Atmos. Chem. Phys. Discuss., 15, C10850–C10855, 2015
www.atmos-chem-phys-discuss.net/15/C10850/2015/
© Author(s) 2015. This work is distributed under
the Creative Commons Attribute 3.0 License.

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Properties of cloud condensation nuclei (CCN) in the trade wind marine boundary layer of the Eastern Caribbean Sea" *by* T. B. Kristensen et al.

T. B. Kristensen et al.

kristensen@tropos.de

Received and published: 25 December 2015

We would very much like to thank Referee 2 for the comments related to the manuscript. We find that the changes suggested by Referee 2 indeed have improved the paper.
Below we address the Referee 2 comments in a point-by-point fashion.

1 General Comments

1. The sampling line from the top of the tower down to the ground level was kept as close to vertical as possible, but it was put together by several different pieces and possible minor bends were not characterised in the field. That is the reason for not including any (uncertain) correction for losses of coarse particles in sampling lines. In Fig. 4 the dust mass measured from filter samples is compared to the PM mass estimated from the measured particle number size distributions in the size range above 0.5 μm. There is a high significant linear correlation between the two data series, and the total dust mass concentration is approximately a factor of 2 higher than the estimate obtained from the size distributions. It is likely to be due to losses in the sampling line of particles larger than ∽2 μm as indicated by the lower panels of Fig. 2. Hence, the actual coarse mode particle number concentration is likely to be a factor $\leq$2 higher than the measured one. As can be seen from Fig. 2 (lower panel to the left), the number concentration in the coarse mode is still an order of magnitude lower than the number concentration in the accumulation mode if a scaling factor of 2 is applied to the coarse mode number concentration. As argued below in P30764L07-10, the particle number concentration in the size range $>$0.8 μm did not contribute significantly to the total number concentration of CCN.

2. The time periods where the wind direction indicates that local land based sources cannot be ruled out are indicated by gray shadings in the figures 1 and 3. In Fig. 4 only time periods when local land based sources can be ruled out are included in the figure. During the sampling of the TEM samples included in the present study, the wind direction was in the range from 84 to 110, which is well within the boundaries for sampling the marine air masses (335 through North to 130). The sentence: "Sampling was carried out while local wind directions were in the range from 84 to 110" has been included in P30772L04. For all results presented in Table 1, time periods when local

land based sources cannot be ruled out (based on local wind direction/speed) have not been included in the calculations. The following has been added to the beginning of the caption of Table 1: "For time periods where local land-based sources can be ruled out:"

3. We expect that our measurements carried out ∽50 m asl are representative of the conditions in the well mixed marine boundary layer (MBL). Hence, our reported CCN properties are relevant to low level clouds. Werner et al.(2014) reported cloud bases down to 500 m asl and reported evidence for the Twomey effect in shallow trade wind cumuli near Barbados. During the SALTRACE campaign, shallow cumulus clouds were frequently observed at altitudes up to 2 km. At higher altitudes the mineral dust was present and typical relative humidities too low for cloud formation (Groß et al., 2015). Aircraft measurements of CCN properties were carried out during the SALTRACE campaign and the vertical profiles of CCN properties are subjects of publications in preparation.

To make it more clear that our study only is relevant for the MBL and low level clouds, the following change has been carried out:
P30761L03-04: "...may influence the CCN properties in that region" -> "...may influence the CCN properties in the MBL in that region"

2 Specific comments/technical corrections

TEM size range:
The ambient aerodynamic diameter should actually be larger than the PAED for the observed particles, in the range of 1.2-1.5 (driven by density and unknown water uptake at the time of collection). However, we also made a mistake in the procedure

description, as the 530 nm cut-off also was used for the second period, but the size range was additionally split by a 330 nm threshold. We have corrected this in the manuscript. The relatively larger fraction of relatively larger accumulation mode particles during the second period corresponds well with the measured particle number size distributions of the accumulation mode during the sampling periods.

P30776L05-07: More details about the calculation of κ assuming an external mixture are provided by replacing: ",but if an external mixture of sulphate and organic species is assumed, then an organic volume fraction at the order of 25% could also explain the observed κ values." by: "However, the measured CCN number concentrations can also be reasonably well modelled by integrations of the particle number size distributions by assuming an external mixture of inorganic sulphate (κ=0.6) and organic species (κ=0.08) and an organic number fraction of $\sim 25\,\%$ in the diameter range ~ 50–300 nm."

P30762L22-25: Size ranges covered by the APS and the MPSS have been included.

P30764L07-10: The κ values presented in the paper have been inferred with the measured APS number concentration with diameters $>$0.8 μm included. A sensitivity study of the inferred κ values was carried out applying factors of 0 and 2 respectively to the particle number concentration in the range $>$0.8 μm - and the variations in inferred κ values turned out to be insignificant compared to the random errors of the κ values.

P30763L12: The flow rate has been corrected to $\sim 40\,\mathrm{m^3/hr}$.

P30765L28: The SS=0.074% is the actual supersaturation for the nominal SS=0.1%, when the temperature setting in the lower part of the CCN column was lower than the set-point. Change made: "(SS=0.074%)" -> "(with an actual SS=0.074%)"

P30773L09: "of" has been added before "super-micron"

P30774L26: "was" -> "were"

P30775L09: "ammoniumsulphate" -> "ammonium sulphate"

P30776L01: "if it it" has been changed to: "if it is".

P30776L29: Brackets have been added to the reference.

P30777L10: "of" added before "organic species".

Fig.2: The scale on the figure color bar has been modified and grid lines have been included.

Fig.3: The CCN number concentrations for SS=0.3% have been included in the top panel. We find that a linear scale is appropriate for depicting the CCN number concentrations and the D_c in the relevant range.

Fig.4: Information about the size ranges have been included in the figure caption: the mineral dust concentration was inferred from the sampled total suspended particulate matter, and the PM_{est} is based on the integration of the particle number size distribu-

tion (not corrected for losses in sampling lines) in the range 0.5-10 µm.

Fig.5: The blue color indicates the number fraction of the refractory PM in the given range of refractory fraction and particle size. To emphasize that only a fraction of the total refractory matter is comprised of sea salt - the blue coloring has been moved from the top of the bar to the lower part of the bar.

References

Groß, S., Freudenthaler, V., Schepanski, K., Toledano, C., Schäfler, A., Ansmann, A., and Weinzierl, B.: Optical properties of long-range transported Saharan dust over Barbados as measured by dual-wavelength depolarization Raman lidar measurements, Atmos. Chem. Phys., 15, 11067–11080, 2015.

Werner, F., Ditas, F., Siebert, H., Simmel, M., Wehner, B., Pilewskie, P., Schmeissner, T., Shaw, R., Hartmann, S., Wex, H., Roberts, G., and Wendisch, M.: Twomey effect observed from collocated microphysical and remote sensing measurements over shallow cumulus, J. Geophys. Res.: Atmos., 119, 1534–1545, 2014.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 30757, 2015.