

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.

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Thanks a lot for your comments and suggestions.

Updated figures can be found here: https://www.science-emergence.com/Jupyter/MODIS_myd06_collection_6_multilayer_clouds_analysis/View/

- 1. Are the findings shown in this manuscript really limited to Aqua? I realize that the evaluation only is possible for the instrument onboard Aqua but is there a reason to think the conclusions are not just as valid for MODIS/Terra? If not, I wouldn't emphasize

C1

the Aqua dependence in the title and abstract.

You are right, the conclusions of the paper should also be valid for Terra as well. So, the Aqua dependence has been removed from the title and abstract. Same thing, I have changed C6.1 to C6 since the conclusions should also be valid for C6 and C6.1.

- 2. The quality of the 2B-CLDCLASS-lidar product used in this study should at least be briefly discussed. For instance, I assume that the identification by lidar-radar of the thermodynamic phase becomes increasingly less accurate for the lowermost detected layers – is that of significance for the results presented here? Also, please explicit what is meant by “mixed phase”.

A couple of sentences have been added to the text to describe briefly the 2B-CLDCLASS-lidar product.

- 3. It would be useful for readers and MODIS users if the authors further relate their results to the actual Cloud Multi Layer Flag SDS. In section 3 the authors describe the 4 methods / tests for multi-layer detection and explain that they are merged into a single confidence-level metric that ranges from 2 to 10 in case of multi-layer. I think that a couple more sentences explaining how the cumulative weight is obtained would be helpful. I realize that this paper does not aim to be too technical or replace the ATBD but it will likely become a reference paper for those interested in the multi-layer detection product. Also, it is unclear how the MODIS multi-layer cases that are shown in the manuscript actually relate to the SDS value, do they correspond to all cases with a value greater or equal to 2?

In the manuscript MODIS multilayer cases relate to the MYD06 SDS value with a value greater or equal to 2 and the MYD06 1km Quality Assurance is also used to extract the PH test. Couple more sentences have been added to explain it.

- 4. Related to the previous comment, and because this paper is likely to become a reference for the C6 multi-layer product, it would be very helpful if the authors included

C2

a brief bullet list of the practical implications of their findings, which users could easily refer to. For instance reminding that i) the MODIS multi-layer detection is to primarily be used as a retrieval quality indicator, ii) the flag should mainly be used when interested in ice cloud retrievals (as liquid cloud retrievals are by construction not too impacted?), iii) perhaps a word on the SDS values to be used (2 or higher?) for different cases, etc.

You are right, it is a good suggestion. The conclusion has been updated to better highlight the practical implications of this analysis.

- 1. p. 6 l. 145: Do I understand correctly that the L2 product in C6 includes the PH04 but the corresponding L3 product does not? If so, it would be worth emphasizing this by repeating it somewhere that be more visible to the readers (introduction or conclusion).
1 2.

Yes, it is correct the Pavolonis and Heidinger multilayer cloud detection algorithm output is available in L2 (through the MYD06 multilayer cloud QA) but it is not used for aggregating the MYD06 cloud products available in L3, since preliminary analysis during MYD06 Collection 6 development have shown that this algorithm was flagging too much cloudy pixels as multilayer clouds (this issue has been addressed in the MYD06 Collection 6 User guide).

- Fig. 3 and its analysis: It is interesting that the proportion of true/false detection of multi-layer cases in MODIS remains the same with or without using PH04. In both cases there is a 50% agreement with 2B-CLDCLASS and only the overall proportion of multi-layer detection changes. Would you then consider that PH04 does not significantly improve the quality of multi-layer detections or does the 8 vs 12% detection rate still make a difference to avoid biases on cloud properties? Fig. 11 indicates that PH04 does improve a bit the agreement ice cloud CER retrievals obtained in single- and multi-layer conditions, but I wonder if it is significant enough to risk higher false rejection rates.

I think it is a tricky question: It really depends on how multilayer cloud is defined and for

C3

what purpose. The MODIS MYD06 multilayer cloud algorithm was first developed to detect only multilayer clouds (based on the assumption of two separated cloud layers) that will impact CER and COT retrievals (which are based on a homogenous monolayer cloud model) and not to detect all possible multilayer clouds from a passive sensor. The PH ML algorithm was designed to detect all multilayer cloud (regardless the impact of CER and COT). So, for MODIS MYD06 multilayer cloud the goal was first to determine if the assumption of a homogenous monolayer cloud model is good or not.

- 3. Fig. 8 and its analysis: Why not also use the $OD > 4$ threshold here, for a better consistency with the following results related to Fig.. 9-11?

I still think it could be interesting for a user to have at least one figure that provides an overview of the MODIS MYD06 CER distributions discriminated by CLDCLASS-Lidar monolayer and multilayer clouds.

- 4. p. 13 l. 303–305: It is typically considered that effective radii retrievals associated with optical depth below 3 or 4 are not accurate, then is it really worth showing and discussing the results of Fig. 11?

Yes there are large uncertainties on CER retrievals for OD lower than 3-4 but since there are some differences between CER distributions it can still be worth it to present them.

- 1. p3 l53: “a two-layer cloud overlapping model” sounds like the layers are not vertically separated, which would be surprising. Perhaps “a two-layer model” is sufficient?

Yes, you are right, a two-layer model should be sufficient. The content has been updated.

- 2. p5 l105: might be worth precisising “thermal IR”.

Thermal IR has been added to the text