

Response to Dr. Lorraine Remer.

We thank Dr. Lorraine Remer for her thoughtful and constructive suggestions.

*This paper makes a thorough analysis of the AOD trend in the MODIS and MISR products using the 10-year data record of these sensors. The authors do not take their initial results at face value but make a complete investigation of why there is an apparent trend in both MODIS sensors, but not in MISR. As part of this investigation they question the radiometric calibration of the MODIS sensors. However, there is a bit of confusion given that both Terra and Aqua show very similar trends, but are separate instruments, each calibrated separately. In the end, after a series of tests, the authors conclude that the apparent trend in the MODIS product must be radiometric calibration drift despite the Terra/Aqua similarity. In fact, the authors are correct in this conclusion. The clue is the “jump” in the time series in 2006. This corresponds to the onset of Collection 5 processing. Aqua began forward processing Collection 5 on 1 April 2006, and followed later that month with a reprocessing of the past data from 2002 to April 2006. Terra began its forward and reprocessing in July 2006. During a reprocessing both the aerosol algorithm and the calibration coefficients change. The MODIS Characterization Support Team (MCST) uses the opportunity of a reprocessing to update and refine each instrument’s calibration coefficients. While on-board calibration devices and monthly lunar views help a great deal to adjust calibration on a monthly basis and reduce drift, these “real-time” calibration adjustments are no substitute for analysis and adjustment to the time series as a whole. Prior to 2006, Collection 5 benefits from analysis of the calibration data as a whole. After early 2006, Collection 5 radiances are being produced on a month-by-month basis. Drift can enter the picture. The next reprocessing to Collection 6 is scheduled for 2011, when we hope that an eleven-year Terra time series can be produced free of artificial trends. The paper does not end with a conclusion about radiometric calibration drift in the MODIS global AOD time series, but produces interesting scientific results concerning regional aerosol trends, and an attempt to isolate anthropogenic from natural aerosol. This is a strong paper, well-written, conservative in approach and a contribution to the community. I recommend making changes to some nomenclature and several statements in the paper, but overall I feel the paper is worthy of publication.*

Thanks Dr. Lorraine Remer very much for clearing our concerns on this issue.

**Comments 1:** *DA versus QA’d. I strongly object to the use of the term “QA’d data assimilation quality” and the label “QAed” in the legends of several of the figures. The “natural MODIS” product is a “QAed” product, meaning a quality has been assigned to each retrieval. Furthermore there are two MODIS Level 3 products: (a) Mean (b) QA\_Mean. The QA\_Mean product is a “QA-weighted” aggregation of the Level 2 product. Seeing QA’d and QAed all over this paper brings to mind the “natural MODIS” QA\_Mean product. The first time I read the paper I did not realize until well beyond Figure 5 that comparisons were being made of “natural” and “DA” products, not the two “natural” products of “Mean” and “QA\_Mean”. This is especially confusing since the paper starts off by referring to the Data Assimilation*

quality product as 'DA', (Figure 1), then switches nomenclature. I strongly recommend changing 'QAed' to 'DA' throughout, not changing 'DA' to 'QAed' for consistency yet confusion. I'm not sure whether "natural" is the right word for the "operational" product. I might have used MODIS\_G (for Goddard) and MODIS\_N (for Navy), or something similar. I can accept "natural" if necessary, but "QAed" is too confusing for the standard MODIS aerosol user community. Don't use 'DA' in the first sentence of the abstract without defining it.

**Answer 1:** Thanks for your suggestion. We changed 'QAed' to 'DA' throughout the paper. We also used "operational" to represent the Goddard operational MODIS aerosol products as suggested.

**Comments: 2.** *At the end of Section 4.3, there is a confusing statement with no support. How can the global trend of AODa be significantly negative when the picture of Figure 10a is entirely positive? This has to be explained. Keep in mind that Eq. 4 may create its own trends. Think about what might happen as MODIS calibration issues create an artificial trend in fine fraction. This has not been explored in the paper, but most certainly must be happening. Aerosol size parameters are extremely sensitive to calibration issues. I would be hesitant about using Eq. 4 and drawing physical conclusions without understanding the role of an artificially changing fine fraction, especially when faced with results that appear to be contradictory. (Global trend of AODa is negative when Figure 10a is entirely positive.)*

**Answer 2:** This is a wonderful suggestion. We added a section of discussions to warn readers the potential limitations of using equation based approaches for the trend analysis. We added the following discussions:

