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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Vicarious calibration of S-NPP VIIRS reflective solar M-bands against MODIS Aqua over dark water scenes" *by* A. M. Sayer et al.

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Summary and recommendation

This paper presents a correction to VIIRS data based on MODIS Aqua over cloud-free dark water surfaces. The applied method searches for matching observations within a 10 minute and 3 degrees viewing geometry envelope among other criteria, run a radiative transfer model (VLIDORT) to create a look up table (LUT) of simulated spectral TOA radiances normalized with the solar irradiance, find the best match between those results and the MODIS Aqua observations in terms of TOA radiances, assume those represent the truth, aggregate the data monthly, and finally compare the LUT to

VIIRS observations to derive correction factors per VIIRS band as a function of time. The LUT has dimensions of viewing geometry, wind speed, Chlorophyl, AOD, and fine mode fraction. I understand that, for each observation, the first five parameters in Table 2 on page 13 are assumed to be known while the fine mode fraction is a retrieved parameter, which is forced to be the same between MODIS and VIIRS. The only free retrieved parameter is AOD with values allowed to range between 0 and 0.2 in order to retain a match. The paper shows a plot (Fig. 9 on page 18) of the correction factors for each VIIRS band as a time series to analyze trends and variances. The latter is used as an uncertainty estimate. The paper continues to show a comparison of the VIIRS retrieved AOD against AERONET, before and after the vicarious calibration factor are applied (Fig. 10 on page 23). Those results indicate something about the sensitivity of the radiometric differences between MODIS aqua and VIIRS on the retrieved AOD values. The results suggest that the (high) bias in VIIRS AOD retrievals with respect to AERONET decreased from 0.031 to 0.015 after the application of the correction factors. There are almost no corrections in the blue (Fig. 9 on page 18), which is interesting because the AOD in those bands decreased as shown in the Fig. 11 on page 23. Please explain this. It may be noted that this work bases on relative comparisons between MODIS aqua and VIIRS and against AERONET. The latter provides more of a direct observation than the satellite based retrievals, but some uncertainties remain. Since no in-situ measurements of TOA radiances or columnar AOD are possible, the conclusions in this paper rely on qualitative arguments about the improvement of AOD due to the application of the derived correction factors to the VIIRS data.

I think that this is a comprehensive and very well written paper. The methods used are not novel, but they are applied in a new and interesting way. This paper covers two main topics: cross-calibration between MODIS aqua and VIIRS and the effect of those corrections on AOD retrievals. This work is therefore relevant to both, the aerosol remote sensing and the instrument calibration community. I can see this method being used more often in the future to inter compare slightly different optical remote sensing instruments and to create homogenized datasets of satellite observations and retrieved geophysical quantities. In summary, this paper addresses two relevant questions within the scope of AMT and I therefore recommend to publish this article in AMT after all comments are addressed.

Minor comments

General

The term 'vicarious calibration' is often used with respect to the absolute radiometric calibration of a satellite or airborne optical sensor under operational conditions where surface and atmospheric parameters are sufficiently known (ideally from in-situ measurements) such that the signal at the sensor level can be modeled using a RTM. This is partially true here as well. However, the work in this paper does not use independent surface and atmospheric measurements. It relies on another remote sensing sensor with comparable observational capabilities and accuracy. It effectively transfers the calibration of MODIS aqua to VIIRS, which is typically called 'cross-sensor calibration'. I therefore invite the authors to think about their use of the term 'vicarious calibration'.

Title

- The title should clearly reflect the AOD related content of the paper.
- 'M-bands' should be spelled out: 'moderate-resolution'.
- 'cross-calibration' instead of 'calibration', as suggested above.

Page 1, line 6

I guess the percent numbers or correction factors apply to TOA sun-normalized radiances. Please clarify and state clearly throughout the paper to what those numbers refer to.

Page 4, Eq. 1-4

This is a comment or a suggestion based on my own personal use of notation. It does not need to be addressed because the notation used in the paper is properly introduced and explained. However, I am confused with the use of I_i to express the spectrally integrated radiance per band, or radiance per band (flux per unit projected area per unit solid angle, L_i, [$W/m^2/sr$]). I am used to I_i expressing intensity (flux per unit solid angle, [W/sr]). The same goes for Eq. 3 where $F_{0,i}$ expresses the spectrally integrated irradiance per band, or irradiance per band [W/m^2]. I am used to F_0 or Φ_0 denoting the solar radiant flux (rate of flow of radiant energy or simply power, [W]). For example, on page 5, line 6 the term 'Sun-normalised radiance' is introduced together with I/F_0, which is confusing to me as I would expect $L_i/E_{0,i}$. Personally, I would prefer a notation change throughout the paper as follows:

- $I_i \Rightarrow L_i$
- $F_{0,i} \Rightarrow E_{0,i}$

Subsection 3.1

Please discuss how cloud contamination issues are addressed. Clouds passing the cloud mask, such as smaller cumulus and thin cirrus, could potentially be a significant contribution to the uncertainties due to the large contrast with the dark water surface. Clouds are very variable in time and space, even within the envelope allowed for successful matchups. I suggest to mention clouds more specifically as well on page 24, line 14ff..

Subsection 3.2

I suggest to shorten this subsection because it sidetracks from the main topic on this level of detail. Isn't the main point here is that gaseous corrections are being made implicitly using VLIDORT to compare the observations from MODIS and VIIRS?

Figure 3
I am not sure how important this figure is. If it is, please explain why.

Figure 4
It may be worth reporting how the AOD at 550 nm is calculated if it was retrieved at another wavelength. Many AOD retrieval algorithms would combine the information from many available bands and not just a single band as shown here. It may also be worth mentioning that the purpose of using single band retrievals here is to reveal band to band calibration differences. Ideally, the AOD shown in Fig. 4b should all fall onto the same value. However, not only the calibration might affect those results, but also that the sensitivity to retrieve AOD. The latter depends largely on the combination of spectral aerosol extinction, the phase function and the surface reflectance spectra. Maybe it would be worth mentioning this even if only dark water surfaces are used in this work.

Page 16, line 22-32
I suggest to remove this paragraph as well as Figs 7 and 8. I believe that those detailed information are not directly relevant to the main findings. I can not identify a clear relation between the results shown in Fig. 9 and the number of matching observations over time. It could go to an Appendix, for example.

Figure 11
Please explain in the text why the influence of the correction factors on AOD are strongest in the blue and getting weaker towards longer wavelengths, especially since the correction factors in those wavelengths (eg at 412, 440 and at 490 nm) are very close to 1. I would have expected larger correction factors at those shorter visible wavelengths to explain the relatively large impact on the spectral AOD.

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