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Interactive comment on "MODIS Collection 6 shortwave-derived cloud phase classification algorithm and comparisons with CALIOP" *by* B. Marchant et al.

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Thanks a lot for your constructive feedback. Please find below our replies and changes:

(1) Line 19, page 11894: what is meant by 'location'? Latitude/longitude? Cloud regime? Cloud detection?

I meant by location the cloud height. Location has been changed to cloud height in the manuscript.

(2) Lines 1-7, page 11895: a fairly new infrared-based cloud phase retrieval is produced from the hyper-spectral AIRS sounder on EOS Aqua and is described and validated

against CALIOP in Jin and Nasiri, 2014, J. Appl. Meteor. Climatol.

Absolutely, Jin and Nasiri's paper is an important contribution to cloud phase classification studies and totally relevant with our paper. So Jin and Nasiri's paper has been added to the manuscript.

(3) Lines 12-15, page 11898: what happens if both liquid and ice tests are triggered at the same time for the same pixel? From an infrared point of view, this happens roughly 1% of the time according to Jin and Nasiri (2014) and in those cases the equivalent phase is assigned as 'unknown' (the same as undetermined in the present work)

If the voting based cloud phase algorithm returns the same number of votes for ice and liquid, the cloud thermodynamic phase is stored as undetermined. Note that, cloudy pixels assigned as undetermined by the cloud phase algorithm are then assumed as liquid (by default) for the cloud effective radius and optical thickness retrievals (same as MODIS C5). In addition, undetermined cloud phase pixels are screened out by the MODIS L3 aggregation code.

(4) Lines 8-16, page 11899: with regard to the 'large vote' and 'weak vote', are these adjustments to the 'one test, one vote' approach in figure 2? This related 'large' and 'weak' discussion isn't entirely clear in the algorithm flow.

The cloud phase classification algorithm flowchart presented in Figure 2 is a simplified version that only shows the main features used in the algorithm to illustrate the main logic (a more detailed flowchart is provided in supplement). The vote of each features (CTT, CERs, etc) in the algorithm are weighted and the weight depends on parameters such as the cloud optical thickness. For example, if the cloud is optically thick and the cloud top temperature CTT is greater than 270K, one can be very confident that the cloud phase is liquid (in that case the vote of the CTT-based test is weighted by a large number or 'large vote') while if the CTT is lower than 240K, one can't be too confident than the cloud phase is ice because of multilayer clouds (e.g thin ice cloud over a thick liquid cloud) (in that case the vote of the CTT-based test is weighted by a small number

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or ‘week vote’). In other words the weight represents the degree of confidence. The weight attributed to each vote has been set up empirically from MODIS and CALIOP comparisons.

(5) Line 19, page 11902: since what year/month is the 1.6 micron detector not operational?

The MODIS Aqua 1.6 micron (Band06) is still operational. However, the detector presents “dead” pixel rows where 1.6 data are then missing. The 1.6 damage or failure is present since the launch of Aqua in 2002. I attached a figure to illustrate the impact of Aqua MODIS 1.6 dead pixels.

(6) Lines 10-21, page 11903: the color scheme of figure 4 is somewhat confusing. In the upper right panel, the ‘purple’ shading looks like gray and my eyes want to match it to the ‘clear sky’ gray pixels in the two panels in the lower row. Also, is there a reason why C5 CTT isn’t shown?

Thanks for noticing that. You are right. It was fixed in the visualization code (the ‘cubic’ bilinear interpolation has been replaced by ‘nearest’ interpolation, which is more appropriate to plot data on a projected map. The problem was the CTT is equal to 0 for clear pixels in the visualization code, so if you do a cubic bilinear interpolation the CTT of cloudy pixels decrease and may be then smaller than 200K: outside the colorbar). So figures 4 and 5 have been updated in the manuscript.

The C5 cloud top temperature (CTT) is not showed here because CTT at 1km resolution is a new MODIS C6 SDS (C5 only stored CTT at 5km resolution).

(7) Lines 27-28, page 11904: how about ‘. . .an expected result. . .’?

You are right: double negation here! So, I changed “a not unexpected result” to ‘an expected result’ in the manuscript.

(8) Lines 9-10, page 11908: in the Jin and Nasiri (2014) paper, statistics are subdivided by ‘homogeneous’ and ‘heterogeneous’ to account for CALIOP phase variability within

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the AIRS field of view. Since the 5 km phase mask is used, I would posit that roughly 5 MODIS pixels fall within the 5 km CALIOP phase feature. How frequently are these heterogeneous versus homogeneous phase? How many are fully cloudy versus partly cloudy? How many are single layer features versus multilayered features? The paper would benefit from some additional discussion, maybe a small table – it does not have to be extensive and detailed – to give the reader some context of whether this study is considering 20% of matched data, 80%, some other number? Does the phase agreement fraction reduce for multilayered or heterogeneous clouds?