*“However, readers should be aware that aerosol size parameters, such as the fine mode AOD fraction and Angstrom exponent, are extremely sensitive to calibration issues, and to retrieval uncertainties at different spectral channels. Therefore, trend analyses using satellite derived aerosol size parameters could contain noise and biases that limit the significance of using such parameters for trend analysis. Future research efforts are necessary to fully understand satellite derived aerosol size parameters before we draw definite conclusions from those parameters.”*

Also, the total average is negative because there are a large fraction of areas of small negative values (shown in white). Therefore, after averaging globally, the total number is negative. The color scheme is set in a way to highlight regions with positive values. We added the discussions as well. We added the following discussions:

*“Note that the color scheme for figure 10a is set to highlight regions with positive trend numbers, and therefore, although areas of positive trend are illustrated, the overall global average shows a slightly negative trend.”*

**Comments 3:** *In Section 1, in the list of papers considering temporal consistency in radiometric calibration, I would add Levy et al. (ACPD, 10, 14815-14873, 2010).*

**Answer 3:** We added the reference to the paper.

**Comments: 4.** *In Section 2, the paragraph that begins with “To minimize the effects of cloud contamination:” The statement about ‘buddy checks’ is unnecessary and needs explanation if kept. Just take it out.*

**Answer 4:** We removed the discussion. Thanks for the suggestion.

**Comments:5.** *In Section 2, next paragraph down. Here standard Level 3 products are mentioned, but not whether this is Mean or QA\_Mean. Please clarify in the text and the caption.*

**Answer 5:** This level 3 product was created based on the operational level 2 MODIS aerosol product. We added discussions below to clear this issue.

**“The operational MODIS level 3 product was created by averaging the available retrievals from the operational level 2 aerosol product at every 1x1 degree Lat/Lon, and only retrievals with QA labels of either “excellent” or “good” were used.”**

**Comments 6:** *Section 4.2, the discussion of the MODIS onboard and external calibration methods. There has been an issue with Terra’s Solar Diffuser, starting in 2003. The door is stuck ‘OPEN’. This means that space dust is collecting on this white plate over time. This degradation of the SD over time has to be corrected. From what I understand, solar diffuser data from Terra is almost totally disregarded in calibration because of this issue.*

**Answer 6:** It is interesting to know the details. Thanks for the discussion. We added the discussions to the text.

**Comments 7:** *Figure 8 and the paragraph in Section 4.3 that begins with “For the first question, we compared AOD spectrum from years 2000-2002: : :” To me, AOD spectrum refers to AOD as a function of wavelength, not these histograms of Figure 8. I strongly recommend changing the nomenclature here from “spectrum” to “histograms”.*

**Answer 7:** we changed from “spectrum” to “histograms”. Many thanks for the suggestion.

**Comments 7 (continue):** *Also, what is with this 6-hour average? Overpass is once per day. At higher latitudes you might see the same spot more than once per day, but to talk about a 6 hour average, as though there was an average from a Geostationary satellite, is misleading. Finally, 2000-2002 is a dangerous period with Terra. That is when there was the flipping between Side A and Side B electronics, which even with several reprocessings was never completely smoothed over. It would have been safer to use a period 2002-2004 as the beginning period.*

**Answer 7 (continue):** 6-hour average was used because our DA quality data is generated operationally every 6-hours for real-time assimilation and aerosol forecasting. However, combining of 6-hour averages for a two-year period should provide insignificant differences from directly averaging the data for the whole two year period. We added discussions to clear the question. Also, since we are showing the relative comparisons from two study periods, and therefore, the averaging process should have not affected the analysis. We added:

”The 6-hour average datasets, used in our operational aerosol forecasts, were then used to compute 2-year averages. Only relative differences between two periods were studied, and therefore, the averaging process should not affect the analysis. “

Thanks very much for the discussion on the study period. We plotted the study period of 2002-2004, as suggested (attached with this response). Similar patterns were found from both MISR and MODIS data that give us confidence on Figure 9. Therefore, we kept the current Figure 9, but added discussions as suggested. Many thanks for the wonderful suggestion.

“Also note that 2000-2002 is a dangerous period with Terra. That is when there was the flipping between Side A and Side B electronics (personal communication with Dr. Lorraine Remer). Yet although not shown here, our study suggested that using the study period of 2002-2004 instead of 2000-2002 shows the similar patterns, suggesting the two year averages are less affected by the electronics changes of the instrument.”

