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Atmospheric
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Discussions

Interactive comment on "LACIS-measurements and parameterization of sea-salt particle hygroscopic growth and activation" *by* D. Niedermeier et al.

D. Niedermeier et al.

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We thank referee 3 for his/her comments.

General Comments:

1a. "...In the present study, the agreement between shape factors for NaCl and sea-salt aerosol only support the assertion that NaCl and sea-salt particles have the same morphology, not that this morphology is cubic."

In the manuscript, nothing is said about that sea-salt particles possess a cubical shape like NaCl particles. It is just said, that the sea-salt and NaCl particles exhibit a similar aerodynamic behavior and therefore a shape factor of 1.08 is used for the sea-salt particles, too.

1b. "...If the diffusion dryer is not efficient enough, the particles may in fact enter the LACIS as supersaturated droplets rather than dry particles. ..."

The RH after the diffusion dryer is below 10%. Additionally, the ELPI measurements showed no droplet shatter patterns, so there was no evidence that water remained on the particles. Additionally, we performed some model calculations using the Pitzer model (Pitzer and Mayorga, 1973) for simulating the hygroscopic growth of the sea-salt and NaCl particles. The results of the applied model suggest only a small or negligible influence of water remaining on the dry particles.

Specific Comments:

1. "p. 3: The authors have not explained the mathematical method that was used to assign the estimated sea salt composition reported in Table 2."

To explain the mathematical method that was used to assign the estimated sea salt composition more clearly, the corresponding paragraph in Section 4 was rewritten: 'Based on the knowledge of the mass fraction and molecular weight of the ions, the numbers of moles of the ions are computed first. Using these values, for each substance the ions are combined to salts which can be found in sea-salt particles: NaCl, MgCl2, Na2SO4, CaCl2 and KNO3. For each sample, the amount of cations is not identical to the amount of anions. But the analysis of the pH value showed that each sea-water sample is nearly neutral. Therefore no compensation with H+ and OH- ions had to be taken into account. Hence, the salts were combined such that only the minimal part (2.1%, 1.4% and 2.5% of the total mass of the sea-salt samples I, II and III) of ions remained.'

2. "p. 4, equation 1: How was the solute volume (Vs) determined? Presumably this was derived from the dry mass equivalent diameter."

The solute volume was derived from the dry mass equivalent diameter. In order to guard against misunderstandings, equation (1) in the old version of the manuscript was replaced by: $S = \exp\left(\frac{4M_\mathrm{w}\sigma_\mathrm{w}}{RT\rho_\mathrm{w}D_\mathrm{wet}} - \frac{\nu\phi_\mathrm{s}\rho_\mathrm{s}}{M_\mathrm{s}}\frac{M_\mathrm{w}}{\rho_\mathrm{w}}\frac{D^3_{\mathrm{me}_0}}{D^3_\mathrm{wet} - D^3_{\mathrm{me}_0}}\right)$

3. "Figure 2/humidity measurements: It was not entirely clear to me how humidity in the LACIS was determined. As I understood it, the authors used the hygroscopic growth of particles of (NH4)2SO4 to calibrate the humidity scale. If this calibration relies on accurate knowledge of the mass equivalent diameter as well, then there may be significant uncertainty in the humidity calibration. Stylistically, when showing a 1:1 linear relationship in a calibration, it would be appropriate to use a figure with a 1:1 aspect ratio. In future, the authors might want to consider an in-situ determination of humidity using IR spectroscopy through the LACIS unless the humidity is not uniform in the flow tube due to the sheath gas."

The procedure of the calibration is now introduced into the new version of the manuscript. The below sentences were added in Sect. 5.1: 'The used RH-range was calibrated with ammonium sulfate particles. The hygroscopic growth of (NH4)2SO4 particles (Dme = 192 nm) was determined for several dew point temperatures, i.e., relative humidities. Köhler theory, according to Eq. (1) with surface tension of water, was applied to obtain the RH in LACIS from the grown particle diameters. Hence, each adjusted dew point is related to a defined value of RH. The sea salt and NaCl investigations were performed at these RHs (dew points).' For high RHs, the uncertainty in LACIS amounts to +/- 0.3% in RH absolute. The uncertainties in RH were added in Fig. 3.

In Fig. 2, the axes were arranged to express the 1:1 linear relationship better.

4. "Figures 5 and 6: The meanings of the various fits and vertical lines are not explained in the figure captions."

The meanings are now inserted in the captions of Figures 5 and 6: 'The intercept point of the polynomial curve and the straight line indicates Dcrit.'

5. "Figure 7: The solid line in this figure is not explained in the legend or figure caption."

The explanation of the solid line is inserted in Figure 7. It is the product of $\phi_{\mathrm{s}}\nu$ after Pitzer and Mayorga (1973).

References

Pitzer, K. S., and Mayorga, G.: Thermodynamics of electrolytes. II. Activity and osmotic coefficients for strong electrolytes with one or both ions univalent, J. Phy. Chem., 77, No. 19, 2300–2308, 1973.

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