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Interactive comment on “MODIS 3 km aerosol product: algorithm and global perspective” by L. A. Remer et al.

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Six months have elapsed since this manuscript was submitted and 4 months since Dr. Wang submitted his review. During this time, work towards finishing the Collection 6 algorithms has continued. The algorithm analyzed in the initial submission has been changed significantly in order to fix discovered bugs in the code, to implement better gas correction, to handle changed inputs from other MODIS teams etc. There came a point when it no longer made sense to publish an analysis of an obsolete algorithm that would never be made public. Therefore, we have re-done the entire analysis using results from the version of MODIS aerosol code that is likely to be submitted for operational Collection 6 processing.

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The basic results and conclusions are the same, but every figure has been re-done using the new test data, and figures and tables will not match the original AMTD version of this paper.

We would like to thank Dr. Wang for his review and interest in our paper and product, and we ask his forgiveness in delaying our response to his comments, while we focused on the algorithm itself, instead of this documentation of it.

Our response to his specific suggestions follow. First we paraphrase his comments, and then we reply.

1. P77 line 16. Provide reference for MOD/MYD35, and briefly describe what will be new in collection 6 for this product.

Because we are working now with versions of both MOD/MYD04 and MOD/MYD35 that are closer to operational production, that specific line was removed from the text. The references for the MODIS cloud mask product are:

Frey, R.A., Ackerman, S. A., Liu, Y.: Strabala, K.I., Zhang, H., Key J., and Wang, X.: Cloud Detection with MODIS, Part I: Recent Improvements in the MODIS Cloud Mask , JTECH.25, 1057-1072, 2008.

Ackerman, S., R.A., Frey, K. Strabala, Y. Liu, L. Gumley, B. Baum and P. Menzel: Discriminating clear sky from clouds with MODIS. Algorithm Theoretical Basis Document (MOD35). Version 6.1. October 2010. http://modis-atmos.gsfc.nasa.gov/reference_atbd.html

We originally had referenced the Frey paper. Now we will also reference the ATBD. I believe that neither of these specifically addresses the changes from Collection 5 to 6. None of the co-authors of this paper are qualified to answer Dr. Wang's question on what will be new in the Collection 6 MOD/MYD35 product, and specifically we do not feel comfortable discussing that within the scope of the present paper. We encourage Dr. Wang to contact Dr. Frey or Dr. Ackerman directly for an update.

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2. P78 Lines 6-10. Does MOD/MYD35 use other information besides spatial variability to mask a cloud? Smoke and clouds can also be separated from multispectral information. So why the cloud identification should be based on spatial variability alone?

These are good questions. MOD/MYD35 is based on many tests, mostly spectral in the IR part of the spectrum, but also some spectral tests in the visible. The MODIS aerosol algorithm uses specific tests from MOD/MYD35, almost all from the IR part of the spectrum, and only in the over ocean part of the aerosol retrieval. The bulk of the cloud clearing in the aerosol algorithm is from visible spatial variability tests and a threshold test using the 1.38 μm channel. The MODIS aerosol algorithm does not use spectral tests in the visible.

Why? In developing a global algorithm, one makes compromises. Any spectral test that we applied for smoke would identify dust also as a cloud. Spatial variability was the best solution to apply a simple cloud mask globally. The tradition that we inherited from Yoram Kaufman is to always look for the simplest solution. Yes, we lose some smoke plumes. Could we bring them back if we tried hard? Probably. But bringing back smoke plumes is not a high priority at this time.

Dr. Wang's comments here do not seem to require any changes to the paper, and I don't believe he is asking us to remodel the entire internal global cloud mask in the aerosol code.

3. How is the global mean AOD computed? Is there pixel weighting? The issue related to the number of valid AOD retrievals is mentioned in the paper, so it will be good to add number of valid retrievals to Figure 7.

The global mean AOD for Figure 7 is calculated by adding up the value of each valid retrieval and dividing by the number of retrievals, globally. There is no pixel weighting, no maintaining spatial or temporal structure. This corresponds to the "straight" average from Levy et al., 2009. Rather than adding the number of pixels to Figure 7, we confront the issue head-on by introducing a new figure. (new Figure 11). This separates the

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changes in going from 10 km to 3 km into changes (1) due to algorithmic differences when the retrievals work from the same data in the same area, and (2) due to the 3 km retrieval introducing new retrievals into new areas.

New Figure 11 is a monthly mean constructed not by the “straight” method, but by accumulating maps and then averaging maps. This maintains spatial structure, and accentuates outliers that highlight the regional differences between the 10 km and 3 km products more clearly.

Besides introducing Figure 11, we have added words in the appropriate places that describe how global means are constructed.

4. A spatio-temporal validation strategy requires a match between spatial and temporal averaging windows. Going from a 25 km radius to a 7.5 km radius requires also reducing the temporal window from 1 hour to 20 minutes.

Dr. Wang brought up an interesting question that we had explored early on in this study, but had not included in the original manuscript. We have added a sensitivity study in the form of a new Table 5 that calculates the 3 km validation statistics against AERONET for both the 25 km and 7.5 km radii, at three temporal windows: 30 minutes, 1 hour and 2 hours.

There are differences in using the two different spatial windows, but these differences manifest differently over land and ocean. As for the differences in temporal windows? The differences are minor. The problem with moving to shorter than a 1 hour window is that there are fewer available collocations and the validation statistics stop being representative of the global situation, especially for the over ocean retrieval. This problem would be even more severe than seen in Table 5, if we had used Dr. Wang’s suggestion of a 20 minute window. AERONET only reports every 15 minutes. This becomes a very confining lower limit on temporal window.

Anyway, Dr. Wang’s comment prompted us to add the sensitivity study into the paper.

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It was a good comment, and we feel that we have made an improvement to the paper because of it.

5. Table 1. What is image optical depth land and ocean?

This is a product that includes all retrievals of all quality > 0. The standard land_and_ocean product uses only QA=3 over land.

6. Table 2. What is PSML003?

This is the new name of what had been referred to as “cloud condensation nuclei”. It stands for “Particles of the Small Mode Larger than $0.03\mu\text{m}$ ”.

7. Table 3. What is aerosol_cloud fraction_land? What is mean_reflectance_land?

Aerosol_cloud_fraction is the fraction of pixels identified as cloud by the internal aerosol cloud mask. It is not a true cloud fraction, and it includes some pixels that are not cloud, but are inappropriate for an aerosol retrieval. Some snow/ice gets mixed into that number, for example. Mean_reflectance_land is the spectral top-of-atmosphere reflectances from which the aerosol is derived. It has been cloud-cleared and pixel-selected for retrieval.

We have added a sentence referring readers to Levy et al., (2013) for clarification of any questions on the product list.

8. Figure 2. Bottom right. ‘and’ should be ‘or’. Clarify that the pixels mentioned in the flow chart are 0.5 km pixels. Describe what happens in a coastal retrieval at 3 km.

We switched ‘and’ to ‘or’, and clarified that the pixels were at 0.5 km in the flowchart. We also added these sentences about coastal retrievals.

“For coastal retrievals, if any pixel in the 3 km retrieval box is ‘land’ or ‘coastal’, then no ocean retrieval will be made. However, if there are 5 ‘land’ pixels in the retrieval box, even if the remainder of the pixels are ocean, a land retrieval will be made, although quality may be degraded depending on how many ‘water’ pixels exist in the box.” 9.

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Figures 11 and 12 (now 12 and 13). Add regression and correlation to the plots. Done.

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