**Comments 8:** *Section 4.3, the final statement in the paragraph with Equation (4) “: : : can be considered a proxy for the fine mode AOD”. AODa is not the same as fine mode AOD. I’m not sure what is meant by “proxy” here. It has been a struggle ever since Yoram published that paper to wean people off the concept that fine mode AOD is the same as AODa. Please don’t contribute to that misconception. You don’t need that sentence. Please remove it. Also, at the end of Section 4.3, it says “: : : are induced by fine mode or anthropogenic aerosols.” Again there is the implication that these are the same things, when they are not. Also, you might mention for the confused audience that AODa is a “combustion” optical depth, and some smoke is natural and some dust might be anthropogenic.*

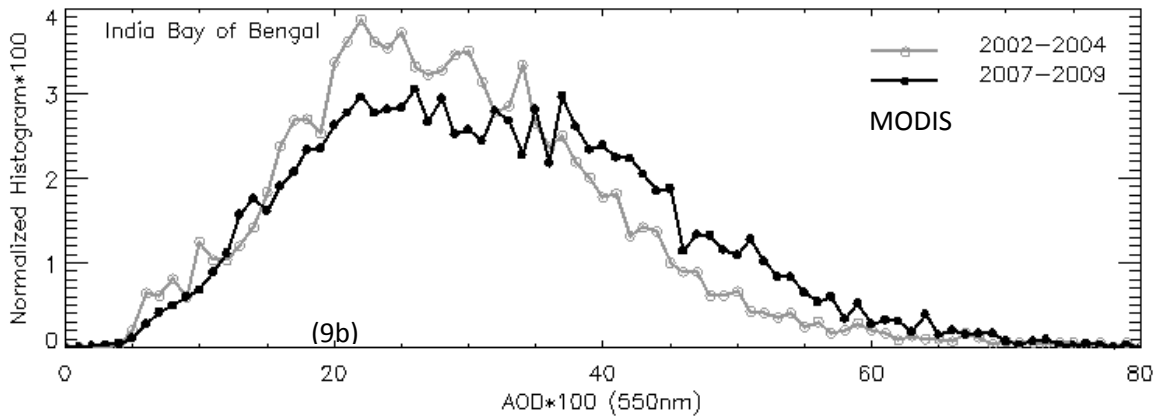
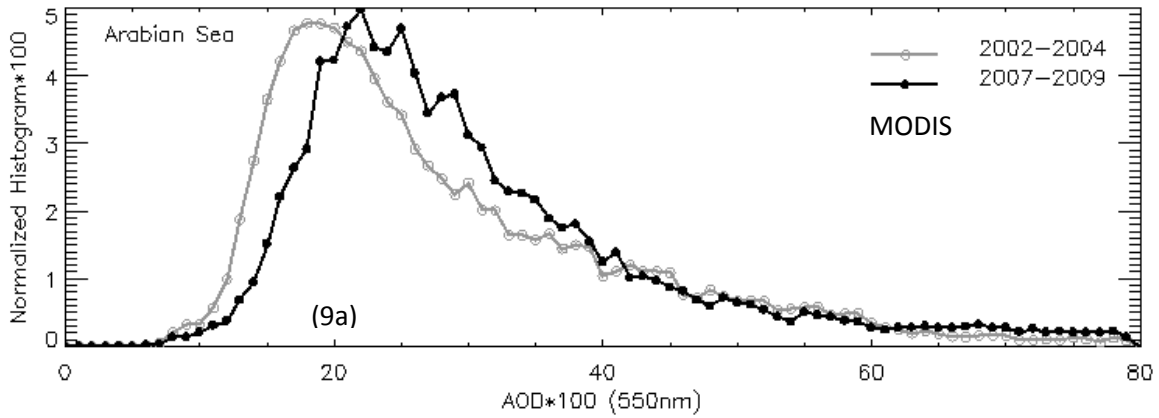
**Answer 8:** Agreed, and we removed those discussions. We also added discussion on AODa as suggested. We added:

“AODa is a “combustion” optical depth. And readers need to be aware that some smoke is natural and some dust might be anthropogenic.”

**Comments 9:** *I would stand by the final conclusion point in the last section. Calibration drift is extremely difficult to (a) notice and then (b) quantify, for any sensor.*

**Answer 9:** Thanks for the suggestion, and we added that to the discussion.

Revised Figure 9 for illustration purpose. Data from 2002-2004 were used as suggested by Dr. Lorraine Remer. **9a)**. Normalized AOD histogram for 2002-2004 and 2007-2009 periods over the Arabian Sea. The 6-hour,  $1 \times 1^\circ$  (Lat/Lon) DA quality MODIS aerosol product was used. **9b)**. Similar to Figure 9a but for Indian Bay of Bengal. **9c)**. Similar to Figure 9a but for Coastal China. **9d-9f)**. Similar to Figures 9a-9c, but for MISR.



MODIS

