Cloud condensation nuclei (CCN) measurements with the HALO aircraft during ACRIDICON-CHUVA and long-term CCN measurements at the ATTO remote rainforest site

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We have employed a cloud condensation nuclei counter (CCNC) on board the research aircraft HALO during ACRIDICON-CHUVA, which has been conducted in September 2014 in Brazil. The scientific objective is to analyze the physical and chemical properties of aerosol particles as cloud droplet precursors and residuals. For this purpose, we used two different inlet systems in front of the CCNC for aerosol sampling: the HALO Aerosol Submicrometer Inlet (HASI) for the aerosol particles and the Counterflow Virtual Impactor (HALO-CVI) inlet to sample cloud droplets, evaporate the cloud water, and analyze the residual particles.

The CCN was measured by a two- column continuous-flow longitudinal thermal-gradient instrument (CCN-200) manufactured by DMT (Roberts and Nenes, 2005). It measures the CCN number concentration as a function of water vapor supersaturation (S), at a time resolution of 1 Hz. The instrument has been calibrated following Rose et al. (2008).

During the campaign the system was operated in two configurations: measuring in parallel at both inlets or at two different supersaturations. During cloud profiling flight maneuvers, Column B was measuring at the HALO-CVI inlet and Column A at the HASI inlet with supersaturations S(Column A)=0.63% ± 0.07% and S(Column B)=0.68% ± 0.07%. These measurements will be used to calculate the upper bound of the cloud peak supersaturation (S_{high}) following Russell et al. (2013). Figure 1 shows the vertical profile of CCN number concentration under clean and polluted conditions. The red markers represent polluted air in an area south of Alta Floresta in Southern Brazil (flights AC12 18 Sept. 2014 and AC13 19 Sept. 2014). The green markers represent the measurements in clean air around Boa Vista, north of Manaus, (flight AC09 11 Sept. 2014). The measurements were performed during cloud profiling flight maneuvers at the HASI inlet and contain in cloud as well as out of cloud conditions. The CCN concentrations for polluted air are very high at low altitudes, have a minimum at 6 km, and then increase again above this altitude. The CCN concentration of clean air higher than 5 kilometers asl are the same as for pollutant air. The large CCN concentration at high altitudes may be an indicator for new particle formation in the cloud. Using measurement data from the new ice experiment-cloud and aerosol particle photometer (NIXE-CAPS) we will distinguish between in-cloud and out-of-cloud conditions. The results will be compared to complementary aerosol measurement data from a condensation particle counter (CPC), a single particle soot photometer (SP2) and a compact-time-of-flight-aerosol-mass-spectrometer (C-ToF-AMS). The C-ToF-AMS data will provide quantitative chemical composition and mass concentrations of non-refractory submicron particles. In addition, we are planning to investigate single particles collected on impactor substrates using scanning transmission x-ray microscopy with near-edge x-ray absorption fine structure spectroscopy (STXM-NEXAFS).

For out-of-cloud conditions, both columns were measuring at the HASI inlet, which acts as a total aerosol inlet for those conditions. By scanning the flow rate at Column A, the CCN number concentration was measured at different S from 0.22% ± 0.07% to 0.68% ± 0.07% Moore and Nenes (2009), Column B was measuring the CCN number concentration at one fixed S=0.66% ± 0.10 %, as a baseline CCN monitoring.

In parallel with the HALO measurements, ground-based size-resolved CCN measurements were performed in the context of GoAmazon at the ATTO site (T0 site). The measurement period already covers 10 months and will be continued. Figure 2 shows the preliminary results of the calculated kappa value for different diameters and the number size distribution at the ATTO site for September 2014. Kappa shows certain temporal variations and also a clear distinction between Aitken and accumulation mode.

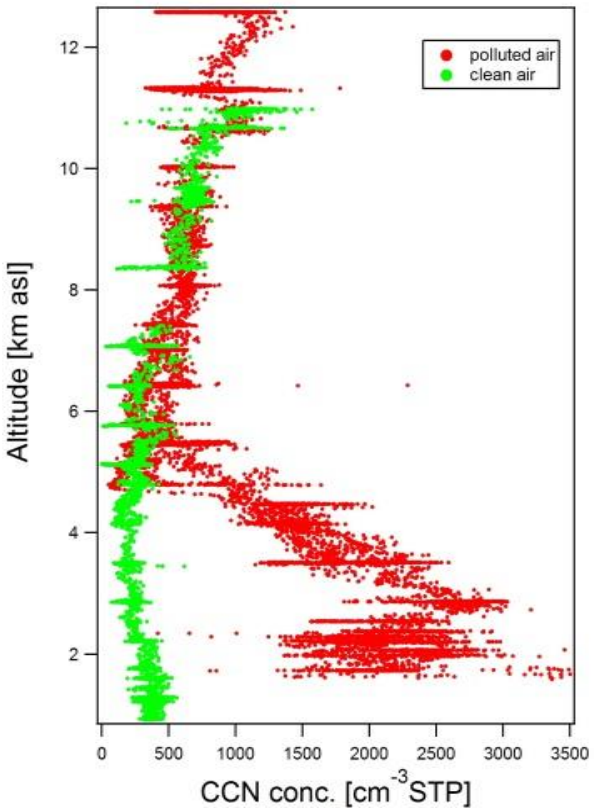

Fig. 1: Vertical profile of CCN number concentration under clean and polluted conditions.

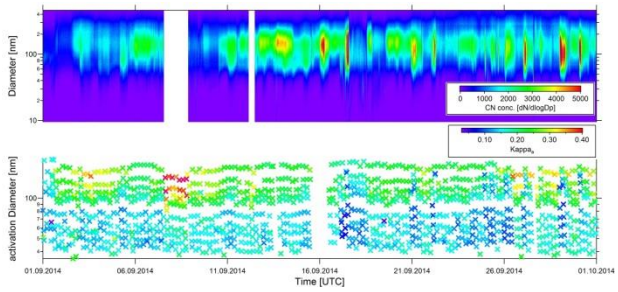

Fig. 2: Time series of the number size distributions and the size-resolved kappa values at the ATTO side for Sept. 2014.

This work is being supported by the DFG projects SPP 1294 (HALO), the Max Planck Society (MPG) and the Max Planck Graduate Center (MPGC).

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