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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Dry versus wet marine particle optical properties: RH dependence of depolarization ratio, backscatter and extinction from multiwavelength lidar measurements during SALTRACE" *by* Moritz Haarig et al.

Anonymous Referee #2

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General Comments

These observations of dry sea salt from lidar are very interesting. The analysis with respect to the measured relative humidity and phase transitions of the aerosols is well done. The presentation is mostly clear. I recommend publication with a few revisions as discussed below.

Specific Comments

Figure 2 is very interesting and helpful for visualizing the sea salt particles at different

stages of the transition. Initially the dust in these images confused me as I was concerned that it might be very hard to separate dry sea salt from dust if they are mixed together like this. On more careful reading, I see that the images in Figure 2 are from a completely different time of year to the case studies. This is perfectly fine, but you might consider putting in another sentence or two in key places to make sure that it is very clear (even to people who are reading a little too fast) that the images in Figure 2 are not from the same time period as the main case studies in the paper.

Page 5, line 9-14 is confusing about whether spherical or non-spherical sea salt particles would be expected to be bigger. Possibly this confusion would be removed if you make a clearer distinction between humidified sea salt particles and droplets. Is it true that crystals are larger than solution droplets, but then the crystals continue to grow as they are re-humidified, so that humidified crystals are larger than solution droplets? Or am I misunderstanding the text in this paragraph?

The quantities shown in the backscatter curtains Fig 3-5 are not the best ones to show. It would be more informative to show geophysical quantities, the same ones shown in Figs 8 and 9. Specifically total true backscatter coefficient rather than attenuated backscatter or the cross-polarized component of attenuated backscatter, and particulate depolarization ratio rather than volume depolarization ratio.

What are the horizontal and vertical resolution of the lidar data shown in the figures?

Figure 10 shows a larger lidar ratio for the dry particles (lower RH). Can you explain in general terms in the paper why this is, in terms of the relative size and refractive indices of the particles?

Page 11, lines 10-13 states that particle backscatter coefficient is an indicator of particle growth if the number concentration stays the same. However, there is no particular reason to imagine the number concentration is the same for these observations, is there? However, you have two wavelengths of extinction, and Angstrom exponent of extinction is a more usual proxy for particle size (indeed you use AOT Anstrom expo-

nent from AERONET in Fig 7). It would be useful to show extinction Angstrom exponent from the lidar measurements to see if this supports the idea of particle growth.

Same place. I also think that particle backscatter coefficient has a dependence on refractive index which may play a role in the trends seen here, although I don't know the relative strengths of the dependencies on N, refractive index and particle size in this observation. Can you comment on this?

Page 12 line 1-2 discusses a poor agreement when extrapolating. It's not surprising that extrapolating from an exponential fit might produce poor agreement. It would be useful to show a linearized version of Figure 13 (that is, log of enhancement factor vs log(1-RH/100)) which may make it more obvious in what regime the parameterization of Eq. 2 holds or might even actually improve the fit and the extrapolation, depending on how the paramters were fitted (that is, was the fit done on the linearized system?)

Page 12 line 10. What does "modeled" mean? Is this the simulated data in Table 1 that is explained much later?

Page 12 line 15. I don't understand this. The increase 2.05 to 3.73 to 5.37 is more than 8% from one wavelength to the next. "Zieger et al stated that the wavelength dependence for marine aerosol". Do you mean the wavelength dependence of the enhancement factor?

Same place: it seems that you could infer the expected behavior of the wavelength dependence by assuming that the angstrom exponent depends more or less linearly on size and use standard paramterization of the hygroscopic growth of particles. Would that be a reasonable assumption and would such a calculation give you similar wavelength dependence to what you see?

Figure 14 and section 5. It would be helpful to mark a line on each panel of Figure 14 showing the value of volume equivalent radius used for the calculation of simulated results in Table 1 and to include this information also in Table 1.

Page 13, lines 16-18. I got distracted trying to understand if the authors mean this last sentence of the paragraph to be related to the rest of the paragraph or not. If it is an unrelated observation, I suggest moving it into its own paragraph. If it is related, I suggest adding some kind of transition to make the reason for making this statement more obvious. Perhaps just "However" or "Nevertheless", that is, if you are meaning to suggest that we need not worry overmuch about the disagreement between measured and modeled lidar ratios since it nevertheless represents a relatively small variation in the properties of the type compared to differences between types.

Page 14, There are some rather vague and unconvincing conclusions here. It seems like you are struggling a little to define the relevance of the observation. I first want to say that this is a very interesting and publishable observation and analysis even in the worst case if it is not particularly relevant to other specific calculations like radiative transfer or aerosol types. If these arguments can't be strengthened, it would be better to take them out with no loss to the paper, in my opinion. More specifically, first, it's not clear to me how or whether this observation affects radiative transfer calculations. What is the mechanism by which dried sea salt aerosol would have a different radiative effect than humidified sea salt in a way that is not captured in the measurements? The differences in backscatter or extinction are directly measured so whether the backscattering comes from depolarizing particles or not is not relevant. Is it because of a poor inference of the refractive index? But you hardly discuss refractive index in this paper. Likewise, what is the mechanism (what characteristic of the dried sea salt) that would cause an error in the AERONET retrievals? Moreover, even if these layers are very common (which it is not at all obvious to me), the layer you observed is very thin compared to the aerosol below it. How much effect would this realistically have on a full column calculation of radiative transfer? The authors could do a rough, approximate calculation to show whether this is a noticeable effect or not, and then I might be more convinced. It also would be good to expand the discussion of aerosol typing to explain why it would matter to analysis such as the cited references if a small amount of aerosol is mistyped. Is this specifically about inferring lidar ratios for aerosol extinction

retrievals, like CALIPSO, or is there some other implication to mistyping?

Technical comments

The abstract seems a little scattered. Each sentence seems to stand alone without clear relationships between them. Rearranging the sentences to be in a more logical order and adding some transitional phrases ("therefore", "however", etc.) or combining sentences would help.

Page 6, line 5. "See AERONET web page, Barbados-SALTRACE site". Please give specific URLs.

What wavelength is Fig 3-5? Please include the information in the figure labels or captions.

Figure 8. From the text, I think this is particulate depolarization ratio (rather than volume). Please confirm, and include that information in the caption.

Figures 8 and 9. It seems there is meant to be a dashed vertical line in all 3 panels, but it appears only in the right panels.

Bigger axis labels and legends are needed in the figures, big enough to be on the order of other font sizes used in the paper

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