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Interactive comment on "A theoretical study of the effect of subsurface oceanic bubbles on the enhanced aerosol optical depth band over the southern oceans as detected from MODIS" *by* M. Christensen et al.

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1   General comments and recommendation

This paper investigates to what extent subsurface ocean bubble rafts, which are not considered in surface reflectance models in over-ocean aerosol optical depth (AOD) retrievals from passive satellite radiometers, may lead to contextual biases in these AOD datasets. This is motivated by trying to understand differences between different

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satellite AOD datasets and apparent biases against validation datasets in e.g. the Southern Ocean. As such the topic is thematically appropriate for AMT. The end result appears to be that the error resulting from a neglect of these rafts is, in most cases, negligible. This is a useful result as I don't believe it has been examined directly before, and by quantifying the size of the effect we can make some assessment about when we might need to worry about it in the future (when we have better sensors/algorithms).

I do not have any major problems with the paper, although there are a few places where I think a small expansion to the analysis/text would improve the utility of the study. As such, I favour acceptance after minor revisions. If it is determined that a second round of reviews is necessary, I am happy to review a revised version. Specific comments follow below.

2 Specific comments

P12797, line 15: I am not sure that Toth et al. (2013) is the best reference in regard to 'early studies' here. I would suggest maybe Smirnov et al. (AMT, 2011). There may be earlier references which escape me at the moment, but I don't think there was much in the way of high-latitude open-ocean AOD validation until MAN.

P12797, line 26: Several other algorithms had been using wind speed data for a few years before these examples (although they are less prominent than MODIS or MISR), see e.g. Sayer et al. (2010) for (A)ATSR and Sayer et al. (2012) for SeaWiFS. Possibly also worth mentioning here is the recent NOAA VIIRS aerosol product, which also does incorporate wind speeds (Jackson et al. 2013).

P12799, line 11: I think Koepke (1984), cited later in the manuscript, is a better reference than Vermote et al. (2006) here. The Koepke work serves as the basic approach used by 6S and others. On a related note, I think that the 6S paper (Vermote et al., 1997) might be better to cite than the code user guide (Vermote et al. 2006) when discussing 6S in the paper, but this is up to the authors.

P12800, line 16: The rationale for looking at 0.66 μm makes sense. However why not also look at e.g. 0.87 μm? This is another key channel present and used for AOD retrieval over ocean by most sensors (MISR for example uses only 0.66 and 0.87 μm over ocean), as well as having ground-truth AOD from AERONET and MAN, and if the authors already have the required data matched up hopefully it is not too complicated to run the RT model at a second wavelength? This would help give some first order idea about the spectral dependence of the effect, which the authors note is the logical next step. I think that this would be a valuable addition to the manuscript, which should not take too much effort, and could be accomplished without excessive length (if necessary key results could be summarised in a table or something). My impression based on Figure 2 is that the effect will become negligible, but it'd be nice to have some numbers behind that, and see also my later comments on Section 2.3 and Figure 2.

P12801, line 20: The MODIS uncertainty should be formatted as +/-(0.03+0.05*AOD), not 0.03+/-0.05*AOD. Strictly, there is a difference between the two, and the former is correct (although the latter is often written). Additionally, it is worth noting that the team now believe that the error is larger than this (Levy et al. 2013), based on preliminary validation of Collection 6 results, which do include ancillary wind data.

P12801, line 25 onwards: It may not make much difference for this study, but are you using Collection 5 or Collection 6 level 1 and cloud mask data? Also, this should be

referred to as MYD35 rather than MOD35 as Aqua is being used.

On the topic of cloud masking, it would be good to state exactly how the MODIS cloud mask was used (I am not familiar with the C6 product but in previous versions at least there were both 'confidently' as well as 'probably' clear and cloudy categories). My guess is 'confidently clear' based on P12802 line 24 but it would be good to be explicit. The data version and categorisation points may contribute to some of the scatter in Figure 3.

I would also suggest taking an average rather than closest pixel for the MAN-MODIS-AMSR-E matchup (40 data pairs) because you have a 30 minute time window and so I think that you can go larger than taking a 500 m MODIS pixel. In fact my suggestion for this part would be to use the 0.3° lat/lon threshold and, in Figure 3, plot the median MODIS reflectance (rather than closest pixel) and put on error bars corresponding to the standard deviation or something. That will make Figure 3 a bit more informative about how much of the scatter can be attributed to RT model or calibration issues, and how much can be attributed to sampling.

P12802, line 10: which AMSR data product and version are used? Is this the latest version 7 (http://www.remss.com/missions/amsre)? This information should be given in the paper.

