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Interactive comment on "Satellite retrievals of dust aerosol over the Red Sea, 2005–2015" *by* Jamie R. Banks et al.

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I am posting this under my name (Andrew Sayer) as I have collaborated with the authors, and the lead author and I were PhD students together. I also provided some comments and suggestions to the authors while the manuscript was in preparation. I feel I am able to provide an objective review.

Summary

This paper examines dust aerosol property retrievals over the Red Sea and Persian Gulf over the period 2005-2015 from SEVIRI and MODIS. This is a validation exercise of the two vs. AERONET and MAN, a comparison of the two against each other, and an examination of the seasonal and interannual variability of aerosol loading here. MISR data are also briefly used. It is relevant to the scope of ACP and of interest to the broader scientific community. Some of the work is an update of Brindley et al (2015) although this uses an updated MODIS data version (Collection 6) and has a broader scope so this is a worthwhile extension. In terms of MODIS, this is of particularly utility because there hasn't been much attention in the literature to validation of the MODIS over-ocean AOD product in dusty scenes. In these cases the assumption of aerosol sphericity causes problems in the retrieved products; this has been known about for a long time but not been published about so much. So this analysis highlights that nicely, and may bring more attention to the topic. Levy et al (2003) showed a bit of this, briefly, but for an older version of the MODIS product.

My recommendation is that this paper can be accepted for publication in ACP, after attention to the follow comments. I also have some general suggestions for straightforward extensions to the analysis, which may improve on the utility of the study for the part of the community interested in AOD retrieval development/validation. I don't feel that all of these extensions are necessary for publication but would encourage the authors to consider adding them. I am happy to review a revised version if the editor would like.

Specific comments

Title/abstract: I suggest adding the Persian Gulf into here as well, since this isn't mentioned at present in either title or abstract. I'd also mention in the abstract that some differences may be related to sphericity assumptions since, as I noted above, this has not got as much attention as it perhaps should have.

General: correlation coefficients are often given to 3 decimal places; I think 2 is sufficient as 3 gives a false impression of the level of precision on an estimate of correlation.

Page 4, lines 4-5: It is important to make the distinction here that the Dark Target algorithm is **NOT** applied over land and ocean. The product is often colloquially referred to as 'Dark Target' but there is not one Dark Target algorithm. There is one algorithm over land and another algorithm over ocean. They use different wavelengths, make different aerosol assumptions, and different surface assumptions, and have very little in common. This is a common misconception in the literature and is misleading so it would be good to make the text clear. The MODIS algorithm applied in this study is the ocean algorithm. So when Deep Blue is considered as well, this makes three algorithms in the MODIS MxD04 product, not two as line 4 states.

Page 4, line 21: I recommend using pixels with QA=1,2,3, rather than only QA=3. The QA=3 recommendation is made for Dark Target land retrievals. For ocean algorithm retrievals, the team recommend that QA=0 are discarded but QA=1,2,3 can be used. This is because the QA flags were not found to mean much over the ocean (aside from QA=0), is what prior ocean validation exercises were done with, and what is done when aggregating into the widely-used Level 3 products. Doing this will give a more realistic representation of how the product is intended to be used, and should increase data volume as well. I'm not sure whether this will quantitatively affect the conclusions

much or not.

Section 2.2: Does the study use both Terra and Aqua data? I did not see it stated, perhaps I missed it. If both are used, is there any significant difference between the two found?

Page 6 line 25: This says that the assimilation makes the model AOD fields consistent with MODIS. The implication of that wording to me is that model AOD becomes replaced with MODIS AOD, but I assume that this is not the case. I think that this last part of the sentence should be deleted since it might cause confusion and the sentence already says it is 4D-Var and gives a reference.

Page 7 lines 30-32: I would state again that quality flags are applied here, just to be clear to the reader, as sometimes people don't use them (which is bad). I realise it was stated earlier in the paper that they were used for MODIS.

