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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Relationship between wind speed and aerosol optical depth over remote ocean" *by* H. Huang et al.

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First of all, the authors would like to thank the referee for the interest in this work and for the detailed comments.All questions asked by the referee are answered below by the main author on behalf of all co-authors.

1. The authors basically examine the effects of wind speed on AOD at 500 nm. It is well-accepted and demonstrated (innumerable liter- ature available right from the 1950s; based on model simulations, analytical considerations as well as in-situ measurements) that the wind-generated sea-salt aerosols are in the coarse mode regime (with the concentration peaking at diameter >2 micrometer). The mode radius shifts to higher values at stronger (>10-12m/s) winds. As such, the impacts would be higher

at coarse mode optical depths or AOD at longer (near IR) wavelengths, and also the Angstrom wavelength exponent, than at 550 nm.. This would be more so when wind speeds exceed 8 to 10 m/s, when in addition to film and jet droplets, spume droplets will be directly produced by shearing off the wave-crests and these would be at still higher sizes even after equilibrating with ambient RH. This is also indicated in the authors™ figures 6, 8 and 9, where the points show a leveling off tendency above wind speed 10 m/s. It would be appropriate to examine AODs at longer wavelengths if available, or at least discuss this possibility and modify the conclusions accordingly. 2. There are also in situ measurements, in the southern ocean, of decrease in the con- centralian of accumulation mode aerosols, during very high winds (exceeding 20 m/s). The consequence of such events will be reflected as a decrease (or less increase) in the extinction at the shorter (mid-visible) wavelengths and thereby assumes adds to comment 1

Reply: *The comment 1 and 2 are concerned with the similar issues. An all-in-one reply is given below.We also added a new part to conclusion part of the new manuscript to discuss this issue. The retrieval algorithm we use is an optimal estimation method. Technically, we find the best fit of all parameters with all the available channels, ie.0.55,0.62,0.87 and 1.6 μm. It is true that over the ocean, enhanced AOD at higher wind speed as a consequence of heavy marine aerosol production invoked by wind. The size distribution of sea salt moves towards to the coarse mode as the wind speed increases. Such increase in the number of large particles would result in an increased extinction efficiency at longer wavelengths. Thus, theoretically, one might expect the relationship between wind speed and AOD to be stronger a longer wavelengths. Thus, theoretically, one might expect that the AOD at longer wavelength increases with wind speed slightly faster than its counterpart at short wavelength. As a double check, we have examined the relationship between wind speed and the AOD at 0.87μm. However, the result obtained are similar to the result of 550nm channel presented in the paper. Possible explanations include deficiencies in the assumed properties (refractive index and size distribution) of the OPAC aerosol class used in the retrieval or that the* *increase in average particle size with increasing wind speed is not significant enough to be apparent in these results.* We have added this part of statement to the result discussion section of the revised manuscript.

3. In this paper the authors first classify / define the oceanic regions, which can be considered as remote based on the wind directions and AOD and this is approach is praise-worthy.

Reply: *Thank you.*

4. The section dealing with data needs to be tightened up. Authors should state the accuracy of AATSR derived AODs, especially when the AOD s are very low and comparable to the uncertainties (instrumental + retrieval + spatial averaging). What will be effect of such an averaging in smoothing off of the wind-induced effects on AOD, especially close to the grids where the winds have large spatial gradients? Second concern here is the accuracy of ECMWF winds. What the measurements that go into this, and what are effects of modelling to interpolate/ extrapolate over no-measurement regions? What is the effect of averaging in space and time domains? What would be the possi- ble effects of the interpolation of these winds to the satellite times (which should also consider the residence times of coarse aerosols in the MABL)?

Reply: *The main purpose of AATSR is to provide a high level of accuracy and stability required for climate research and modelling (0.3 K accuracy). The brightness temperatures measured by thermal channels are accurate up to 0.05K . The error of visible channels measured with the Earth reflectance is less than 1%. The uncertainty of AOD from retrieval and measurement is about 0.003. The AOD data used in the paper is of a resolution of* 1×1 *degree averaged from pixels with a size of* 10×10*km to match the*

resolution of ECMWF wind data. The averaging process undoubtedly smooths some peak values away. But since we are more interested in the large temporal and spacial scale, the elimination of some rare peak values should not influence the result very strongly.

