Atmos. Chem. Phys. Discuss., 6, S7144–S7151, 2007
www.atmos-chem-phys-discuss.net/6/S7144/2007/

Atmospheric Chemistry and Physics Discussions

ACPD

6, S7144–S7151, 2007

Interactive Comment

Interactive comment on "Estimating a relationship between aerosol optical thickness and surface wind speed over the ocean" *by* P. Glantz et al.

P. Glantz et al.

Received and published: 8 March 2007

Figures 5 and 6:

15) By using the present y-axel values shown in Figures 6 and 7 we think it is easier to compare the results of the low and high AOT values in figure. Furthermore, now when the solid lines, identical in Fig. 6 and 7, are explained in the figure captions of both figures (see point 18 below) we think different y-scales could be used without confusing the readers.

16) In Section 4.3 the absolute change in sea salt AOT is estimated, according to the present parameterizations. In the expression by Gong et al. (1997) sea salt particle mass is related to surface wind speed. For the lowest wind speed range 0 to 1 m s-1 we assume that the retrieved AOT was mainly caused by ammonium sulfate particles.

Thus, for the latter aerosol only a relative change in AOT has been estimated, suggested by Charlson et al. (1978). This means that for the lowest wind speed range the revised value of AOT (˜0.03) is assumed to have been caused mainly by an ambient ammonium sulfate aerosol, determined by RH1. For the lowest wind speed range (0 - 1 m s-1) we assume then that AOT = 0.03 was mainly caused by the ambient state of the background ammonium sulfate aerosol (squares) and a very small part due to increase in sea salt particle mass concentration (stars minus squares, equation 1 and 2). Thus, for a wind speed equal to zero you could say that the intercepts for the stars and squares have the same values. We could present influences on the AOT due to hygroscopic growth of the sea salt and ammonium sulfate particles separately, but prefer to present the combined effect shown in Fig. 6. The reviewer suggests that the dry state of the particles should be calculated. However, there is no reason to do that. The satellite retrieved AOT is highly dependent on the ambient state of the aerosols. In any case we have included the following text "(Eq.3)" at the end of the second sentence of Section 5.2 in an attempt to make it easier for the readers to understand Fig.6 and the following sentence in the test has been rewritten to; "The squares describe the changes that are associated only by hygroscopic growth of the sea salt and ammonium sulfate particles (Eq.3 - Eq.1 - Eq.2). Furthermore, the mean values shown in the figure have been averaged according to the box model derived mean AOT values, obtained for all SeaWiFS scenes retrieved over the North Pacific for September 2001. "

17) We agree with the reviewer and have, therefore, included the following sentence in the figure caption of Figure 6 "The solid line is a power fit according to the 12 mean values of AOT." and in the figure caption of Figure 7 "The solid line is a power fit, the same as the one shown in Fig.6." Furthermore, the first sentence in the figure caption of Figure 6 has been changed to "SeaWiFS retrieved mean AOT and corresponding one standard deviations, for theĚ."

18) We agree with the reviewer and have rewritten a sentence in the middle of the abstract; "The validation approach is based on previous parameterizationĚĚ..."

ACPD

6, S7144–S7151, 2007

Interactive Comment

19) See point 16 above.

20) We have included Section 5.3 in an attempt to compare the present SeaWiFS retrieved AOT, at least with some available independent and simultaneous measurements obtained over the remote area of North Pacific for September 2001. This is written in the first sentence of this section. The results of the comparisons are discussed at the end of the section. In line with the reviewer's comments in point 3 we have now also taken the results obtained at the high altitude AERONET station (Mauna Loa) into account, when the AOT is estimated for the marine boundary layers over the North Pacific. We agree that the present comparisons between SeaWiFS and AERONET derived AOT is relatively weak mainly because we can not use SeaWiFS land retrieval of AOT because these values are significant higher than the values obtained the surrounding ocean areas. This is probably due to uncertainties in the surface reflectance over the island described in the retrieval approach. We think that the comparisons shown in Figure 8 should, in any case, be presented for the readers, despite the limitation described above. The AERONET instruments are located only at disturbed places on earth, like islands or coastal sites and do not reflect undisturbed sea conditions, which means that a relationship between AOT and wind speed may not be representative for open ocean areas. In any case, once again we have included several references, which all support relatively strong relationship between measured AOT and local surface wind speed obtained at sites also located on islands or at the coast (see end of Section 5.4). In any case, a more appropriate comparison between SeaWiFS derived AOT and AOD obtained at AERONET ground based stations are important in an attempt to validate the satellite retrievals. However, the comparisons should be performed over the land pixel corresponding to the land stations but then when land reflections are better described in the aerosol retrieval model for remote islands and coastal sites