Page 8 lines 14-15, 21: Smirnov et al (2000) should probably also be cited at one of these points as it describes the cloud screening for the level 2 data used.

Page 9, lines 27-30: It's possible that this is due in part to SSA assumptions, since SSA influences the point at which the reflectance vs. AOD curve flattens out. I'm not sure what the difference between MODIS and SEVIRI assumptions is. MODIS ocean retrievals include a green band so there will be some dust absorption at that wavelength, but the SEVIRI wavelengths (and longer MODIS wavelengths) should all be fairly nonabsorbing for dust. (Note that the MODIS ocean product also provides output AOD at 470 nm, where dust absorption would be stronger, but this band is not actually used for the inversion-a few papers are incorrect on that matter.)

Page 10 lines 18-19: it is good to include MISR as another point of comparison, but worth mentioning more directly that as this is another retrieval, with stated uncertainties comparable to MODIS, better agreement with MISR does not necessarily mean that a product is closer to the truth.

General, figures: some look a bit overly digitised, not sure if this is a problem in the source files or the conversion for embedding in the manuscript but this should be checked.

General, figures: most font sizes could do with being increased 1-2 points as a few scales are hard to read at 100 % magnification (this could be related to the above point as well).

Figure 7: I would change the caption to read *MODIS-SEVIRI offset* rather than *MODIS-SEVIRI bias* as people often read bias to imply that the reference is truth, while offset is a more neutral word. Same with some of the text on e.g. pages 10-11.

Figures 7,9: it would be good to include a short plot title rather than just a letter, for easier quick reference to what is in the plot when browsing between text and figures.

Suggestions for extension

Both MODIS and SEVIRI over-ocean products retrieve AOD and Ångström exponent; MODIS also retrieves fine-mode AOD fraction (from which one can get fine mode AOD and coarse mode AOD). I'm not sure if it is possible to derive fine mode fraction from

the SEVIRI product as well (my impression from the cited references is that it's not a direct output). It would be interesting to compare the Ångström exponent retrievals with AERONET and with each other, as well, since some of the effects of the MODIS spherical assumption might also manifest there (in the same way as they are seen in the AOD comparisons). This is discussed briefly on page 10 but it does not go into much detail.

The MODIS product could also be broken down to give fine and coarse mode AOD, which could be compared with that from AERONET's SDA product. This product has also not been evaluated widely for MODIS (Kleidman et al., 2005 is the main exception), and not at all to my knowledge for Collection 6. SDA is available at Level 2 for the Kaust site; it is only Level 1.5 for Abu Al Bukhoosh (because I think of the limited number of spectral channels) but that might be able to be used with caveats. Adding this to the analysis would give important information about the quality of this product, as well as perhaps indicating how the 'spherical dust' assumption affects the robustness of total AOD vs. the fine/coarse-mode split.

MISR also has a 'nonspherical AOD' product which could be taken as a proxy for mineral dust AOD, and compared with MODIS-derived coarse-mode AOD in a similar way to e.g. Figure 9.

Is it possible to evaluate the SEVIRI retrievals as a function of time of day (maybe comparing diurnal cycles with AERONET or just plotting bias vs. hour or something)? I understand if there might not be enough data. However temporal resolution is something that geostationary sensors have an advantage over polar-orbiters with, so I think it would be good to emphasise this aspect of the SEVIRI retrieval.

References

Kleidman, R. G., N. T. O'Neill, L. A. Remer, Y. J. Kaufman, T. F. Eck, D. Tanré, O. Dubovik, and B. N. Holben (2005), Comparison of Moderate Resolution Imaging Spectroradiometer (MODIS) and Aerosol Robotic Network (AERONET) remote-sensing retrievals of aerosol fine mode fraction over ocean, J. Geophys. Res., 110, D22205, doi:10.1029/2005JD005760.

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Smirnov, A., B. N. Holben, T. F. Eck, O. Dubovik, and I. Slutsker (2000), Cloud-screening and quality control algorithms for the AERONET database, Remote Sens. Environ.,73 (3), 337-349.

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