A lot of relevant questions, there are of course several ways to screen and/or combine the data. In our analysis, the CALIOP 5km cloud phase product has been resampled at 1km resolution and then combined with CALIOP 1km cloud phase product to finally compare with MODIS. So, in this approach it does not make sense to define a heterogeneous cloud scene at 5km resolution such as in Jin and Nasiri 's paper. I completely agree that it is interesting to give some general context about the data used in the comparisons. So, I did some analysis using July 2008 data and our collocated dataset (based on CALIOP 1km and 5km cloud products) to figure out exactly what we are looking at. The histogram (in attachment) shows the distribution of cloud scenes ((1) only ice cloud layers found, (2) only liquid cloud layers found, (3) both cloud phase found) observed by CALIOP. More than 20% of CALIOP cloudy pixels have both ice and liquid layers. In our comparisons analysis cloudy pixels with several cloud phase have been screened out because the cloud phase determination is then ambiguous for MODIS. We also found (not showed in the histogram) than roughly 1% of CALIOP ice only pixels (meaning than CALIOP found only ice layers in the vertical profile) are classified as PCL (partially cloudy CSR=1,3) by MODIS and 5% of CALIOP liquid only pixels are classified as PCL by MODIS. In the manuscript I will not show the histogram but I will add a sentence specifying the general context instead.

About the question: "Does the phase agreement fraction reduce for multilayered or heterogeneous clouds?" I will answer by another question: How to define a phase

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agreement for multilayered or heterogeneous clouds?, which is very ambiguous. For example, in the case of an optically thin ice cloud overlapping a liquid cloud, what is the correct cloud phase? (Knowing that MODIS cloud optical retrievals is based on a plane-parallel single-layered cloud radiative transfer model). I guess, the answer depends on the model used. A cloud phase algorithm based solely on infrared can find that ice is the best answer while a shortwave-based cloud phase algorithm can find that liquid is the best answer. So both algorithms will not be in agreement but can provide a proper answer anyway. In my opinion the only way to determine the correct cloud phase in case of multilayered or heterogeneous cloud is to use a radiative transfer model by simulating multilayered clouds, comparing with a single layered cloud and looking at the errors (on cloud effective radius and cloud optical thickness). It is a very interesting question that should be study in detail in a future work.

(9) Table 1: the details on how the CER and COT thresholds play into the algorithm flow and voting process isn't immediately clear in figure 2 and the discussion.

I think that question is similar to question 4

(10) Figure 3: Would suggest using different colors for upper left, lower left, and lower right. The burgundy and grayish blue look rather similar. Also, in the upper left and lower right, are these the thresholds from Table 1?

I tried different combinations of colors without getting a better result here (mainly due to the number of points plotted in figure 3 a). In addition, I would prefer to keep the current colors to be consistent with figure 11.

The upper left thresholds are from MODIS C5 cloud phase algorithm while the lower right thresholds are from C6 (table 1). Note that only thresholds based on forced ice cloud effective radius at 2.1 micron are showed here.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 11893, 2015.

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Interactive Comment

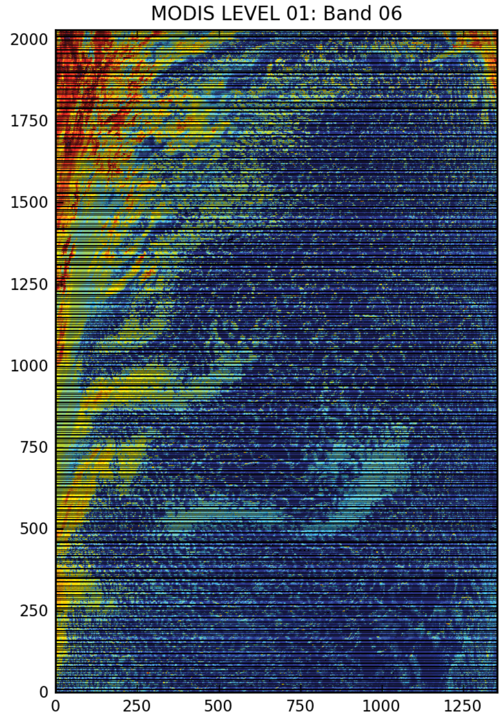

Fig. 1.

