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Interactive comment on "Simultaneous determination of aerosol optical thickness and water leaving radiance from multispectral measurements in coastal waters" *by* Chong Shi and Teruyuki Nakajima

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I have a few questions/comments about the approach taken in this paper. In general I think that a simultaneous atmosphere/ocean inversion like this is a good way to go, and Optimal Estimation is a good inversion technique to apply for a problem like this. The application to data within Sun glint is also interesting. But I had some questions about the details which I didn't spot in the manuscript (perhaps I missed something).

A strength of Optimal Estimation is the uncertainty estimates provided (Equation 7),

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Discussion paper

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as well as the ability to use a priori data. The authors note the a priori values for parameter, but I don't see the a priori uncertainties anywhere (except for Chl where it is noted to be the variance of the standard MODIS product). What are they?

Likewise, I am curious what the averaging kernels look like for these retrievals. Although one can retrieve 8 things from 8 measurements, considering that there is a high degree in spectral correlation between the measurements, there must be far fewer than 8 degrees of freedom. So it is likely to me that there are degenerate solutions, large null space uncertainties (hinted at for e.g. wind speed outside of glint, in Figure 7), and/or strong dependence on the a priori assumptions in some cases. For example I wonder if some of the skill for the aerosol composition is coming from a tight constraint to the SPRINTARS model?

It would also be useful to include the uncertainty estimates on retrieved parameters on the validation results shown in e.g. Figure 4. That way we can see whether they are reasonable or not. Figure 7 shows simulations but since there is validation shown with real data, it would be good to see the uncertainty estimates for these real data as well.

I suggest adding the MODIS 1.2 and 2.1 micron bands as well. These will not have much ocean colour information, but may help better constrain the aerosol contribution to the signal. By increasing the number of measurements relative to retrieved quantities, this should in general decrease any degeneracies in the retrieved state.

I am curious how the minimisation actually works computationally (I did not see this mentioned in the paper). Is it a minimisation from a multidimensional lookup table? Or is the radiative transfer code called for each iteration of the retrieval? If it is a lookup table, is the full atmosphere/ocean state included in the simulation (which is the most accurate but then requires a higher-dimensional lookup table) or is there some assumption like linear mixing to include the contribution from multiple aerosol components more simply? Linear mixing is used in e.g. the standard MODIS AOT product for computational efficiency, but has system-

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atic biases when there is absorption in the atmosphere. See Abdou et al (1997, http://onlinelibrary.wiley.com/doi/10.1029/96JD03434/abstract) for some discussions of limitations of linear mixing and a modified method (which decreases, but does not eliminate, this error source).

What is the first guess at the retrieval solution? Is this initialised from the a priori value?

Page 7, lines 15-16: I do not understand this sentence. Is the soot fraction in fine particles retrieved (as stated in line 15) or assumed (as stated in line 16)?

For the vicarious calibration, are 18 points really enough to state with confidence that there is no significant temporal or geometric dependence in the results? What are the uncertainties on the derived calibration coefficients?

Also, are the Werdell (2006) results shown in Figure 3 the latest coefficients used in the MODIS ocean colour algorithm? There have been numerous reprocessings since then and calibration coefficients have changed. I looked at the MODIS webpage and the calibration gains there for the 2014 Aqua reprocessing (https://oceancolor.gsfc.nasa.gov/reprocessing/r2014/aqua/), which I think is the latest, are different.

I think it is also worth stating up front as well that the vicarious calibration effectively calibrates out the average bias in the sensor plus forward model at the calibration site, as some readers may not be aware of this. This in turn means that biases can be introduced in conditions which are different from those at the site used to tune the data in this way.

Figures 5, 8: I would remove the regression lines from these plots. Linear least squares regression is not valid for AOT data because the expected error is AOT-dependent (and type-dependent), the uncertainties are not Gaussian, the points are not independent, sampling is highly skewed to the low-AOT end, and the expected relationship between truth and retrieval is not necessarily linear. So the slope and intercept, and their uncer-

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tainties, estimated using this technique are misleading. It is a popular technique but it is mathematically inappropriate for these data.

Although not directly relevant to the point of coupled ocean/atmosphere inversion, since the authors also look at the MODIS ocean colour product, it would be interesting to see the comparison of AOT for the MODIS aerosol products as well. This sort of simultaneous inversion should result in better results than the MODIS aerosol product, since the standard aerosol product does not account for variations in ocean colour (as the authors rightly point out in the introduction). Similarly it should help by having more aerosol information than the standard ocean colour approach, which may alleviate some biases in standard ocean colour products. On that point the authors may be interested in the study Kahn et al (2016, http://journals.ametsoc.org/doi/abs/10.1175/JTECH-D-15-0121.1), which assesses some of these contextual biases in ocean colour data.

Finally, it would be interesting to see some mapped results of the algorithm as opposed to just scatter and line plots. I suggest the authors add some case studies with different aerosol/ocean features, and show true colour images together with their retrieved data fields and uncertainties. It would also be instructive to show some of the standard NASA MODIS ocean colour and/or aerosol products, to see whether spatial patterns are consistent, and whether any differences or discontinuities can be related to surface/aerosol features not accounted for by one of the algorithms. In particular, since this paper was submitted to ACP and not AMT, it would be good to see more comparison/application of the results rather than just algorithm description and validation.

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