Section 5.4

21) We have rewritten the text and improved the language in Section 5.4. We agree

ACPD

6, S7144–S7151, 2007

that a quantitative discussion of possible errors in the relationship should be improved. Therefore, we have at least include the following text “Additionally, a study by Moore et al. (2000) supports relatively small increase in reflectance due to whitecaps also for somewhat higher wind speeds. They found that the augmented reflectance of white caps in the open ocean for the wave lengths 410 to 670 nm is between 0.001 and 0.002 over the wind speed range 9 - 12 m s-1. Thus, these values are significant lower compared with the surface reflectance over sea water used in the retrieval approach for the wave length 555 nm (Hoyningen-Huene et al., 2003). “ at the end of Section 5.4. Furthermore, even as this is not a quantitative estimation of possible errors we have, in any case, included several references that all support relatively strong relationships between retrieved AOT and surface wind speed (see the end of Section 5.4),

22) We agree with the reviewer that the sentence below (middle of the second paragraph of Section 5.4 in the original version of the manuscript) is not distinctly written and is now removed; “In any case, the assumption that the marine aerosolsĚĚ.”

23) We agree with the reviewer that the sentence below (middle of the third paragraph of Section 5.4 in the original version of the manuscript) is not clear and have, therefore, been removed: “Even so, the supermicron particles as well as the hygroscopic growthĚ.”

24) We agree with the reviewer and think that the discussion in the middle of the third paragraph of section 5.4 is unclear and have therefore been rewritten; “First of all the relatively long turn over time for the submicron sea salt particles (Gong et al., 1997) may induce uncertainties that could be significant. The uncertainty may not be so bad if the local wind speed is such a good substitute for the lagrangian wind speed over the accumulation mode lifetime as indicated by Nilsson et al. (2001), but represents non the less a difference between the coarse mode and the accumulation mode results. Secondly, the fields of wind speeds calculated at the ECMWF will not be able to catch all local and temporal variability, especially on the short time scale and small spatial scale of turbulence. This is however a problem that our analysis has in common with

ACPD

6, S7144–S7151, 2007

Interactive Comment

all large scale models that use similar wind speed data fields, and in that perspective we compare the resulting average AOT and average wind speed of a grid point. Applied in a large scale model, our relationship will again derive the average AOT based on the average wind speed for each grid point. Thirdly, the present approach to estimate mean AOT (Section 4.2) may also induces uncertainties that could be significant."

6. Conclusions

25) Here we mean nearly a factor of 2 higher AOT for the wind speed range 0 to 12 m s-1 (revised version of the manuscript). We think the present sentence is clear written, despite that the wind speed range is not explicit described. In any case the first conclusions has been changed to "Nearly a factor of 2 higher mean AOT is obtained for a wind speed up to about 12 m s-1 over remote ocean areas."

26) We do not agree with the reviewer (see end of point 29 below)

27) The reviewer is right no radiative effect is computed. However, the aerosol optical thickness, estimated in the present study, is an important aerosol optical property for the estimation of radiative effects. A factor of 2 higher AOT for the relatively narrow wind speed range (0 to 12 m s-2), despite that areas associated with these highest values are smaller than areas associated with lower wind speeds, actually suggests a significant direct radiative effect over the North Pacific. Thus, we think this information is relevant in Section 6. We have, in any case, rewritten this sentence (the first one after the conclusions in Section 6); "The results presented in this study make the basis of subsequent investigations to estimate direct radiative effects over the North Pacific."

28) With the sentence in point 27 above rewritten, we think the following sentence should be unchanged "However, the radiative effect could be lower over oceans where organic species, with lower hygroscopicity, are internal mixed with sea salt." We think this is useful information for the readers due to the fact that a significant wind driven organic fraction would probably weakness the present relationship between AOT and surface wind speed over oceans where not only sea salt and ammonium sulfate aerosols

ACPD

6, S7144–S7151, 2007

are presented in the remote marine atmosphere.

