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Measuring and modeling cloud condensation nuclei concentrations at the Jungfraujoch high alpine site

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Atmospheric aerosol particles that are able to act as cloud condensation nuclei (CCN) are important for the climate and the hydrological cycle, but their properties are not fully understood. Total CCN concentration at different supersaturations was measured during CLACE 2008 (CLoud and Aerosol Characterization Experiments) in May 2008 at the high alpine measurement site, Jungfraujoch (3580 m asl.). Simultaneously, an aerosol mass spectrometer (AMS) and a scanning mobility particle sizer (SMPS) were providing information on the chemical composition and size distribution of the measured aerosol.

Number size distribution and chemical composition data were used to model CCN concentrations using a simplified Köhler theory. This theory uses the water activity parameterization of Petters and Kreidenweis (2007) with the assumption that the surface tension of the solution droplet at the activation can be substituted with the value of pure water and the Zdanovskii-Stokes-Robinson (Stokes and Robinson, 1966) mixing rule. Solving the Köhler equation, the critical dry diameters (D_{crit}) as a function of time and the supersaturation in the CCN counter were derived. This information was then used to predict the CCN concentration by integrating the size distribution for D>Dcrit.

The predicted and the measured CCN concentration is highly correlated (R^2 ~0.98) and they agree within ±15% at every supersaturation, though a systematic underprediction is generally observed (Fig. 1, blue points). Closure test with polydisperse ammonium sulphate (AS) aerosols indicate that the prediction bias is just beyond measurement uncertainty. One would need to assume very hygroscopic aerosol, pure AS or even more hygroscopic (kappa = 0.55-0.75), which is unlikely to be present at Jungfraujoch, in order to fully match the prediction with the measurement. Contrary to this an average 15 % of surface tension depression is able to explain the difference between the predicted and measured CCN concentration.

Neglecting the time variation of the chemistry data by averaging it for the whole one month measurement period (Fig. 1, green points) gives almost identical results as the full model, and does not significantly decrease the quality of the prediction. To further investigate the importance of the chemical composition a sensitivity study was performed where changes in the predicted CCN concentration were calculated while the chemical composition was varied. The study showed that knowledge of the average chemical composition is enough to reliably model the CCN concentration at sites with similarly aged and internally mixed aerosols as encountered at the Jungfraujoch.

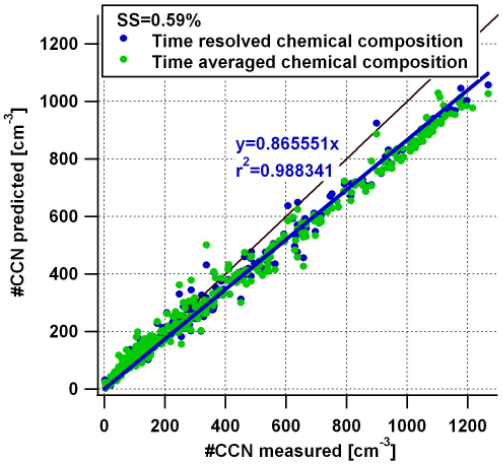

Figure 1. The predicted CCN concentration as function of the measured at 0.59% supersaturation. Blue points were calculated using time resolved chemical information, for the green ones time averaged chemistry data was used.

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