Atmos. Meas. Tech. Discuss., 4, C2651–C2658, 2012
www.atmos-meas-tech-discuss.net/4/C2651/2012/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Fast simulators for satellite cloud optical centroid pressure retrievals, 1. evaluation of OMI cloud retrievals" *by* J. Joiner et al.

J. Joiner et al.

joanna.joiner@nasa.gov

Received and published: 17 January 2012

We thank the reviewer for constructive comments that helped to improve the manuscript. We address the detailed comments below in boldface and repeat the comments in regular font.

In general, this is a very interesting paper that discusses the development and testing of a fast simulator to provide estimates of the cloud Optical Centroid Pressure (OCP) given a vertical profile of optical extinction. While a number of relatively minor suggestions are provided to correct grammatical issues or refine figures, two major suggestions should additionally be considered before publication in AMT.

Major suggestions:

1. Section 3: with regard to the use of the CloudSat 2B-Tau product: : :this is based only on CloudSat data, not a combined CloudSat-CALIPSO product such as in the 2B-GEOPROF-Lidar product that provides a much more accurate cloud geometrical profile. The CPR on CloudSat is insensitive to small ice particles and ultimately low optical thickness ice clouds (i.e., cirrus), but this is a strength of CALIOP (the lidar on CALIPSO) so the combined product would be more useful to evaluate the OCP cloud pressures for cirrus clouds and for discrimination of multilayered clouds too. The paper would be strengthened considerably by complementing the current work with further analysis using the combined lidar/radar product.

   We indeed considered the use of a combined CloudSat-CALIPSO product. While the 2B-GEOPROF-lidar product provides an accurate cloud geometrical profile cloud mask, it does not provide estimates of the extinction profile that are needed for the OCP simulations. Only the CloudSat 2B-TAU product provides the needed information.

   We appreciate your concerns regarding clouds that are not detected by CloudSat and have revised the text accordingly. In Sect. 2.2, we now clearly state that CloudSat does not detect all of the optically thin cirrus seen by CALIPSO. As noted, our paper focuses on situations where $\tau > 5$. There are several reasons for this. As mentioned, CloudSat does not see all of the optically thin cirrus clouds. We added a sentence stating that OMI MLER retrievals for thin clouds conditions ($\tau < 5$) can have large errors as shown by simulation results in Vasilkov et al. (2008). For the cases included in the paper ($\tau > 5$), the effect of the optically thin cirrus layers is likely to be very small as their relative reflectances will be low as compared with optically

AMTD
4, C2651–C2658, 2012

Interactive Comment

thicker cloud layers below. We also added some text to explain this.

Far more serious for our cloud OCP calculations are missed low clouds by CloudSat (obscurred by ground-clutter) that are seen in the combined CloudSat-CALIPSO cloud mask product (e.g., Stephens et al., 2008). We have added a more detailed paragraph on so-called "difficult" cloud cases for CloudSat discussed by L'Ecuyer et al. (2008) (reference added) and their potential effect on our cloud OCP calculations in Sect. 2.2 as well additional discussion later in the results section (see comment below on point #2). In response to your comment, we applied an additional filter based on the CloudSat-CALIPSO GEOPROF lidar product (added Mace et al., 2009 reference). We use this product to check for cases of missed low clouds by CloudSat as discussed in the revised section 2. When we eliminate those cases, the agreement between OMI and CloudSat-simulated OCP improves. We have updated all figures for July 2007 as well as the table with results. We find for July 2007 that standard deviations for differences between OMI-retrieved and CloudSat-simulated cloud OCPs are reduced by ∼15% when the filter for missed low clouds is applied and the number of successfully collocated points reduces by 41% and 27% over ocean and land, respectively. In the scatter diagrams, the results are visibly improved as a signficant number of outliers have been removed. However, the GEOPROF lidar product is likely still not catching all of the cases of missed low clouds, because the lidar is not able to penetrate high level clouds with moderate optical thicknesses. We thank the reviewer for suggesting the use of the CloudSat-CALIPSO GEOPROF lidar product that improved our results.

2. Section 5.1, comparisons with CloudSat-based fast simulator over land. As shown in Figs. 7 and 8, there is a cluster of pixels where the CloudSat-based OCPs near 400 hPa, and both the OMI OCP algorithms infer significantly higher pressures. The authors suggest that part of the problem could be due to a snow-

AMTD

4, C2651–C2658, 2012

Interactive Comment

covered surface or perhaps multilayered clouds. But this is something that could be explored further by the authors by looking at the co-located MODIS and CloudSat products within the OMI FOVs. My thought is that the MODIS data, or even the CloudSat data, could be used to separate the OMI FOVs into those with homogeneous scenes as opposed to inhomogeneous scenes. That is, separate the OMI FOVs into those with multiple cloud heights from those with single-layered clouds. Or separate those FOVs for which the MODIS cloud mask has clear-sky pixels over a snowy surface. This section could, and should, be strengthened by actually digging a little deeper in the co-located data sets to better quantify where the major OCP differences come from. Perhaps use of the 2B-GEOPROF-Lidar product would be useful here, too. If these suggestions were explored further, the discussion of the final two figures, Figs. 15 and 16, would probably be able to provide more useful insight as to why the differences are so large in specific regions.

