Abstract for Nano Conference at ETH

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Title: Measurements at an alpine site with a new CCN counter

Introduction

Clouds play a very important role in the climate system. Could droplets are formed in the atmosphere in the presence of aerosol particles and a certain supersaturation, i.e. a relative humidity of more than 100%. Aerosol particles that can form cloud droplets are so called cloud condensation nuclei (CCN). Until today long term measurements on clouds condensation nuclei concentrations are lacking. In the GAW (Global Atmosphere Watch) program the need for a CCN counter is acknowledged. In cooperation with the Fachhochschule Aargau we developed a new CCN counter in order to make long term measurements on GAW stations.

The working principle of the CCN counter is making a supersaturation in the cloud chamber by fast expansion of this chamber. The expansion leads to a homogenous supersaturation which can activate particles simultaneously. This is a great advantage on the existing CCN counters that work on the principle of thermal gradient. We can choose up to 63 different expansions, i.e. 63 different supersaturations, with a maximum of 1.8% supersaturation. The number concentration is determined by measuring the optical depth and the scattered light intensity. Laboratory experiments showed a low uncertainty in the determination of the droplet number concentration of 7%. We are able to measure droplet number concentrations down to 40cm^{-3}.
March 2004 a first measurement campaign was held at the Jungfraujoch high alpine research station to study the interaction between aerosol particles and clouds. We present results from the CLACE (Cloud and Aerosol Characterization Experiment) campaign. CCN concentrations are measured at different supersaturations and it is clearly seen, that at higher supersaturation more particles are able to activate. This corresponds well with the expectations.

Conclusion

The new CCN counter showed that it is able to measure low droplet number concentration at low supersaturation. The uncertainty in the number concentration determination was 7%.

Measurements at an alpine site with a new CCN counter

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Introduction

An new expansion type CCN counter (principle after Hudson, 1989) has been designed and operated at the high alpine site Jungfraujoch (3580m asl). During the CLACE III (Cloud and aerosol characterization experiment) campaign measurements were made at supersaturations (SS) varying between 0.3% and 0.8%. The CCN concentration was in the order of 50-60% of the total aerosol concentration. The new CCN counter was able to measure at low supersaturations and shows accuracy at number concentration down to 50 per cc.

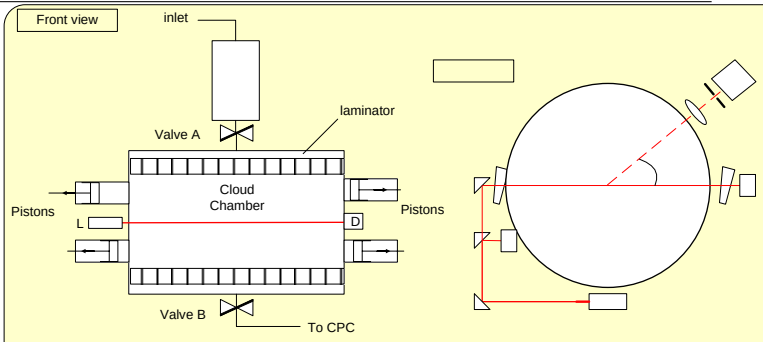


Fig 1: CCN counter schematically. Sampled air enters the cloud chamber by passing a humidifier, where the air humidifies to RH=100%. The chamber is closed before an expansion of the cloud chamber creates a supersaturation (between 0 and 1.5%). The growth of cloud droplets in the chamber is observed with light scattering and optical depth.

Instrument

Number concentration.

Scattered light intensity and optical depth signal were correlated to a known number concentration and turned out to have a linear relationship, with a constant F. In formula: $N_{ccn} = F_{OD}(Q_{OD} / Q_{mie})$ where N_{ccn} is the CCN number concentration, Q_{OD} is the optical depth signal and Q_{mie} is the optical depth according Mie theory. In the same way we achieve number concentration from the scattered light signal. The CCN concentration determination is very accurate, the uncertainty in the number concentration is 7%.

