Relationship Between Wind Speed and Aerosol Optical Depth over Remote Ocean: Reply to referee 3

Replied by H. Huang on behalf of co-authors

This paper should not be published because it is scientifically unsound in the results which it produces!! This paper reports a linear relationship between wind speed over the ocean and AOD. It is reported that the AOD ranges from 0.1 to about 0.18 over a wind speed of 0 to 20 m/s. Relative to the most recent studies (Mulcahy et al and Smirnov et al) using an absolute column measurement of AOD, where a range of 0.05 to 0.35-0.45 is observed (depending on wavelength - and the latter upper estimates are for wind speeds of 18 m/s), the current estimates are significantly astray.

Moreover, analysis of MODIS AOD in clean remote marine areas (not published but available) support the above Mulcahy range particularly at the lower wind speeds. At the higher wind speeds MODIS reports lower values than Mulcahy but this is to beex ected with different and more rigorous cloud screening used by Mulcahy, nevertheless these values are significantly higher than what is reported here. The authors need to justify why in clean and remote marine areas the AOD of 0.1is so high - this has never been supported by ground based AOD measurements. The upper limit at high wind speeds is, on the other hand, too low but perhaps is the subject of debate. Nevertheless, the slope of the reported relationship needs to be justified. n order to do this, the authors must demonstrate that the reported values are realistic as follows: (1) calculate a typical remote marine aerosol AOD at low and high wind speeds. (2) Use an accumulation mode dry radius of 0.08 microns. (3) Assume a clean accumulation mode concentration of 80 /cc and a mixed growth factor of 50/50 seasalt and ammonium sulphate. (4) Assume a boundary layer height of 1000 m with RH=98% at top. (5) Calculate the resultant AOD. (6) The take any steady state or flux function for super micron sea salt at 20 m/s and repeat the above steps, but this time assume only sea salt groth factors. If you do the above, I believe you will find serious errors in your retrieved AOD values - I know because I have done it!! t is insufficient to simply report new satellite products relating to process-based relationships which are in stark contrast to the state of the art without rationale and robust supporting material. This paper has none of the above!!! In summary, I believe this paper should be rejected as even if the above exercise is conducted, it will only demonstrate the satellite products reported here are seriously in error.

Reply: *We sincerely thank the referee 3 for comments , they made us reconsider our result. The comments have a centred issue: the values of AOD at low wind speed presented in this paper are relatively high. We will give the details discussion about the issue below and we also added a short discussion of this issue to the result section.*

Validation against Aerosol Robotic Network (AERONET) data shows the AATSR AOD product has a systematic positive bias of 0.056(Portela et al., 2009). One of the possible explanations of the positive bias is that the validation result is for land based and coastal AERONET stations, and thus may not be directly applicable to the remote ocean, but it does suggest that the GlobAEROSOL AATSR product suffers from a positive bias in its AOD values. However, since the bias appears to be relatively independent of AOD (Portela et al., 2009), it should have a limited impact on the observed AOD vs wind speed relationship. Another possible reason for the possible bias in the AATSR AOD is contamination by residual cloud. Although the AATSR cloud mask is considered quite stringent, it is possible that thin cirrus, which is now believed to be very common (Baran, 2009) , might not be removed. This could cause a small, consistent offset in the observed AOD. Fig.6 to Fig.9 in the paper are our results of AOD vs wind speed. Different regions agree pretty closely. We see a linear trend of AOD with windspeed. This result will not be effected by the systematic error.

According to the referee's suggestion, we test the marine AOD at low and high wind speed theoretically. The model used is OPAC (Optical Properties of Aerosols and Clouds) software package. In OPAC, the aerosol optical properties

(including AOD) are calculated by Mie theory, the sizes of particles are assumed to follow the log normal distribution, more details about the OPAC is described by (Hess and Schult, 1998). As suggested by the referee, we assigned the height of MBL is 1km. In the MBL, the optical properties of aerosol are decided by the number concentration (NC), size distribution of the particles and ambient relative humidity(RH). The NC is determined by the production of aerosol which is a function of wind speed and the RH determines the growth (size) of particles.

The source function of production of aerosol used here is the well-accepted exponential function : $N = N_0 exp(a_0 U_{10})$, where the N is the NC of particles and the N_0 is the NC of particles at 0 ms^{-1} wind speed, a_0 is a parameter decided by locations with a range of 0.04-0.39. According to Bigga et al. (1995), the value of averaged value of a_0 over the southern Indian is 0.037. The U_{10} is the 10m wind speed. The OPAC assumes there are three components of clean marine aerosol: water soluble sulfate, fine mode sea salt and rare coarse mode sea salt.

The reviewer suggested at the beginning, before the growth of particles, the NC of fine mode marine aerosol was 80/cc and half of them are sea salt and half were sulfate, and they were with a mode dry radius of 0.08μm because it would be meaningless to use a constant dry radius for all the particles, so we assume it should be a mode radius. We think the NC of 40/cc for fine mode sea salt is too high while for sulfate is too low. As suggested by Lewis and Schwartz (2004), the range of sea salt NC is between 1-30/cc. So we use the default values given by OPAC for the clean marine aerosol type: the values of N_0 are 1500, 20, 0.023 /cc for water soluble, fine sea salt and coarse sea salt respectively.