We spent a significant amount of time examining colocated MODIS data within the OMI FOV and also variability seen by CloudSat along its track within the OMI FOV. We also looked at many individual cases where CloudSat and OMI OCPs did not agree. Instead of presenting those individual cases, we tried to summarize the overall results.

As stated in the paper, we filter the data based on variability of the MODIS cloud top pressure within the OMI FOV (we remove cases where the cloud-top pressure standard deviation >100 hPa). However, as also stated in the paper, MODIS variability in cloud-top pressure is not always a good predictor of variability in cloud OCP. This is because in frontal systems and tropical storms, the cloud top pressure can remain at a high altitude while there is significant variability in cloud vertical structure below the cloud top.

We also compute variability of CloudSat-simulated OCP along the OMI track

AMTD

4, C2651–C2658, 2012

Interactive Comment

within the OMI FOV and eliminate data with standard deviations $>$100 hPa. We did a significant amount of testing to arrive at these threshold values, though results do not change substantially if these threshold values are varied within $\sim \pm$100 hPa. In our previous paper (Joiner et al., AMT, 2010), we also examined variability of MODIS cloud optical thickness within the OMI FOV. We found that this was not a good predictor of cloud OCP variability.

As this information was a bit scattered throughout the paper, we have revised the text to bring it together in a more clear and focused way. We have now put all this information into a separate subsection under the "Satellite data set" section entitled "Quality control including removal of inhomogeneous OMI observations."

With regards to differences shown in Figs. 15 and 16, we have revised the discussion to place more emphasis on missed low clouds by CloudSat (see response to first comment) with reference to Stephens et al. (2008). We believe this to be a significant contributor to the differences seen and at least zonally the differences are consistent with the results shown in Stephens et al. (2008).

With respect to the issue of snow cover, we have revised the text to state more clearly that there are cases of identified issues with the NISE data set. After "Some of these cases coincide with frontal clouds that may have produced fresh snow that has not yet been identified in the NISE data set." We added "Analysis of these cases shows that the snow flag is set on subsequent days. We also found a few isolated areas where snow is likely (e.g., northern Canada in winter) and the snow/ice flag is not set, while it is set for the surrounding region."

Minor suggestions:

AMTD

4, C2651–C2658, 2012

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

- grammatical suggestion: change "in order to" –> "to" throughout the paper. The words "in order" are superfluous: : :but this is simply a suggestion.

  This has been done.

- abstract, last line: “small fraction of OMI pixel" $-- >$ “small fraction of an OMI field of view (FOV)" Suggest using pixel to refer to an imager such as MODIS, and perhaps using FOV for a larger field of view such as OMI. The sizes are very different. Again, simply a suggestion here and throughout the paper if implemented.

  This has been done.

- page 4, paragraph beginning with "Cloud OCP errors have been calculated: : :" In this paragraph, a number of papers are listed that intercompare various OCP retrievals with simulations, but no results are summarized. It would be useful for a reader that is not intimate with these previous studies to have a bit of a summary included as to the pertinent findings of these previous studies.

  We have added several sentences in this paragraph summarizing results of the previous intercomparison studies as well as additional information (see response to reviewer 1) in the “Satellite data set” section.

- Section 2.1.2: it would be useful to provide some details regarding the surface albedo climatology used in this study, such as the pertinent spatial and spectral details, whether it is a static or monthly product, etc.

  We added that this is a monthly product derived at 360 nm from TOMS at 1° latitude by 1° longitude spatial resolution.

- Section 3: cloud simulations are listed, but the simulations are quite vague. Are separate simulations performed for water and ice clouds? If so, provide details separately for water and ice simulations. For the ice clouds, it would be useful to discuss optically thin versus optically thick ice cloud results.

AMTD

4, C2651–C2658, 2012

We have now provided differences between the various simulations performed and clarified that we performed 3 separate simulations. For example, we added "Our focus in this work is on cases where τ >5. For these cases, we find that the ice cloud model produces cloud OCPs on average 23 hPa higher than those simulated using the C1 model with σ = 31 hPa. Similarly the H-G cloud OCPs are about 22 hPa higher than those from the C1 model with σ = 28 hPa. Since these differences are not large, all subsequent results use the C1 cloud model exclusively."

- Section 4.2, page 13: "Rayleighscattering" –> Rayleigh scattering

  fixed, thank you.

- Section 4.2, last sentence: "with bias of 7.4 hPa, standard deviation of 82 hPa, and correction coefficient of 0.89" $-->$ with a bias of 7.4 hPa, a standard deviation of 82 hPa, and a correction coefficient of 0.89

  done

- Section 5.2, last sentence of first paragraph: "with higher a cloud" $-->$ with a higher cloud

  fixed, thank you.

- Section 5.4: it is clear that the large size of the OMI FOV is not optimal for inferring OCP for sub-pixel scale clouds such as trade cumulus.

  noted

- Figures 5-16: please consider labeling each of the two panels in each of these figures, with an (a) and (b). This would help clarify what is in each figure.

  done

AMTD
4, C2651–C2658, 2012

Interactive Comment

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

- Figure 5: the solid blue curve is listed as the result of a standard fast simulator in the upper panel, but is denoted as a weighting function in the caption. Please clarify.

  We have modified the figures (both 5 and 6), legends, and captions to clarify. We now show the OCPs computed from the various simulators as symbols rather than horizontal lines. As before, we show the weighting function as a blue curve.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 6185, 2011.

AMTD

4, C2651–C2658, 2012

Interactive Comment