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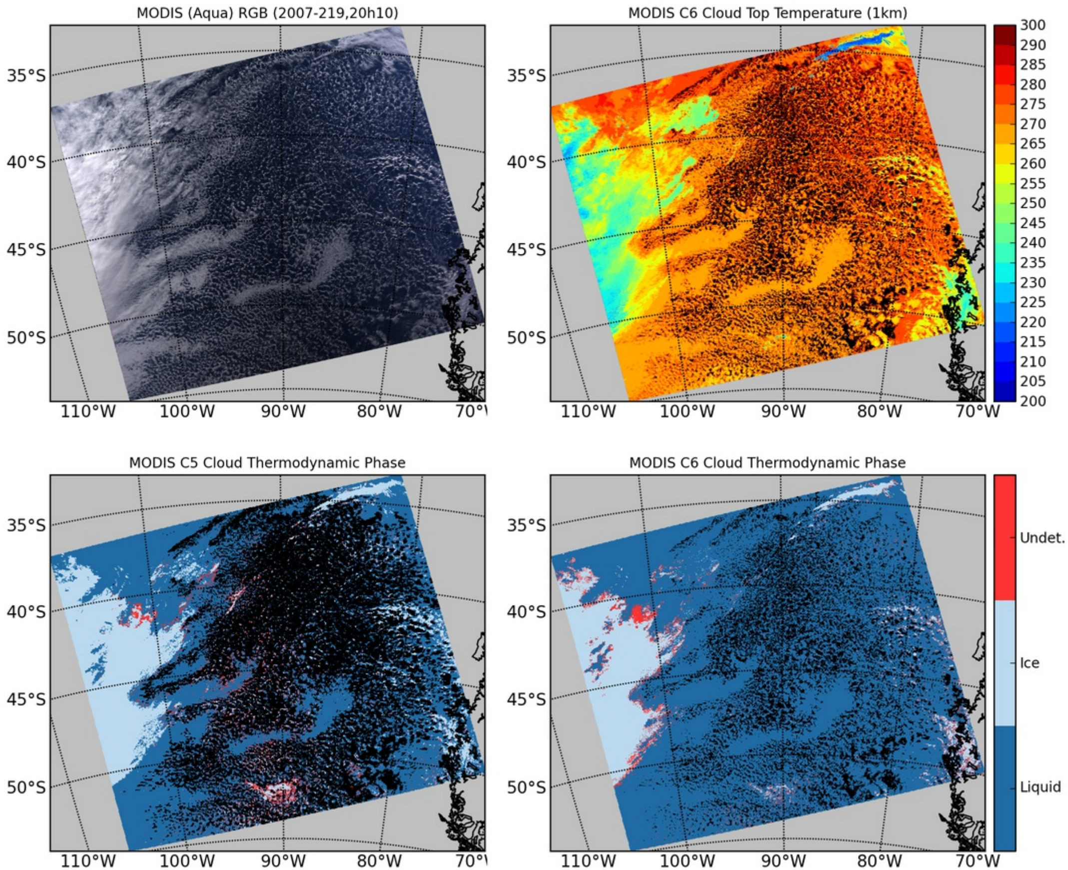

Fig. 2.