Instead of only RH of 98%, we calculate for 4 RHs, 50%, 80%, 90% and 98%, according to (Lewis and Schwartz, 2004), the typical RH over the ocean is 80%, and ECMWF data for the sourthern oceans are consistent with this (Fig. 1).

The Fig .2 shows the variation of AOD with the wind speed under different RHs modeled by OPAC. The values of AOD at low wind speed fall into the range of AOD of our result. When the RH is equal to or greater than 80%, the AOD at 0 wind speed is near 0.08-0.09.

Using the default clean marine aerosol parameters given by OPAC and three values of N_0, the relationship of AOD and wind speed under the RH of 80% is modelled (Fig.3). The modelled and observation results have the similar slopes but different offsets, which are sensitive to the value of N_0. Though the aerosol properties from OPAC are generalized and contain many assumptions, it confirms that the slope of our result is not effected by the systematic error we have amended the manuscript to make these points, however, the offset of the relationship might be influenced. This requires more understanding about systematic errors in the retrieval.
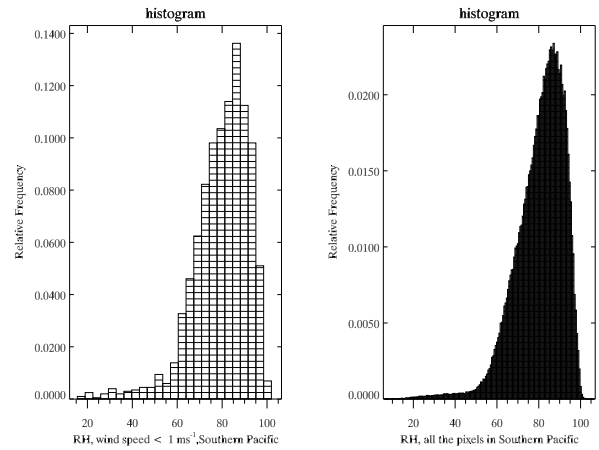

Fig. 1. The histogram of RH over the Southern Pacific. The RH over the other two regions discussed by the paper: Southern Indian and Southern Atlantic follow the similar pattern, ECMWF
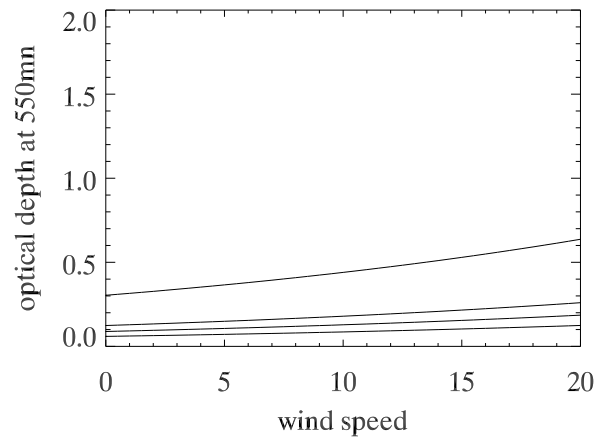
Fig. 2. The relationship of wind speed and marine AOD under different RHs simulated by OPAC, the four curves from top to the bottom are : 98%, 90%, 80% and 50%, repectively

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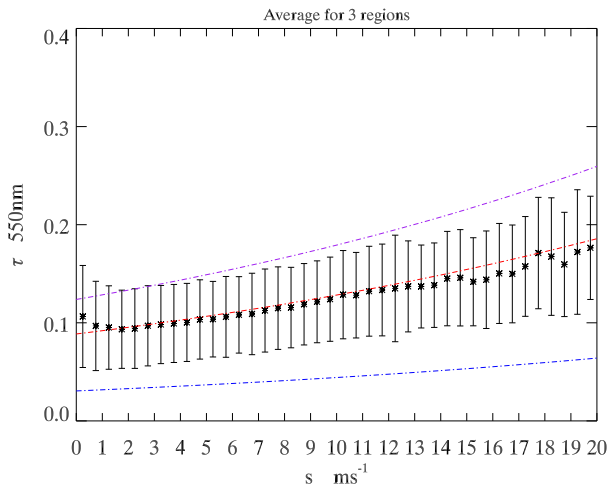
Fig. 3. The relationship between wind speed and AOD at RH 80%, the black crosses are the averaged result for three regions as shown in Fig.9 in the paper, the three dash lines are the OPAC modelled result using different values of N_0 of sea salt, purple:30 cm^{-3}, close to the upper limit of number concentration; red: 20 cm^{-3}, the default value of OPAC; blue: 3.5 cm^{-3}, closed to the lower limit of number concentration.

final report, Tech. rep., European space agency and Oxford University and Rutherford Appleton Laboratory, 2009.