Second, after doing this comparison, the difference of monthly/seasonal mean can be due to the sampling and aggregate methods. I think the authors can provide a map of observation numbers for different months/seasons and a month with more temporal coverage is more likely to have a more reliable statistical result.

Section 2.2: the comparison of nighttime CALIOP and daytime MODIS product is made based on the consideration “Kittaka et al., 2011 shows that daytime and nighttime global seasonal-mean AOD distributions for JJA 2006 from CALIOP are generally similar in both outflow and source regions (see their Figure 1).” (Lines 242-244). First, Kittaka’s conclusions are based on the global distribution, while this present study is specifically on dust source regions and dust outflow regions. Kittaka’s conclusions should not be simply applied to present study. Second, previous studies have shown significant diurnal variations of dust event frequency in dust sources regions (e. g, Figure 17 of Yue, X., H. Wang, Z. Wang, and K. Fan (2009), Simulation of dust aerosol radiative feedback using the Global Transport Model of Dust: 1. Dust

cycle and validation, J. Geophys. Res., 114, D10202, doi:10.1029/2008JD010995.).

Line 647, in Summary and Conclusions: it seems the trends and interannual variability of DAOD are similar. I don't see the advantages and limitations clearly for each dataset. Please clarify.

Specific comments:

Line 21, abstract: add "(2007-2019)" after "the last two decades".

Line 27, abstract: delete "and".

Line 127: Self-consistent: Please briefly explain the word here, and not wait until Section 2.

Lines 131-132: is it any critical difference for dust between these version and previous version? This is important, as it may indicate the results shown in this study may be different from previous versions because of version updates.

Line 155: please provide some supporting information for "70% agreement".

Lines 162-163: if 40 sr is too low, is it possible to increase this value and update the product? What is the lidar ratio?

Line 174: I don't understand "or" here. Please clarify.

Sections 2.1 and 2.2: is it possible to make a table and put the comparison of key features of CALIOP and MODIS in it?

Line 242: Kittaka et al. (2011) also analyze the AOD including all aerosol types. I am wondering whether their conclusions applied to specific dust source regions and dust-effect regions.

Line 248: "in hoping that": this statements may be misleading. I think the key point is that observations do shows some significant diurnal of dust events in the source regions mainly because of the wind speed difference. Please clarify.

Line 268: I am wondering whether this new data includes all the algorithms mentioned in previous paragraph.

Line 272: how about the sampling over land? Is there a minimum number required for deriving monthly statistics?

Lines 279-280: is there any measure to keep the ocean and land product consistent with each other?

Section 3.1: this section is too long. Consider adding subtitle or dividing it into two sections.

Lines 313-314: I don't think it is because of more frequent miss but it is an expected result of using a threshold to detect dust.

Line 368: I don't think this can suggest dust activities occur relatively small scales. Since a threshold is applied in conditionally DAOD, it is easily to understand conditionally DAOD have much higher values than climatological DAOD.

Line 401: I can't see this "exception". Please check.

Lines 446-448: this can explain the secondary peak of DAOD in summer for MODIS, but it can't explain the difference of two datasets. Please clarify.

Line 480-495: it seems the authors suggest a true DAOD should fall between CALIOP and MODIS. If so, please explicitly state this in the text.

Line 523-524: broad East Asian region (ESA defined in Figure 4): I can't find ESA in Figure 4. Please clarify.

Line 531: change "DOAD" to "DAOD".

Line 535: I don't think it is "much weaker".

Line 538: please explain a little bit why EVI, MERRA2 near surface (at 10m) wind speed and precipitation are reliable for this analysis. Probably cite some references which have already demonstrated this.

Line 541: add " $p > 0.05$ " after "precipitation", as the determination of significance depends on the level of significance. I guess here you are using $p = 0.05$ as a threshold.

Line 601: please expand DPR.

Line 603: I am wondering how the uncertainty is defined. Please add a definition.

Line 618: is it also applied to this study? If so, I am wondering whether a true DAOD is even higher than MODIS DAOD. Please clarify.

Line 640: it is possible that CALIOP misses some dust events. But this study is based on long-term statistics and the impacts should be eliminated if the observation number are substantial large. Do the authors suggest the impacts are not negligible in this study?

Line 664: add "during 2007-2019" after "DAOD".

Line 780: avoid using “decadal trend” here as there are only 13 years indeed.

Line 782: the symbol “+” can’t be clearly seen.

Line 805: it is also helpful to put together the time series of EVI vs DAOD, wind vs DAOD, precipitation vs DAOD with the year for x-axis. This can be put in the supplement for references.

Lines 935-938: a duplicated reference.