The ECMWF 10m wind is a re-analysis product, the raw sources of data mainly come from ships, buoys, as well as satellites. Over the southern oceans, the in-situ observations are rare. Sometimes, the data over this region need to be interpolated, introducing some uncertainties to the data, but the interpolated ECMWF data is constraint by measurements. The ECMWF data are produced 4 times per day with a time interval of 6 hours. We interpolate the wind data to the satellite passing-over time(local solar time 10:30am) by using the two nearest time slots. The life time of coarse marine aerosol is in range of hours to days(Lewis and Schwartz, 2004), so the error introduced by this coarse temporal resolution should be minimal. We have modified the data section of the revised manuscript to include this part.

5. While binning the AOD data in terms of wind-direction, how long back the authors go in time for the direction? And what is the rationale? An earlier wind, favoring continental transport would have brought-in some (possible different type of) aerosols, which would still remain in the atmosphere? This possibility, at least, is to be discussed, though it is difficult to totally eliminate.

Reply: *For each* 1×1 *degree pixel, if the wind direction on one day falls the into some direction bin, the AOD on this day would be binned into the corresponding AOD bin. So, it is roughly binned based on the daily wind direction. Though the referee's suggestion is correct in general, it is our intention to look at the relation between near-constant speed of wind and the AOD, which is probably the simplest one to start with. As the referee suggested, the long lifetime continental aerosol might have an effect,* *emphasizing the importance of correct remote ocean identification.*

6. Another concern is the possible elimination of real data, caused by changes in the wind speed, by the elimination procedure adopted in this study. In the case when the wind-induced effects are variable in a 1degx 1 deg bin, it is possible that the sigma value could be genuinely high, even if there is no transport. And the threshold of 0.035 appears too small, especially if we consider the uncertainties in the retrievals of winds and AOD.

Reply: *That might be true, but it should be a minor effect. In the storm condition, with absence of transport, the sigma would be high. But what we focus is in the averaged large scale (1 degree), the elimination of some peak values would not influence too much. Any method which is designed for filter data would probably result in some valid data is lost, but that would not have a significant impact on the overall result.*

Minor Comments:

1. Multiple references appearing in the same context are to be cited chronologically; applicable for the entire paper

Reply: *We have rearranged the references order accordingly.*

2. Introduction, Second Paragraph: There is an excellent work by Satheesh et al., (GRL, VOL.33,L03809,doi:10.1029/2005GL024856,2006), which used MODIS-derives AODs and NCEP winds over different oceanic regions, very much similar to case here. This paper should be referred in the text, and also it is suggested the authors may examine their results in the light of this paper also.

Reply: *We thank the referee kindly pointing out this paper which we were not aware of. A reference has been added in the introduction part.*

3. The same paragraph, the sentence the link between marine aerosol optical properties and wind speed is not difficult to. . ..ÂÎ Did the authors mean it is difficult or not difficult, because of the effect of long-range transport?

Reply: *It is a mistake, corrected as '...and wind speed is difficult to...'.*

4. Next paragraph, second line (and elsewhere): replace locates by located

Reply: *We have modified it.*

5. Discussion of Fig. 2 : It appears that variation of the standard deviation is examined in the figure as a function of the wind direction. Then should the ordinate be st, rather than t? It would be nice if the ordinate is specified as wind direction (in degrees) rather than by a symbol q. I take that it is the arrival direction of the wind. Better it is stated explicitly

Reply: *Sorry for the confusion, all the wind direction in the paper is the coming direction, for example, if a wind direction is 90 degree, it means the wind comes from west, and if 180 degree, it means the wind comes from north.*

References

Lewis, E. R. and Schwartz, S. E.: Sea Salt Aerosol Production: Mechanisms, Methods, Measurements, and Models, American Geophysical Union, 2004.