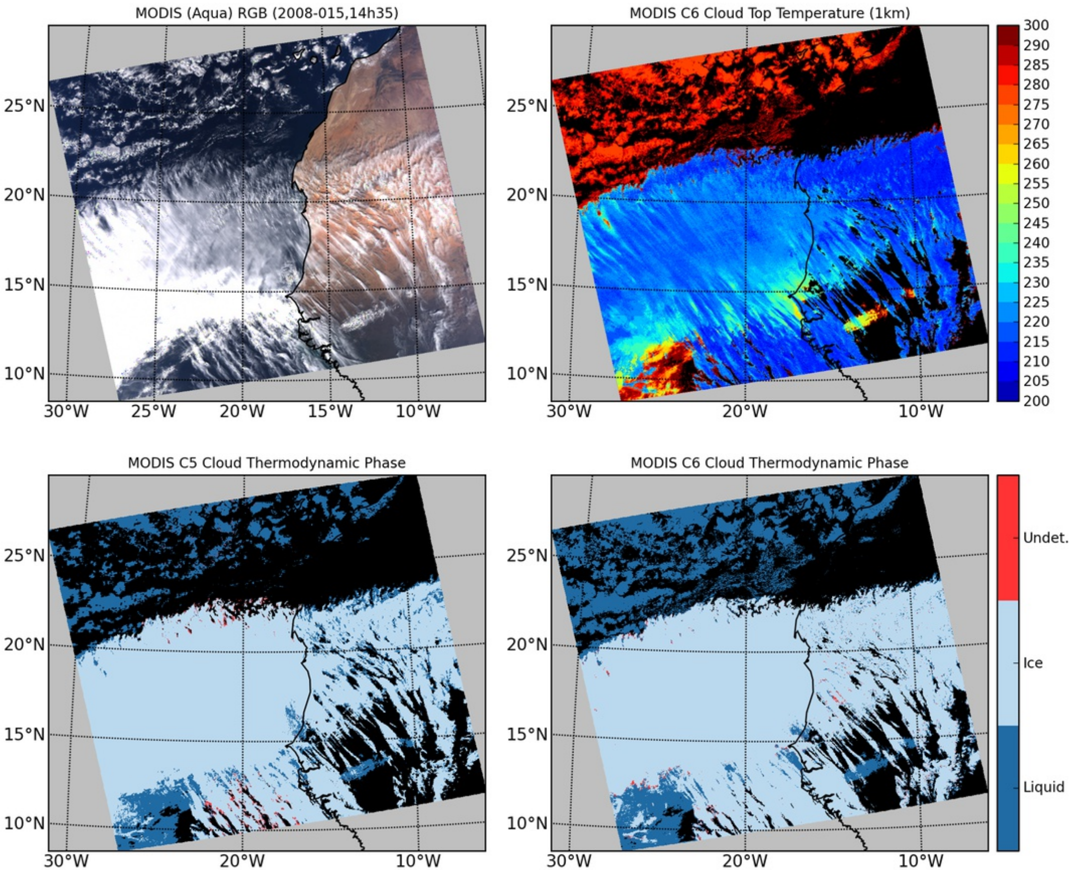

Fig. 3.

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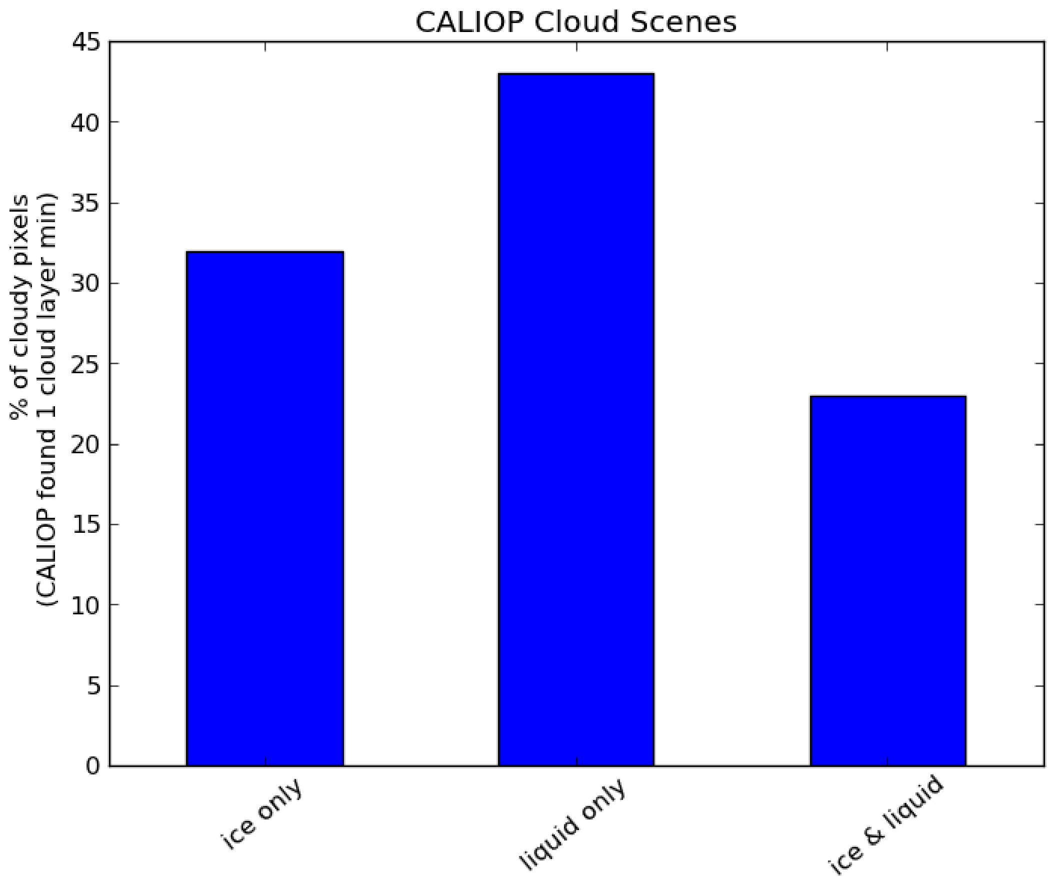

Fig. 4.

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