Particle losses. In the laminator (Fig 1) particles losses due to diffusion are in the order of less than 20% for particle sizes greater than 100nm.

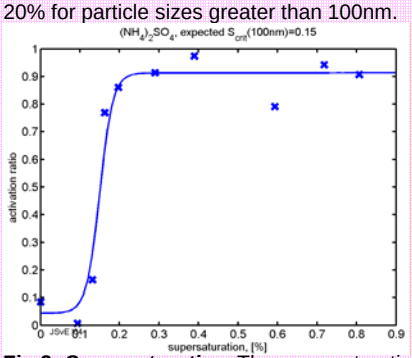
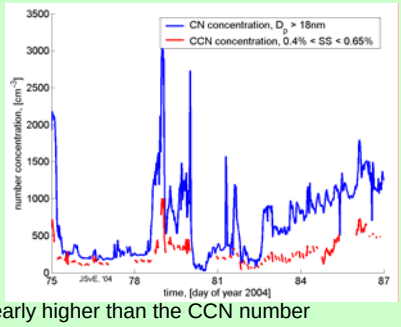


Fig 2: *Supersaturation.* The supersaturation (SS) can be determined theoretically from adiabatic expansion theory. Particles grow into droplets, when they are exposed to a certain threshold SS. As an example: For 100nm ammonium sulphate particles the experimental curve is shown (Fig 2). The activation is at SS=0.15%, which is very close to the theoretical value (0.148%).

Fig 3: Time series CLACE campaign.

The first measurements with the new expansion CCN counter were conducted at the high alpine site Jungfraujoch. The CCN concentration is plotted over 11 days of the measurement campaign. The blue curve is the number concentration of all aerosol particles greater than 18nm. Under polluted condition and periods of particle formation, the SMPS total number concentration was clearly higher than the CCN number concentration. Under stable aerosol conditions the CCN concentration (0.4%<SS<0.65%) was in the order of 50% of the total particle concentration.



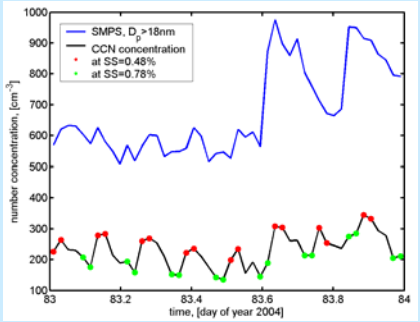


Fig 4: Number concentration 23 March 2004. At 23 March stable aerosol conditions were present at the Jungfraujoch. The particle concentration from the SMPS system did not vary much. The CCN concentration was measured at different supersaturations (SS= 0.48, 0.63 and 0.78%). More particles got activated at higher supersaturation. In the afternoon small particles increases the number concentration of SMPS data, but not the CCN data.

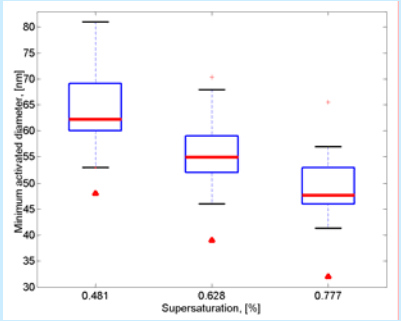


Fig 5: Activation diameter 23 March 2004. The activation diameter, the diameter of an aerosol particle at which the particle will activate into a cloud droplet, becomes smaller at higher supersaturation. The internally mixed aerosol at the Jungfraujoch is less easily activated than expected from a pure ammonium sulphate aerosol (red dot in fig 5). This was already shown with an HTDMA (Weingartner et al., 2002).

References:
Holländer et al., 2002. *American Met. Soc*. 1811-1825
Hudson, 1989. *J.Atmos.Oceanic Technol*., 6, 1055-1065
Weingartner et al., 2002. *ES&T.,* **36**, 55-62

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