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Evaluating the cloud droplet number from particle size distribution measurements: A comparison of evaluated and measured cloud droplet number concentrations

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INTRODUCTION

While a large number of field investigations on aerosol CCN activity and cloud microphysics have been performed, very little information on the activation characteristics of the smallest aerosol particles (those close to or below 0.1 μm in diameter) is available. Here we approach the problem in a slightly different way to traditional methods by measuring simultaneously the cloud interstitial particle size spectrum and nearby out-of-the cloud particle size spectrum. The main advantage of this approach is that one can determine the activated fraction of different-size particles over the whole submicron size range (Komppula *et al.*, 2005). This paper presents a comparison of the cloud droplet number evaluated from particle size distributions and the measured cloud droplet number.

SITE DESCRIPTION AND METHODS

Measurements were done in Finnish Meteorological Institute's Pallas-Sodankylä Global Atmosphere Watch (GAW) station located in northern Finland (Hatakka *et al*., 2003). The two measuring sites, Sammaltunturi (67˚58'N, 24˚07'E, 565 m asl) and Matorova (68˚00'N, 24˚14'E, 340 m asl), are six kilometres apart. The higher-altitude station, Sammaltunturi, is inside the cloud during 10 % of all days (5 % of the time),

while the lower-altitude Matorova station is almost always outside the cloud. This provides an opportunity to investigate the cloud droplet activation of aerosol particles. Similar DMPS (Differential Mobility Particle Sizer) systems are used at both sites for nanometer particle sizing, measuring the dry particle diameter in the size range from 7 - 500 nm. On days with no low clouds present the size distribution is usually similar in both the measurement sites (Komppula *et al.*, 2003). The number of activated particles and the activation percent were estimated by comparing the number concentration in- and outside the cloud. In detailed analysis these estimations could be done separately for each particle size and the diameter corresponding to 50 % activation efficiency could be calculated. Actual cloud droplet number is measured with a FSSP (Forward Scattering Spectrometer Probe).

RESULTS AND CONCLUSIONS

Here we compare the results obtained from the First PaCE (First Pallas Cloud Experiment) campaign held in October-November 2004. The DMPS-evaluated droplet number is compared to the droplet number measured by the FSSP. One-hour average values were compared from different days and weather situations. The correlation was found to be surprisingly good taking into account that methods of measuring were totally different. The difference in droplet number concentration between the instruments varied from 0 to 40 droplets per cubic centimeter. The difference was about 10-15 % on average. In certain conditions instruments are counting slightly different. In the case of probable mixed phase or ice clouds the FSSP values may get lower than the droplet number obtained from the DMPS, due to the FSSP detection efficiency in these conditions. In the case of particles larger than the DMPS detection limit ($Dp > 500$ nm) activating to droplets, the DMPS evaluated values are lower than the actual droplet number. Though, this situation is very rare in Pallas area. Overall this study shows that the introduced DMPS-method is useful when measuring cloud droplet activation of aerosol particles.

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