29) Considering the reviewer's comments on the following sentence "For this purpose the fit in Fig. 5, AOT = 0.028 + 0.00032 * U2.0 may serve as a first one-line parameterization of the whole complex chain of steps from breaking waves to aerosol backscatter.". We indeed assume that also the influence of ammonium sulfate aerosol is included in the formula (see point 16 above). As a first step we suggest that this relationship is only valid over the North Pacific (see end of Section 6 and point 28 above). Considering the AOT retrieval cut off at 0.15 and transported sea salt see our comments in the points 4 and 1, respectively. Different humidity regimes are, actually, taken into consideration in the present relationship due to a direct link between surface wind speed and emission of water vapor. Furthermore, considering vertical mixing regimes; the vertical mixing of the sea salt particles and humidity is actually highly dependent on the surface wind speed. For the situation when a coupled marine boundary layer has been formed the reviewer is right, the mixing of the local produced sea salt particles will probably be reduced. Therefore, the following sentence "Additionally, decoupled marine boundary layers prevent the particles to reach higher levels than the lower compartment of this boundary layer." has been included after the second sentence "Gravitational settling and dry depositionĚĚ" in the second paragraph of Section 5.4. Compared to buoyancy generated turbulence, wind-shear turbulence seems to have a minor effect on the vertical mixing of sea salt (Glantz et al., 2004). Increasing sea-surface temperature seems instead to be more important for the deepening of the marine boundary layer. Furthermore, an approximately time scale for precipitation is one week. Thus, this has no effect on the locally produced coarse mode sea salt particles and neither on the somewhat longer lived accumulation mode sea salt particles as well as the hygroscopic growth of the marine aerosols. How wet removal processes influence the content of the ammonium sulfate aerosol over the remote marine atmosphere is, however, an open question. Finally, we suggest that the transport of sea salt may not be very important for the present estimated relationship between SeWiFS retrieved mean AOT and ECMWF surface wind speed because the local wind is a good

enough proxy for the lagrangian wind on the time scales considered for the accumulation and coarse mode aerosol particles (see point 1 above). Thus, this means that also the present box model, used in the validation of the results, may be nearly as accurate as a transport model. We certainly hope that our relationship will be tested also in transport models or even RCM/GCMs. Besides that this is outside the scope of the current study, our simple approach has advantages in its simplicity: we can easily follow effects of each process that are included, and we do not need to deal with the complex differences that exists in between different large scale models, where e.g. differences in advection, convection or turbulence schemes could have significant effects on the resulting aerosol and limit the value of a “validation” made by a specific model.

30) It is not shown in our paper, but certainly in the literature, which we have already refered to in our paper. For decades numerous projects have reported an exponential relationship between sea salt mass and the local wind speed and to less extent sea salt number and the local wind speed. It is such a well-established observation that we were sloppy enough not to repeat the references from the introduction in the summary. Gong et al. (1997) reviews a small selection of the literature for sea salt mass to wind speed relationships, but there are many more. Nilsson et al. (2001) shows both a mass-wind relationships for different components of the sea salt, and the probably widest range of number concentration to wind relationship (from 15 nm to 2.2 um over open sea). O’Dowd et al. (1997) is one of the most cited number-to-wind-relationships, and it has the advantage that it reports sea salt number concentrations rather than total number concentration, since a volatility heater is used to evaporate everything except sea salt. Some investigators, like Bigg et al., has made a large effort to establish the “most valid” coefficients for the aerosol-wind relationship, but Nilsson et al. (2001) showed that all concentration-wind relationships suffer an influence of the effect of wind speed in the boundary layer depth and the aerosol deposition, and effects of the preexisting non-sea salt aerosol, and showed the first aerosol-flux-to-wind relationship, which was then followed by Geever et al. (2005).

ACPD
6, S7144–S7151, 2007

Interactive Comment

EGU

31) Here it seems that the reviewer misunderstand the objective in the present study and mix up the present relationship obtained based on SeaWiFS retrieved AOT and ECMWF surface wind speed with the results obtained with the box model. We attend not to use sea salt and ammonium sulfate concentrations in climate models. However, the present relationship, hopefully associated with enough accuracy, could be incorporate in climate models to estimate aerosol direct effects based on the surface wind speeds over the North Pacific. Note that the latter quantity is also associated with relatively small uncertainties in climate model calculations compared to other quantities.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 11621, 2006.

ACPD

6, S7144–S7151, 2007

Interactive Comment