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Assessment of cloud supersaturation by aerosol particle and cloud condensation nuclei (CCN) measurements

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Atmospheric aerosols consist of particles spanning a wide range of size and chemical composition from various natural and anthropogenic sources. They can act as cloud condensation nuclei (CCN) and affect climate by influencing the properties of clouds and precipitation. The water vapor supersaturation at which aerosol particles are activated as CCN depends on particle size, composition and mixing state.

Techniques for the direct measurement of cloud supersaturation are not available. Thus, indirect methods have been developed to estimate the value of water vapor supersaturation in a cloud, which determines the fraction of particles that are activated and form cloud droplets.

In this study we show how size-resolved measurements of aerosol particles and cloud condensation nuclei (CCN) can be used to characterize the supersaturation of water vapor in a cloud. The method was developed and applied for the investigation of a cloud event during the ACRIDICON-Zugspitze campaign (17 Sep to 4 Oct 2012) at the high-alpine research station Schneefernerhaus (German Alps, 2650 m asl). Number size distributions of total and interstitial aerosol particles were measured with a scanning mobility particle sizer (SMPS), and size-resolved CCN efficiency spectra were recorded with a CCN counter system operated at different supersaturation levels.

During the evolution of a cloud, aerosol particles are exposed to different supersaturation levels. We outline and compare different estimates for the lower and upper bounds (S_{low}, S_{high}) and the average value (S_{avg}) of peak supersaturation encountered by the particles in the cloud. For the investigated cloud event, we derived $S_{low} \approx 0.19\% - 0.25\%$, $S_{high} \approx 0.90\% - 1.64\%$ and $S_{avg} \approx 0.38\% - 0.84\%$. Estimates of S_{low}, S_{high} and S_{avg} based on aerosol size distribution data require specific knowledge or assumptions of aerosol hygroscopicity, which are not required for the derivation of S_{low} and S_{avg} from the size-resolved CCN efficiency spectra.