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Atmospheric Measurement Techniques Discussions

Interactive comment on "Evaluation of the Aqua MODIS Collection 6.1 multilayer cloud detection algorithm through comparisons with CloudSat CPR and CALIPSO CALIOP products" *by* Benjamin Marchant et al.

Anonymous Referee #2

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The manuscript addresses the fidelity of the Aqua MODIS Collection 6.1 multilayer cloud detection product against coincident observations from CloudSat and CALIPSO matched to the MODIS pixels. The MODIS multilayer product is a combination of four different tests, one of which depends on the discrepancy of thermodynamic phase derived from the mid-infrared and the shortwave infrared, two of which depend on ancillary water vapor products or derived column water vapor products, and the last based on the algorithm of Pavolonis and Heidinger. The CloudSat/CALIPSO combined 2B-cldclass-lidar product is used for ground truth of multilayer clouds and the phase

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Discussion paper

determination of each cloud layer detected. The 5-km CALIPSO cloud layer product is used to obtain cloud optical thickness for the different features detected and is over-sampled to 1-km for comparison purposes. The comparisons are stratified by whether single or multilayer clouds are detected, whether the optical thickness according to MODIS is greater than or less than four, or whether the multiple layer clouds are of the same or different phases. Histograms of cloud effective radius are shown for single and multiple layer clouds, and also for the different tests used for detecting multiple layer clouds. The histograms show that the purpose of the MODIS multilayer flag is sufficient to detect most outliers in the retrieved cloud effective radius product.

This is a useful study that dives into the details of the performance of the MODIS multilayer algorithm and the results are generally presented well. One area of the manuscript that left me a bit surprised is how often the multilayer flag of MODIS detects multiple cloud layers while the radar+lidar combination does not (see Figure 3, left panel, left column, middle row: 12.25%). My suspicion is that the disagreement between MODIS and the active sensors isn't nearly as poor as one might take away from these results because there could be some underlying sensitivity to the multilayer tests to cloud vertical structure within single contiguous layers. In other words, the cloud water content could vary with altitude within a single layer but could trigger the multilayer flag in MODIS. One additional comparison that might be worth adding is some stratification based on how vertically homogeneous the cloud water content profiles are within single layers, and whether these are related to MODIS multilayer detections when C/C detects a single layer. CloudSat provides two flavors of cloud water content profiles (2B-CWC-RO and 2B-CWV-RVOD), and there is one flavor of a combined CloudSat/CALIPSO ice water content profile (2C-ICE). Perhaps these products could be stitched together on a profile-by-profile basis to make a single vertical profile of combined liquid and ice CWC? Perhaps the clouds that have a strong dependence of CWC on altitude within the layer have a multilayer flag that behaves differently than those that do not? I haven't thought through every technical detail to do this, but if feasible, I believe it is worth doing.

Otherwise, I only have minor suggestions for the revised version, and they are listed below.

The 'intent' of the algorithm is touched on at line 59 and lines 97-99. The latter occurrence seems out of place and would fit better near line 59. In fact, the 'intent' should be articulated for other multilayer algorithms besides MODIS.

Lines 77 and 79, references should have years added

Line 95, section should be two, not three

The discussion of figure 1 starting at line 138 is a little bit disjointed. I wasn't sure if panel (b) should be the sum of panels (e) to (h), or whether multiple positive tests can occur in a single pixel. I'm pretty sure it's the latter but it needs to be laid out clearer than is.

To be clear, the Pavolonis and Heidinger algorithm is available within the L2 products but not in the L3 products? If that is correct, why is that the case?

line 212, (a) and (b) should appear before including and excluding, respectively

line 252, answer about

figures 4 and 7 appear to have problematic axes. The number spacing in both axes is not uniform. Perhaps there is a rounding issue at play or the axes need to have additional bins or tick marks.

Figures 8 to 11, would be helpful to make clearer in each column at the top that this is "liquid" and "ice", or perhaps "liquid 2.1 um", "liquid 1.6 um", etc. The subpanel titles are pretty useless and could be included in the figure caption.

Furthermore, it would be easier to read the paper if cloud optical thickness reduced to the tau symbol or COT, and likewise with cloud effective radius could be r_e or CER

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