P12805, section 2.3 and Figure 2: It would be good to add some context by making a statement about what fraction of the total TOA reflectance these bubble rafts contribute, i.e. show/state $\Delta R/\pi$ in terms of percent of total reflectance (for a typical scene) as well as in absolute units as given in Figure 2 presently. At the moment it's hard to get a feel for how small these small numbers are. Figure 3b doesn't do the

job here because, if I understand correctly, the bubble raft contribution is folded in with the other surface contributions (e.g. glint, whitecaps). The other issue with Figure 2 is that although the absolute contribution from rafts appears to decrease as wavelength increases, Rayleigh and aerosol scattering do as well. So the relative contribution to the signal may not be decreasing as fast (and could even be increasing) at longer wavelengths.

In the same section, is Equation 2 (with Equation 3) all that is needed (with the coefficients in Table 1) to include the bubble raft contribution at this wavelength, or is there something more? I think this should be more explicit. If this is all, and the L/J coefficients are easy to find/calculate for other wavelengths, then stating this more up front would be good to encourage people to incorporate rafts into their surface models.

Figure 3b: What is the x axis here? I think that the x axis labels should be removed. In fact I think that 3b itself can be removed, and only 3a is necessary.

Figure 4: It would be good to add some horizontal and vertical error bars to the triangles, so we can see the variability in AOD error and in wind speed within each bin. Also, the figure and caption could be clearer: are the triangles/black line the average AOD absolute error, or the average AOD difference (bias)? From the text it sounds like the error, but from the plots the error looks smaller than the cited validation results suggest (e.g. +/-0.03+0.05*AOD).

Figure 5: The y axis and start of caption say MAN-MODIS, but the later sentences say MODIS-MAN. I think that MODIS-MAN is the logical way to plot things (i.e. bias of MODIS relative to MAN as a 'truth'), so suggest this is redrawn as MODIS-MAN.

Figure 6 and related text: Is there any seasonality to the correction, driven by seasonality in wind speed? It would be good to state/show this somewhere.

There's one more point which is not directly addressed but may be relevant. As discussed, whitecap fraction parametrisations also depend on wind speed, and so when retrievals include wind speed data (as opposed to assuming a single value) they get better because the surface reflectance assumed gets better. However there remains a large amount of scatter in both parametrisations of whitecap fraction as a function of wind speed (I think about an order of magnitude), as well as the spectral reflectance of the whitecaps themselves (I think about 50 %). These result both from the uncertainty on the measurements but also presumably real variability (as wind speed is not the only driver of whitecap fraction, and colour of whitecaps depends on things like their size and age). This is discussed a bit in some work the authors cite (e.g. Frouin for whitecap reflectance) and by other authors (e.g. M Anguelova, A. Callaghan). For example the whitecap fraction expression used in 6S (from Koepke 1984, which I think used Monahan?) comes out, I think, quite a lot higher at high wind speeds than more recent measurements. As the present study is looking in large part at radiative transfer simulations this uncertainty doesn't matter so much (as the authors are looking at reflectance changes), but on application in a real retrieval, it's possible that the error from neglecting bubble rafts could be swamped in the error from the whitecap fraction or whitecap reflectance parameterisations, or even from the error on the ancillary wind data ingested. I think this should be acknowledged more directly in the manuscript, but am unsure of the best way to resolve it. One thing to look at would be how large the modelled raft contribution is compared to the modelled whitecap contribution. Addressing this would help to figure out whether retrieval errors can be best reduced by focussing on improving parameterisation of whitecap fraction/reflectance, better ancillary wind speed data, or including rafts in models, first.

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3   References (if not cited in the submitted manuscript):

- Jackson, J. M., H. Liu, I. Laszlo, S. Kondragunta, L. A. Remer, J. Huang, and H.-C. Huang (2013), Suomi-NPP VIIRS aerosol algorithms and data products, J. Geophys. Res. Atmos., 118, 12,673–12,689, doi:10.1002/2013JD020449.

- Sayer, A. M., G. E. Thomas, and R. G. Grainger (2010), A sea surface reflectance model for (A)ATSR, and application to aerosol retrievals, Atmos. Meas. Tech., 3, 813-838, doi:10.5194/amt-3-813-2010.

- Sayer, A. M., N. C. Hsu, C. Bettenhausen, Z. Ahmad, B. N. Holben, A. Smirnov, G. E. Thomas, and J. Zhang (2012), SeaWiFS Ocean Aerosol Retrieval (SOAR): Algorithm, validation, and comparison with other data sets, J. Geophys. Res., 117, D03206, doi:10.1029/2011JD016599.

- Vermote, E. F., et al. (1997), Second Simulation of the Satellite Signal in the Solar Spectrum, 6S: an overview, IEEE TGARS, doi: 10.1109/36.581987.

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